THE EFFECTS OF LIGHTING CONDITIONS ON VISUAL COMFORT, SATISFACTION AND MOTIVATION LEVELS OF ARCHITECTURE STUDENTS

A Thesis Submitted to
the Graduate School of Engineering and Sciences of
İzmir Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

in Architecture

by
Merve DURGUT

June 2021

İZMİR

ACKNOWLEDGEMENT

Many people have made contribution in this process in different ways, sometimes with their guidance and wisdom, sometimes with their love and support and making me feel they have always been there for me.

I would like to express my special thanks to my supervisor Prof. Dr. Zehra Tuğçe KAZANASMAZ, for giving me a chance to work with her and learn from her, for her great guidance and support, wisdom, kindness and understanding. I appreciate her contributions to this remarkable journey.

I would like to thank all my instructors and faculty who helped me to administrate the survey. Many thanks to the participants who spared their time and made major contributions to my study by responding to the survey. I am so grateful for being a part of IZTECH family.

I would like to give my special thanks to my lovely family. Thank you for being a rainbow in my sky, for being the notes of my life song and for shining my way in life. I would like to thank my mother Begüm DURGUT, for being a worthlessly amazing mother who always supports me, cares for me and be always there for me with her endless love. Many thanks to my dear father Hasan DURGUT for being a great father, for his great support and care for my whole life and being with me with his endless love. Special thanks to my lovely sister Gözde DURGUT who I shared and still share the most memorable moments of my life-my childhood and youth-thank you for being a wonderful sister who always supported me in every stage of my thesis and of my life, to enlighten my life with your bright mind and wisdom, and love. Thank you, my lovely family, for always being there for me. Last but not least, I would like to thank my amazing grandparents Remziye TEKİRLİ and İbrahim TEKİRLİ for being the greatest parents and grandparents. Thank you for taking care of all of us. You will always be with us.

This thesis was a great journey through which I both had fun, learned a lot, and one of the stepping stones to my academic path.

Hope our paths cross again in another journey.

ABSTRACT

THE EFFECTS OF LIGHTING CONDITIONS ON VISUAL COMFORT, SATISFACTION AND MOTIVATION LEVELS OF ARCHITECTURE STUDENTS

Education is a significant part of human life as people spend important part of their lives in learning spaces. Various studies indicate that the quality of physical environment in learning spaces has a crucial impact on students' mood, motivation, performance, productivity, health, and well-being. There are many different physical conditions in an environment and among these factors lighting is one of the most important ones as it is a visible condition. Although there is a wealth of research on the effects of lighting conditions on students' learning, well-being, visual comfort, and performance in regular classrooms, there is a dearth of research about lighting conditions' effects in architecture design studios. Moreover, while research on the effects of lighting conditions on students' performance and well-being is abundant research that focuses on motivation levels of the students is scarce. In this regard, the aim of this study is to investigate how lighting conditions affect the visual comfort, satisfaction, and motivation levels of architecture students. Field measurements and surveys were utilized in three architecture studios. Findings demonstrated that lighting conditions have an important impact on students' visual comfort, satisfaction, and motivation levels. Lack of daylight illuminance, glare, improper artificial lighting, and insufficient lighting were all found to contribute to inappropriate lighting conditions. Lighting conditions have also been found to affect seating preference of users. Seating arrangement and distance from windows affected the perception of users regarding lighting conditions. Based upon the results, some suggestions that would help resolve problems caused by inappropriate lighting were also offered.

ÖZET

AYDINLATMA KOŞULLARININ MİMARLIK ÖĞRENCİLERİNİN, GÖRSEL KONFOR, MEMNUNİYET VE MOTİVASYON DÜZEYİNE ETKİLERİ

Eğitim uzun yıllar boyunca hayatımızın çok önemli bir parçası olmuştur. Pek çok kişi zamanın çoğunu eğitim yapılarında geçirir. Bu yüzden eğitim yapılarının fiziksel koşulları çok önemlidir. Pek çok çalışmanın sonucunda eğitim yapılarının fiziksel koşullarının öğrencilerin görsel konfor, sağlık, motivasyon, memnuniyet, performans ve verimlilikleri üzerinde önemli etkileri olduğu bulunmuştur. Bir yapıya dair pek çok fiziksel koşul bulunabilir. Bu faktörler arasında aydınlatma, görsel koşul olması nedeniyle özel bir yere sahiptir. Aydınlatma koşullarının sınıflarda öğrencilerin öğrenme, görsel konfor ve performansı üzerindeki etkilerine dair pek çok çalışma olmasına rağmen, mimari tasarım stüdyolarında mimarlık öğrencilerine olan etkisi üzerine çok az çalışma bulunmaktadır. Mimarlık öğrencileri çizgiler, şekiller ve renklerle çalıştığından aydınlatmanın mimari tasarım stüdyoları için özel bir yeri vardır. Ayrıca, yapılan çalışmalar aydınlatmanın öğrenciler üzerindeki fiziksel ve psikolojik pek çok etkisini incelemesine rağmen, motivasyon düzeylerine olan etkileri üzerine çok az çalışma bulunmaktadır. Tasarım eylemi yüksek enerji, motivasyon ve yaratıcılık gerektirir. Bu yüzden mimarlık öğrencilerinin motivasyonları önem taşımaktadır. Bu çalışmanın amacı aydınlatma koşullarının mimarlık öğrencilerinin görsel konfor, memnuniyet ve motivasyon düzeyleri üzerine olan etkilerini araştırmaktır. Bu doğrultuda, üç farklı mimarlık stüdyosunda aydınlatma ölçümleri yapılmış ve bu stüdyoların öğrencilerine anket çalışması uygulanmıştır. Çalışmanın sonucunda aydınlatma koşullarının öğrencilerin görsel konfor, memnuniyet ve motivasyon düzeyleri üzerinde önemli etkileri olduğu bulunmuştur. Yetersiz günışığı seviyesi, kamaşma, uygun olmayan yapay aydınlatma ve yetersiz aydınlık seviyeleri yetersiz aydınlatma koşullarına sebep olmuştur. Ayrıca, aydınlatma koşullarının kullanıcıların oturma düzeni tercihlerini etkilediği bulunmuştur. Oturma düzeni ve pencereye olan mesafe öğrencilerin aydınlatma koşullarına dair algısını etkilemiştir. Çalışmanın sonuçları doğrultusunda, yetersiz aydınlatma koşullarına dair çözüm önerileri sunulmuştur.

