Examination of Day Lighting and the Glare Problem: The Case of Primary Schools in Famagusta

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ABSTRACT

The objective of the current investigation is to examine the effect of daylighting based on the direction of the openings and class organization on students in primary schools. Daylighting within the built environment is a critical factor in human expansion and functioning. Daylighting is an essential factor in the design of education buildings as it creates a pleasant environment; it promotes healthier conditions and ensures energy saving. Qualitative research is carried out through review of various theoretical sources on the subject and the case study assessment to define the appropriate daylighting system and the ways to reduce visual comfort issues. The data collection of the case study is based on observation, photography, plan and section drawings, and 3D modeling of classes. For filling the aim of the present thesis, an in-depth daylighting performance analysis was carried out in typical classrooms of primary schools in Famagusta, North Cyprus, in which the selected classrooms have south direction windows with direct light which cause glare. The thesis shows sufficient lighting levels in the case of Famagusta primary schools; however, high lighting contrast and bright visible light source in the field of view can cause glare issues, which will reduce comfort and hence the level of learning among students. Conclusions regarding potential improvements are proposed to achieve better visual comfort in typical educational school premises in North Cyprus with similar climatic characteristics and typologies in educational architecture.

Keywords: Daylight, Interior space, Opening, Class organization, Famagusta, North Cyprus

ÖZ

Bu araştırmanın amacı, gün ışığının ilkokullardaki öğrenciler üzerindeki etkisini, sınıf açıklıklarının yönü ve sınıf düzenlemesini temel alarak incelemektir. Yapılı bir çevre içerisinde "aydınlatma", insan gelişimi ve işleyişi için önemli bir faktördür. Gündüz aydınlatması, hoş bir ortam yarattığı, daha sağlıklı koşulları teşvik ettiği ve enerji tasarrufu sağladığı için eğitim binalarının tasarımında önemli bir yere sahiptir. Bu nedenle, nitel araştırma yöntemi, teorik materyaller ve vaka çalışması değerlendirmesine göre, uygun aydınlatma sistemini tanımlamak ve görsel konfor sorunlarının azaltma yollarını belirlemek için seçilmiştir. Vaka çalışmasında kullanılan veri toplama yöntemi gözlem, fotoğraflama, plan ve kesit çizimleri, ve sınıfların 3 boyutlu modellemesine dayanmaktadır. Araştırmanın amaçları doğrultusunda, Kuzey Kıbrıs, Gazimağusa'daki ilköğretim okullarının tipik sınıflarında geniş kapsamlı bir günışığı performans incelemesi gerçekleştirilmiştir. Bu araştırmada, pencereleri güney yönünde olan, doğrudan ışık alan sınıflar seçilmiştir. Çalışma, Gazimağusa ilköğretim okullarındaki aydınlatmanın yeterli olduğunu göstermektedir; ancak, yüksek aydınlatma kontrastı ve görüş alanındaki parlak görünür ışık kaynağının, parlama sorunlarına neden olduğu ve öğrenciler arasındaki öğrenme düzeyini azaltabileceği tespit edilmiştir. Gazimağusa'da bulunan ilkokullarında benzer iklim özellikleri ve tipolojileri olan eğitim binaları mimarisinde daha iyi bir görsel konfor elde etmek için olası geliştirmeler ve ilişkin sonuçlar önerilmiştir.

Anahtar Kelimeler: Gün ışığı, İç mekân, Açıklık, Sınıf organizasyonu, Gazimağusa, Kuzey Kıbrıs

To My Beloved Family

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Chapter 1

INTRODUCTION

This chapter presents the background of the thesis, statement of the problem, the aim of the thesis, research questions of the thesis, methodology, thesis limitation, and the structure of the thesis.

1.1 Research Background

Lighting is always regarded as an essential factor in human development and performance. Wurtman (1975) mentioned that light is considered to be the most significant input in handling many functions. Of course, it is worthy of mentioning here that today, daylight must be along with artificial lighting, and many buildings are designed in such a way to use both of them (Wurtman, 1975).

At the beginning of the 20th century, daylight was seen as the primary source for building illumination. During two decades, electric lighting sources received more attention because it was easy to use and because of convenience mostly. Energy conservation and environmental concerns have modified, and daylighting is regarded as an essential factor in designing buildings (Shishegar & Boubekri, 2016). For several decades, the use of the proper lighting design was mostly based on the visual needs of each building, and then emotional concepts got more attention. The connection between building occupants' health and wellbeing and lighting has been at the focus of attention in architectural design (Day & Gunderson, 2015). There is a direct relationship between lighting and humans' performance and humans' health. Light not

only provides visual information but also it helps to humans' cognitive performance and mental focus (Revell, Arendt, Fogg, & Skene, 2006). Light is also regarded as an essential learning element in the classroom environment. Moreover, it has strong influences on cognition and learning process. (Marzano, Pickering, & Pollock, 2001).

Daylight is regarded as one of the elements that play a significant role in the interior space and the user's performance and health. Also, it's always considered to be an essential element in the design and organization of the areas. Considering the qualitative factors in the design of educational spaces have a significant effect on making a suitable environment and also the performance of the primary users of these spaces, namely, students. Consequently, one of the most effective environmental factors is the use of daylight in the classroom design, which also affects students' function, behaviors, and health (Tierney, 1988).

1.2 Statement of Problem

Glare, high level of brightness, not enough opening area, poor daylighting, inappropriate shading or daylight controlling system, unsuitable class organization according to the direct sunlight are the main problems which can be happened by inappropriate daylighting in classrooms. Inadequate lighting in classrooms can cause several issues, such as; an undesired reflection of light beams from the classroom environment. Also, a low level of natural light in classrooms or a high level of brightness which makes glare in the majority of classrooms in primary school are counted as major problems (Ramasoot & Fotios, 2008).

In the classrooms, students carry out various activities that may take several hours. Then, direct daylight or low daylight levels and artificial light make the environment

inappropriate. Also, the amount of light in the classroom affects the level of concentration, drowsiness or spore, physical and mental issues (Tuncer & Yildirim, 2012).

Classrooms need to have a suitable design to provide enough visual comfort for easy learning of students. Because of being used all day long, educational buildings require a high level of daylighting and should benefit from daylight to increase student's performance and academic staff. However, daylight may become insufficient to meet the necessary lighting conditions in several times, so artificial lighting has become essential. In an educational environment, daylighting has a crucial impact on academic performance and alertness of students, provides a healthier study environment. Besides visual responses, light has other effects on human beings, such as performance, mood, and attention. (Bellia, Pedace, & Barbat, 2013). Glare is one of the main problems happening because of the high level of brightness from direct light in classrooms, especially from the south direction or from the high reflection of light from inappropriate finishing color, texture and material of surfaces. This problem can be solved with interior design features such as shaders, curtains, changing the class organization, or walls, floor and furniture finishing color, texture or material or changing the height and number of windows.

1.3 Aim of the Thesis

This thesis aims to find out the best ways for an appropriate daylighting based on openings direction and class organization. One of the objectives of this thesis is to reach a suitable daylight integration level in the classroom. Also, the selection of appropriate light for the students in the space of classrooms is another principal object of this thesis. Besides, defining solutions for glare problem based on the light

reflection of finishing color, material, and texture of walls, ceiling, floor and furniture and also the type of class organization is another primary objective which was considered. According to these aims, nine primary schools in Famagusta city, North Cyprus are selected as case studies for better understanding the problems in this field and their solution.

1.4 Research Questions of Thesis

Given the aim of this thesis, the following research questions are addressed, which are finding solutions for glare problems based on the finishing color, material, and texture of walls, ceiling, floor, and furniture and also the type of class organization. Another item is to find the connection between the direction of windows and class organization in the classroom. How with different seat arrangement can control and reduce the glare and the high level of brightness which cause issues in visual comfort of students. And In the end, defining the implication of classroom light for students.

So, the main question is; How glare could be controlled in educational environments with interior design solutions?

And the sub-questions are; Which type of seat arrangement can provide visual comfort for students and help to reduce glare?

Which type of used color, texture and material of walls, floor, ceiling and furniture can affect visual comfort?

How window size and direction can affect the amount of daylight penetration and make glare problem?

How daylighting can be controlled in classrooms with interior design solutions?

In the end, based on the literature review and case study analysis answers to this question will be defined.

1.5 Limitation of Thesis

The analysis of the classroom is limited to the daylight of primary classrooms. Geographical conditions, climate, color, temperature also have impacts on the daylighting amount and direction. The studies in this thesis are limited to daylighting and its issues based on the size and direction of openings and type of class organization. For more clarification based on the climate and direction of light in Famagusta, North Cyprus, 3D modeling of selected classrooms is done in three different times of day as Talim ve Terbiye Dairesi (2005) specified the primary school break times in North Cyprus 7.55 am, 9.45, and 11.35 am. The 3D modeling of chosen classrooms is considered in the December month as the 3D modeling has done in different months during the fall semester and it is understood that December month is the most problematic time on the analysis at sketch up program. And this thesis is trying to find a solution in the most problematic time of the fall semester. For more clarification these different 3D modeling renders are included in chapter 4 for one of the primary schools as an example of the North Cyprus climate. It should be noted that classrooms which have south direction windows with direct light are selected because this type of light make glare problem.

1.6 Methodology of Thesis

The qualitative research method is employed in this thesis, which includes two parts. Firstly, documenting related theoretical materials such as books and articles and secondly analyzing the case study based on three main steps.

The first step includes classrooms' observation, photography, and measuring their openings and space, which are categorized into several tables. In the second step, the results which are obtained from analysis which for more clarification 3D models of the selected classroom by Sketch-up is done based on the sun direction in the December month at 7.55 am, 9.45 and 11.35 am, were interpreted to understand the effect of daylight in the classroom.

And in the third step, based on literature and analysis, items for daylighting improvement and control are recommended. This technique can help people to discover a key to design in a way to have proper light and organization for classrooms. Table 1 demonstrates the methodology parts and steps.

Table 1. The methodology of the thesis (Author)

METHODOLOGY OF THESIS		
First Part	Documenting related theoretical materials such as articles and books related to daylighting, class organization and glare.	
Second Part	Analyzing case studies, nine primary schools in Famagusta, North Cyprus, in three main steps.	**Step 1:** Observation, Measuring, Photography.
		Step 2: 3D modeling is done of selected classrooms in three different times a day.
		Step3: Finding problems and defining solutions based on finishing materials, class organization, and window types.

1.7 Structure of Thesis

The first chapter of the thesis contains a statement of the problem, the objective of thesis, methodology, limitations, and structure of the thesis. The second and third chapters of this thesis include a review of the related literature, according to the information and theories related to daylighting, artificial light, different types of

lighting, daylighting strategies, class organization, and school location and orientation. The fourth chapter is a case study and its analysis based on information, plans, sections, and 3Ds of each selected classroom. The fifth chapter included the conclusions. Figure 1 demonstrates the structure of the thesis.

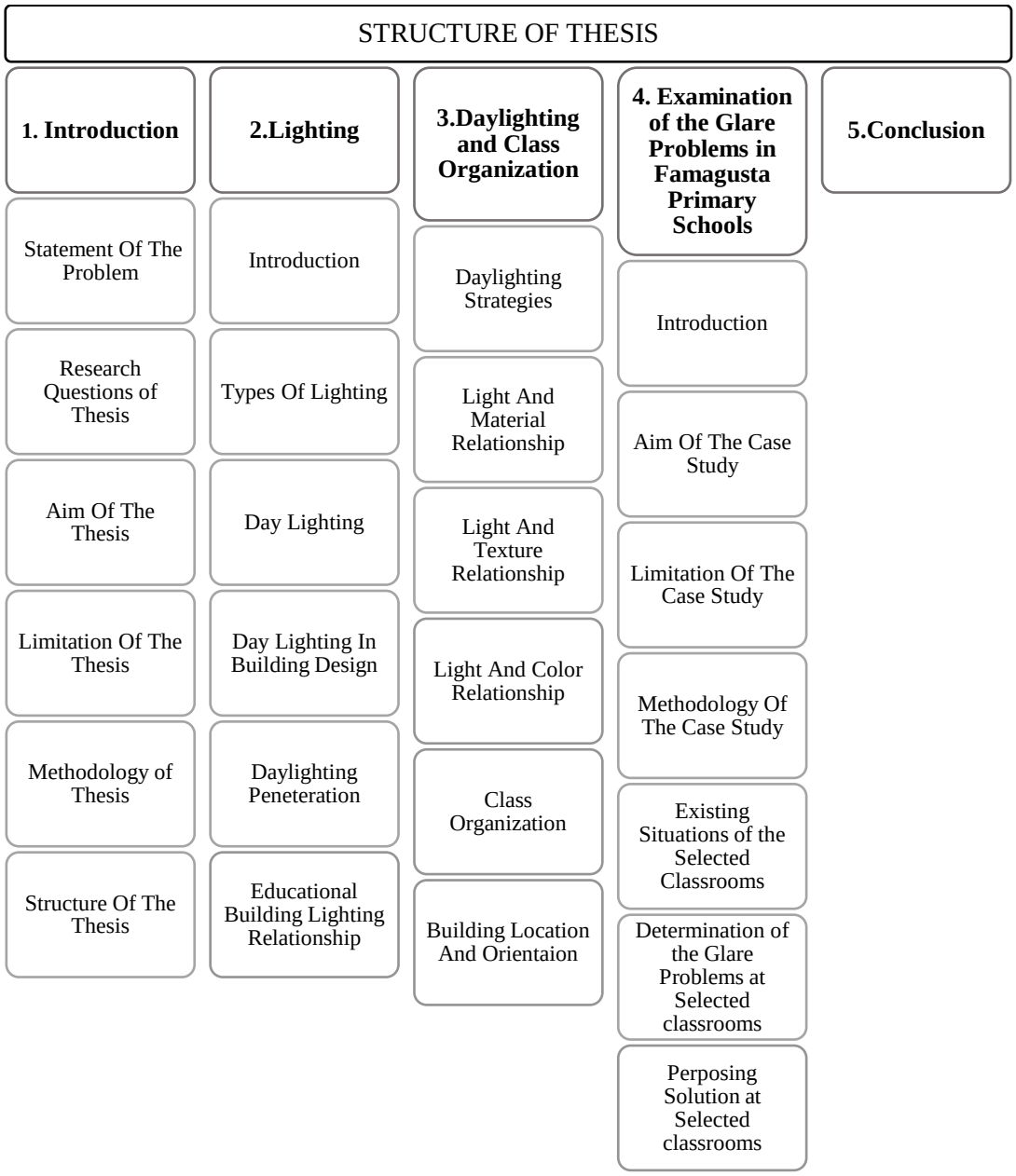


Figure 1. Structure of thesis (Author)

Chapter 2

LIGHTING

2.1 Introduction

This chapter includes a review of the related literature, which is based on the general information and theories about daylighting, artificial light, different types of lighting, daylighting system and the effect of daylight at schools and its influences on students' performance.

The conception of space is directly related to how light is mixed with it. What is interpreted from an environment is directly derived from the lightening. Given the architecture aspects, the lighting situation plays an important role in designing buildings. Concept of architecture and light is directly related to each other. A successful architect always regards the light in every step of his/her work. Paying attention to textures, colors, and forms of a space assist architecture in deciding the way of employing daylighting or artificial lighting in their design. Generally, vision is regarded as an essential element, and it influences directly on one's perception, and thus the lighting enhances how one considers architecture even more (Altan, 1989).

Using daylight in architectural design makes a useful and pleasing space for people. Natural lighting creates patterns on space brightness as well as performing a direct connection to the outside. There are some irregularities in natural lighting levels in the

space, but its impact on the comfortability of people in this environment is noticeable (Ander, 1995).

It can be said that lighting plays a significant role in the way in which people experience and find out architecture. Regardless of the types of buildings, lighting is regarded as a tool that allows people to see and appreciate the fantastic and beauty aspects of buildings around them. Light has a direct effect on one's emotions and feelings. The natural origin of light is daylight. Daylight is an essential element in designing buildings. Even those buildings that rely on artificial light also need daylight (Altan, 1989).

Light is a type of electromagnetic radiation that also is released in a visible wavelength range between 380- 780 nm. If the lighting system well designed, it will help to see what people do easily as well as revealing the space design and increase the beauty of forms, colors, and materials (Livingston, 2014).

According to Altan (1989), lighting has a direct effect on people's behavior and feelings. It causes people to feel happier. In designing a place, the rate of the lighting of that place needs to be taken an account. The functional aspects of lighting in designing the building, especially in pedagogical settings, should be regarded.

2.1.1 Definition of Light

The real definition of light from the dictionary is called luminous energy in which provides vision, and it makes the dark place light, and it is usually considered at the range of about 400 to 700 nm (Dictionary, 2019). The light is useful for people's lives, and it influences their performance and their function (Dictionary, 2019).

Light is seen as a vital element of the science of architecture. Light gives us the chance to see in the darkness. Light enhances one's vision in seeing the world and objects, and it assists people to touch the physical world and elaborate it. People cannot see things without light, and light makes it possible for us to see the physical world, even in the darkness (Altan, 1989).

Many architects prefer to design a building in such a way to use daylight mostly. It can be said that the use of daylight creates harmony between the internal and external atmosphere of the building, and it makes a connection between humans and nature. Architects think the combination of daylight and artificial colored light can make the space more beautiful, and they regarded this technique as an effective technique architecture design (Kobayashi & Oh, 1989).

Moreover, the proper use of light in space has a direct effect on people's moods and emotions. It is crucial to design a building with balanced light. For example, when people go to a place that has harmony light, it has a direct effect on how they feel the space. Light can have a positive impact on people's life. It regarded as an emotional reaction that people think is the place (Kobayashi & Oh, 1989).

2.1.2 The History and Culture of Lighting

It is critical here to stress the significant role of the daylight inside and outside of the building again. Thus, it can be said that daylight is the natural beginning of the use of light in buildings (Kobayashi & Oh, 1989).

Moreover, the background and history of architecture are equal to the background and use of windows and daylighting in the buildings. Even at an earlier phase of

architecture, in controlling the rate of daylight, air, heat, and cold, the windows were regarded as the tool for doing this effectively (Yildiz, 1995).

During centuries, the windows have expanded. The primary role in the windows, which is letting daylight come to buildings, always remained constant. People open the windows to be in touch with nature and modify their climate. Earlier, different materials were used for windows. The development of glass was regarded as a vital thing in the development of windows (Yildiz, 1995).

By the mid of the 1960s, the use of artificial light has grown and is regarded as a supplementary light in buildings. Of course, it is worthy of mentioning here; daylight was the primary source of the light during days (Meiss, 1991).

At an earlier time, people used only natural lights. For example, during the day, the use the natural light of the sun, and at nights, they used the natural light of the moon, stars, and sometimes they make a fire, which was the primary element of nature. Prehistoric people learned to make a fire in the heart of life and use it for their destination. For using fire, other related tools such as a torch, candles, and original lamps were invented. However, they smell unpleasant, and sometimes using flames inside the house was dangerous. In the mid-19th century, the use of the artificial light was enhanced, and it caused to make the darkness of the night lighter and brighter. After that, the light was used only for safety and security at night. Many people and authorities started to use the light without any restrictions and barriers. They use it for many purposes, including advertising and making facilities easier (Coch & Serra, 1994).

About 150 years ago, the first outdoor lighting systems were employed in European cities, and after that, many villages and rural places stated to use artificial lights. The development of artificial lighting is regarded as a great achievement in culture. Artificial lighting was available on a large scale at any time that you want. With the development of industry, many people even worked at night, and as a result, the consumption was increased. At the beginning of the 19th century, the first gas lamps were employed for lighting in many European cities. At the beginning of the 20th century, Vienna used mostly gas in comparison to using illuminating the streets. In respect to inventing electric power, it can be said that it is designed and developed by Thomas Alva Edison in the late 18th century. It was a big revolution in the human world. At this time, the artificial light instantly replaced the natural light, and many electrical tools were installed either inside or outside the buildings. In mid-1930, people mostly used gas discharge lamps for outdoor lighting. After 14 years, the light-emitting diode (LED) lamp was expanded, and it has become a whole source for outdoor and indoor lighting (Coch & Serra, 1994).

2.2 Types of Lighting

In this section, different types of lighting were investigated and analyzed. The influence of light in humans' life is touchable. After entering light in humans' experience, the relationships of people with each other and with their environment redefined. The light had two primary sources: daylight and artificial light (Coch & Serra, 1994).

As it was mentioned, the source of daylight is nature. Earlier people knew how to use natural light in their life. Modern people learn how to employ artificial light sources and make themselves dependent on daylight. People also understand the effectiveness

of daylight and its advantages in human's life. At this time, artificial light became dominant, and it was seen inside and outside the buildings. It makes the night brighter. In fact, in the lack of daylight, it is beneficial. It can be said that artificial lighting has many benefits and advantages both inside and outside the buildings. Artificial lights can be presented in different shapes and color, and it is used for many purposes (Plummer, 2012).

Artificial light created many commercial chances and possibilities for people. It means that it not only makes the dark space lighter but also provides some other commercial chances for people. The employment of these lights creates a calm atmosphere. Figures 2 and 3 show artificial light in two buildings (Plummer, 2012). Figure 4 indicates the use of artificial light outdoor.

Figure 2. Artificial light in outdoors (URL 1. www.indesignlive.com, 2019)

Figure 3. Artificial light in a building (URL 1. www.indesignlive.com, 2019)

Figure 4. The use of artificial light in outdoors (URL 1. www.indesignlive.com, 2019)

2.2.1 Artificial Light

Three main artificial lights consisted of task lighting, general lighting, and accent lighting (Plummer, 2012). The following sub-sections explain each of these artificial lights in detail.

2.2.1.1 Types of Artificial Lighting

As you can see in Figure 5, the artificial light is divided into three main types that include; task light, general light, and accent light. Besides, the general light is divided into five sections; direct lighting, semi-direct lighting, homogenous lighting, semi-indirect lighting, and indirect lighting.