Dedicated to the shining stars of my life: My Family

TABLE OF CONTENTS

LIST OF FIGURES

Figure **Page**

Figure **Page**

Figure **Page**

Figure **Page**

Figure **Page**

LIST OF TABLES

Table **Page**

CHAPTER 1

INTRODUCTION

Education has been a crucial part of human life for centuries. Children and young generation spend most of the time of a day in learning environments. Previous studies suggest that physical parameters of a learning environment have crucial impacts on students' physiology and psychology. There are many physical parameters regarding environment such as air, noise, humidity, temperature, and lighting. Among these parameters, lighting is one of the most basic ones as it is a visible condition. Research revealed that lighting conditions of an environment can affect visual comfort, satisfaction, well-being, health, mood, motivation, performance, and productivity of the occupants. Poor lighting conditions which do not fit with the required regulations and do not meet the lighting requirements of different tasks and inadequate lighting luminaries lead to inappropriate lighting in surveyed workspaces (Katabaro, 2019). Similarly, inadequate lighting has also been found to cause physical and mental tiredness as well as reduced levels of concentration (Pauley, 2004). Insufficient lighting conditions also lead to reduced vitality, sleepiness during daily hours, increased accidents, discomfort, and work dissatisfaction (Jusl′en & Tenner, 2005).

Oldham & Rotchford (1983) indicated that people working in dark and crowded office environments might show less job satisfaction. Veitch et al. (2002) found that satisfaction with lighting, ventilation and privacy affected satisfaction with workspace environment and in turn modestly linked to job satisfaction. Satisfaction with lighting conditions was related to the illumination level on the desk, reflected light amount on the computer screen, illumination level for computer studies, access to outside view, and overall lighting quality in the work environment.

People who perceived higher quality lighting in their office environment evaluated the space as more attractive. They had higher mood and indicated less discomfort and demonstrated higher satisfaction with their environment and performance (Veitch et. al., 2008). All these studies indicate the importance of lighting in work environments from the side of users' perception.

There is a myriad of studies focusing on the effects of lighting conditions in educational spaces as well. Lighting has significant impacts on the act of learning and students' motivation levels in educational spaces as adequate lighting helps students to better focus on the class. Poor lighting, on the other hand, can have an adverse impact on the physical of the users (Kazanasmaz, 2015). Similarly, students also evaluate lighting as a significant design factor in classroom (Castilla et al., 2017). Quality lighting increases alertness and productivity of students in learning spaces (Hughes, 1981). With quality lighting visual comfort of the users can be obtained. Visual comfort in learning spaces is crucial for learning as it enhances the educational process (Winterbottom & Wilkins, 2009). Students experience sleepiness and concentration problems in spaces with poor lighting conditions. To improve the quality of lighting in classrooms, it is essential to design the lighting system in accordance with the subject of study in classrooms and studios. Providing quality lighting conditions by combining daylight and artificial light in educational spaces motivate students for learning more and enhance their performance (Samani, 2012).

A great body of scholarly work has emphasized the importance of adequate lighting conditions in learning environments as they significantly affect visual comfort, satisfaction, well-being, concentration, motivation, and performance of the students. However, although there is a wealth of research on the effects of lighting conditions on students' visual comfort, learning, health, well-being, mood, performance and productivity in classrooms, there is a dearth of research on the impacts of lighting conditions specifically on architecture students in architectural design studios. Architectural design studios have a different structure than a regular classroom in terms of educational process. Architecture as a discipline is, by its very nature, based on "design" and thus the process of architectural education is much more practice-oriented rather than being a theoretical learning process. The study style of architecture students is very different than those of other study fields as their study centers on the act of design. There is a collaborative environment and high level of interaction in architecture design studios. Students could study individually or sometimes as groups. Various tasks can be carried out in an architecture design studio at the same time, so the studio environment requires different type of lighting design. These tasks could be reading and writing, model making, drawing, computer using, discussion and presentation. It, therefore, poses a significant challenge to meet lighting requirements specifically for each task or

according to the expectations of the architecture students. Thus, results from previous studies may not necessarily fit with the architecture students. Also, most of the studies focused on the well-being, performance, and productivity of students; however, motivation levels of the students did not take as much attention. For architecture students, motivation is particularly important because the act of design itself is a very challenging process and requires high level of energy, motivation, and creativity. The designer needs to devote herself to the task to obtain satisfied results. According to Ryan and Deci (2000), motivation is "to move to do something" and it feeds creativity. As the creativity is the base of the design process, motivation levels of architecture students are highly important.

In this regard, the aim of this study is to investigate how the lighting conditions affect the visual comfort, satisfaction, and motivation levels of architecture students by their own perceptions. Thus, the following research questions will be addressed in the present study:

1) How do the lighting conditions affect the visual comfort, satisfaction, and motivation levels of architecture students?
2) How important is the lighting conditions in terms of architecture students' visual comfort, satisfaction, and motivation levels?
3) How do the seating arrangements of the students affect their perceptions regarding lighting conditions?

1.1. Limitations

The study has also some limitations. A similar study could be conducted with larger sample size. In addition, the duration of the study could be longer, and the measurements could be taken for longer periods.

1.2. Structure of the Thesis

The first chapter of the thesis consists of a brief introduction to the previous studies related to the thesis topic, problem statement, purpose of the study, research objectives, and structure of the thesis.

The second chapter includes a detailed literature review related to the thesis topic. First, the basics of lighting and its parameters are explained. Then, the impacts of lighting conditions- with a particular emphasis on visual comfort, satisfaction, and motivation of users in work and educational spaces-are presented along with the findings of the previous studies. Next, the lighting requirements for architecture design studios as well as the effects of lighting conditions in these spaces are explained with existing research findings.

The third chapter includes the presentation of the studied architecture design studios; its physical attributes and lighting conditions. Then, the chapter presents a description of the users. After that, the methods used in the study, which include surveys and field measurements, are explained. In this chapter, the field measurements, the purpose and structure of the survey are described in detail, and the evaluation process of the data is explained.

The fourth chapter presents the results of the field measurements and the survey. Results are discussed according to the order of the questions in the survey. Field measurement results and survey results are presented comparatively.

The last chapter of the thesis includes the discussion of the results and conclusion which summarizes the main findings and presents the implications/suggestions for further study.

CHAPTER 2

LITERATURE REVIEW

This section presents a review of literature for lighting condition parameters and their impacts on users.

2.1. Basics of Lighting

The International Commission on Illumination defines lighting as the arrangement of lights to ensure that the objects and the environment can be seen properly (CIE-Commission Internationale de L'Elairage). Lighting enables the occupants to perceive the objects in an environment and to be able to carry out an activity or a task. Without light, it is impossible to see and visually perceive any element in an environment. The occupants carry out tasks and perceive their environment without any prevention under correct lighting. The objects that are exhibited, the activities performed in a space, the users of the space and the time spent in an environment can vary, however, lighting should be designed very carefully considering all those parameters so that it can meet all the requirements regarding the function of the environment and aim of the lighting action (Sirel, 1992).

Lighting is not only related to quantification but also qualification. Good lighting can provide the users with better vision for a long time, make them feel visually comfortable, support their physiology and psychology. It reduces the mistakes related to the tasks holding in an environment. It supports performance, visual comfort, satisfaction, health, mood, well-being, and motivation of the occupants. However, poor lighting can cause various problems related to both physiology and psychology of the occupants. These problems could be eye strain, stress, headache, state of sleep during daily hours, tiring, loss of concentration, low performance in daily tasks/activities, negative mood, visual discomfort, and dissatisfaction etc. (02 licht.wissen: Good lighting for a better learning environment).

2.1.1. Quantification of Light

In this part, the terms related to quantification of light such as illumination level and luminance are explained.

2.1.1.1. Illumination level and Luminance

Illumination level indicates the amount of light falling on the unit surface. Its unit is lux (lm/m²) refers to the luminous flux of 1 lm on a surface of 1 m² and it is symbolized with letter "E" as "E (lux) = ϕ (lm) /A (m²)" (Şahin, 2012).

Luminance indicates the quantity of light that is reflected from a surface. The unit of luminance is candela per square meter (cd/m²) It is symbolized with letter "L" (Şahin, 2012). While the lm value and angle of light source, the distance between the surface and light source are key parameters for illumination level, in addition to these parameters, the texture and color of the surface are also determining factors for luminance value. Luminance is the perceived amount of light for observers. If luminance is too high, glare problem occurs (aydınlatma.org).

The main difference between illumination level and luminance is the properties of the illuminated surface because properties like color and texture define how illumination will be reflected from the surface. Each surface reflects different luminance values because of their own surface properties, thus there are variable luminance values in a space and there become luminance contrasts between these surfaces. Luminance contrasts can help the occupants differentiate the task surface from its surroundings or a text from a paper. Luminous contrast ratio is the ratio between the luminance value of task surface and luminance value of its surrounding area (Manav, 2005). It could be helpful when creating an emphatic lighting; however, when luminous contrast ratios are above the standards the adaptation capability of the occupants' vision could decrease, because of which physiological comfort is affected. To provide visual clarity and smooth adaptation for occupants' vision, it is essential to arrange luminance contrasts carefully (Manav, 2005). The standard luminous contrast ratios are indicated in the table below.

Table 2.1. The luminous contrast ratios between task surface and background (Manav, 2005).

2:1	Luminous contrast ratio to distinguish detail
3:1	Luminous contrast ratio between the object and its immediate surrounding
10:1	Luminous contrast ratio between the object and its distant surrounding
20:1	Luminous contrast ratio between artificial light sources or windows and surfaces in immediate surrounding
40:1	This luminous contrast ratio should be never exceeded in any points of field of view
50:1	Only the object is emphasized but the background cannot be distinguished

2.1.2. Qualification of Light

In this part, the terms of lighting related its qualification such as distribution of illumination, color of light and color temperatures and glare are explained.

2.1.2.1. Distribution of Illumination

The uniform distribution of illumination is of crucial importance, and it is essential that an educational space or offices consider the visual comfort of the users in lighting design. All the users in a space may not have equal daylight illumination level in their study area; however, when this is the case, with the help of artificial lighting even illumination could be provided for the occupants so that they can study on the tasks comfortably. Uniformity value is defined with the letter “U”. The uniformity of light could be understood by calculating the average illumination level divided by the minimum illumination level (U=Emin/Eavareage) or the maximum illumination level divided by the minimum illumination level (U=Emin/Emax). For classrooms, 0.6-0.8 values which is calculated 70 cm above from the ground horizontally means a uniformly distributed light (Çelik & Ünver, 2017). Carter et. al. (1994) found that Emin/Emax>0.5 is acceptable and Emin/Emax>0.7 is preferrable for office environment.

The extreme changes in illumination levels on the task area cause distraction and reduction on visual performance. In this case, uniformity value indicates the minimum

value to prevent extreme contrast and distraction. As the difference between maximum and minimum value of illumination in a space increases, the space becomes less uniformly illuminated. This situation causes glare and insufficient illumination in some sections of the space (Kazanasmaz, 2015). Thus, there emerge well-lit areas and less lit areas in the space. To provide visual comfort and improve the well-being of all the users in a space, it is important to provide even illumination for each occupant and thus a space which is uniformly illuminated.

2.1.2.2. Color of Light

Color of light is identified according to the temperature of the light source. Color temperature refers to the level of temperature that a specific object needs to give light with a specific color (Şahin, 2012). Each light source has its own temperature to brighten and so its own color. The light color spectrum runs from red to blue (warm to cool). The higher the temperature is, the cooler the color and the lower the temperature is, the warmer the color. The unit of color temperature is defined as Kelvin (°K) (Şahin, 2012). The color of light is divided into three basic groups as; warm-white (<3300 K), neutral white (3300-5300), and cool white (> 5300) (04 licht.wissen: Office lighting: motivating and efficient). Previous research found that when the illumination level is high, the occupants prefer higher temperatures, thus cooler colors and when the illumination level is low, they prefer lower temperatures (Sözen, 2002). Kruithof (1941) examined the relationship between illumination level and color temperature in a detailed way and constituted Kruithof Curve.

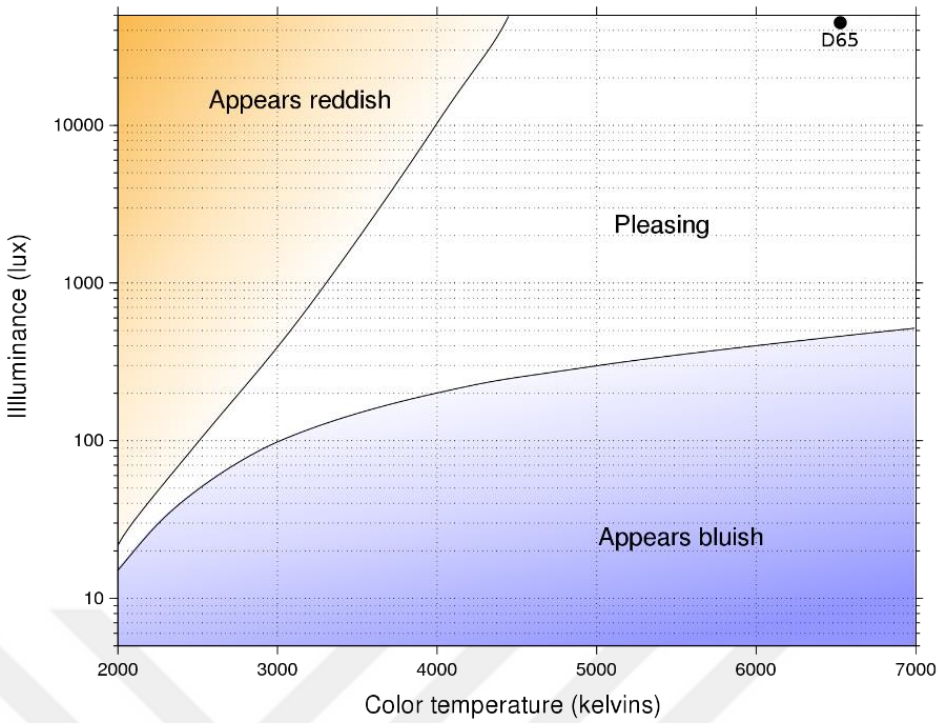


Figure 2.1. Kruithof Curve updated version (Source: Wikipedia).