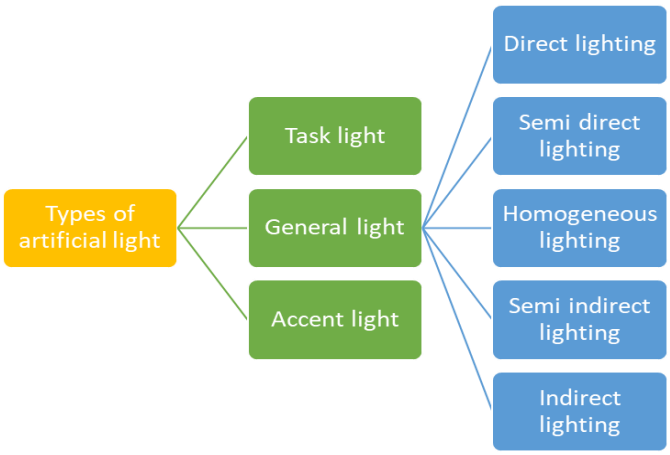


Figure 5. Types of artificial light (Plummer, 2012)

Task Lighting: Task lighting refers to enhancing the rate of light at one point to do something better. This type of light focuses on one point to accomplish work. These types of lighting usually use for different purposes. It uses for specific purposes such as reading, cooking, designing, drawing, and working with computers. Usually, in this type of lighting, brighter light is used. For having more pleasant lighting, it is usually recommended that avoid using harsh lights. You can have this light separate from the general light of your room (Plummer, 2012). Figure 6 indicates a task lighting example.

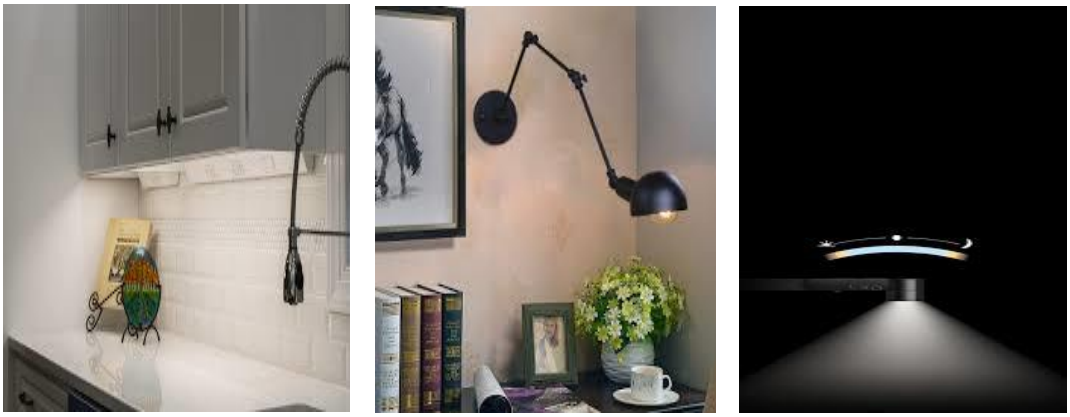


Figure 6. Task lighting (URL 1. www.indesignlive.com, 2019)

General Lighting: In fact, the term 'general lighting' or 'ambient lighting' indicates the levels of light as the background light in a specific place. Moreover, the general lighting presents a background light space in contrast to other types of lights. Both sources of artificial lighting and daylighting can be used or combine to make general lighting. In such cases, there must be harmony between artificial light and daylight to make a place pleasant (Plummer, 2012).

The introduction of new artificial light also causes many things else such as the emergent of colored light, the combinations of the colored light, and daylight. Thus,

many designers tried to use both types of lighting in designing buildings. They decided to combine the artificial power systems and natural sources of energy in such a way that they could make a comfortable environment. Moreover, they also considered some other factors, such as seasonal situations (Routledge, 2002).

As it was mentioned before, the general lighting presents the light at such level against accent lighting, and it is usually used for commercial purposes. In this situation, the interaction and coordination between general and accent lighting is regarded as an essential element in making harmony lighting and creating a pleasant experience. In some other situations, the general lighting may be in line with task lighting for reinforcing light levels for particular tasks (Plummer, 2012). There are five general lightings types, which are direct lighting, semi-direct lighting, homogeneous (luminous) lighting, semi indirect (semi indirect) lighting, and indirect lighting.

Accent Lighting: It is a type of lighting that is mostly used to achieve the desired effect, and it is mainly focused on the specific point of interest. It is mostly employed to highlight an architectural feature or set of things or objects for a particular purpose. As a general rule, for effective accent lighting, it needs to install enough light on the desired point to get consistent results. Figure 7 shows the accent lighting example.

Figure 7. Accent lighting (URL 1. www.indesignlive.com, 2019)

Lighting in Decorative Purposes: Lighting for decorative purposes alludes to appealing lights or lamps to supply a point of notice or an attractive characteristic in an interior. Here it is the light itself that gives the attention and not the illuminated thing. The decorative lighting is regarded as the fourth level of lighting, which is used inside the building and makes the inner space shiny and bright (Sezgin, 2011). Figure 8 shows examples of lighting in decorative purposes.

Figure 8. Lighting in decorative purposes (URL 4. www.finefurnished.com, 2019)

2.2.2 Daylighting

Definition of Daylight: Daylighting means the natural light that can be seen during the day before it gets dark. Daylight refers to the time when people can see each other and the other things without trouble. It mostly relays on the sun. Daylight usually provides adequate internal lighting. In designing a building, the proper use of daylight and to maximize visual comfort has been at the focus of the attention of architects (Cesar, 2007).

Daylighting for being practical in giving interior lighting, deliberation must be compensated to the area of windows or unlike openings and sharp edges on the foundation that the purpose is to enhance optical support or to constraint liveliness utilization. Liveliness utilization can be inhibited by refuse in the utilization of

abnormal (electric) lighting or hidden day light-based warming. Presenting less emotional lights or modified trading of electric lights inside the sight of daylight is a thing identified as day light-collecting (Marsh & Lowenthal, 1965).

2.2.2.1 Types of Daylight

Generally, the types of daylight included general (ambient) lighting, task lighting, accent lighting, and decorative lighting:

a. Task Lighting: Task lighting gives to concentrate light on a special task the completion of visual tasks simpler. Lighting at the reading corner, sketch table, or a special object is all cases of task lighting. The common needs of these are to signify and distinguish tiny sections of the whole optical cause. Task lighting is separated from area and mood lighting, which are designed easily to various light locales of a gap, occasionally making especially needed impacts. The task lighting is too designed to work collectively with the general lighting to supply the right quantity and quality of lighting for visual performance. Lighting is clarified with the four valuable views; task lighting its stage and spreading, differ in the duty, the difference between the task and its surroundings, absence of inconvenience shine. For task lighting, individual control is possible that have considerable psychological benefits for persons. To stop darker surrounding regions and over the top brightness proportions, several background lightings are necessary (Cuttle, 2010).

Figure 9. Task lighting (URL 4. www.finefurnished.com, 2019)

b. General (Ambient) Lighting: General lighting presents the necessary horizontal lighting over the whole zone with a certain grade of regularity. Too famous as ambient lighting, it carries a comfortable stage of brightness devoid of shine and permits regarding and walking about securely. The majorly useful achievement of this sort of lighting is the flexibility in making the gap removed. Since lighting is nearly like in all places, the settlement is comparatively simple (Boyce, 2014).

Figure 10. General (Ambient) lighting (URL 4. www.finefurnished.com, 2019)

c. Accent Lighting: In fact, accent lighting is in somehow directional lighting to emphasize a specific thing or to sketch notice to a piece of the subject of sight. It makes the atmosphere in the gap with the help of optical hobby, light, and shadow. It is used to spotlight paintings, houseplants, design, and other prized wealth, or to highlight the texture of a wall. Since it is a powerful producer of the visual atmosphere, it requires concentration. Accent lighting requires at least ten times as a great deal light on the main aim as the general lighting about it. Accent lighting is particularly utilized as in the next titles: Modeling, silhouetting, downlighting, wall washing, up lighting, and touching (Sezgin, 2011).

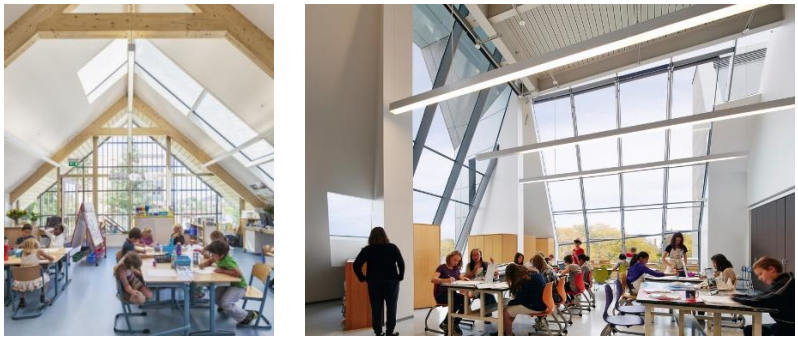


Figure 11. Accent lighting (URL 4. www.finefurnished.com, 2019)

2.2.2.2 Benefits of Daylighting

The general purpose of daylight is to reduce the employment of artificial light, and it decreases the costs and hotness, which is derived from electrical lighting. Indeed, electrical lighting makes more heat. If we use daylight more than artificial light and in harmony with each other, we can reduce the use of artificial light and the heat, which is derived from them significantly (Plummer, 2012).

For many buildings, the use of daylight and artificial light together has been at the focus of attention, and they try to use 15 to 40 percentages of daylight. However, many companies may use daylight more than artificial light, but it can also reinforce their task, and it causes satisfaction and increased productivity of employees and customers. People love nature, and they attract to natural places. Daylight influences well-being, productivity, and a sense of satisfaction among people. Even many well-known companies try to use daylight to increase their performance and reinforce the comfort of their customers. In many stores, the use of daylight causes the rate of their sales to increase (Read, 1974).

2.3 Daylight in Building Design

For centuries, daylight was the just capable supply of light accessible. The architecture was overwhelmed by the aim of spanning massive places and making openings huge

sufficient to spread out daylight to inside the buildings. The advanced daylighting system, handling, and controlling strategies are the other phases in presenting daylight, using green energy, and enhancing the efficiency of buildings. These systems have to be combined with the architectural approach and they have to be regarded in the designing process (Baker, Fanchiotti, & Steemers, 2013).

2.4 Day Lighting Penetration

Opening spaces are a critical part of designing a building for making the buildings more functional, especially when firing happens on the premises. Generally, there should be a standard distance in this respect, and at the time of designing the building, the architects have to consider it (Waldram, 1950). In the following paragraphs, the central opening, which is a window that lets daylight penetrate to space, will be discussed. The categorization of the lights that enters through windows is explained.

2.4.1 Windows

A window is regarded to be an opening space in the wall of the buildings, and it permits the daylight and the light of the sun to enter the building. There are two types of main windows; they are on the wall, and they are on the roof, which is known as skylights. Of course, it is worthy of mentioning here the quantity of daylight that enters inside the building relays on the size of the windows and the height of the roofs. Daylighting is regarded as a rich source for completing tasks, improves energy usage effectively. Moreover, it considered being a significant source of making things visible and reinforces the tasks. (Raji, Tenpierik, Bokel, & van den, 2019).

The rate of natural daylight that enters a building generally comes through windows, especially when they are open, and it causes the climate of the inside of the premises to change. It is perfect, and it creates an excellent visual vision and gets into to the

urgent surrounding environment (Mohammed, 2014). Window openings at the same time have two functions that include the following items.

- ✓ Entering the light inside the building for making the atmosphere better and pleasurable
- ✓ It permits the inhabitant to have a visual connection with the external world and nature (Jenkins & Muneer, 2004).

There are three types of lighting opening:

a. Side lighting;

b. Horizontal lighting

c. Atria, light courts, reentrants.

a. Side Lighting: This type of lighting has been employed as the primary method of daylight dispersion into buildings. Moreover, this type of light makes visual access to outside and nature possible. In this case, the size of the openings is a valuable item, and we should not ignore this vital point (Leslie, 2003).

Side lighting can be signified as four bunches with different features:

• Single side lighting: the daylight penetrates from one side

• Two-sided lighting: the daylight penetrates from both parties, and the harmony of it relays on the space and size and height of windows

• Polygonal lighting: the light penetrates from a few sides of the room, and it enhances equality of lighting

• Clerestories: in this way, the windows are situated at 2.10 m higher than the wall and deeper diffusion of light (Leslie, 2003). Table 2 is demonstrating these four types of side lighting with some pictures.

Table 2. Side lighting categorization (Leslie, 2003)

SIDE LIGHTING CATEGORIZATION	EXAMPLE	PICTURE
1. Single Side Lighting	Penetration of daylighting from one side.	 (URL 2:www.m.takeluckhome.com)
2. Two-Sided Lighting	Entering light from two sides of the room happening Uniformity of spreading depending on the area, height of windows, and depth of the floor.	 (URL 2: ... m.takeluckhome.com)
3. Polygonal Lighting	Entering of light from a few sides of the room and enhancing equality of spreading.	 (URL 2:www.m.takeluckhome.com)
4. Clerestories	In this plan, high windows which situated at least amount 7 feet (2.10 m) higher than the floor introduces a high regularity of spreading and deeper diffusion of light.	 (URL 2:www.m.takeluckhome.com)

b. Top Lighting: Openings are placed in the roofline and create a piece of the building roof. Based on this strategy, the dispersion of light illuminates more profound zones. Occasionally they have been utilized where the side lighting is unsuitable (Baker, Fanchiotti, & Steemers, 2013).

Figure 12. Top lighting (URL 1. www.indesignlive.com, 2019)

c. Horizontal Lights (Skylight): This type of light generally provides identical light inside the buildings. This type of light is regarded as the horizontal light. The use of light can prevent glare trouble since its task is not to build an exterior view. The most proper separations for skylights are uniform to roof height without side lighting windows, and for spaces with the presence of side, lighting is a synonym of top Height of the side lighting window (Shi & Chew, 2012).

The aim of designing skylight is to provide enough light without paying attention to more summer light and spreading the light equally with side lighting. For getting this purpose, such strategies and techniques are suited in this way. Employing skylights and suited it in the north and south directs can minimize the light enters the room in the summers, and it enhances the light at winters, which have some advantage. Designing a skylight on the north of the wall causes the light to spread properly in comparison with the wall. Figure 13 shows horizontal lights inside the building (Shi & Chew, 2012).

Figure 13. Horizontal lights (skylight) (URL 1. www.indesignlive.com, 2019)

It should be reminded that top lights are located on the roofs, but horizontal lights are designed on the highest level of walls with some orientation in which the sky can be seen (Shi & Chew, 2012).

2.4.2 Features That Affect the Quality of Daylighting from Windows

One of the main features that let enough daylight enter the space and also can control the glare is the window with an appropriate design based on window size, its location, glazing assets, shading systems, ceiling limits, and interior design elements. In the following paragraphs below, some guidance for reaching to the clear daylight will be presented (Robinson & Selkowitz, 2013):

- **Higher window, deeper daylighting:** As can be seen in figure 14 useful amount of daylight is normally 1.5 to 2 times bigger than the height of the window which this amount can be increased by reflective light shelves. The standard window and ceiling heights can be 2.7 to 3 meters for sufficient daylight within 6.1 meters from the window (Robinson & Selkowitz, 2013).

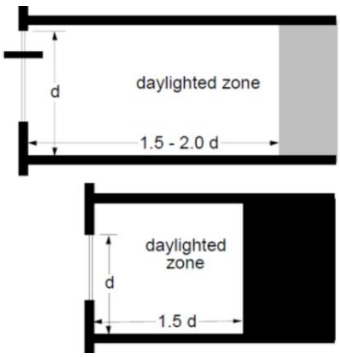


Figure 14. Typical daylight penetration rule-of-thumb (Robinson & Selkowitz, 2013)

- **Strip windows, more normal daylight:** as shown in figure 15, one of the easiest methods to make sufficient daylighting in space is using the continuous strip windows in the place. Also, Punched windows can be suitable, but the breaks between windows

can form dark areas. By using glare control features such as separated window openings, this problem can be solved (Robinson & Selkowitz, 2013).

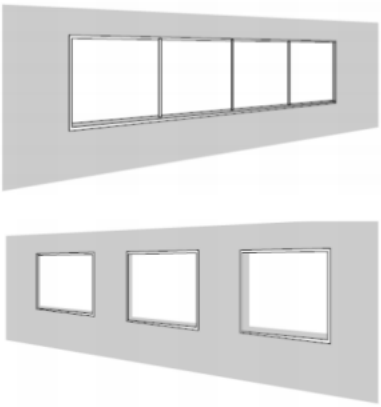


Figure 15. Strip windows (Robinson & Selkowitz, 2013)

• **Integrated shading elements with windows**: Shading strategies complete three duties, firstly, they control sun's heat; secondly, they can eliminate uncomfortable glare from direct sunlight, and thirdly they soften strict daylight contrasts. Figure 16 and 17 shows how to design an exterior shading system which can block sunlight but also enhance interior daylight level in comparison with simple overhang (Robinson & Selkowitz, 2013).

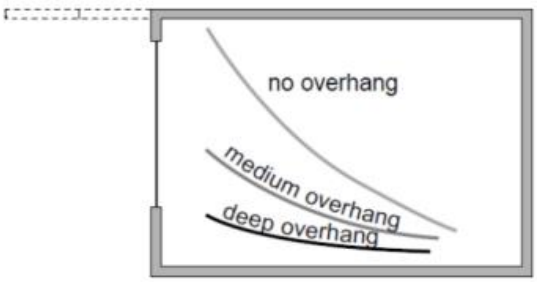


Figure 16. A room section showing the effects of shading systems on daylight level based on room depth (Robinson & Selkowitz, 2013)

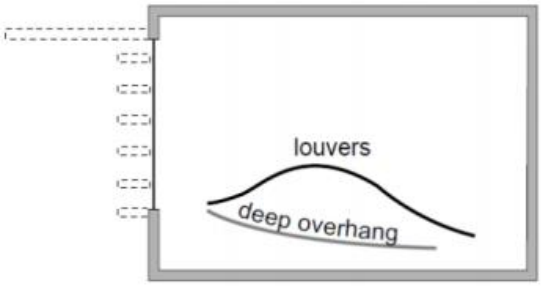


Figure 17. Using horizontal shapes to make a better daylight quality (Robinson & Selkowitz, 2013)

• **Horizontal window shapes:** Horizontal window shapes can let more daylight in, but vertical shapes create more dark areas in which taller windows make deeper daylight distribution. It should be noted that long and wide windows can create less glare in comparison with the tall and narrow windows (Robinson & Selkowitz, 2013).

• **Windows on each orientation can deliver suitable daylight**: North: High-quality daylight with the least sun's heat, but thermal loss during heating situations and related comfort issues. South: Good access to the strong and original source of sunlight and shading can be easier. East and West: Shading can be more difficult, and it is critical for comfort on both sides and also for heat, too, particularly on the west side (Robinson & Selkowitz, 2013).

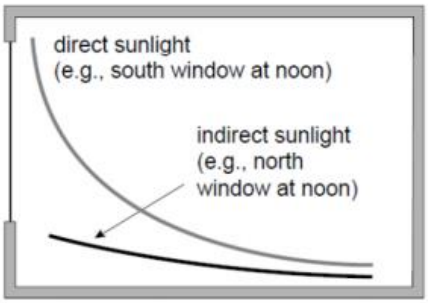


Figure 18. Light levels of window orientation. Curves show light levels when the window is facing the part of the sky (Robinson & Selkowitz, 2013)

2.5 Educational Building Lighting Relationship

In this part, initially, the history of the lighting in the educational buildings will be discussed. Then the visual requirement, lighting supply, effect of daylight, and artificial light sources will be presented.

2.5.1 History of Lighting in Educational building

a. School building (Before 1930): Generally, one of the great views of school buildings was daylighting, since artificial lighting was not sufficiently available. Buildings of educational facilities accurately designed, and they took place in such a way that they can use the best daylighting qualities, and these were accurately demonstrated and profoundly received architects' attention in that period. Many earlier architects acquired more specific perceptions concerning proper and sufficient daylighting in comparison to nowadays, architects. Hamlin (1910) stated that light has to be entered in such that it has to be over the left shoulder of each student. It means that the light should be close to their hands, which are the main tools of doing the task. In this period, the daylight standard and architects mainly focused on the size of the windows and the ratios of the window to floor area. These types of classrooms are generally employed in many schools (Hamlin, 1910).

b. The Progressive Era (1930-1945): Weisser (2006) stated that for overcoming depression, especially the has a negative influence on students' performance, some well-equipped instruments were made in the mid of the 1930s that somehow it made about 70 percentages of school facilities new for local communities. However, during two decades of the 1930s and 1940s, many of the pedagogical facilities in the US were according to the characteristics of the earlier tools. Still, suddenly newer pedagogical models received more attention, and they become popular. Moreover, many European

models become prominent, and many European architects become leaders (Weisser, 2006).

In this respect, Hille (2011) stated that these leaders and designers lived and improved the idea of learner-centered. They reinforced research methods which they have made according to the fundamental of today's pedagogical approaches. During two decades of the 20s and 30s, a different phase of the advancement at schools manifested, and many of the educational facilities and tools were rebuild and build by modernist architects such as Saarinen, Aalto, and Neutra. The schools move toward the open-air and refresh the atmosphere. The open-air school was the name of these schools. They were called by this name because of their design, air, fresh atmosphere, and outdoor environment learning. These schools were also called functionalist because of their natural air, the activity outside of the building, and the physical health that they were the fundamental principles of psychological wellbeing. In the mid-1930s, many psychological articles stated to investigate the school buildings and thus focus on the plans that were concentrating on the significance of child care design (Weisser, 2006)

c. Post War Boom (1945-1960): In 1949, some articles were conducted concerning designing pedagogical facilities and tools that they were about the effect of lighting, heating and acoustic, and many other factors in designing school building. During the two decades of 1940 and 1950, the advancement of economics causes some improvement and progress in artificial lighting in pedagogical settings rather than natural light that is entering through windows. In this time, designing a suitable and proper building for schools were at the focus of attention since the lighting standards were changed. Building Research Institute (1959) stated that the results of some tests

had signified some new light level standards. Then they decided to increase the classroom's lighting standards from 30 foot-candles to 70 foot-candles (Ogata, 2008).

d. The "Impulsive" Period (1960- 1980): In the domain of saving the energy, not only ventilation and eating were regarded as the essential topics, but also the lighting is the other critical topic that it should be considered in the domain of energy conservation. At the end of the 1960s, Castaldi (1958) noted that the emphasis had been modified from the use of daylight to artificial light, and some architects want to design a building in such a way that it reinforces with artificial light. Baker (1959) stated that the rich sources of full brightness and lighting are natural things such as sky, sunlight, and bright wall areas at buildings. In this time, the classes without windows have become an essential and vital topic for articles (Baker, 1959).