As it is seen in figure 2.1. the findings of previous research are parallel to Kruithof curve. The color of light is more related to the quality aspects of lighting, while the illumination level is more related to the aspects of quantity. A proper level of light along with the proper color could enhance users' visual comfort.

2.1.2.3. Glare

Glare is defined as a phenomenon of unpleasantness and loss of vision that occurs because of excessively high and uncontrolled light levels. The reasons of glare can be 1) the angle or position of light sources, 2) the type of light sources, 3) extreme light contrast which occurs when there is a lot of difference between the illumination level of the task area and its surrounding area or background, 4) excessive light levels, 5) material reflectance and 6) uncontrolled daylight illumination. Glare is separated into two categories according to the sources of glare: direct glare and indirect glare. Direct glare occurs when the light sources in the field of vision is too bright. Here, the source of glare is the light sources itself. Indirect glare occurs when light which is scattered from light sources is reflected off the surfaces to the eye of the occupants. Here, the light sources indirectly cause glare (Özkum, 2011).

In terms of its impacts on occupants, the most common types of glare are disability glare and discomfort glare. Disability glare occurs when the level of visibility decreases because of the scattered light from too bright light sources which leads to reflectance on the task surface. This generally results in visual discomfort and having difficulty in doing tasks that require visual attention (J.T.P. van den berg, 2009). Discomfort glare is more related to the feeling of distraction and discomfort because of the high illumination of extremely bright sources or illumination contrasts in surrounding area. The eyes have difficulty in adapting because of the differences between the illumination on the task surface and surrounding high brightness (Mork et. al., 2020).

Glare can be prevented by adjusting the light sources with correct position and angle, choosing the materials and colors considering their reflectance value, masking the light sources, considering uniformly distributed light in the space to avoid high contrasts between light levels, avoiding extreme brightness to which human eye may not adapt and applying daylight control systems.

2.1.3. Lighting Control and Automation Systems

Lighting control systems are based on controlling the usage of artificial lighting. Lighting control systems are separated into three groups based on how users control lighting. These are manual control systems which users control illumination levels manually, automatic control systems which adjust required illumination level without intervention of users and lighting automation systems through which users are able to control many attributes of lighting (Altuncu, 2016).

Manual control systems work with the intervention of users. The system includes switching or dimming capabilities. Switching could be on/off for all the light sources or it can help control the sources separately as on/off. Dimming, on the other hand, enables gradual increase or decrease among light levels (lightngicontrolassociation.org). It is possible to catch sudden or smooth transition regarding lighting inside the space as desired. Dimming is more flexible in terms of providing various levels of light according to users' preference. Automatic control systems work with sensors or any other system that stimulates the control system. This stimulus could be related to the existence of occupants, time, light levels, or any other condition (lightngicontrolassociation.org). In this system, users are not able to intervene with lighting as much as they do in the manual

system. In terms of users' satisfaction, automatic controls may not be very practical to meet user needs as they do not offer many options. These systems provide users with the flexibility to adjust illumination levels as they prefer. In terms of energy efficiency, user comfort and flexibility, these systems become preferable (Manav, 2005).

Lighting automation systems are separated into such groups as occupancy-based, time-based, daylight-linked systems and mixed control system (Hassan et al., 2014). Switching and dimming are the control methods of automation systems. Dimmable light sources provide gradual changes between illumination levels and are very helpful in the spaces where critical tasks are carried out. With the help of dimming system, occupants can arrange light levels according to the task on which they study thanks to the flexibility of the system. The users have the control of where, when, how much and how the lighting exists in spaces with the help of lighting control systems. Not only the light levels but also the color of light could be arranged with the help of these systems (lightngicontrolassociation.org). This is a very important feature as there is a strong relationship between illumination level and color temperature. As the illumination level increases people tend to prefer higher color temperatures, thus cold colors like cool-white, white, and bluish and as it decreases, they prefer warmer colors (Sözen, 2002). Thus, the ability to control not only the illumination level but also the color temperature is important.

2.2. Lighting and User Relationship

In this part, the effects of lighting on visual comfort and satisfaction of users will be presented with findings from research literature.

2.2.1. The effects of Lighting on Visual Comfort and Satisfaction

Lighting is an essential parameter of our physical environment that needs to be met with high quality and careful consideration. It has various impacts, both psychological and physiological, on the occupants in the space. While quality lighting affects mood, well-being, performance, motivation, satisfaction, and comfort of the users positively, improper lighting may cause negative impacts on the users. Quality lighting is vital to the visual comfort and satisfaction of the occupants. Creating a well-illuminated task area is

fundamental to optimize visual comfort of the occupants in work and study spaces (Králiková et al., 2016). Lighting quality cannot be measured by only proper quantity of light; there are some other factors that affect lighting quality like uniformity, distribution of luminance, color of light and glare (Králiková et al., 2016). Therefore, the question of "how much to illuminate" is not enough while investigating the lighting quality; however, the question of "how to illuminate" should also be addressed with careful consideration. Quality lighting can be evaluated according to visual comfort and satisfaction of the occupants and whether it is appropriate for the space or activity in terms of visual and psychological needs of the occupants (Králiková et al., 2016). Visual comfort is achieved when users of a space feel visually comfortable in a luminous environment. Even if there are some subjective factors that affect visual well-being of the occupants, there are also some physical factors that affect visual comfort such as presence and quantity of daylight, illumination level, uniformity, distribution of light, luminous contrasts, glare, light color, color rendering index of light sources and flicker (Frontczak, 2010). While visual comfort enables users to perceive the environment as well as the objects in it without any difficulty, visual discomfort hinders users' ability to do so (Çetin, 2009). In other words, visual discomfort causes eye strain which makes it hard to perceive the objects in the field of view. The reasons behind visual discomfort may be insufficient light, excessive levels of light, glare, shadows, and flicker (Teri, 2018).

Lighting conditions that meet occupants' needs provides visual comfort and thus contribute to their satisfaction (Apikoğlu, 2014). Providing adequate lighting conditions is necessary for users to maintain their tasks properly. Providing an appropriate illumination level is only the starting point to present adequate lighting. However, it should be noted that excessive light levels can cause inadequate lighting just as insufficient lighting can do (Králiková et al., 2016). Inadequate lighting is related with visual discomfort, somnolence, fatigue, eyestrain, headaches, migraine, lack of concentration and alertness, sleepiness during daily hours, anxiety, nausea, and pain on the back, shoulder, and neck. These impacts mostly result in reduced performance and productivity (Pauley, 2004). Therefore, to provide quality and adequate lighting conditions, illumination level and its uniformity, distribution of luminance, color rendering index and color temperature of light sources, methods to control glare, flicker of light sources and daylight availability should all be arranged with attention (International Commission on Illumination, 2002; Veitch & Newsham, 1998).

A uniformed illumination level is required to carry out a specific task on a surface (Lee et al., 2014). The type and the position of the light sources, mounting height, and the way light is distributed form light sources determine the uniformity, quality, and quantity of illumination on the work surface. Research has indicated that well-distributed, adequate levels of illumination can help prevent headache, eye strain and fatigue and improve users' visual perception (Lee et. al., 2014; Wessolowski et. al., 2014). Correspondingly, Samani (2012) observed loss of concentration and sleepiness among students as a result of insufficient lighting in classrooms. Also, appropriate illumination levels were found to enhance users' alertness and mood while reducing sleepiness (W. Van Bommel, 2004).

Another important factor in visual comfort and satisfaction is color temperature and color rendering index (CRI) of light sources. Color temperature and CRI, both of which determine how the light is perceived in an environment, have a crucial impact on users' psychological, physiological, and cognitive functions, visual comfort and satisfaction, mood, and visual perception (Královičová et al., 2016; Lee et al., 2014). Therefore, it is necessary to apply proper color temperature in workspaces to improve cognition, health, productivity, and motivation of the occupants (Kuller, 1993).

Daylight is assumed to be the most effective light source since it has a splendid color rendering with perpetual spectrum which provides more efficient light in terms of visual comfort. It also offers natural light with various levels of intensity during the day in accordance with the season (Shisregar, 2016; Katabaro, 2019). Correspondingly, Hoffman et al. (2008) also demonstrated the positive outcomes of variation in light levels on employees' subjective mood.

Previous studies showed that daylight and outside view can improve physiology and psychology of students (Kuller, 1992; California Energy Commission, 2003). There is this crucial psychologic impact of daylight as it can help create visual contact with nature and outside view through the openings of buildings. In this way, it can enhance the mood of the building users (Gelfand & Freed, 2010). Availability of daylight and outside view through window openings was also found to increase visual satisfaction while decreasing workers' discomfort (Jamrozik et al., 2018). According to Veitch (2005), the lighting satisfaction of the users who have access to windows is higher than the ones who do not. Farley (2001) indicates that there are many impacts of windows with natural views on occupants' well-being, including but not limited to increasing employees' satisfaction

with the work environment, self-productivity perceptions, interest in work and reduce in being inclined to quit the job (Mandala, 2019). It was also found that occupants with views of natural environment pay more attention while performing a task or activity (Heerwagen, 2000). Daylighting goes beyond much more than providing outside view as it also increases alertness for repetitive and common tasks especially at post-lunch hours (Robbins, 1986). Likewise, Shishegar (2016) also indicate that alertness, attention, mood, and cognitive performance could be enhanced with the help of natural light optimization. A study conducted by Corbett et al. (2012) demonstrated that state of being awake and sleep parameters enhanced by the impact of an exposure to bright morning light for one hour. It also affects alertness and cognitive performance. Similar findings were suggested by Leichtfried et al. (2015); they found out that early morning illuminance advances mood and subjective alertness. Findings from these studies indicate that there is a direct connection between early morning daylight and alertness, vitality, and cognitive performance. Thus, exposure to bright light during morning hours is necessary for students to promote active class participation (Shisregar, 2016).

Research has indicated that users demonstrate higher performance and work satisfaction under daylighting conditions in work environments. (Kuller & Wetterberg, 1993) According to Veitch (2005), when provided with an option to choose, users prefer daylight rather than artificial lighting in their work environment. Borisuit et al. (2014) conducted a research study among twenty-five subjects in two conditions to investigate the effects of daylight on performance in terms of visual comfort, mood, and alertness; in one of the conditions the subjects were exposed to only artificial lighting and in the other they were exposed to daylight (without windows and view). The subjects spent afternoon times in either conditions. Results revealed that, even when there was no view, the subjects found daylighting conditions much more visually acceptable than the one with artificial lighting. It was also found that well-being and alertness of the occupants were found to decrease in both conditions; however, they became sleepy under artificial lighting conditions earlier than daylighting conditions. Since visual comfort, well-being and alertness are some of the factors that affect satisfaction of workers, they require careful consideration (Shisregar, 2016). Presence of daylight is highly important as it boosts visual comfort (Hassan, 2014).

Visual comfort is one of the key factors that affects satisfaction of the workers. According to research findings of Veitch et. al. (2008), users found daylight without glare

supplementary to artificial lighting. The research revealed that, given an option to users, they prefer to utilize daylight and dim electric lighting in such conditions. Daylight affects mood and morale positively and reduce fatigue and eyestrain; however, it should also be noted that reflection from interior surfaces and direct sunlight can cause glare and thus visual discomfort and eyestrain (Shisregar, 2016; Hassan, 2014). Glare creates a luminous obstacle between the occupant's sight and the target object reducing the visibility in the field of view. As mentioned above, there are two common types of glare: disability glare and discomfort glare. As a result of disability glare, occupants feel tired both mentally and physically. Likewise, discomfort glare makes it difficult to concentrate on tasks for occupants especially those working on tasks which are visually compelling (Jusl´en & Tenner, 2005). To benefit from daylight without being exposed to daylight glare, some daylight control systems should be considered and integrated for occupants' well-being, visual comfort, and satisfaction.

2.2.2. The effects of Lighting on Motivation

Motivation is an instinctive feeling to be willing to do something or carry out a task persistently. Previous studies suggest that lighting conditions of an environment have impacts on motivation levels of the users. Motivation is also closely related with other factors such as mood, well-being, and performance (Boyce et al., 2003). In the figure below, the relationship between lighting, motivation and other factors is shown.