According to Weinstein's (1987)'s reviews, the articles at the beginning of the 1970s demonstrated that those classrooms that did not have any windows. They did not have any significant and critical adverse effects on the learning process of the students, even when they were dissatisfied with the quality. Although the dissatisfaction of users did not have any impact on the idea of the architects of the time, and it became popular during the 1970s (Weinstein, 1987).

In this respect, McGuffey (1982) stated that there is no significant difference between the children's performance in the classroom with windows and the classroom without windows. Moreover, he reexamined that schools which were located underground. The results of his research did not show any negative influence of the classroom on student performance, anxiety levels, behavior, and mood. However, in contrast to these findings, many earlier studies emphasized the importance of daylight, and they

believed that the classroom without windows reduces the students' performance (McGuffey, 1982).

e. Declines of the 1980 and the New Movements of the 1990s and 2000s: Although lighting standards are mainly signified, there are still some challenges about how much lighting should be presented to classrooms (Baker, Fanchiotti, & Steemers, 2013). The rate of the daylight, quality, and the way of the distribution of light and other particular issues in designing the building with daylight can be considered as these difficulties. Today, researchers are concentrating mostly on performance-based standards such as visual comfort and lighting (Baker, Fanchiotti, & Steemers, 2013).

After daylighting becomes prominent, articles on lighting in classrooms have been at the focus of attention in the past two decades. For example, the thesis investigated hormone production and the abilities of the concentration in children who did not have any access to sunlight, and they found that there is a positive relationship between daylight and the cortisol hormone (Küller & Lindsten, 1992).

Heschong and Mahone (1999) investigated daylighting in classrooms, and they demonstrated that there is a direct relationship between the students' performance and school buildings. Then, other researches focused on the vital role of daylight in students' performance and their health. Many schools have made based on sufficient daylight criteria, and unfortunately, less attention has been paid to the problem of visual comfort (Heschong and Mahone, 1999). Table 3 remarks on the crucial points of each era.

Table 3. Essential points in the history of lighting in educational buildings (Author)

ERA	TIME	IMPORTANT POINTS
A. School Building	Before 1930	• No artificial lighting • Using a particular concept of daylighting in their design • The light should come over each student's shoulder (they should be right-handed) • Standards of definite window areas and the ratio window to floor
B. The Progressive Era	1930-1945	• Open-air school movement • Natural air, outdoor activity, physical health, and natural sun lighting
C. Post War Boom	1945-1960	• The evolution of economical fluorescent lighting • New lighting level standards- from 30 foot- candles to 70 foot- candles
D. The "Impulsive" Period	1960- 1980	• Energy conservation research • Scientific resources on windowless classrooms • Windowless classrooms were the modernization of the school design.
E. Declines of the 80's Decade and The New Movements	1980- 2000	• Understanding that daylight had a positive effect on the production and concentration abilities in children • Building schools with sufficient daylight in the classrooms

2.5.2 Visual Requirement in Educational Building

Both qualitative and quantitative needs should be satisfied with presenting good lighting. Lighting needs are distinguished by the satisfaction of three basic human needs; visual comfort, visual performance, and safety. Showing proper lighting for performances and activities is vital and vital for comfort. For providing a comfortable atmosphere, it is crucial to have a balance between daylight and artificial light (Küller & Lindsten, 1992).

For performing an excellent visual performance, the distribution of light plays a significant role. Regardless of the position of the light in the room, the rate of delivery of light should not be less than 1/3 of the lighting of the task. It is generally offered that lighting not only influences the visual performances but also it has a direct effect on non-visual jobs. For example, Loe and Rowlands (1996) studied influence of

lighting on an intellectual performance that there is a significant improvement in memorizing, logical thinking focuses, and intelligence level of the quality of lighting. Also, there is a relationship between the percentage of the windows and the size of the class, which is the proportion of windows should cover 15% until 20% of the whole class area (Building Bulletin 90, 1999).

2.5.3 Lighting Supply for Educational Building

Generally, quality lighting does not have this ability to present enough illumination to the work area. Many factors have a role of inefficient lighting systems. Two of these factors are closely related, and they are glare and uniformity (Epstein, McCowan, & Birleanu, 2003).

Visual comfort, uniformity, and balanced brightness refer to lighting quality. These factors can reinforce students' performance and their long-term concentration on one specific task. Today, schools are responsible for presenting an environment through which students feel comfortable, and they learn in the best shape. If the quality of the learning is high, the children will learn best, and it reinforces and improves students' moods, behavior, focuses, and as a result, their learning. The following factors refer to quality issues: Amount of light on walls and roof; Handling of direct and reflected glare; Uniformity; Daylight (Epstein, McCowan, & Birleanu, 2003).

In general, the natural and daylight have this ability to provide part of lighting for visual tasks. It can be presented at different levels, and it can be varied inside the buildings. Daylighting has many advantages over artificial lighting. Windows play a significant role in this process and through which daylight across and it enters the premises. They regarded as the tool that makes the connection between outside to inside. In such a situation, there is a need for supplementary lighting to create a balance

in the distribution of lighting. For decreasing glare from windows, screening should be presented where suitable windows are a complicated part of a building design. For designing space organization, both skylight and sunlight need to be regarded. Windows were also seen carefully for enhancing the benefits and reducing the dissatisfaction of the students (Rockcastle & Andersen, 2014).

It is proved that daylight presents the best lighting conditions. In many schools building, many places receive enough light, and some areas do not receive enough sufficient light. In these cases, it is necessary to find a way to mix both daylighting and artificial lighting to remove the needs of the people. In this situation, the task and the appearance effects should be considered (Schneider, 2002).

2.5.4 Effect of Daylight on Psychological Function in School Building

There is a direct relationship between lighting and how one perceives a building. Unfortunately, guidelines for choosing the type of light in such a way to reinforce the positive mood are lacking. Windows are used significantly in the working environment, and many people prefer to use it (Veitch, 2001).

Daylight improves the mental situation of both teachers and students. According to Knez (1990) and Vetich (1997), lighting influences on one's mood and attitude. In this respect, Heschong (2003) noted that the physical features of the classroom, such as lighting, do not influence student absenteeism. In contrast, Hathaway (1994) discovered a good relationship between lighting and student attendance (Mirrahimi, Ibrahim, & Surat, 2013).

The level of lighting is regarded as a particular psychological factor in schools. Researchers showed that daylighting could increase mental performance, and it decreases violent behavior and depression (Sleegers, et al., 2013).

Stress is distinguished by hormonal and physiologic modifications in reaction to threats and inconsistent events. For example, an unpleasant environmental situation is regarded as these events (Larsen, 2000). Also, researchers noted that daylight inside the building make students feel secure (Tanner, 2000). Daylight influences the function, performance, and one's internal clock. Therefore, the positive effect of daylight on humans is one of the most critical aspects considered in architectural design (Edwards & Torcellini, 2002). As you can see in figure 19, daylighting has two significant effects on psychology that can cause different improvements in mental and physical health.

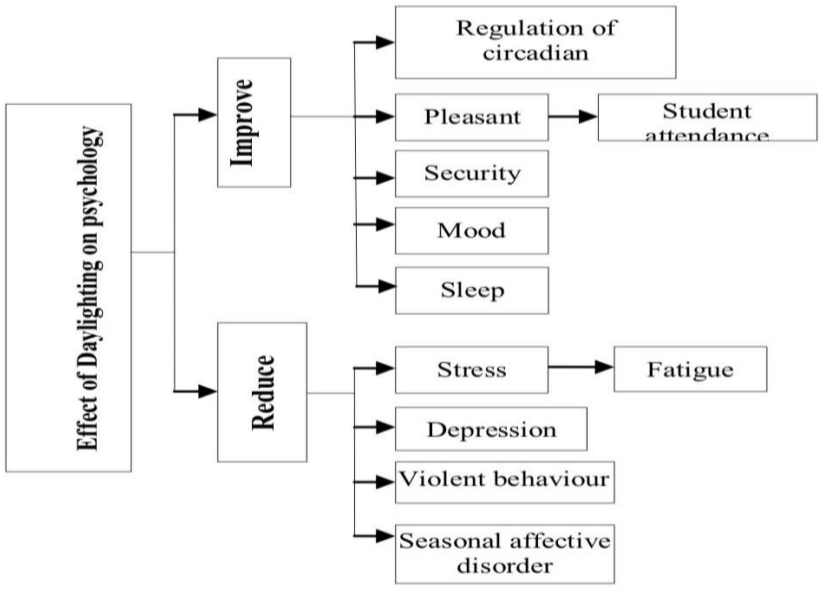


Figure 19. The impact of daylight on psychological function (Larsen, 2000)

Undoubtedly, the rate and type of light have a direct effect on the human's perception of comfort in a specific place. Illumination has a critical and vital impact on human

performance for particular tasks. In this respect, quality is less colorful. Boray (1989) has mentioned that the aim was to assess how various types of lighting influence human mental performance, the attractiveness of the room, judged room size, and the pleasure of place. That there is no significant difference between these variables and the types of light that have been employed.

If the rate of light is high, it creates a better atmosphere, and it has a positive effect on the quality of the classroom. In contrast to this idea, the use of a high rate of light causes the negative performance of the students. Kruger and Zannin (2004) examined luminance in classrooms in different courses in August 2003. One of the rooms have a window with light shelves, but the other one does not have any windows. Both of the classes were on the same side of the building, and the other variables remained constant that both rooms had some benefits and disadvantages. For example, in the late afternoon, the rate of natural light decreased, and it needs to combine with artificial light. The other class produced enough lighting throughout the day. This shows that even some characteristics like daylighting might have some disadvantages.

2.5.5 Impact of Morning Bright on Student's Alertness

It is worthy of mentioning here; different types of sunlight will have different effects on human's physical and psychological aspects. Indeed, the touchable and untouchable influences that sunlight has on humans rely on the rate of light, which is perceived through eyes. In this respect, the wavelength spectrum of the morning has significantly different from long-wavelength of afternoon sunlight on the human's body and mind. It is proved that being at the exposure of blue light for 6 to 7 hours during the biological night reduces sleepiness, and it increases one's performance in comparison with those who are at the expose of green light (Webb & Sheeran, 2006).

The alerting effects relay on the wavelength, and there is an excellent sensitivity to short waves in comparison to long waves in the visible spectrum. The results even being exposed at the light with any wavelength for second will cause some changes in the mind (Lucas, 2014).

Vandewalle (2007) investigated 50-second exposure of blue light with a green light. He proved that morning light has a vital role in setting the metabolic rhythms in a cycle of 24 hours of the earth. In fact, without regular daylight, the biological clock of the people will be out of work, and it causes some problems in sleep hours and awake of people. The effect of early morning sunlight on the circadian system of the students has also been examined by Figueiro and Rea (2010), and they got the same results (Vandewalle, Gais, Schabus, & Balteau, 2007).

The lack of short-wavelength light in the morning harms students' performances. Those who are in the real context of the school environments performed significantly better. The natural setting has many advantages, both psychological and physical, for students (Lucas, 2014).

The use of sufficient light can also increase alertness and students' achievement, and finally, it has a positive effect on their performance. The impacts of enough light on the rate of the healthiness and arranging daytime for working hours. Sufficient daylight has many advantages for humans. There is a direct connection between person's compelling performance and the rate of light. They claimed that hourly light exposure was a significant predictor of vitality. Those who are exposed to more light or proper light will experience the feelings of life more. Even in the absence of sleep and light-

deprivation, sufficient light increases physical and psychology's performance (Beute & de Kort, 2014).

Leichfried (2003) proved that early morning lighting reinforces alertness and mood, but it had no impact on the mental performance of the individual. If a human does not be sufficiently at the expose of light, it may harm his mind and body.

Moreover, if people do not be at exposure to enough light, their biology clock will be out of work, and they cannot perform well and do their job. To be at the exposure of bright light for a long time reduces the fatigue and feeling of stress, and it causes active the autonomic nervous system. Many everyday works, such as driving and texting messages, will be improved if a person is exposed to sufficient light. The adequate light not only has some positive influence on the cognitive ability of one person, but also it has some positive effect on one's physical health and individual performance (Peirson, Brown, Pothecary, Benson, & Fisk, 2018).

Thus, there is a direct relationship between the wave of the light, for example, the wave light in the morning and their cognitive performance of the students. All of these factors are regarded as the critical key elements that have a direct effect on one's work and the performance of an individual. The effectiveness of using daylight on increasing achievements of the students. It is proved that students need to be at the expose of enough light during the early part of the day. Designers have to regard these elements when they are designing a school building. They have to consider sunlight as the most proper lighting source at schools that can present sufficient light for students and reinforce their performances at schools (Reinhart, Mardaljevic, & Rogers, 2006).

Chapter 3

DAYLIGHTING AND CLASS ORGANIZATION

3.1 DAYLIGHTING STRATEGIES

Architects and lighting designers always are trying different strategies both in their interior and exterior designs in various stages of the project. They should see their design in different circumstances to reach an appropriate visual system by trying multiple options such as changing materials, surface finishing colors, and considering day and night lighting situations (Navvab, 2009).

In the following paragraphs, some relevant problems in different situations on daylighting in general and also in classrooms and the way of control these conditions are discussed, such as glare, used material, and window elements.

3.1.1 Glare

As mentioned before, the quality of daylight in educational buildings is related to various features. Initially, the daylight amount should be high enough that students and teachers can easily do their visual tasks (CIBSE, 2011). One of the natural lighting in classrooms which can make problems in the learning process for students is glare. Glare happens when too bright daylight directly enters the visual area, which can cause visual discomfort or even temporary visual impairment (Group, H.M, 2003). There is no doubt about the advantages of daylight both physically and mentally on students, so designers are always trying to develop some policies to reach active daylight.

For reducing the glaring amount in the space, some methods can be considered, such as having a one-story building which is located in the east-west axis. This kind of orientation let the northern light enter as well as controlling the south light. Placing skylight or clearstory or tall side windows in the classroom is another strategy. Another method is to let daylight enter from several locations into space to decrease the glare. It should be noted that in classrooms, using indirect lighting can decrease the glaring amount. Also, using light shelves can help to carry daylight deeper into space and help reducing glare (Ne'eman & Shrifteilig, 1982).

Michael and Heracleous (2017) had researched four schools located in Cyprus. They had chosen four classrooms of a typical plan which were oriented to the four central axes, for analyzing daylighting. Notably, it has been revealed that the combination of static louvers with an interior portable semi-transparent fabric can help to reduce the glare problems without any significant affection on the sunlight amount. So, they became with the idea of using some vertical static louvers with the size for free space proportion equal to one with a 0.5 reflection value on west and east orientations. Also, using interior curtains with at least 0.3 solar reflection value for reduction (Costanzo, Evola, & Marletta, 2017).

If external features for controlling light and shadows well prepared in the classrooms that face south axis, the direct sunlight that makes glare will be managed. Also, the classrooms which are facing the north axis let the best amount of light with the less glare enter the space, especially from the skylights because the north daylight comes indirectly to the classroom. However, it should be noted that the north-oriented classrooms do not have enough potential to exploiting passive heating during the winter season, so this orientation cannot be counted as appropriate for classrooms

(Costanzo, Evola, & Marletta, 2017). Also, with taking a deep facade method, glare can be kept out. A facade with some depth makes a buffer zone that can cover shading features and other transformers to filter glare and block the sun, as Figure 20 shows a deep wall section creating some self-shading that make a combination of a light shelf which surfaces reduce glare. Also, sloped surfaces will help to decrease glare. By adding a blind or shade in the clerestory, glare will be reduced from a small sun angle.

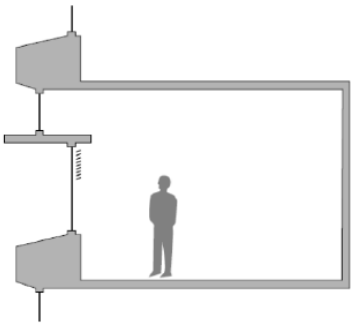


Figure 20. Deep wall section creating some self-shading (Robinson & Selkowitz, 2013)

3.1.2 Reflection Based on Finishing Surface Color and Material

Read (1999) mentioned that different colors in the interior spaces could improve on the level of cooperation behavior of children in the school. First of all, enough natural light in the classroom should be considered by using transparent features such as windows and skylights. Then using the materials and surface finishing color with high reflection in the space (Read, Sugawara, & Brandt, 1999).

Color and Material: Surface finishing color and material affect the quantity and quality of penetrated daylight into space. Ceilings tiles can be used for its covering, which typically is white and has a high reflectance. Usually, the floor covering material and color is chosen based on the easy cleaning. The most important part of the color selection came back to the color of the walls (Simm & Coley, 2011). The Chartered

Institute of Building Service Engineers (CIBSE) and Society of Light and Lighting (SLL) Code for Lighting suggests the reflection value of colors for the walls in the classrooms between 0.3 – 0.8 (CIBSE/SLL, 2002), and also, a broader range for other surface material, texture, and colors. Best paint colors for enough reflection are pale cream, light grey, mid-grey. For materials brickwork, carpet, and white papers are the best choices for better representation of daylight in classrooms (Building Bulletin 90, 1999).

Even though the strongly colored surfaces can be inspiring for students, but they must not use in significant areas (Lighting Research Centre, 1998). Low chroma and high reflectance finishing materials, textures, and colors should be used in most of the surfaces covering. In this way, daylight will be reflected in higher levels into space, and the amount of the shadow will be reduced as well (The Society of Light and Lighting, 2009).

The wall behind the teacher, the area where the teacher is teaching, should be the foreground, which the other walls should fade into the background. Lower reflectance value for the finishing surface of the behind wall where the teacher stands should be considered. Whereas, color differentiation can help present color as an accent wall, which will be beneficial on relaxing the eye tiredness, improving the attention to the teacher, reducing the glare from daylight as well as from reflection of the whiteboard and also making inspiring space (Brubaker, 1997). Additionally, it should be mentioned that improving focus on the teacher by using the accent wall can be useful for the traditional teaching methods in classrooms (Sojoudi & Jaafar, 2012).

For more clarification, the reflectance rate of Furniture, doors, and walls must be between 40- 55%. This number of ceiling changes to 90-100%. In this condition, the reflective contrast proportion could be 2.5 to 1 generally, and it cannot ever exceed 3 to 1. Generally, the classroom average surface reflection should be 40-60% (Brubaker, 1997). This amount can help with diminishing distraction as well as making a clean contrast between background and foreground.

Texture: It should be noted that the texture of the finishing surfaces also has impacts on the light reflection and they should be as clean and smooth as possible for reflect light properly and also to avoid shadows, for example, a cut in textured material lit by direct daylighting to the surface. The reduction can be observable in the direct daylighting because of the high level of luminance contrast, which happens for the highlights on the sides of the cut and the deep shadow in the cut (The Society of Light and Lighting, 2009). Table 4 shows the best choices for each item in the classroom.

Table 4. Appropriate finishing color, material and texture choices for interior items (Author)

		FINISHING COLOR	FINISHING MATERIAL	FINISHING TEXTURE
Ceiling		White	Ceiling Tiles, Paintings	Smooth and Clean
Floor		Light Gray, Mid-Gray	Easy Cleaning Material Such as Tiles	Smooth
Wall	**Behind Teacher**	Different Color with Other Walls in Pale Cream, Light Gray and Mid-Gray	Paintings, White Paper	Completely Smooth and Clean
	Other Walls	Pale Cream, Light Gray and Mid-Gray	Paintings, White Paper, Brick Work	Smooth and Clean
Doors		Pale Cream, Light Gray and Mid-Gray	Paintings	Smooth
Furniture		Pale Cream, Light Gray and Mid-Gray	Paintings	Smooth

3.2 Class Organization

This thesis highlighted the critical role of the organization in the classroom. It is stated that organization is the real combination of elements that lead us toward success. These include making a positive learning atmosphere, the physical arrangement of the tools of the class, and class management. Performing and conducting these aspects of the organization is the best way that leads to the optimal success of both teachers and students. Moreover, it should be noted that the recommended size of the elementary school classroom in the United States is around 85 square meters. According to policy, 95 square meters per classroom is needed for 20 students and their one teacher (Kenneth Tanner, 2009). But, for example, in the United Kingdom before the changes, Building Bulletin 99 established that standard primary school classrooms with 30 students need 70 square meters. However, Building Bulletin 103 in 2014 found, children's classrooms for 30 students should be 62 square meters (Building Bulletin 103, 2014).

3.2.1 General Information about Class Organization

One of the crucial ways to make a positive learning atmosphere is to reinforce students and increase their engagement. Class engagement is highly related to students' academic performance and achievement (Finn & Pannozzo, 2004). Overall, the learning-center class is the proper way to employ a positive learning environment (Bailey, Beasley, & Swafford, 2014).

Generally, the physical set-up of the class is essential and critical since it is the first visual thing that influences on students. External factors such as bookshelves, desk patterns can all make a difference in this way. If the room is disarranged, it has adverse effects on students' performance. A messy, (physically) unorganized classroom also

creates a sense of instability. It is critical to not only keep a tidy classroom but to utilize space as well appropriately (Li, 2006).

An essential factor in identifying how to set up a classroom is the age group of the students. When regarding how to set up a classroom for elementary students, it is wise to have a more open environment where there is room for low-key activities, such as sitting in a circle on the floor during story time or show and tell. On the other hand, when considering how to set up a classroom for secondary students, room for activities is not as important. Instead, creating a set-up that is conducive to discussion among the class should be heavily regarded. Students must be able to not only learn from the teacher but from each other as well. Another aspect to consider when creating the classroom set-up that often gets overlooked is the teacher's desk/workspace. A teacher's desk says a lot about them since it is their personal space. If it is untidy, cluttered, and overly secluded from the rest of the room, it will make it hard for students to feel comfortable approaching the teacher during independent work time with questions, for example. There is much to consider when orchestrating the organization in the physical set-up of the classroom. Here are three critical points to recall when arranging the classroom:

1. Create a positive and safe environment for the students;
2. Make an environment that increases the learning outcome;
3. Make an environment that reduces the misbehaviors of the students.

3.2.2 Types of Class Organization

Jeremy Harmer (1998) proposed eight types of seating arrangements, which are explained in the following paragraphs:

a. Orderly rows: In this arrangement, both teachers and students can see each other, and they have direct eye contact. In fact, in this arrangement, keeping the discipline is

regarded as a more comfortable way. Teachers and students have personal interactions with each other. This arrangement is also useful for employing board, explaining a grammar top, especially when the teacher can work with the whole class. In this arrangement, teachers engage with the whole of the course. It is the best setting for large classrooms (Harmer, 1998).

Figure 21. Orderly rows sample (URL 3. www.liamd.pw, 2019)

b. Circles and horseshoes: It is mostly used for small classes. Of course, there is a difference between rings and horseshoes. In horseshoes, the position of teacher is at the center of the class where there is blackboard while in circle one, teachers' attitude is among circles. In this type of arrangement, there is an equal sense among students and teachers' positions. Of course, in horseshoe, it is not true because the teachers mostly stay at the center of the class, and the chance of getting close to students is high. The most critical benefit of this type of setting is that all of the students can see each other that it is not possible in orderly row arrangement (Garrett, 2013).

Figure 22. Circles and horseshoes samples (URL 3. www.liamd.pw, 2019)

c. Separate tables: This type of arrangement is most informal. In this arrangement, students are seated in small groups in different tables. The role of the teacher is a facilitator, and the teacher monitors the students' activity. The atmosphere of the class is less hierarchical. When the teacher works with the students of one table, other students can use her guidance. The negative aspect of this arrangement is that students may distract from their leading role in the class. Another problem is related to this point that it is hard to teach the whole class (Harmer, 1998).

Moreover, nature needs to be regarded as the nature of the lesson and students in arranging the seats. The arrangement and the way of setting the chair and tables are considered to be the critical factor in the class that reinforces students' performance and achievement. They have to be arranged in such a way that teaching and learning happen effectively. Moreover, it has to be ensured about the rate of the interaction in the class. All of the students have to have active participation in the class (Garrett, 2013).

In this respect, Alexandra Ramsden (1999) noted that the best arrangement of the tool's relays on the class and teacher's position. She explained six popular types of seating

arrangements that can be employed by the teachers. She also indicates the positive and negative aspects of the methods.

Alexandra Ramsden (1999) stated that “the best arrangement relays on the situation of the class and teacher.” In her paper, she discussed six common types of seating arrangements that can be used by the teachers. She also pointed out the positive as well as the negative sides of the arrangements. Some of these factors are elaborated below.

Figure 23. Separate table’s sample (URL 3. www.liamd.pw, 2019)

d. Clusters: In this arrangement**,** four or five desks put in front of each other. In each desk, four or five students are put. It is not set in a linear situation. They are scattered in different points of the class, and there is enough space among clusters. The chairs do not set so close to each other, and the teacher can walk easily (Harmer, 1998).

This type of arrangement is very suitable for those classes that have more group work. The students of these groups have eye contact, and they can work with each other and help each other in the group. Before employing this arrangement, the teachers have to be thought that if the class does this potential to do this or not. It needed students to be at different levels to help each other. The idea behind this arrangement mostly

reinforces group work and collaborative work. In this arrangement, teachers have a medium role and can help and guide students (Garrett, 2013).

This type of arrangement also has some disadvantages. It is not good at the time of the exam since it enhances the chances of cheating among students. It may distract learners from their primary role in the class. Generally, students, instead of paying attention to their task, they may talk with each other (Harmer, 1998).

Figure 24. Clusters sample (URL 3. www.liamd.pw, 2019)

e. Desk rows: It is the other arrangement that traditionally used. In this type of arrangement, desks are put in several rows, and they are situated in front of the class. Vertically, there is a gap among desks. Thus, the teacher can walk easily in the class without the need to move anything. Before employing this arrangement, teachers have to analyze the students' behavior and signify who has to sit back or front.

It is beneficial in the exam situation, and also it is a good position for instructing content because students all can listen carefully to the lessons and using the instructions properly. It is also easy for teachers to control the class. The only problem of this arrangement is that those students who are sitting at the back or corner of the

class may have a less active role in-class participation and interaction. It is also a problematic issue for group work (Harmer, 1998).

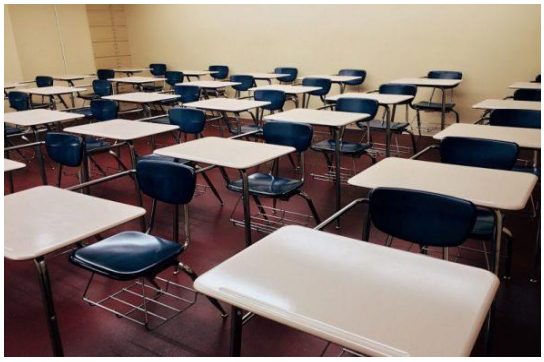


Figure 25. Desk rows samples (URL 3. www.liamd.pw, 2019)

f. Table Rows: In this type of arrangement, long tables are situated vertically from front to back of the class. Students have to sit next to each other. It is a good arrangement for group work. This arrangement also increases the collaborative learning. The students can share their works with their peers. The problems of this type of arrangement included the lack of the attention of the students who are seated at the back in direct instruction, the difficulty of the teacher to monitor and control the class. It is also a bad arrangement for test-taking. Moreover, it is so hard to have a whole class discussion because students need to move from their place to see who is talking. It is good for the situation that is not direct instruction in the class, and students only want to do free group activities (Harmer, 1998).

Figure 26. Table Rows sample (URL 3. www.liamd.pw, 2019)

g. Semi-circle: This type of arrangement includes few desks near each other in a semi-circle shape. All of the desks are situated in front of the class. Because of this point, students can use the instructional aid properly. The purpose of this arrangement is to teach students better, and it enhances group learning. Students can perform different class activities, such as group projects. Moreover, teachers can easily walk in the class, and the teacher can control the class easily. Moreover, it is hard for teachers to interact with students who are close to each other. This type of arrangement is not useful for task taking because students are so close to each other (Garrett, 2013).

Figure 27. Semi-circle sample (URL 3. www.liamd.pw, 2019)

h. Pairs: This arrangement includes two desks situated together. Each pair is far away from other pay. Students can see the instructional aids easily. This arrangement is highly recommended for test-taking situations. In this arrangement, the teacher can also walk easily, and she can monitor the class easily. Before employing this arrangement, teachers have to decide about the pairs and other factors, such as the purpose of teaching, teaching material, and course objective. In this arrangement, students are allowed to work both individually and in a group. Those students that are at the corner may have a less active role in the class (Harmer, 1998)

Figure 28. Pair sample (URL 3. www.liamd.pw, 2019)

3.3 Building Location and Orientation

3.3.1 Building location

It is defined as a range of probable locations and spaces on the site, and designers have to consider all of these points. All of the effective factors in pedagogical settings have to be considered, and it should be based on universal standards. The desired location should be considered concerning site service, external facilities, and all of its restrictions have to be taken to account (Garrett, 2013).

3.3.2 Building Orientation

Building Orientation has to be seen in the context of a balance of needs consisted of if security, natural light, and energy efficiency. Those schools that have a proper system of employing solar systems have high achievement among students.

The science of daylighting does not only focus on the rate of daylighting on students' performance but also it talks about this point how to employ it without adverse effects. The employment of the windows plays a significant role in this process, and it makes a balance between the outside environment and the inside environment. In this process, the quality of the window and glass play a significant role (Beute & de Kort, 2014).

Generally, a daylighting system consisted of systems, technologies, and architecture. Of course, it is worthy of mentioning here; all of these elements are not required for the everyday lighting system. These factors include:

- Day light-optimized building footprint;
- Climate-responsive window-to-wall area ratio;
- High-performance glazing;
- Day lighting-optimized fenestration design;
- Skylights (passive or active);
- Tubular daylight devices;
- Daylight redirection devices;
- Solar shading devices;
- Day light-responsive electric lighting controls;
- Day light-optimized interior design;

The system of the building should be employed in such a way that it uses daylighting at a high level. It is not only used for the new system, but also old systems have to be employed. The daylight system controls electric lighting in the right way. It makes a balance between artificial light and natural lighting. The structures of the building, such as the size of the windows and the position of buildings, should be in a suitable location to reduce the rate of using artificial energy. The use of sufficient light can also increase alertness and students' achievement, and finally, it has a positive effect on their performance. The impacts of adequate light on the rate of the healthiness and arranging daytime for working hours. Sufficient daylight has many advantages for humans. There is a direct relationship between one's compelling performance and the rate of light. They claimed that hourly light exposure was a significant predictor of vitality. Those who are exposed to more light or proper light will experience the

feelings of vitality more. Even in the absence of sleep and light-deprivation, sufficient light increases physical and psychology's performance (Beute & de Kort, 2014).

A window is regarded to be an opening space in the wall of the buildings, and it permits the daylight and the light of the sun to enter the building. There are two types of main windows; they are on the wall, and they are on the roof, which is known as skylights. Of course, it is worthy of mentioning here the quantity of daylight that enters inside the building relays on the size of the windows and the height of the roofs. Daylighting is regarded as a rich source for completing your task, growing your plans, and use of the energy effectively. Moreover, it considered being a significant source of making things visible and reinforces the tasks. (Raji, Tenpierik, Bokel, & van den, 2019). Also, it should be noted that how a relatively small overhang presents full direct seasonal solar protection to the workspace (figure 29). The area immediately adjusts to the south facade is circulation space.

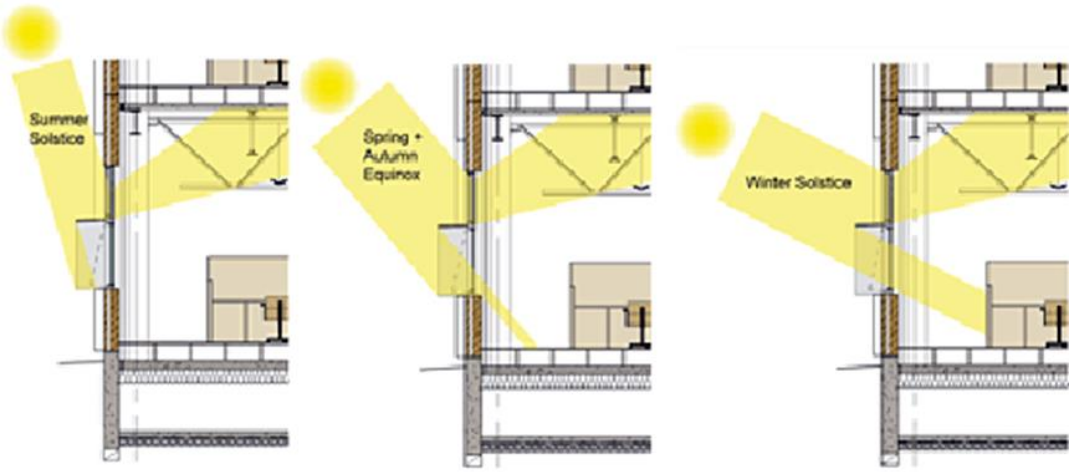


Figure 29. Seasonal performance of shading, redirection devices (URL 3. www.liamd.pw, 2019)

Chapter 4

EXAMINATION OF THE GLARE PROBLEM IN PRIMARY SCHOOLS OF FAMAGUSTA

4.1 Introduction

This chapter presents the analysis of the data collected in the present thesis by observation, measuring, drawings, and 3D SketchUp modeling that are organized in different tables.

Appropriately incorporating daylighting into the building design can improve the economics of a school, positively impact utility costs, and by extension, the environment as well as a result in improvements to the health, productivity, and mood of those working and learning in the structure. Specifically, integrating daylighting into school building design has potentially significant benefits to students. The use of daylighting was standard in most architecture for much of human history until the early 19th century when the use of electricity became a standard and integral aspect of the lighting in most buildings.

For people in educational settings, the achievement of the students is regarded as the most significant indicator of their success. In general, everything in the pedagogical settings may influence the students' performance, sometimes negative aspects, and occasionally positive ones (Newmann & Wehlage, 1995).

Inevitably, the design of the class that has a direct role in students' performance in the class often is neglected. Fortunately, many trainers have modified their attitudes toward learning, and they understood that they have to make an ideal environment for different groups of learners. The traditional arrangement of the tool reduces students 'concentration, and it harmed their performances. The most crucial worthy purpose of educators is to give students the best educational chance (Gargiulo & Metcalf, 2017). Glare is one of the main problems happening because of the high level of brightness from direct light in classrooms, especially from the south direction or from the high reflection of light from inappropriate finishing color, texture and material of surfaces. So, by analyzing case study, the glare problem will be reviewed and solutions based on the interior design elements will be examined such as changing the class organization, changing walls, floor and furniture finishing color, texture or material and also changing the window size or direction.

4.2 Aims of Case Study

The main aim of the case study is to find out how daylighting in the selected classrooms in nine primary schools in Famagusta, North Cyprus causes problems related to the glare problem. And defining the solutions that can be useful for controlling glare based on the class organization, finishing color, material and texture of surfaces, and the window size and shape. This case study analysis helps to understand better the daylighting, daylighting problems, and how to control or solve these issues for the same situation in other classrooms and primary schools. For more clarification, table 5, is demonstrating six detailed stages of case study analysis with explanations and elements which contain the information about how classroom selected, based on which elements their information is tabulated and based on which features solutions are recommended.

Table 5. Stages of case study analysis (Author)

STAGES	EXPLANATION	ELEMENTS
1	Tabulating all 32 primary schools in Famagusta and the villages around.	With names and pictures.
2	Selecting one classroom in 9 primary schools in Famagusta city.	Based on the south direction window because of direct light which cause glare problem.
3	Tabulating information related to each classroom from table 9 to 12.	• Several students in the classroom. • Type of daylighting and artificial lighting. • Window size, shape, axis, and numbers. • Finishing color, material, and texture of walls, ceiling, floor, and furniture. • Type of seat arrangement.
4	Tabulating the drawings of each selected classroom of 9 primary schools from table 13 to 21.	• Ground floor plan of the school. • Plan of the selected classroom with dimensions and furniture. • Two sections. • Photo of the selected classroom. • 3D modeling of the classroom in three different hours (7.55, 9.45, 11.35 am) for showing the amount and direction of light in classes.
5	Analyzing each selected classroom and finding problems affect the visual comfort of students.	• Type of light. • Amount of light. • Glare (both on desks and wall behind teacher) • Daylight reflection based on the finishing color, material, and texture of walls, ceiling, floor, and furniture. • The appropriate number of students in the classroom. • Type of seat arrangement.
6	Defining solutions for glaring problems and a high level of brightness.	Based on • Finishing color, texture, and material of surfaces. • Class organization. • Window type and size.

4.3 Limitation of the Case Study

This thesis only covered the schools at the primary level in Famagusta, North Cyprus. Thus, it cannot be overgeneralized. The focus of the thesis was limited to the daylight and direction of the opening and type of class organization at school, and it would not investigate the other factors. In other words, the researcher was supposed to work in the direction of the opening and class organization as the purpose of the thesis and also define some solutions for glare problem based on the light reflection from finishing color, material, and texture of walls, floor, ceiling and furniture and type of class

organization. It should be noted that the 3D modeling of chosen classrooms is considered in the December month as the 3D modeling has done in different months during the fall semester and it is understood that December month is the most problematic time on the analysis at sketch up program. And this thesis is trying to find a solution in the most problematic time of the fall semester. For more clarification these different 3D modeling renders for one of the schools at 11.35 am which the amount of entering light is high, are shown in table 6.

Table 6. 3D modeling of Şehit Hüseyin Akil primary school in different months of the fall semester at 11.35 am (Author)

Month	3D Modeling	Month	3D Modeling
September		October	
November		December	
January			

As can be seen in table 6, in December month there are more desks (two rows) under the direct light which cause glare for most students in the classroom. Also, in the

analysis of selected classrooms, 3D modeling of them is rendered at three different times of day, 7.55, 9.45 and 11.35 am as primary schools' classes started in these times (Talim ve Terbiye Dairesi, 2005).

Based on the data presented on table 7, Famagusta has 32 primary schools but this thesis focused on 9 schools which are Alasya Primary School, Canbulat Primary School, Gazi Primary School, Karakol Primary School, Polatpaşa Primary School, Şehit Hüseyin Akil Primary School, Şehit Mustafa Kurtuluş Primary School, Şehit Osman Ahmet Primary School, Şehit Zeki Salih Primary School. These 9 schools were at the center of the Famagusta and Gazimağusa Maarif Primary School and Alasya Vakif Primary School were nursery and Gazimağusa Özel Eğitim Merkezi was for the disabled student.

Akdoğan Dr. Fazil Küçük Primary School, Akova – Yildirim Primary School, Alaniçi Primary School, Beyarmudu Primary School, Çayönü – İncirli Primary School, Dörtyol Primary School, Eşref Bitlis Primary School, Geçitkale Primary School, Güvercinlik Rauf Raif Denktaş Primary School, İnönü Primary School, Mormenekşe Primary School. Pile Türk Okulu Primary School, Serdarli Primary School, Şehit Salih Terzi Primary School, Şehit Özdemir Anaokulu Primary School, Tatlisu Primary School, Türkmenköy Primary School, Ulukişla Primary School, Vadili Primary School, Yeniboğaziçi Primary School were in the village (KKTC Milli Eğitim Ve Kültür Bakanliği, 2020).

Table 7. Schools' information (Author)

	SCHOOL NAMES	PHOTOS (Author, 2019)
1	ALASYA PRIMARY SCHOOL	
2	POLATPAŞA PRIMARY SCHOOL	
2	CANBULAT PRIMARY SCHOOL	
4	KARAKOL PRIMARY SCHOOL	

5	ŞEHIT HÜSEYIN AKIL PRIMARY SCHOOL	
6	ŞEHIT ZEKI SALIH PRIMARY SCHOOL	
7	ŞEHIT MUSTAFA KURTULUŞ PRIMARY SCHOOL	
8	ŞEHIT OSMAN AHMET PRIMARY SCHOOL	
9	GAZI PRIMARY SCHOOL	

4.4 Methodology of the Case Study

Analyzing the case study is done based on the classrooms' observation, photography, and measuring their openings and space, which are categorized in several tables. The case study analysis is categorized into three different steps.

The first step includes observing these nine primary schools and their plan on the December month, based on the common factor between them for daylighting, from each school one classroom selected for better comparative evaluation. Hence, all the chosen classes with the windows on the northeast axis, which is counted as one of the worst daylighting directions because of the indirect and low amount of light.

Moreover, the researcher mentioned the seat arrangement in the chart, and it gives information about how they can sit and how daylight in different hours affects the students' visual comfort and their level of learning. It also provides information about the types of the system, and the types of light can be recognized by observation. In the window part, it is explained the types of windows, and the numbers of windows and their size are measured and also the size of the class by the meter. It is found that there was a relationship between the percentage of the windows and the size of the class, which is the proportion of windows should cover 15% until 20% of the whole class area (Building Bulletin 90, 1999).

In the second step, for more clarification of daylighting in classrooms, beside plan and two sections, three different 3D modeling has been done for showing the level and direction of daylight in three different hours in a day in the December month at 7.55, 9.45 and 11.35 am for starting the classes. The researcher investigated how they sit in class and the number of students in each class. The following tables present

information about the numbers of students and the essential factors about lighting that affect students.

The third step contains analysis and finding problems related to visual discomfort of students according to the amount of entering daylight and its direction. In the end, based on the literature review, some suggestions for reducing the issues of glare and high level of brightness are recommended, such as changing the seat arrangement, changing the color of the walls, using different curtains, or reducing the number of students as possible.

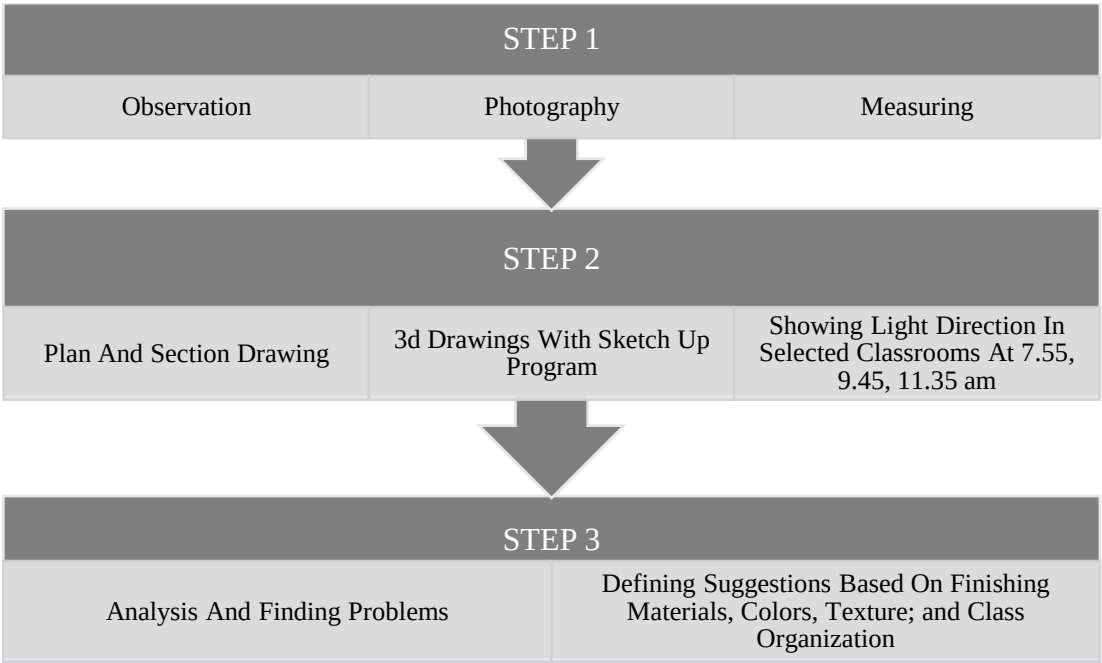


Figure 30. Three steps of the second part of methodology (Author)

4.5 Existing Situations of the Selected Classrooms

In this section, all the information about the selected classrooms such as the daylighting factors such as window size, axis, and several windows, artificial lighting types are also indicated the plans, section, and 3D modeling of classrooms in different hours of the day are demonstrated after visiting the classes. Also, the number of

students in each class and types of the seat arrangement of the class are documented. As you can see in chapter 3, the researcher explains the types of seat arrangement and its classification of seven models. All the following information about the primary schools is tabulated in different tables. The researcher saw the types of light and types of windows and the model of the window. Then, the researcher calculated the size of the windows and the size of the class with the meter. Because the vital thing in this thesis was the windows and use of daylight. The main focus in this thesis is daylight, but there are some crucial aspects of the artificial light that the types of it and the number of them in each class were observed.