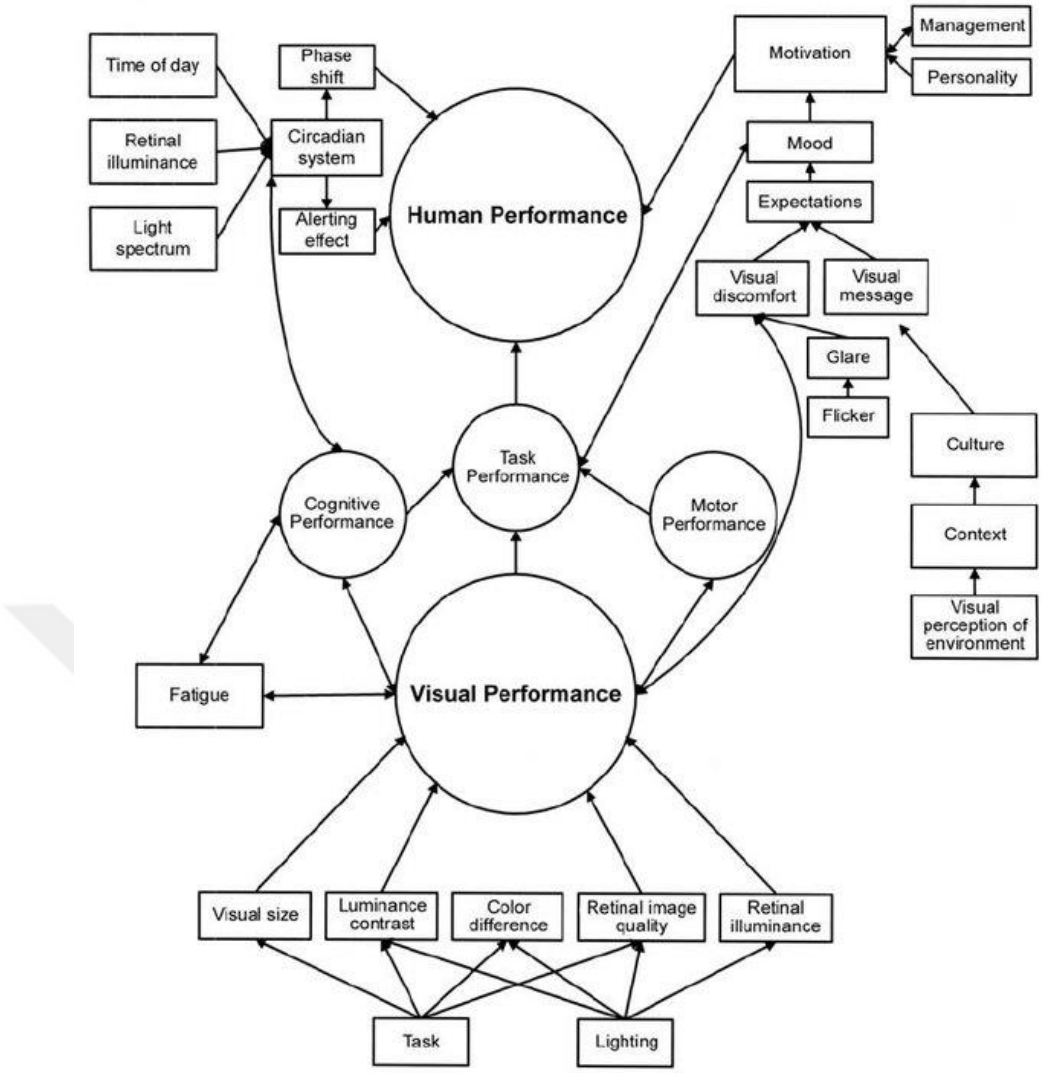


Figure 2.2. The relationship between lighting and humans (Boyce et al., 2003).

Boyce et al. (2003) found that motivation has significant effects on task performance. Visual performance is a strong parameter as a self-determinant of individuals whether the task can be done; however, motivation which is an instinctive feeling to carry out a task is vital to the task performance. Therefore, it is highly important that how the occupants visually perceive their environment. If they perceive the light as insufficient for the visibility of the task, they could be less motivated to do the task (Fotios, 2011). Veitch et al. (2008) indicated that occupants who perceive better quality lighting in their office environment evaluated their workspace as being more attractive and demonstrated better mood, better well-being, vigilance, and enhanced motivation.

Lighting conditions can be evaluated according to the preference judgement of the occupants whether they are appreciated or not from the luminous environment. In turn,

these preferences impact the motivation to do the task and mood of the occupants and hence their task performance (Fotios, 2011). Especially in the prolonged tasks, gloomy and dim lighting can cause visual discomfort that may affect the mood and motivation of the occupants (Boyce, 2003). On the other hand, quality lighting boosts workers' motivation and performance in offices (04 licht.wissen: office lighting: motivating and efficient). Korkmaz (2008) investigated the factors that affect motivation of healthcare staff. One of the factors was the lighting system. He addressed a question as how affective sufficient lighting on motivation of the occupants. Results of the research showed that almost all the occupants stated as certainly effective and effective. As a result, it was found that lighting system has a significant effect on motivation. S. Lamb (2015) conducted a study to investigate insufficient Indoor Environmental Quality (IEQ) effects on the well-being and performance of office workers. The study included 114 occupants lasting for eight months. Results suggest that environmental stress factors-one of which is insufficient lighting-either individually or together indirectly influence performance by reducing alertness, focus and motivation of the occupants. Increase in environmental stress factors cause a decline in the state of well-being and mood, which leads to further decrease in motivation levels, distraction, and tiredness, affecting the performance of office workers negatively (S. Lamb, 2015).

As research findings of Samani (2012) shown, adequate classroom lighting can enhance students' motivation to learn better. By the effect of quality lighting students feel relax and motivated for better learning. In addition, they do not experience sleepiness and demonstrate better concentration. Students could show more academic success if they have motivation in their learning environment (Fielding, 2006; Pulay, 2010). Thus, it is essential to improve lighting conditions in learning spaces to boost students' performance and motivation for learning (Samani, 2012). Optimized lighting conditions contribute to an effective learning environment, motivate students, and lead them to concentrate for long hours. In addition, higher illumination levels during daily hours can lead to higher alertness (02 licht.wissen: Good lighting for a better learning environment). Students who are more alert are also more motivated and watchful. Higher illumination levels help improve motivation and well-being of the occupants. For instance, in wintertime, when daylight is less available, occupants could experience fatigue. These negative impacts on occupants could be prevented by enriching the space with more light with appropriate adjustments (02 licht.wissen: Good lighting for a better learning environment).

Even though, performance and mood of the occupants could be increased by day-lit spaces (Gou et. al., 2013), quality indoor spaces with higher illumination levels, uniformly distributed light, non-existence of glare and luminous ambience could support better performance and motivate occupants (Veitch & Geerts, 2005). Motivation, well-being, and performance of the occupants are related with the dynamism of light which is provided by continuously changing structure of daylight. Artificial lighting, on the other hand, is not able to match the endless positive and complicated properties of daylight (02 licht.wissen: Good lighting for a better learning environment). Thus, designing spaces with maximized daylight illumination -according to the required illumination level related to the function of the space- has vital importance for occupants' well-being, motivation, health, performance, visual comfort, satisfaction, and mood. Benefiting from daylight illumination at utmost level is crucial for users of the space; therefore, while designing the buildings, daylight availability should be given a primary consideration. After providing a well day-lit space to occupants, consideration should be given to artificial lighting design to maintain a perfect combination of natural light and artificial light in the indoor environment. As mentioned above, factors that contribute to good quality lighting include right amount of illumination and uniformed distribution, adequate luminous contrasts, absence of glare, proper color temperature and color rendering index of light sources, avoiding sharp shadows that will distract and annoy users and pleasant luminous ambience for occupants, all of which have a significant contribution to users' psychological and physiological well-being, mood, health, alertness, watchfulness, performance, visual comfort, satisfaction and motivation levels.

2.3. Lighting Conditions in Architecture Design Studios

In this part, the lighting standards for architectural design studios and visual comfort and satisfaction of architecture students will be presented.

2.3.1. The lighting requirements of architecture design studios

According to CIBSE standards (CIBSE, 1994), the minimum illumination level value should be 500-750 lux for studios in educational buildings. As the tasks/activities

vary in an architectural design studio environment, the standard illumination level values for various tasks are given in the table below.

Table 2.2. The standard illumination levels for different tasks in an architecture design studio.