4.5.1 Determination to the Class

In this part, the information related to the selected classroom of nine primary school are tabulated from table 9 to 12. The information in tables is categorized into 5 aspects as the sample below (table 8). Firstly, the number of students in the selected classroom is shown. Secondly, the artificial light and daylighting types are shown. Thirdly information about windows as a type of light entering from windows, number, axis, shape, and the proportion of window area to the whole classroom area are explained. Fourthly, the finishing color, material, and texture of walls, floor, ceiling, and furniture was demonstrated. And lastly, the type of seat arrangement was shown.

Table 8. Sample of observation tables (Author)

SCHOOL NAME	LIGHT								WINDOWS							TEXTURE COLOR MATERIAL				SEAT ARRANGEMENT							
	Day Light			Artificial Light					Type Of Light																		
	Task	Ambient	Accent	Fluorescents	Incandescent	High-intensity Discharge	Luminaries	Number Of Artificial Lights In Classroom	Top Light	Side Light	Horizontal Light	Number of Windows	Size and Axis of Windows	Size of Class	Window Shape (Horizontal or Vertical)	Proportion of window area to whole class area (percentage)	Wall	Floor	Ceiling	Furniture	Orderly Rows	Circle and Horseshoes	Separate Tables	Clusters	Desk Rows	Semi Circle	Pairs
Number of students																											

Table 9. Alasya primary school and Polat Paşa primary school information (Author)

SCHOOL NAME	LIGHT								WINDOWS							TEXTURE COLOR MATERIAL				SEAT ARRANGEMENT						
	Day Light			Artificial Light					Type Of Light																
	Task	Ambient	Accent	Fluorescents	Incandescent	High-intensity Discharge	Luminaries	Number Of Artificial Lights In Classroom	Top Light	Side Light	Horizontal Light	Number of Windows	Size and Axis of Windows	Size of Class	Window Shape	Proportion of window area to whole class area (percentage)	Wall	Floor	Ceiling	Furniture	Orderly Rows	Circle and Horseshoes	Separate Tables	Clusters	Desk Rows	Semi Circle	Pairs
ALASYA 34 students	✓			✓				4		✓		6	2.14*0.77(3) North-West 2.14*1. 2(3) South-East	8*5	Horizontal	17.58 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Brown Wood					✓		
POLAT PAŞA 25 students	✓			✓				4		✓		6	1.3*2.60 (3) North-West 2.60*0.45 (3) South-East	9*6	Horizontal	17.16 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Brown Wood					✓		

Table 10. Canbulat primary school and Karakol primary school information (Author)

SCHOOL NAME	CANBULAT 30 students	KARAKOL 26 students
LIGHT		
Day Light		
Task	✓	✓
Ambient		
Accent		
Artificial Light		
Fluorescents	✓	✓
Incandescent		
High-intensity Discharge		
Luminaries		
Number Of Artificial Lights In Classroom	6	6
WINDOWS		
Type Of Light		
Top Light		
Side Light	✓	✓
Horizontal Light		
Number of Windows	6	6
Size and Axis of Windows	0.9*0.8 (3) South-West 2.6*1.5 (3) North-East	1.5*1.15(3) North-West 2.1*0.35 (3) South-East
Size of Class	9*6	7*5.5
Window Shape	Horizontal	Horizontal, Vertical
Proportion of window area to whole class area (percentage)	13.8 %	7.35 %
TEXTURE COLOR MATERIAL		
Wall	Smooth White Paint	Smooth White and Yellow Paint
Floor	Smooth Gray Tiles	Smooth Gray Tiles
Ceiling	Smooth White Paint	Smooth White Paint
Furniture	Smooth Gray Wood	Smooth Pale Cream Wood
SEAT ARRANGEMENT		
Orderly Rows		
Circle and Horseshoes		
Separate Tables		
Clusters		
Desk Rows	✓	✓
Semi Circle		
Pairs		

Table 11. Şehit Huseyin Akil primary school and Şehit Zeki primary school information (Author)

SCHOOL NAME	LIGHT									WINDOWS							TEXTURE COLOR MATERIAL				SEAT ARRANGEMENT						
	Day Light			Artificial Light						Type Of Light																	
	Task	Ambient	Accent	Fluorescents	Incandescent	High-intensity Discharge	Luminaries	Number Of Artificial Lights In Classroom		Top Light	Side Light	Horizontal Light	Number of Windows	Size and Axis of Windows	Size of Class	Window Shape	Proportion of window area to whole class area (percentage)	Wall	Floor	Ceiling	Furniture	Orderly Rows	Circle and Horseshoes	Separate Tables	Clusters	Desk Rows	Semi Circle	Pairs
ŞEHIT HUSEYEIN AKIL 30 students	✓			✓				6			✓		5	2 *1.7(2) South-East 1.5*1.20(3) North- West (2) North- East (1)	8*6	Vertical	12.06 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Pale Cream Wood					✓		
ŞEHIT ZEKI 18 students	✓			✓				4			✓		5	2 *1 (5) North-West (1) South-East (4)	9*6	Vertical	14.16 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Pale Cream Wood					✓		

Table 12. Şehit Mustafa Kuruluş primary school and Şehit Osman primary school and Gazi primary school information (Author)

SCHOOL NAME	LIGHT								WINDOWS								TEXTURE COLOR MATERIAL				SEAT ARRANGEMENT						
	Day Light			Artificial Light					Type Of Light																		
	Task	Ambient	Accent	Fluorescents	Incandescent	High-intensity Discharge	Luminaries	Number Of Artificial Lights In Classroom	Top Light	Side Light	Horizontal Light	Number of Windows	Size and Axis of Windows	Size of Class	Window Shape	Proportion of window area to whole class area (percentage)	Wall	Floor	Ceiling	Furniture	Orderly Rows	Circle and Horseshoes	Separate Tables	Clusters	Desk Rows	Semi Circle	Pairs
ŞEHIT MUSTAFA KURULUŞ 14 students	✓			✓				4		✓		6	1.6*0.6 (2) North-East 2 *0.6 (4) South- West (2) North-East (2)	7*5	Horizontal, Vertical	9.23 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Pale Cream Wood		✓					
ŞEHIT OSMAN 24 students	✓			✓				4		✓		6	1.6 *1.2 (6) South-West (2) South-East (3) North- West (1)	7*5	Vertical	8.9 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Brown Wood					✓		
GAZI 24 students	✓			✓				**4**		✓		**6**	1.50*0.8 (3) North-East 0.9*0.8 (3) South- West	7*5	Horizontal, Vertical	6.83 %	Smooth White Paint	Smooth Gray Tiles	Smooth White Paint	Smooth Pale Cream Wood					✓		

1. Alasya Primary School: The selected classroom with 34 students has the desk rows seat arrangement with six windows with the sidelight with three south-east axis horizontal windows and three north-west axis horizontal windows which took 17.58% of the whole classroom area which is enough based on the literature mentioned before. Its daylight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

2. Polat Paşa Primary School: The selected classroom with 25 students has the desk rows seat arrangement with six windows with the sidelight with three south-east axis horizontal windows and three north-west axis horizontal windows which took 17.16% of the whole classroom area which is enough. Its day alight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

3. Canbulat Primary School: The selected classroom with 30 students has the desk rows seat arrangement with six windows, three south-west axis horizontal windows, and three north-east axis horizontal windows with the sidelight which took 13.8 % of the whole classroom area which is not enough. Its day alight type is task light, and it has six fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

4. Karakol Primary School: The selected classroom with 25 students has the desk rows seat arrangement with six windows, three north-west axis vertical windows, and three south-east axis horizontal windows with the sidelight that took 7.35 % of the whole classroom area which is not enough. Its day alight type is task light, and it has

six fluorescent lamps as artificial light. The color of the walls is white and yellow paint, and the ceiling is white painting, and the floor is covered with gray tiles.

5. Şehit Huseyein Akil Primary School: The selected classroom with 30 students has the desk rows seat arrangement with five windows, two south-east axis vertical windows, and three north-west axis vertical windows with the sidelight which took 12.06% of the whole classroom area which is not enough. Its day alight type is task light, and it has six fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

6. Şehit Zeki Salih Primary School: The selected classroom with 18 students has the desk rows seat arrangement with five windows, one north-west axis vertical windows, and four south-east axis vertical windows with the sidelight which took 14.6 % of the whole classroom area which is not enough. Its day alight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

7. Şehit Mustafa Kurtuluş Primary School: The selected classroom with 14 students has the Circle and horseshoes seat arrangement with six windows, four south-west axis two horizontal and two vertical windows, and two north-east axis horizontal windows with the sidelight which took the 9.23 % of whole classroom area which is not enough. Its day alight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

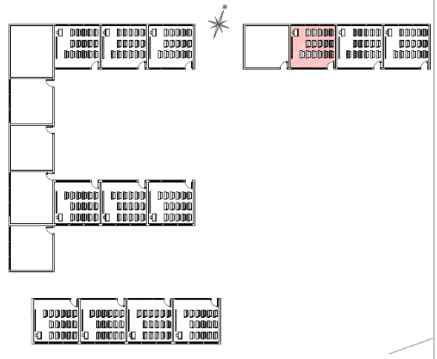
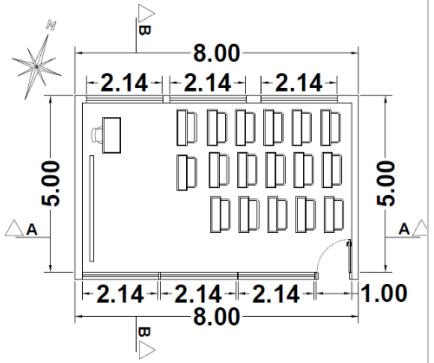
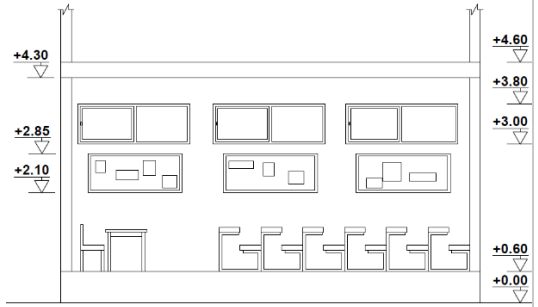
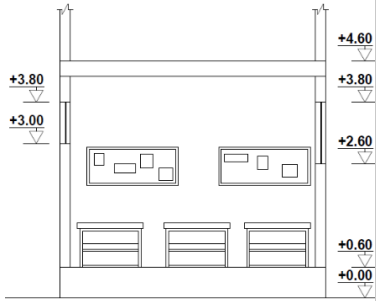
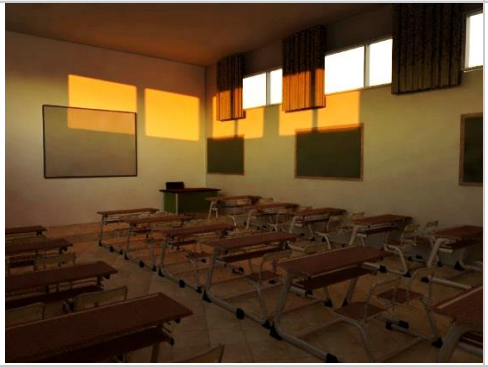
8. Şehit Osman Primary School: The selected classroom with 24 students has the desk rows seat arrangement with six windows, two south-west axis vertical windows, three south-east axis vertical windows, and one north-east axis vertical windows with the sidelight which took 8.9 % of the whole classroom area which is not enough. Its day alight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

9. Gazi Primary School: The selected classroom with 24 students has the desk rows seat arrangement with six windows, three south-west axis vertical windows, and three north-east axis horizontal windows with the sidelight which took 6.83% of the whole classroom area which is not enough. Its day alight type is task light, and it has four fluorescent lamps as artificial light. The color of the walls and ceiling are white painting, and the floor is covered with gray tiles.

4.6 Determination of the Glare Problems at Selected Classrooms

In the tables 13-21, the drawing plans, sections, and also 3D modeling of each selected classroom are tabulated separately from table 13 to 21 and also, their analysis are explained one by one, and then all classes are compared together for better clarification. It should be mentioned that the selected classroom position on the ground floor plan of each school are shown by red hatching.

Table 13. Alasya primary school drawings and models (Author)

ALASYA PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

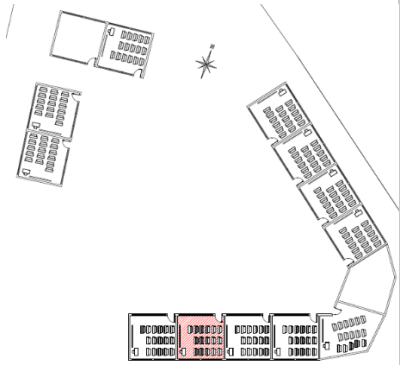
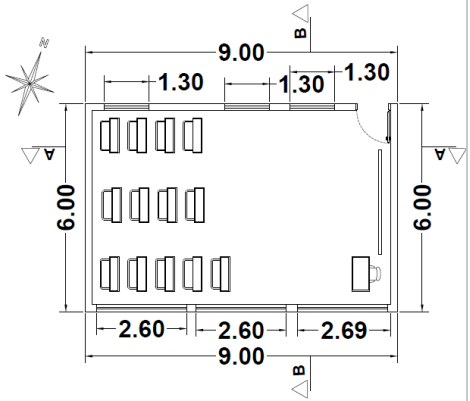
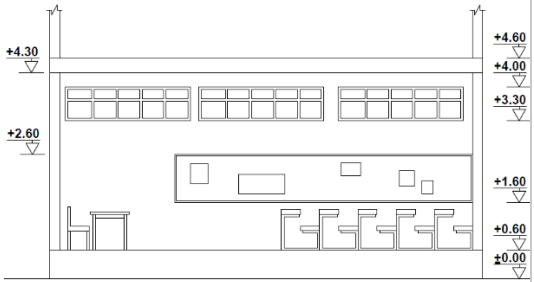
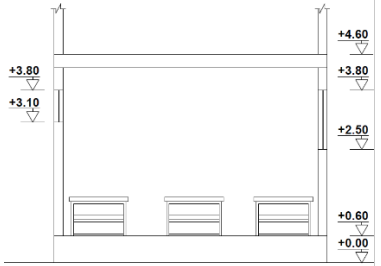
1. Alasya Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is not a sufficient level of daylight in the classroom, and lighting levels should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on one of the rows, which will cause glare, and students cannot focus on learning, which with curtains can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, still, on the middle rows, the level of brightness is so high, and again curtains can help to control glare. Because of the high level of daylight, there is no need for artificial lights, but in some days of the year, artificial lights can help, all of them or just one or two numbers of them.

The positive points of this type of classroom are size and number of windows that cover the level of daylight that classroom needs and the color of walls and ceiling distance of windows from the ground which will reduce glare, canopy for control the light and the negative points are the high numbers of students as each student need 2.1 to 5 m2 space which in this classrooms each student have 1.2 m2 area, the improper layout of benches and improper placement of buildings which make a shadow.

Table 14. Polat Paşa primary school drawings and models (Author)

POLAT PAŞA PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

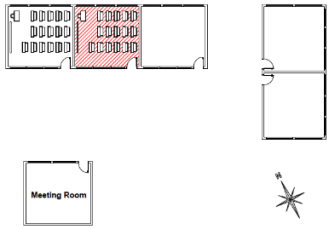
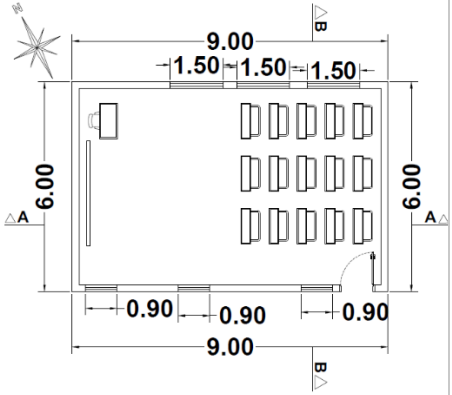
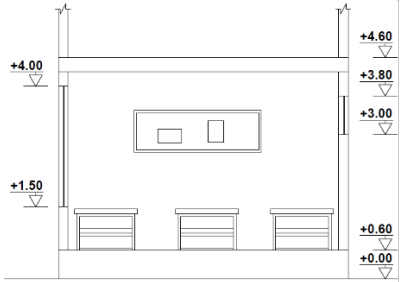
2. Polat Paşa Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is not a sufficient level of daylight in the classroom, and lighting levels should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on one of the rows which will cause glare, and students cannot focus on learning, which with curtains can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, still, on the middle rows, the level of brightness is so high, and again curtains can help to control glare. And in this case, yet the level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are size and number of windows that cover the level of daylight that classroom needs and the color of walls and ceiling and distance of windows from the ground which will reduce glare, canopy for control the light and the number of students as each student need 2.1 to 5 m2 space which in this classrooms each student have 2.2 m2 space and the negative points are the improper layouts of benches and improper placement of building which make a shadow.

Table 15. Canbulat primary school drawings and models (Author)

CANBULAT PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

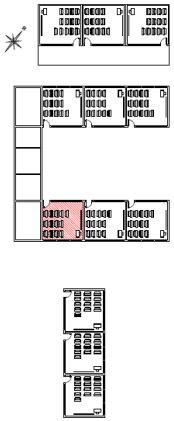
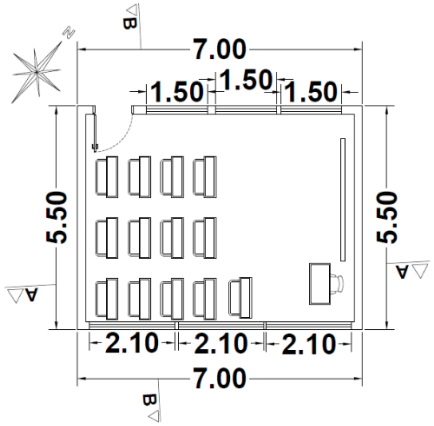
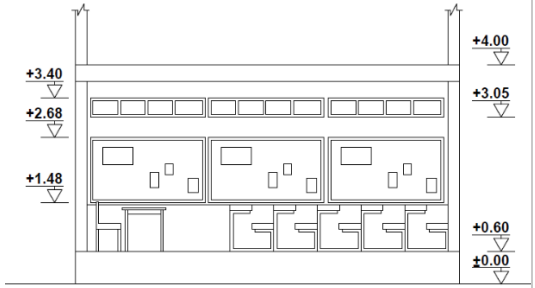
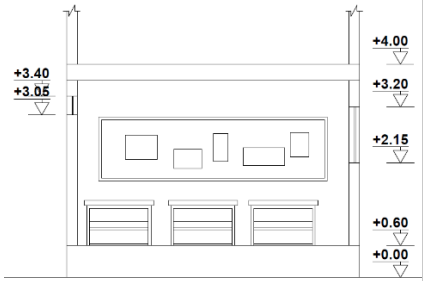
3. Canbulat Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is not a sufficient level of daylight in the classroom, and the lighting level should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on the wall behind the teacher and on the board, which will cause glare and students cannot see the board and teacher and cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, still on the board and the wall behind the teacher, the level of brightness is so high, and again curtains can help to control glare. And in this case, yet level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the size of windows and the color of walls and ceiling. The distance of windows from the ground which will reduce glare and the negative points are the high number of students as each student need 2.1 to 5 m2 space which in this classrooms each student have 1.8 m2, not enough number of windows for covering enough daylight is needed for class and the improper layout of benches.

Table 16. Karakol primary school drawings and models (Author)

KARAKOL PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

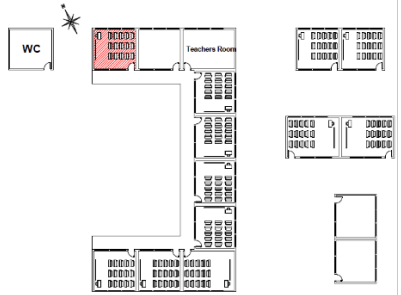
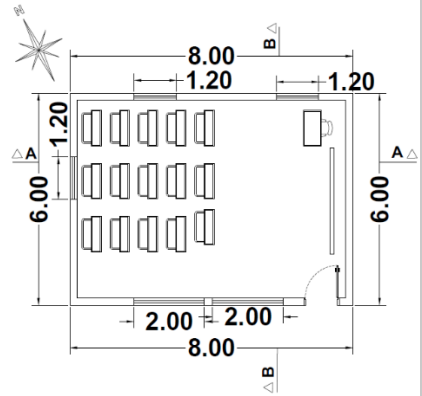
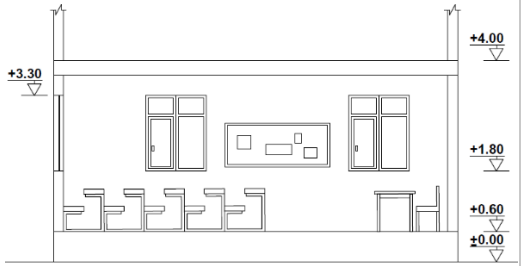
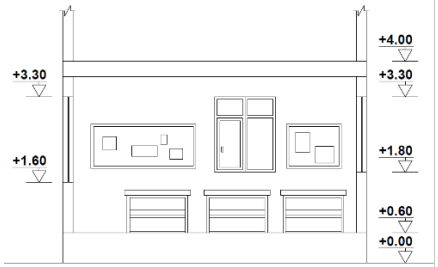
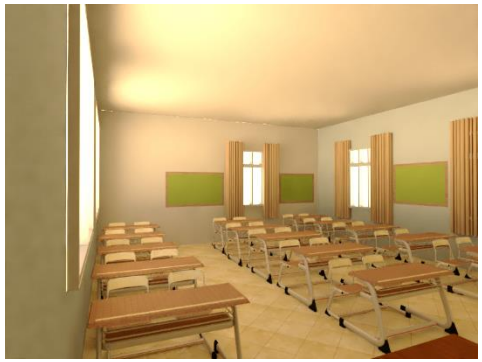
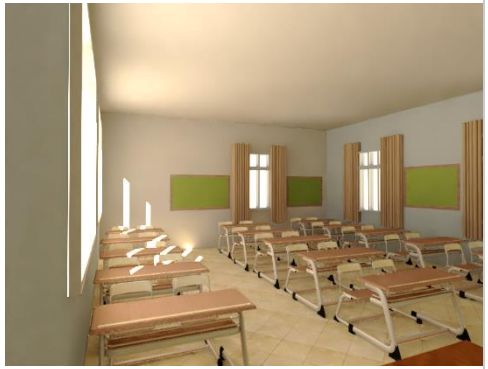
4. Karakol Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is a sufficient level of daylight in the classroom, and the high level of brightness on walls cannot bother students.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on the wall behind the teacher, especially on the part of the yellow painting of the wall and on the board, which will cause glare and students cannot see the board and teacher. They cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, yet on the board and the wall behind the teacher, the level of brightness is high, and again curtains can help to control glare. And in this case, still level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the size of windows. The negative aspects are the high number of students as each student needs 2.1 to 5 m2 space which in this classrooms each student have 1.5 m2, the yellow paintings of the wall which reflect the daylight more than enough which is not appropriate, not enough number of windows for covering enough daylight is needed for classroom and the improper layout of benches.

Table 17. Şehit Huseyein Akil primary school drawings and models (Author)

ŞEHIT HUSEYEIN AKIL PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

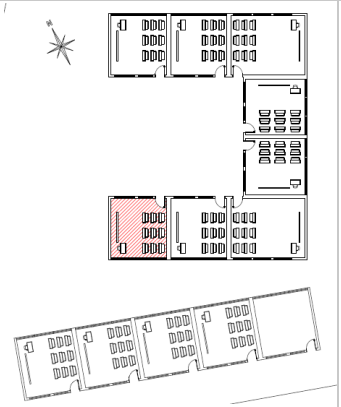
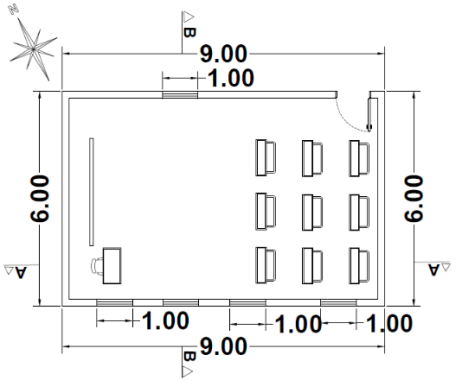
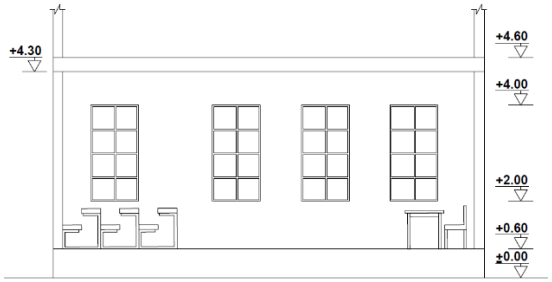
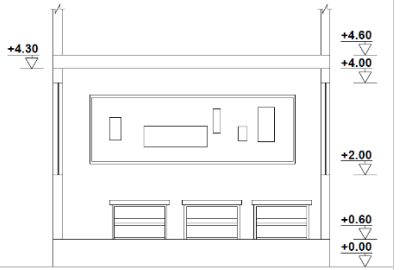
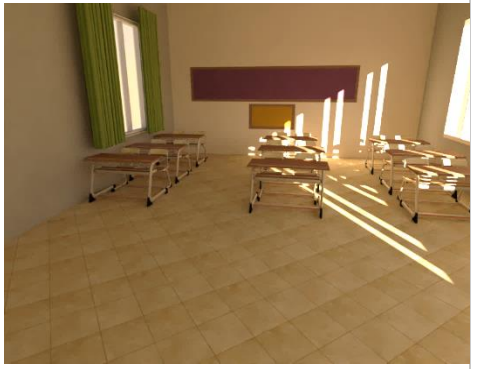
5. Şehit Huseyein Akil Primary School: As can be seen in the 3D modeling, it seems at 7.55 am, there is not a sufficient level of daylight in the classroom, and the lighting level should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is high on one of the rows that will cause glare, and students cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, the level of brightness is so high on two rows of benches, and again curtains can help to control glare. And in this case, still level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the size of windows. The color of walls and ceiling and the negative aspects are the high number of students as each student needs 2.1 to 5 m2 space which in this classroom each student have 1.6 m2, not enough number of windows for covering enough daylight is required for the classroom, the improper layout of benches and improper placement of the building.

Table 18. Şehit Zeki primary school drawings and models (Author)

ŞEHIT ZEKI SALIH PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

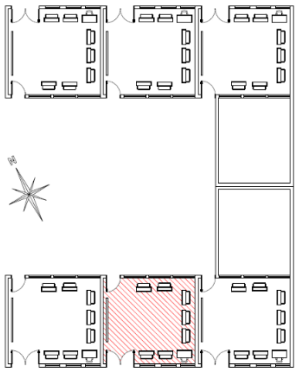
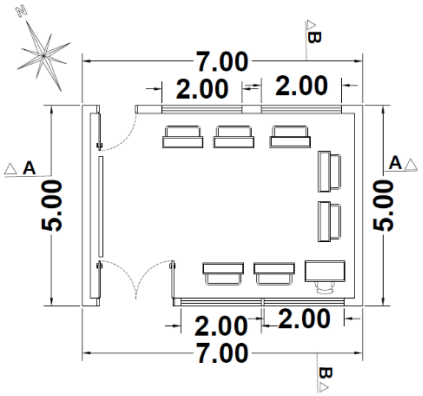
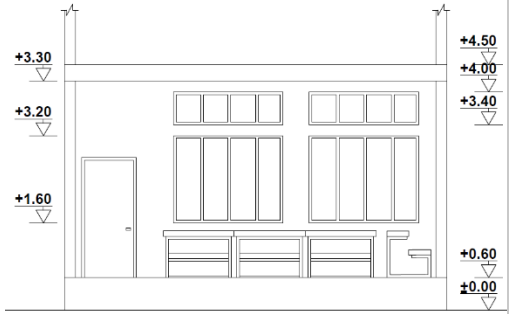
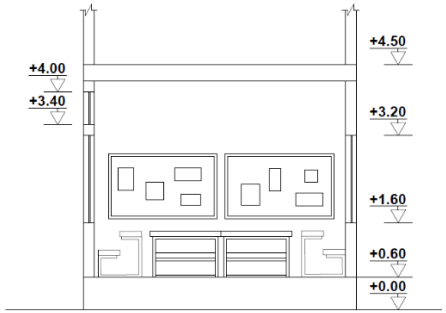
6. Şehit Zeki Salih Primary School: As can be seen in the 3D modeling, it seems at 7.55 am there is sufficient level of daylight in the classroom, and high level of brightness above one of the rows can cause some problems on the visual comfort of students which can be controlled by curtains, so lighting level should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on two rows of benches, which will cause glare, and students cannot see the board and teacher and cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, still, two rows of benches, the level of brightness is high, and again curtains can help to control glare. And in this case, again level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the color of the walls and ceiling. The number of students as each student needs 2.1 to 5 m2 space which in this classroom each student have 3 m2 and the negative points are the size, number and window shape which cannot cover the level of daylight needed as well as letting the not appropriate level of brightness enter the space and making high amount of glare, and the improper layout of benches.

Table 19. Şehit Mustafa Kuruluş primary school drawings and models (Author)

ŞEHIT MUSTAFA KURTULUŞ PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

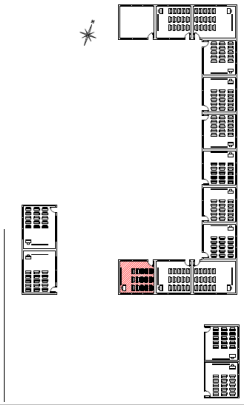
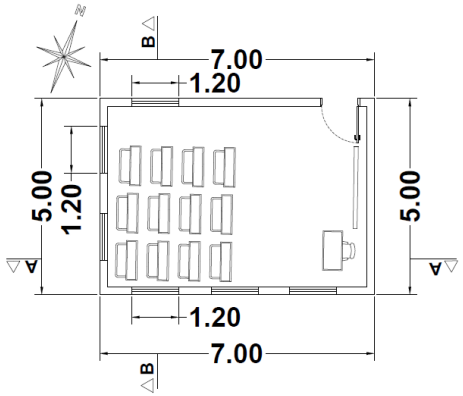
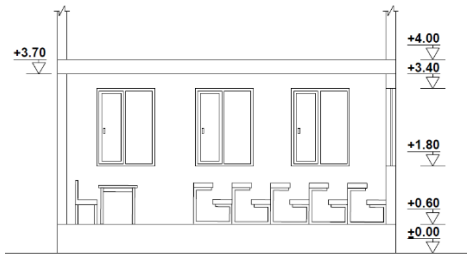
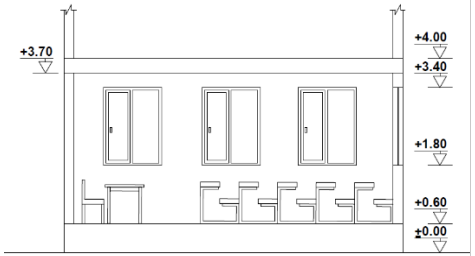
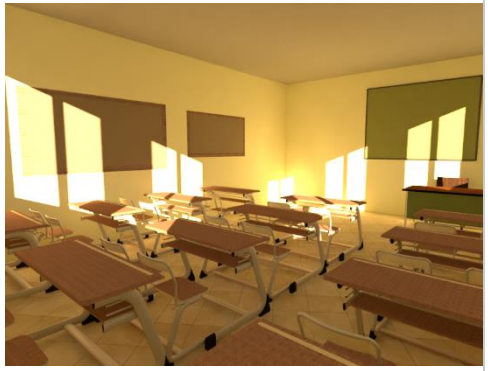
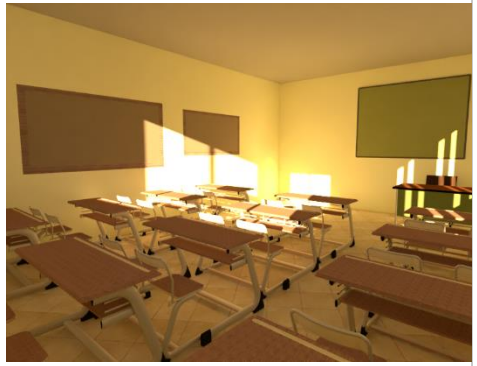
7. Şehit Mustafa Kurtuluş Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is not a sufficient level of daylight in the classroom, and the lighting level should increase with artificial lights.

At 9.45 am, it seems there is still not enough light, so artificial lights should be used, which has been done.

At 11.35 am, on the board and the wall behind the teacher and three of the benches, the level of brightness is so high, and again curtains can help to control glare. And in this case, still, the level of light will be decreased, and artificial lights should use which has been done.

The positive points of this type of classroom are the color of walls and ceiling, the number of students as each student needs 2.1 to 5 m2 space which in this classroom each student have 2.5 m2 and also appropriate seat arrangement of the class is helpful on controlling glare on some of the desks. The negative points are the size, number, and window shape, which cannot cover the level of daylight needed as well as letting the not appropriate level of brightness enter the space and making glare even with the presence of shaders behind the windows.

Table 20. Şehit Osman primary school drawings and models (Author)

ŞEHIT OSMAN PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

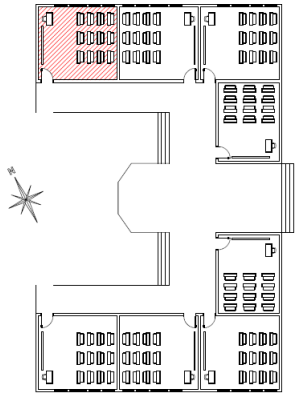
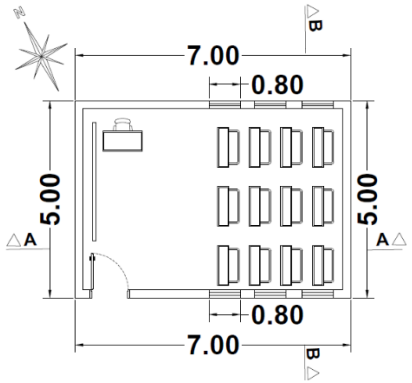
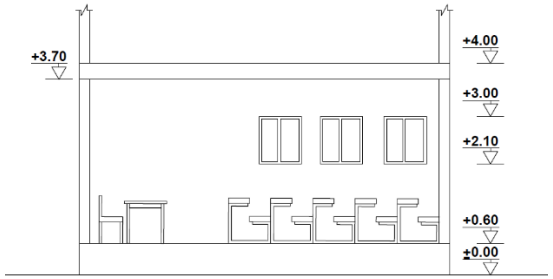
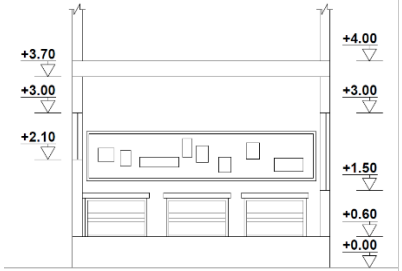
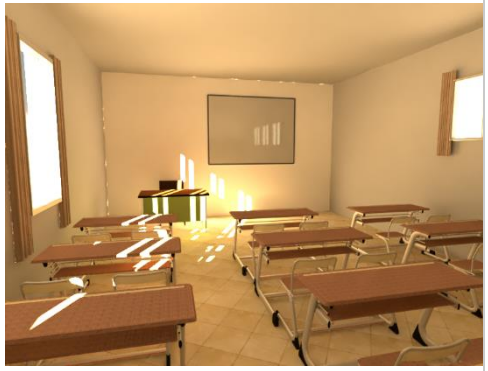
8. Şehit Osman Primary School: As can be seen in the 3D modeling, at 7.55 am it seems there is a sufficient level of daylight in the classroom the high level of brightness can be seen on one of the walls which can make some problems on the visual comfort of some of the students on the side row of desks. So, the curtains can be helpful, but the lighting level should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is so high on the wall behind the teacher, on the board and the frontier desks which will cause glare and students cannot see the board and teacher and cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, again on the board, the wall behind the teacher and the frontier desks the level of brightness is so high, and again curtains can help to control glare. And in this case, again level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the color of the walls and ceiling. The negative aspects are the size, number and window shape which cannot cover the level of daylight needed as well as letting the not appropriate level of brightness enter the space and making glare, the high number of students as each student needs 2.1 to 5 m2 space which in this classroom each student have 1.5 m2 and the improper layout of benches.

Table 21. Gazi primary school drawings and models (Author)

GAZI PRIMARY SCHOOL			
School's Ground Floor Plan	**Plan**	**Section A-A**	**Section B-B**
			
Picture of Class	**3D Model At 7.55 AM**	**3D Model At 9.45 AM**	**3D Model At 11.35 AM**
			

9. Gazi Primary School: As can be seen in the 3D modeling, at 7.55 am, it seems there is not a sufficient level of daylight in the classroom, and the lighting level should increase with artificial lights.

At 9.45 am, it seems there is enough light, but the level of brightness is high on the wall behind the teacher, which will cause glare, and students cannot see the teacher and cannot focus on learning, which with curtains it can be controlled. And in this case, again, the level of light will be decreased, and artificial lights should use which has been done.

At 11.35 am, on two rows of desks, the level of brightness is so high and makes problems on the visual comfort of students, and again curtains can help to control glare. And in this case, again level of light will be decreased, and artificial lights should use which has been done

The positive points of this type of classroom are the color of the walls and ceiling. The negative aspects are the size, number and window shape which cannot cover the level of daylight needed as well as letting the not appropriate level of brightness enter the space and making glare, the high number of students as each student needs 2.1 to 5 m2 space which in this classroom each student have 1.5 m2 and the improper layout of benches.

Comparative evaluation: Based on the findings it should be noted that, the most of the primary schools in Famagusta have the same plan design (interior space organization), which is a built-in U shape. Only Şehit Mustafa Kurtuluş is the only primary school that is different based on seat arrangement. In contrast, the other

schools have row model class organizations in which this type of seat arrangement had been helpful to reduce the number of students who should sit under the high level of sunlight brightness, and this will make glare and problems on their learning process. So, the circle and horseshoes can be one of the ways to use daylight appropriately.

All the schools have 5-9 windows with sidelight and also 4-6 artificial fluorescent light in the selected classes. Their daylight type is task light. Three classes have horizontal windows, three classes have vertical windows, and three classes have both vertical and horizontal windows. It can be said that direct lights in classes with the horizontal windows on the high sunlight axis are more likely to make fewer problems on the visual comfort of students.

To control the light directly, all schools used curtains to control the high level of daylight, which can cause some problems with the visual comfort of students in some hours of the day during the educational year.

Based on the data which had been given on literature review about the percentage of the area of the windows regarding the whole area of class that should be between 15-20% to have better daylighting in classrooms, only Polat Paşa and Alasya have enough window area.

Also, it should be noted that only Alasya, Şehit Zeki, and Şehit Mustafa Kuruluş have enough number of students based on the area each student needs in classroom-based on the UK and US rules on the literature review (2.1- 5 m2).

All the classes' walls and ceilings are covered with white color, which has a suitable light reflection. Still, in Karakol, half of the walls are painted with the yellow tint which has a high level of light reflection, and specially, in this case, this color is increasing the amount of direct sunlight, which is causing glare.

4.7 Proposing Solution to the Glare Problems at Selected Classrooms

Classroom Daylight has an essential effect on the learning environment. The careful introduction of daylight into educational building reduces operating costs, improves student's vision and perception, and contributes to student's health, comfort, productivity. In general, classrooms should get as much daylight as possible, although a designer must control the light of areas within the student's fields of vision. Effective use of daylight in the classroom can help educational buildings realize significant energy saving, increase students' performance, demonstrate environmental responsibility, and provide a better environment in which students can learn.

In the following parts, the recommendation is offered based on the literature review for improvements for the selected classrooms in the nine primary schools that have been studied in the Famagusta city. These solutions are explained in three different parts based on the classroom organization, using color, material, and texture, and also according to the window size and direction.

It should be noted that these solutions are described based on many examinations which had been done in sketch up program to reach to the better interior design solutions according to the different type of class organization, different type of finishing color and different proportion of windows for controlling direct light and glare problem.

4.7.1 Solution to the Glare Problems According to the Classroom Organization

1. Alasya Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: In the selected classroom for controlling the glare which happens to the two desk rows, beside using the curtains, due to the high number of the students even changing seat arrangement cannot be useful so the number of students should be reduced to 14 students from 34 students as a first step.

11.35 AM: In the selected classroom for controlling the glare which happens to the two desk rows, beside using the curtains, the seat arrangement can be changed to the horseshoes model because in other seat arrangement models still the high number of desks will be placed under the direct daylight. But due to the high number of students even this solution cannot be useful so the number of students should be reduced to 14 students from 34 students as a first step as shown in figure 31.

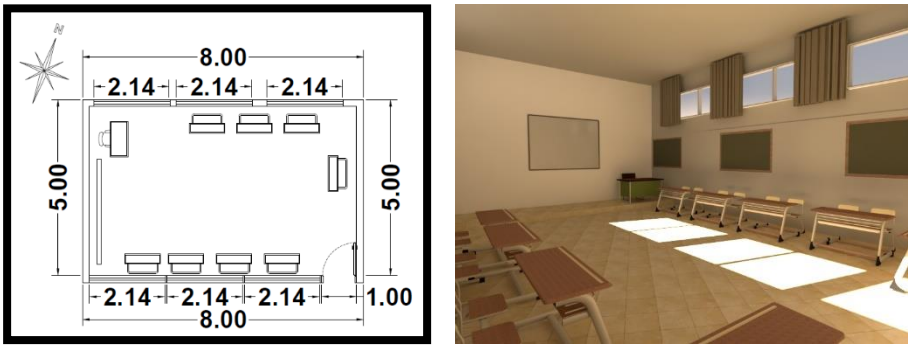


Figure 31. Alasya primary school different class organization at 11.35 am (Author)

2. Polat Paşa Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: There is no glare problem on desks and wall behind the teacher.

11.35 AM: In the selected classroom for controlling the glare, which happens to the one desk row from at 11.35 am, beside using the curtains, the seat arrangement can be changed to the horseshoes model because in other seat arrangement models still the high number of desks will be placed under the direct daylight. Which can be seen in figure 32 the plan with different seat arrangement and also a 3D modeling of it at 11.35 am to reduce the number of students under the high level of brightness as much as possible.