Model making	Technical drawing	Reading and writing	Computer studies and CAD drawing
500-1000 lux (IESNA, 2000)	750 lux (CIBSE, 1994)	300-500 lux (CIBSE, 1994)	300-500 lux (Can go up to 500 lux for CAD drawing) (CIBSE, 1994)

2.3.2. Visual comfort and satisfaction of architecture students

Previous research examined the effects of lighting on visual comfort and satisfaction of the occupants in various work and education environments; however, there are a few studies focusing on the users of architecture design studios. One of these studies belongs to Mandala (2019). He examined the perception of visual comfort and room atmosphere of architecture students and evaluated the quality of light in the related architecture studio. Then, he provided recommendations regarding lighting design to enhance occupants' creativity and productivity. The findings of the study demonstrated that even though the studio has lower illumination level than standard minimum requirements, the students' response in terms of visual comfort regarding lighting quality is adequate. Participants in windowed area showed higher visual satisfaction regarding room atmosphere. They feel relaxed, pleasant, and warmer and find the room more attractive compared to the ones in windowless area. Daylight has a dynamic structure which can change mood of the occupants during a day; electric lighting, on the other hand, has a constant structure and may show the atmosphere as less attractive. This finding again, emphasized the need of daylight in study and workspaces. Students also suggested that more illumination level via task lighting should be provided in work areas, especially the ones in the middle of the room with lower illumination. They also mentioned about their need of daylight for better productivity (Mandala, 2019). Results

of this study show that students' main concerns are sufficient daylight illuminance and individual control over lighting levels.

Sharmin (2011) investigated various architectural characteristics which influence the luminous environments of architecture studios and made suggestions to improve these luminous environments giving a special consideration to daylight inclusion. She examined various architecture studios in different universities and conducted a field survey and simulation study. Findings of the questionnaire survey indicated that students are not satisfied with illumination level and lighting quality in the surveyed studios. Daylight illuminance is very low; except the areas near the openings, the other parts get very poor daylight. Since south openings cause glare, students commonly close the curtains to avoid glare problem. Thus, they cannot benefit from daylight illuminance, even the ones who sit next to the windows. Glare strongly affects students during computer-based tasks, and they cannot study with computers while the curtains are open. Because daylight illuminance cannot be used beneficially, students generally depend on artificial lighting. However, artificial lighting was found to provide only general illumination and not address lighting requirements of variable tasks of studio environments. Some tasks required higher illumination, but no task lighting was available for those tasks. Since daylight illuminance was her primary concern, Sharmin (2011) examined the geometry, orientation, and other physical attributes of the studios to suggest better luminous environment by providing available daylight illuminance.

Obeidat (2012) examined if physical environment of design studios meets the users' needs investigating the perspectives of architecture educators and professionals. No specific studio was selected to examine physically. A survey regarding physical properties of studio environment was distributed to the participants. The participants were asked to rank the importance of interior environment features like furniture, color, flexibility of furniture arrangements, temperature, and lighting in a design studio. Participants stated that lighting is the most important feature of interior environment of a design studio. Since the process of learning in design studios is based on shapes, lines, and colors, an appropriate lighting is necessary (Obeidat, 2012).

Nieveen van Dijkum (2013) conducted a study to form a set of guidelines for the improvement of quality workspaces of architecture students so that the studios can better support them. Interviews with students demonstrated that sitting next to the windows allows students to control the amount of light; the students stated that this is very

important because they sometimes need a lot of light. On the other hand, sometimes sunlight could shine on their face and it annoys them. Students who sit next to a window indicated that different activities have different needs, and it is very nice to have control over lighting conditions. For instance, for some tasks like drawing, s/he needs more amount of light, but for some others such as computer studies, that same amount of light could be too sharp. Thus, having control over illumination level is quite important. They also stated that they would prefer it as being more diffused; lots of light could be in the space, however, not necessarily directed at one. Some students stated that having control over blinds is beneficial. For example, in the evening, the sun could shine through eyes or on the screen, so being able to control the light is important. Preferring one workspace over another in a studio depends on level of control, such as control over the amount of light penetrating through a window (Nieveen van Dijkum, 2013).

Studies suggested that it is very important to provide adequate daylight illuminance; however, daylight illumination alone could not be enough as it changes during daily hours. Its amount could increase and decrease during the day. Thus, careful consideration and focus should be given to artificial lighting design as well. Students' opinions regarding artificial lighting are highly important to determine an adequate lighting design.

CHAPTER 3

THE METHODOLOGY

This section presents the methods used in this study as well as the physical attributes, lighting conditions and user profiles of the selected architecture design studios.

3.1. Description of the Architecture Design Studios

Three architecture design studios in Faculty of Architecture- Izmir Institute of Technology have been selected for the study. The location of the Faculty of Architecture is 38 ° 32'N Latitude 26 ° 63'L Longitude. The Faculty of Architecture consists of five blocks as A, B, C, D, and E. Two of the selected studios are in B block and the other one is in A block. The bird eye view of A and B block are shown in the figure below with the color of blue.

Figure 3.1. Location of the A and B blocks in the Faculty of Architecture, IZTECH (Source: Google Maps).

The 3D views of A and B block are indicated in the figures below:

Figure 3.2. 3D view from the front side of the blocks (Research highlights, 2012).

Figure 3.3. 3D view from the back side of the blocks (Source: Mapio.net).

3.1.1. Physical Attributes

The selected studios are A206, B207 and B208. A206 is in A block and B207 and B208 are in B block. The orientation and size of the studios differ. All these studios are on the second floor. The size of A206 is 12m x 12.1m. It has eastern (main façade) and northern façades. It has three windows whose sizes are 2m x 2m on east façade and one 2m x 2m and one 0.8m x 2.5m on north façade. East façade has sea view and north façade faces rest of the field. It has no obstacle at both facades. B207 and B208 are next to each other and they are similar in terms of room size. They have 11.9m x 17.8m room size. While B207 has western (main façade) and southern facades, B208 has eastern (main façade) and southern facades. B207 has three windows on west façade and one window at south façade whose sizes are 2m x 2m. B208 has three windows on east façade and two windows on south façade with the size of 2m x 2m. B207 has mountain view from both facades; on the other hand, B208 has sea view from east façade and mountain view from

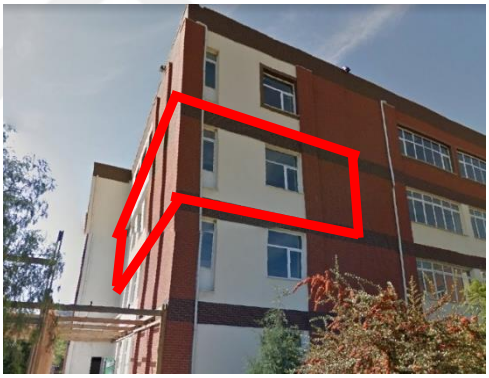
south façade. B207 has a tree obstacle at west side. B208, on the other hand, has no obstacle at both sides. When these three studios are compared, there are both common properties and discriminative properties. In the table below, the commonalities and differences between the studios are shown.

Table 3.1. A comparison of the physical attributes of the studios.