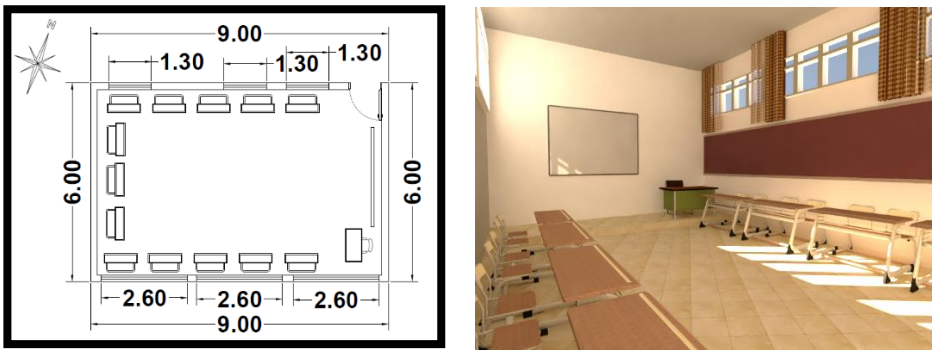


Figure 32. Polat Paşa primary school different class organization at 11.35 am (Author)

3.Canbulat Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: In the selected classroom, because of the high amount of daylight on the board and the wall behind the teacher, beside using the curtains, the class arrangement can be changed to the opposite side which can be seen in figure 33. Also, the number of students should be reduced to 25 students from 30 students.

Figure 33. Canbulat primary school different class organization at 9.45 am (Author)

11.35 AM: In the selected classroom, because of the high amount of daylight on the board and the wall behind the teacher, beside using the curtains, the class arrangement can be changed to the opposite side as can be seen in figure 34. Also, the number of students should be reduced to 25 students from 30 students.


Figure 34. Canbulat primary school different class organization at 11.35 am (Author)

4. Karakol Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: In the selected classroom, because of the high amount of daylight on the board and the wall behind the teacher, beside using the curtains, the class arrangement can be changed to the opposite side as can be seen in figure 35.

Figure 35. Karakol primary school different class organization at 9.45 am (Author)

11.35 AM: In the selected classroom, because of the high amount of daylight on the board and the wall behind the teacher, beside using the curtains, the class arrangement can be changed to the opposite side as can be seen in figure 36.


Figure 36. Karakol primary school different class organization at 11.35 am (Author)

5. Şehit Huseyein Akil Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: There is no glare problem on desks and wall behind the teacher.

11.35 AM: In the selected classroom for controlling the glare, which happens to the two desk rows at 11.35 am, beside using the curtains, the seat arrangement can be changed to the horseshoes model. Which can be seen in figure 37 the plan with different seat arrangement and also a 3D modeling of it at 11.35 am to reduce the number of students under the high level of brightness as much as possible. Also, the

number of students should be reduced to 22 students from 30 students that make this type of class organization more useful for controlling the glare.

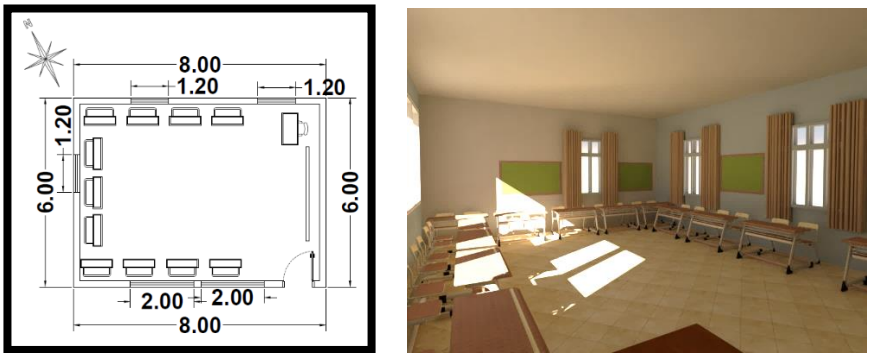


Figure 37. Şehit Huseyein Akil primary school different class organization at 11.35 am (Author)

6. Şehit Zeki Salih Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: In the selected classroom for controlling the glare, which happens to the one desk row at 9.45 am, beside using the curtains, the seat arrangement can be changed to the horseshoes model. Which can be seen in figure 38 the plan with different seat arrangement and also a 3D modeling of it at 9.45 am to reduce the number of students under the high level of brightness as much as possible.

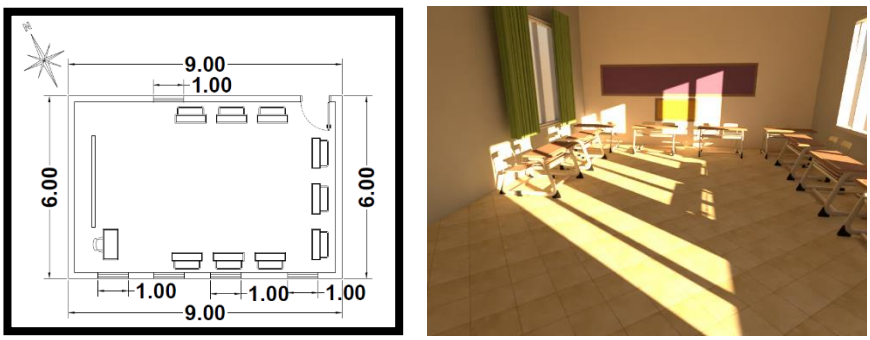


Figure 38. Şehit Zeki primary school different class organization at 9.45 am (Author)

11.35 AM: There is no glare problem on desks and wall behind the teacher.

7. Şehit Mustafa Kurtuluş Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: There is no glare problem on desks and wall behind the teacher.

11.35 AM: There is no glare problem on desks and wall behind the teacher.

8. Şehit Osman Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: There is no glare problem on desks and wall behind the teacher.

11.35 AM: Beside using the curtains, changing class organization to the horseshoes model will be helpful when the number of students reduces to 16 students from 24 students to avoid direct light on desks as figure 39.

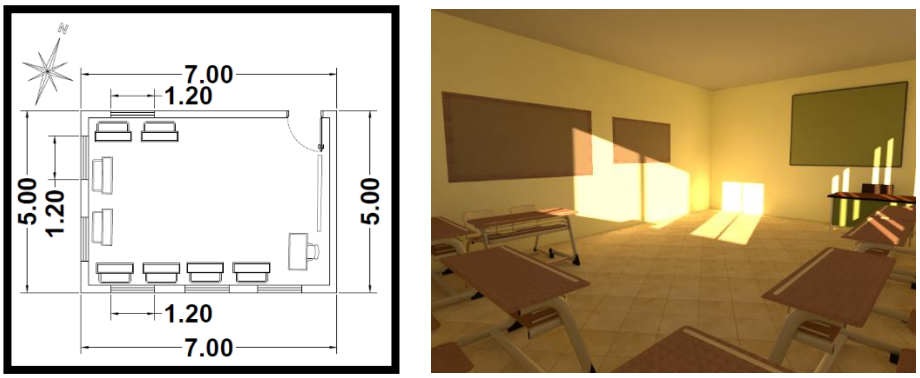


Figure 39. Şehit Osman primary school different class organization at 11.35 am (Author)

9. Gazi Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher.

9.45 AM: There is no glare problem on desks and wall behind the teacher.

11.35 AM: In the selected classroom for controlling the glare, which happens to the three desk rows at 11.35 am, beside using the curtains, the seat arrangement can be changed to the horseshoes model. Which can be seen in figure 40 the plan with different seat arrangement and also a 3D modeling of it at 11.35 am to reduce the number of students under the high level of brightness as much as possible. Also, the number of students should be reduced to 16 students from 24 students that make this type of class organization more useful for controlling the glare.

Figure 40. Gazi primary school different class organization at 11.35 am (Author)

4.7.2 Solution to the Glare Problems According to the Use of Color, Material and Texture

1. Alasya Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: The amount of glare increases on one the desks row because of the high reflecting value of finishing the color of desks at 9.45 am so by changing the finishing color of desks to the darker wood it will reduce the amount of glare like the figure 41.

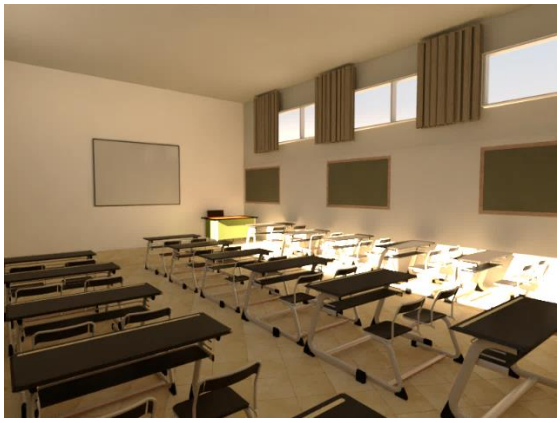


Figure 41. Alasya primary school different with finishing color of desks at 9.45 am (Author)

11.35 AM: The amount of glare increases on desks row in the middle of class because of the high reflecting value of finishing the color of desks at 11.35 am so by changing the finishing color of desks to the darker wood it will reduce the amount of glare like the figure 42.

Figure 42. Alasya primary school with different finishing color of desks at 11.35 am (Author)

2. Polat Paşa Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: The amount of glare increases on one the desks row and the wall behind teacher because of the high reflecting value of finishing color of desks, teacher desk and the wall behind teacher at 9.45 am so by changing finishing color of desks and teacher desk to the darker one, and also changing color of walls to the darker color such as dark green it will help to reduce the amount of glare like the figure 43.

Figure 43. Polat Paşa primary school with different finishing color of desks and walls at 9.45 am (Author)

11.35 AM: The amount of glare increases on desks row in the middle of class because of the high reflecting value of finishing the color of desks at 11.35 am so by changing the finishing color of desks to the darker wood it will reduce the amount of glare like the figure 44.

Figure 44. Polat Paşa primary school with different finishing color of desks and walls at 11.35 am (Author)

3.Canbulat Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: The amount of glare increases on wall behind teacher because of the high reflecting value of finishing color of wall at 9.45 am so by changing finishing color of walls to the darker one such as dark green it will help to reduce the amount of glare in a small scale like the figure 45.

Figure 45. Canbulat primary school with different finishing color of walls at 9.45 am (Author)

11.35 AM: The amount of glare increases on wall behind teacher because of the high reflecting value of finishing color of wall at 11.35 am so by changing finishing color

of walls to the darker one such as dark green it will help to reduce the amount of glare in a small scale like the figure 46.

Figure 46. Canbulat primary school with different finishing color of walls at 11.35 am (Author)

4. Karakol Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: In the selected classroom, because of the high level of daylight on the board and the wall behind teacher curtains can be useful to control the daylight. But, parts of the walls that were painted to the yellow color should change to the white color to reduce the high amount of daylight reflection in figure 47. Also, for more clarification the color of the walls changed to the darker one such as dark green to see the effect on reflecting the light which can be seen as it is not useful.

Figure 47. Karakol primary school with different finishing colors of walls at 9.45 am (Author)

11.35 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

5. Şehit Huseyein Akil Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

11.35 AM: The amount of glare increases on the desks row in middle and the wall and the floor because of the high reflecting value of finishing color of desks, walls and floor tiles at 11.35 am so by changing finishing color of desks to the darker one, the amount of glare will be reduced. But, changing the color of walls to the darker color such as dark green and color of floor tiles to darker one will not help to reduce the amount of glare as can be seen in figure 48.

Figure 48. Şehit Huseyein Akil primary school with different finishing color of desks, walls and floor at 11.35 am (Author)

6. Şehit Zeki Salih Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: The amount of glare increases on the two desks rows and the wall and the floor because of the high reflecting value of finishing color of desks, walls and floor tiles at 9.45 am so by changing finishing color of desks and walls to the darker one, the amount of glare will be reduced. But, the color of floor tiles to darker one will not be so helpful to reduce the amount of glare as can be seen in figure 49.

Figure 49. Şehit Zeki primary school with different finishing color of desks, walls and floor at 9.45 am (Author)

11.35 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

7. Şehit Mustafa Kurtuluş Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

11.35 AM: The amount of glare increases on the two desks rows and the wall and the floor because of the high reflecting value of finishing color of desks, walls and floor tiles at 11.35 am so by changing finishing color of desks and walls to the darker one, the amount of glare will be reduced. But, the color of floor tiles to darker one will not be so helpful to reduce the amount of glare as can be seen in figure 50.

Figure 50. Şehit Mustafa Kurtuluş primary school with different finishing color of desks, walls and floor at 11.35 am (Author)

8. Şehit Osman Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: The amount of glare increases on few of desks and the walls because of the high reflecting value of finishing color of desks and walls at 9.45 am so by changing finishing color of desks and walls to the darker one, the amount of glare will be reduced as can be seen in figure 51.

Figure 51. Şehit Osman primary school with different finishing color of desks and walls at 9.45 am (Author)

11.35 AM: The amount of glare increases on few of desks and the walls because of the high reflecting value of finishing color of desks and walls at 11.35 am so by changing finishing color of desks and walls to the darker one, the amount of glare will be reduced as can be seen in figure 52.

Figure 52. Şehit Osman primary school with different finishing color of desks and walls at 9.45 am (Author)

9. Gazi Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

9.45 AM: There is no glare problem on desks and wall behind the teacher based on the inappropriate finishing color, texture, and material.

11.35 AM: The amount of glare increases on few of desks and the walls because of the high reflecting value of finishing color of desks and walls at 11.35 am so by changing finishing color of desks and walls to the darker one, the amount of glare will be reduced as can be seen in figure 53.

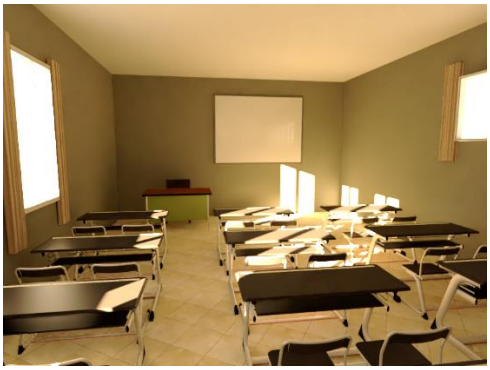


Figure 53. Şehit Osman primary school with different finishing color of desks and walls at 11.35 am (Author)

4.7.3 Solution to the Glare Problems According to the Window Size and Directions

As mentioned before in literature, useful amount of daylight is normally 1.5 to 2 times bigger than the height of the window (Robinson & Selkowitz, 2013). So, in following part the height of windows will be increased or decreased according to this rule.

1. Alasya Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: If window height in the south-east side would be reduced from 120 cm to 70 cm and the distance between floor and windows would be changed from 200 cm to 310 cm to be changed as a clerestories side lighting type of window, the direct light could be controlled easily, as shown in the section from the south-east side of the classroom and the 3D modeling (figure 54).

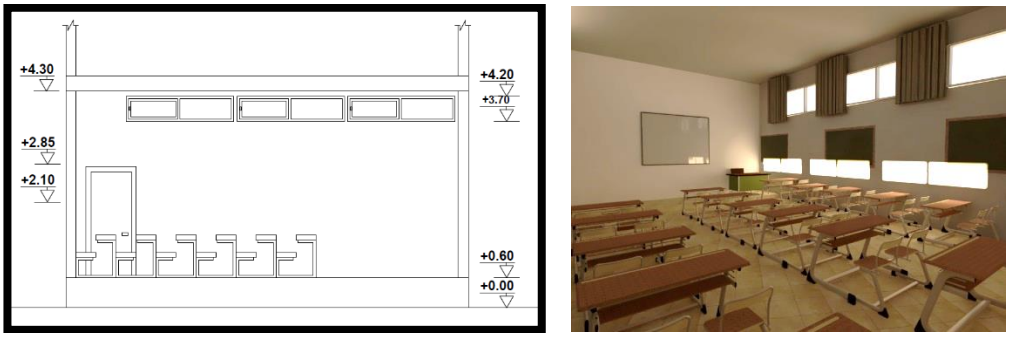


Figure 54. Alasya primary school with different window size at 9.45 am (Author)

11.35 AM: If window height in the south-east side would be reduced from 120 cm to 50 cm and the distance between floor and windows would be changed from 200 cm to 310 cm as shown in figure 55, the direct light could be controlled easily.

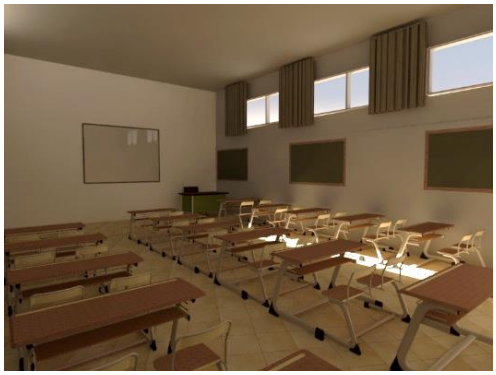


Figure 55. Alasya primary school with different window size at 11.35 am (Author)

2. Polat Paşa Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: If window height in the south-east side would be reduced from 120 cm to 50 cm and the middle window would be eliminated as shown in the section from the south-east side of the classroom and the 3D modeling (figure 56), the direct light could be controlled easily.

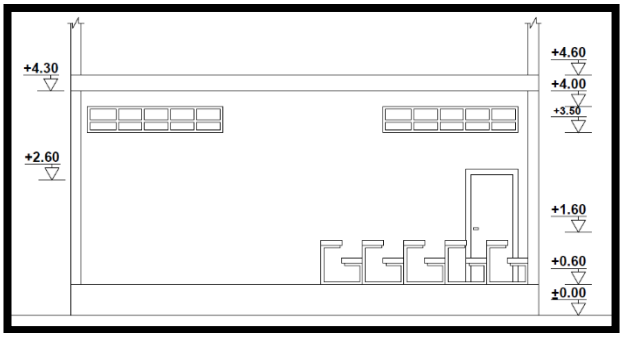


Figure 56. Polat Paşa primary school with different window size at 9.45 am (Author)

11.35 AM: If window height in the south-east side would be reduced from 120 cm to 50 cm and the middle window would be eliminated as many examinations had been done in sketch up program to reach to the better size for controlling direct light as shown in figure 45, the direct light could be controlled easily which can be seen in figure 57.

Figure 57. Polat Paşa primary school with different window size at 11.35 am (Author)

3.Canbulat Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

11.35 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

4. Karakol Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

11.35 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

5. Şehit Huseyein Akil Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

11.35 AM: If window height in the south-west side would be reduced from 170 cm to 70 cm and its width would be reduced from 200 cm to 150 cm, also the distance of window from the floor would be increased from 100 cm to 140 cm as shown in the section from the south-west side of the classroom and the 3D modeling (figure 58), the direct light could be controlled as much as possible.

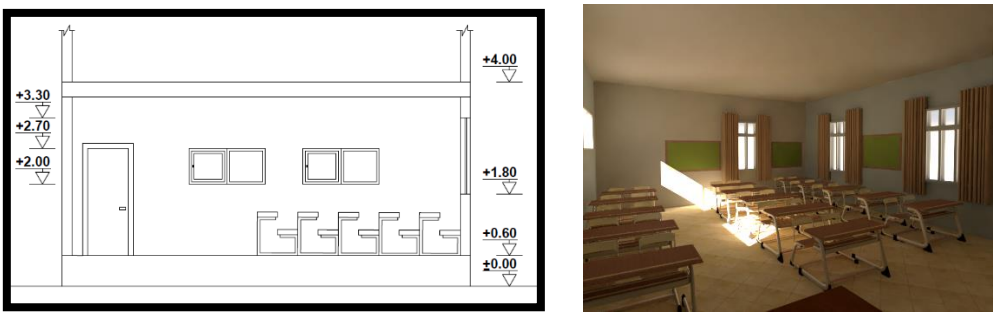


Figure 58. Şehit Huseyein Akil primary school with different window size at 11.35 am (Author)

6. Şehit Zeki Salih Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: If window height in the south-west side would be reduced from 200 cm to 130 cm and the distance of window from the floor would be increased from 100 cm to 230 cm to be changed as a clerestories side lighting type of window, as shown in the

section from the south-west side of the classroom and the 3D modeling (figure 59), the direct light could be controlled as much as possible.

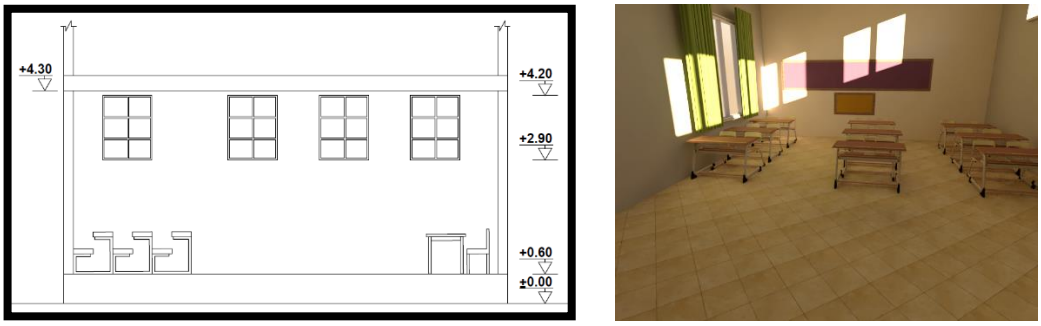


Figure 59. Şehit Zeki primary school with different window size at 9.45 am (Author)

11.35 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

7. Şehit Mustafa Kurtuluş Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: If window height in the south-east side would be reduced from 160 cm to 100 cm and two top windows would be eliminated, as shown in the section from the north-east side of the classroom and the 3D modeling (figure 60), the direct light could be controlled as much as possible.

Figure 60. Şehit Mustafa Kurtuluş primary school with different window size at 9.45 am (Author)

11.35 AM: If window height in the north-east side would be reduced from 160 cm to 100 cm and two top windows would be eliminated, the direct light could be controlled as much as possible which can be seen in figure 61.

Figure 61. Şehit Mustafa Kurtuluş primary school with different window size at 11.35 am (Author)

8. Şehit Osman Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: If window height in both south-east and south-west sides would be reduced from 160 cm to 110 cm and one of the windows from the south-east side would be eliminated, and also, the distance of window from the floor would be increased from 120 cm to 190 cm, as shown in the sections and the 3D modeling (figure 62), the direct light could be controlled as much as possible.

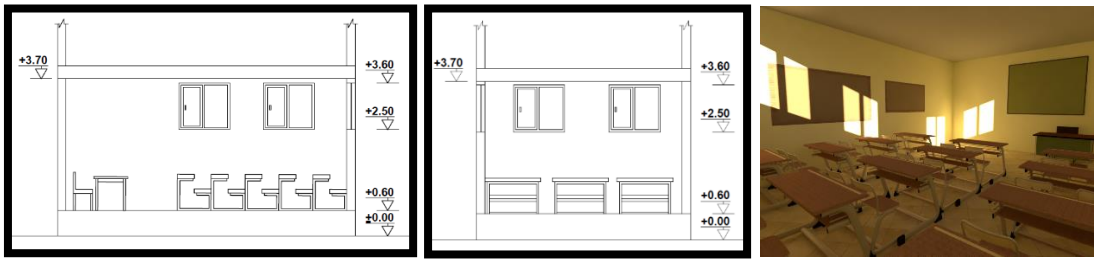


Figure 62. Şehit Osman primary school with different window size at 9.45 am (Author)

11.35 AM: If window height in both south-east and south-west sides would be reduced from 160 cm to 110 cm and one of the windows from the south-east side would be eliminated, and also, the distance of window from the floor would be increased from 120 cm to 190 cm, the direct light could be controlled as much as possible as can be seen in figure 63.

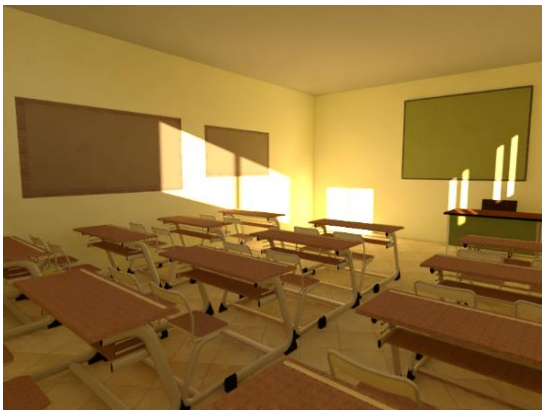


Figure 63. Şehit Osman primary school with different window size at 9.45 am (Author)

9. Gazi Primary School, 7.55 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

9.45 AM: There is no glare problem on desks and wall behind the teacher because of window size and direction.

11.35 AM: If window height in both south-west side would be reduced from 150 cm to 110 cm and one of the windows would be eliminated, and also, the distance of window from the floor would be increased from 90 cm to 180 cm, as shown in the sections and the 3D modeling (figure 64), the direct light could be controlled as much as possible.

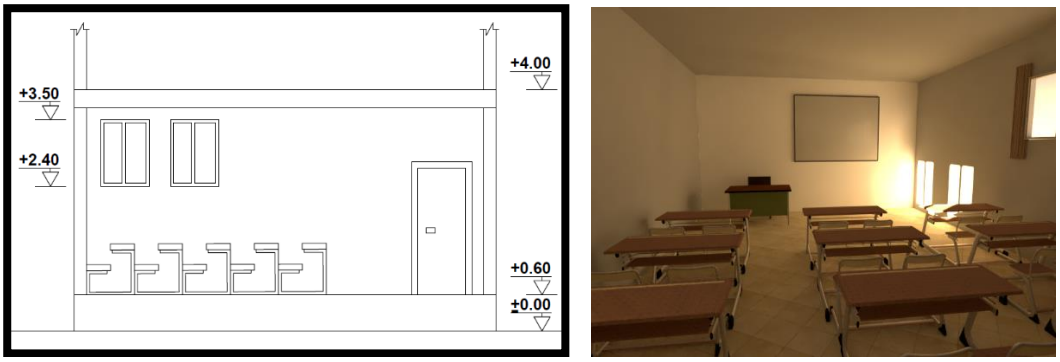


Figure 64. Gazi primary school with different window size at 9.45 am (Author)

In the solutions related to class organization, one of the important factors is that most of the classrooms have the high number of students that firstly they should reduce them to the standard number such as Alasya, Canbulat, Şehit Huseyein Akil, Şehit Osman, and Gazi, then, changing the seat arrangement type. As mentioned before in literature, each student need 2.1 m^2 to 5 m^2 space according to the policy of United Sates and United Kingdom which in these classrooms each student does not have enough space so the number of students should be reduced.

For two classrooms in Canbulat and Karakol just turning the seats to the opposite side is enough and the glare that appearing on the wall behind the teacher can be controlled. On the other classrooms, changing seat arrangements to horseshoes model is the only suitable idea, because other types of seat arrangements are not appropriate based on the spaces that are under direct light.

In the solutions based on the finishing material, texture, and color of surfaces, the only school which has a problem based on the reflection value of finishing color of surfaces is Karakol. Part of the walls are painted to the yellow, and it case more reflection of light than standard light reflection, so, it is better to color the yellow parts to white or pale cream to reduce high reflection of light. For other schools, the parts of classrooms

which are under direct light such as desks, walls, and floor, the finishing color is changed to darker one to reduce the amount of glare. The most effective one was changing the desks finishing color to darker wood then in a few classrooms changing the color of the walls was useful and changing the color of floor tiles was not so helpful.

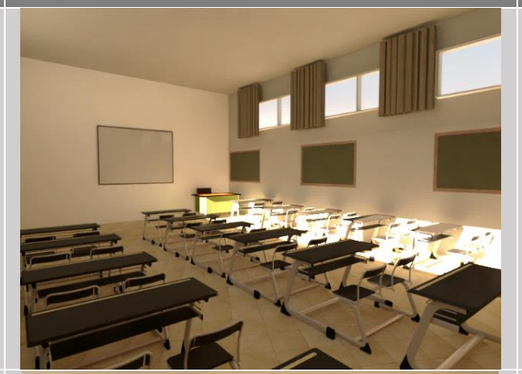
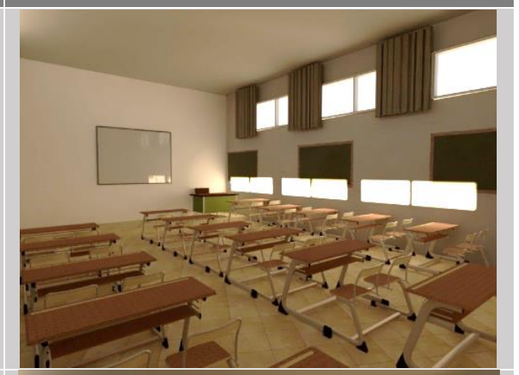
In the solutions according to window size and direction, in all classrooms except the classrooms in Canbulat and Karakol (because the glare which is happening is not related to the window size), reducing window height or width, increasing the distance of windows from the floor and in some cases change the type of side lighting to clerestories type are helpful to reduce glare. Also, in some cases eliminating one of the windows is so helpful such as Polat Paşa, Şehit Osman, and Gazi.

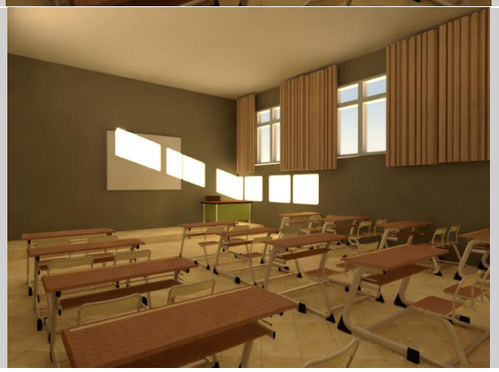
For more clarification of chapter 4, table 22 is demonstrating the data analysis process of nine primary schools in Famagusta, the issues of each selected classroom, and also the way of controlling or reducing these problems are addressed. Table 23 is showing the problematic existing situations and the related solutions according to seat arrangement, finishing color and window size.

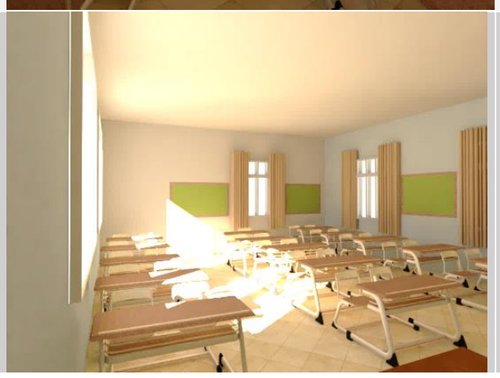
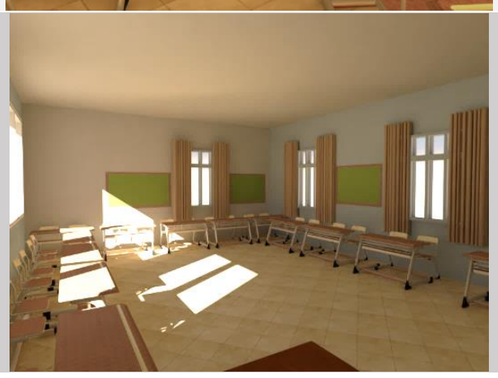
Table 22. Essential points of problems and solutions of the case study (Author)

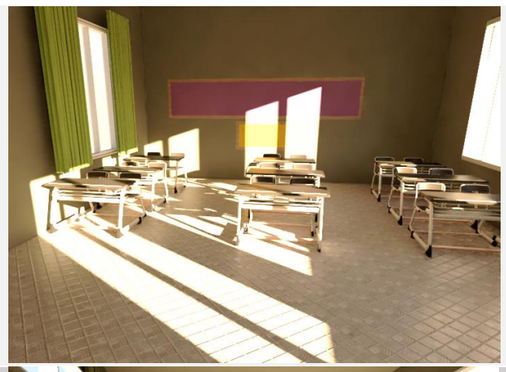
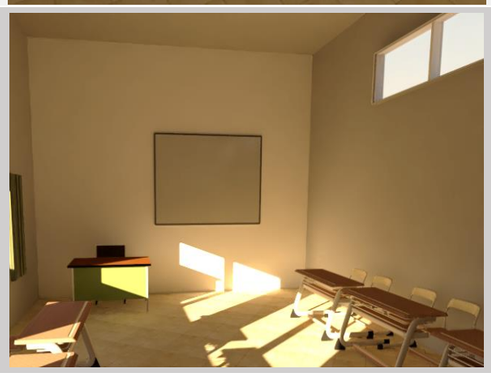
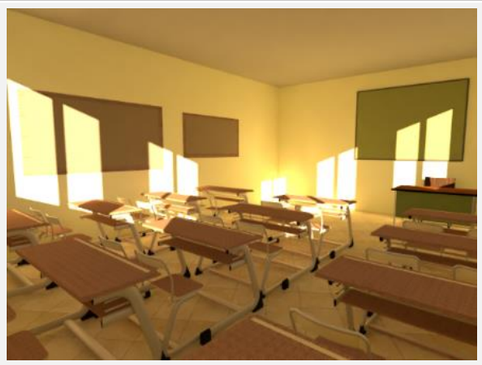
SCHOOL NAME		PROBLEMS					SOLUTIONS			
		Window	Finishing Color	Seat Arrangement	Number of Students	Area of Class	Window Size	Finishing Color	Seat Arrangement	Number of Students
1	ALASYA	Direct light and high light intensity on desks at 9.45 and 11.35 am.	Color of desks.	Desk Rows	34- High	40 m^2	Changing window size and its type of side lighting to clerestories.	Changing the color of desks to the darker one.	Changing seat arrangement to horseshoes.	Reduce to 14
2	POLAT PAŞA	Direct light and high light intensity on desks at 11.35 and also on the walls at 9.45 am.	Color of desks and walls.	Desk Rows	25- Standard	54 m^2	Changing window size and eliminating the middle window.	Changing the color of desks and walls to the darker one.	Changing seat arrangement to horseshoes.	-
3	CANBULAT	Direct light on the wall behind the teacher at 9.45 and 11.35 am.	-	Desk Rows	30- High	54 m^2	-	-	Changing seat arrangement to the opposite side.	Reduce to 25
4	KARAKOL	Direct light on the wall behind the teacher at9.45 and 11.35 am.	Yellow color of the wall.	Desk Rows	26- Standard	38.5 m^2	-	Changing wall color to white or pale cream.	Changing seat arrangement to the opposite side.	-
5	ŞEHIT HUSEYEIN AKIL	Direct light and high light intensity on desks and walls at 11.35 am.	Color of desks and walls.	Desk Rows	30- High	48 m^2	Changing window size.	Changing the color of desks and walls to the darker one.	Changing seat arrangement to horseshoes.	Reduce to 22
6	ŞEHIT ZEKI SALIH	Direct light and high light intensity on desks and walls at 9.45 am.	Color of desks and walls.	Desk Rows	18- Standard	54 m^2	Changing window size and its type of side lighting to clerestories.	Changing the color of desks and walls to the darker one.	Changing seat arrangement to horseshoes.	-
7	ŞEHIT MUSTAFA KURTULUŞ	Direct light and high light intensity on desks and the wall behind the teacher at 11.35 am.	Color of desks and walls.	-	14- Standard	35 m^2	Changing window size.	Changing the color of desks and walls to the darker one.	-	-
8	ŞEHIT OSMAN	Direct light and high light intensity on the wall behind the teacher and desks at 9.45 and 11.35 am.	Color of desks and walls.	Desk Rows	24- High	35 m^2	Changing window size, eliminating one window.	Changing the color of desks and walls to the darker one.	Changing seat arrangement to horseshoes.	Reduce to 16
9	GAZI	Direct light and high light intensity on the wall behind the teacher and desks at 11.35 am.	Color of desks and walls.	Desk Rows	24- High	35 m^2	Changing window size, eliminating one window.	Changing the color of desks and walls to the darker one.	Changing seat arrangement to horseshoes.	Reduce to 16

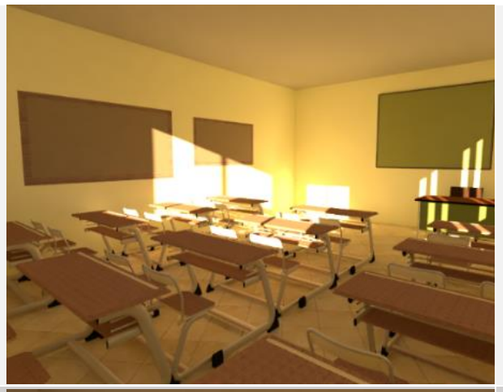
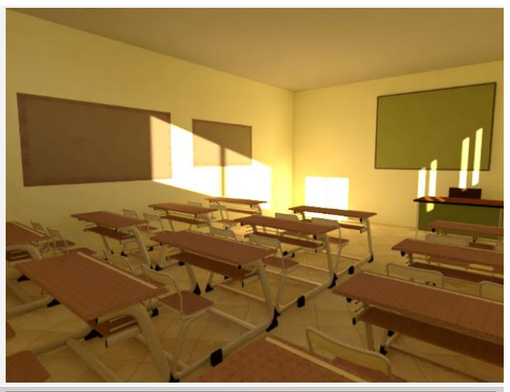
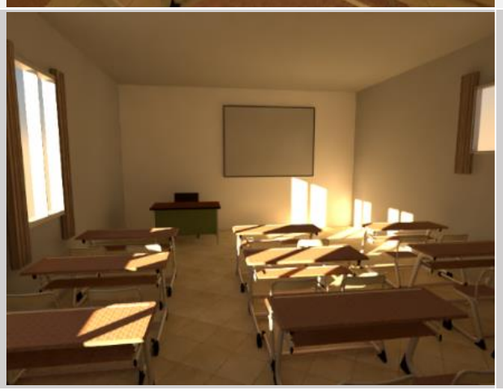
Table 23. Problems and related solutions (Author)

SCHOOL NAME	TIME	PROBLEM	SOLUTION		
		EXISTING SITUATION	SEAT ARRANGEMENT	FINISHING COLOR	WINDOW SIZE
ALASYA	9.45 AM		Not Related		
	11.35 AM				
POLAT PAŞA	9.45 AM		Not Related		

	11.35 AM					
CANBULAT	9.45 AM					Not Related
	11.35 AM					Not Related

KARAKOL	9.45 AM				Not Related	
	11.35 AM			Not Related	Not Related	
ŞEHIT HUSEYEIN AKIL	11.35 AM					

ŞEHIT ZEKI SALIH	9.45 AM				
ŞEHIT MUSTAFA KURTULUŞ	11.35 AM		Not Related		
ŞEHIT OSMAN	9.45 AM		Not Related		

	11.35 AM				
GAZI	11.35 AM				

Chapter 5

CONCLUSIONS

Daylighting is an essential factor in the design of education buildings as it creates a pleasant environment; it promotes healthier conditions and ensures energy saving. Lighting has always been a fundamental element in the conception of architectural spaces, for it is capability of playing with volumes, distorting the perception of space, and even dramatizing the shapes and textures of the materials, enhancing their aesthetic features dramatically. Lighting is of vital importance when creating an architectural project. It is also an element with the capacity to transform spaces, with an ability to communicate, and the capability to modify the subtle messages space transmits to those living there." It is, therefore, no wonder that lighting is considered to be the "fourth dimension" in architecture (Routledge, 2002).

Daylighting has two significant effects on psychology that include reducing and improve. The improved aspects include regulation of circadian, pleasant, security, mood, and sleep. The reduce aspects include stress that causes fatigue, depression, violent behavior, and seasonal affective disorder. Daylighting in school buildings significantly affects students. The majority of schools generally do not provide adequate lighting to encourage the circadian system. Therefore, incorporating sufficient daylight into school buildings will improve circadian stimulation and entrainment. Buildings occupants prefer to utilize the outside view and natural light instead of electrical light. In well-designed interior zones, daylight increases visual

quality and mental health benefits, which are costly and hard to reproduce through artificial lighting. Several adverse effects are linked with the use of artificial light. Baker and Steemers (2002) state that using artificial light causes strain, fatigue, and circadian dysfunction in building occupants.

Natural school environments have an essential role in improving the psychological health of students. Lighting is one of the most critical factors for a positive learning environment. The relationship between functional area and lighting should be under optimal conditions to provide a background for high-quality learning in classrooms. Daylighting affects the performance of students and the psychology of students in classes.

According to Knez (1990) and Vetich (1997), lighting affects mood and attitude. Heschong et al. (2003) stated that the physical characteristics of the classroom, such as lighting, do not influence student absenteeism; however, Hathaway (1994) found a good correlation between lighting and student attendance.

The introduction of new artificial light also causes many things else such as the emergent of colored light, the combinations of the colored light, and daylight. Thus, many designers tried to use both types of lighting in designing buildings. They decided to combine the artificial power systems and natural sources of energy in such a way that they could make a comfortable environment. Moreover, they also considered some other factors, such as seasonal situations (Plummer, 2012).

As before it mentioned, the general lighting presents the light at such level against accent lighting, and it is usually used for commercial purposes. In this situation, the

interaction and coordination between general and accent lighting is regarded as an essential element in making harmony lighting and creating a pleasant experience. In some other situations, the general lighting may be in line with task lighting for reinforcing light levels for particular tasks (Plummer, 2012).

One of the main problems of daylighting is glare, which is causing problems in the visual comfort of students and will be reduced their level of learning. Glare happens when too bright daylight directly enters the visual area, which can cause visual discomfort or even temporary visual impairment (Group, H.M, 2003). So, the main aim of this thesis is to define experimental solutions for reducing glare based on the interior design features such as changing the finishing color, material, and texture of walls, floor, ceiling, and furniture and type of class organization and also changing window size and direction. To fulfill the aim of this thesis, an in-depth lighting performance analysis was conducted in a typical classroom in Famagusta, North Cyprus, and it evaluated the power of lighting and visual comfort in Famagusta primary schools. From each school, one classroom selected based on the south window direction because the southern light with direct light cause glare problem. The results of this thesis indicated that the level of lighting is sufficient in the case of Famagusta primary schools. Moreover, it can be concluded that for getting better visual comfort in typical educational school premises in Cyprus with similar climatic features and typologies in educational architecture, the potential improvements are proposed.

The methodology of the case study is divided on two parts, the first part documenting related literature from theoretical materials such as books and articles, and the second part is analyzing the case study, which is done in three steps. The first step is observation, photography, and measuring. The second step is 3D modeling of

classrooms in three different times of day in the December month for more clarification of direction and the amount of daylighting in selected classes. And the last step was finding problems and defining solutions based on class organization, finishing color, material, texture of surfaces, and the window size and direction for solving the glare problem.

In the solutions related to class organization, one of the important factors is that most of the classrooms have a high number of students that firstly they should reduce them to the standard number. Then, changing the seat arrangement type. As mentioned in literature, each student need 2.1 m^2 to 5 m^2 space according to the policy of United Sates and United Kingdom which in these classrooms each student does not have enough space so the number of students should be reduced. On the other hand, if the number of students could not be reduced to the standard number such as Alasya, Şehit Huseyein Akil, and Şehit Osman the double horseshoes seat arrangement is an appropriate choice. For example, one of the rows in horseshoes model have double row desks where there is no direct light in that part of classroom. For two classrooms just turning the seats to the opposite side is enough and the glare that appearing on the wall behind the teacher can be controlled. On the other ones, changing seat arrangements to horseshoes model is the only suitable idea, because other types of seat arrangements are not appropriate based on the spaces that are under direct light.

In the solutions based on the finishing material, texture, and color of surfaces, the only school which has a problem based on the reflection value of finishing color of surfaces is Karakol. Part of the walls are painted to the yellow, and it case more reflection of light than standard light reflection, so, it is better to color the yellow parts to white or pale cream to reduce high reflection of light. For other schools, the parts of classrooms

which are under direct light such as desks, walls, and floor, the finishing color is changed to darker one to reduce the amount of glare. The most effective one was changing the desks finishing color to darker wood then in a few classrooms changing the color of the walls was useful and changing the color of floor tiles was not so helpful.

In the solutions according to window size and direction, in seven classrooms, by reducing window height or width, increasing the distance of windows from the floor and in some cases change the type of side lighting to clerestories type are helpful to reduce glare. Also, in some cases eliminating one of the windows is so helpful.

This thesis has presented some information for the other scholars on enhancing the health and performance of the students that are employing daylight at schools. For in depth study of this subject, analyzing all the classrooms daylighting situation in all the primary schools in the city, for recommending better and complex architectural solutions for designing primary schools. For further study, other related subjects such as program, sense of place, student psychology and future student can be studied. Besides, this review study can assist designers and architects in designing daylight at schools, which generally presents an insufficient thesis concerning daylight.

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