	Orientation	Room size	Main view
A206	East and North	12m x 12.1m	Sea
B208	East and South	11.9m x 17.8m	Sea
B207	West and South	11.9m x 17.8m	Mountain

As it is seen in the table above, B208 has common properties with B207 in terms of room size and orientation, and with A206 in terms of view and orientation. The location of the studios within the buildings are shown with the color of red in the figure below:

a) Studio B207 in B block (Source: Mapio.net)

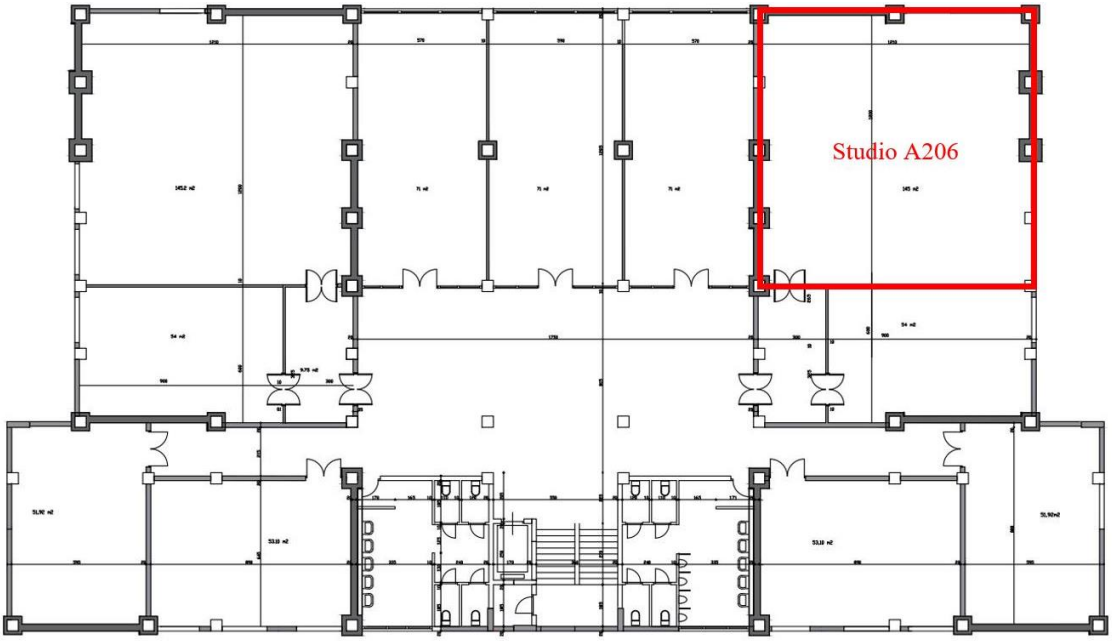


b) Studio A206 in A block (Source: Google Maps)

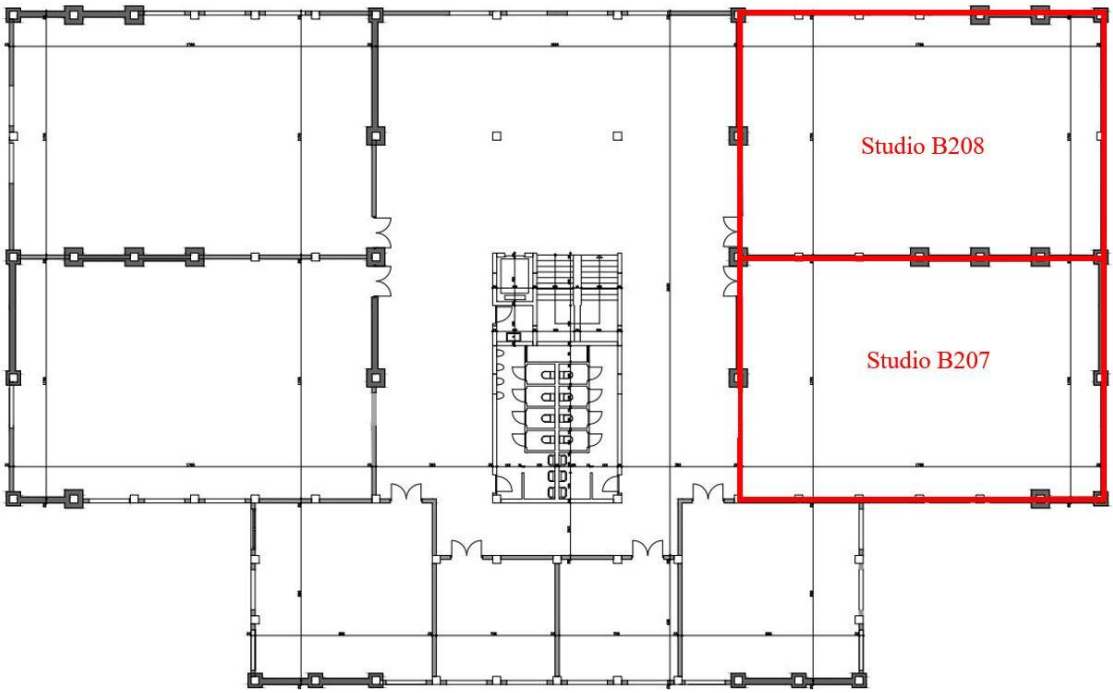
c) Studio B208 in B block (Research highlights, 2012)

Figure 3.4. The location of the studios within the buildings: *a) Studio B207 in B block, b) Studio A206 in A block, and c) Studio B208 in B block.*

The plan drawings of the second floors of A and B blocks are shown in the figure below and the location of the studios are indicated:



a) Studio A206 in A block.



b) Studio B207 and B208 in B block.

Figure 3.5. The location of studio A206, B207 and B208 inside the buildings: *a) Studio A206 in A block, b) Studio B207 and B208 in B block.*

3.1.2. Lighting Conditions

All three studios are lit by both daylight and artificial light. However, the direction and amount of daylight illuminance are different. Also, the amount of artificial light fixtures differs. Studio A206 takes daylight illuminance mainly from its eastern façade and secondly from northern façade. The type of artificial light sources is T12 surface-mounted fluorescent lamps. The lamps are placed symmetrically in a row (see Figures 3.6-3.8). Seven lamps are arranged on three horizontal main axes. In total, there are twenty-one lamps (see Figure 3.6). Daylight illuminance enters the space mainly through eastern façade and secondly from southern façade in studio B208, and in B207, it enters mainly through western façade instead of east. In both B208 and B207, there are thirty-five lamps-same type of lamps as in A206-which are lined up on five main axes, seven on each (see Figure 3.7 and Figure 3.8). The color temperature of these light sources is 5000 K. Artificial lighting is utilized as a general lighting system and the way of illumination is direct lighting. In the field observations, it is observed that the lamps frequently seize up. For instance, some lamps may not work sometimes, but from time to time they do.

In the figures below, plans and sections of the studios which indicate the arrangement of artificial light sources are shown:

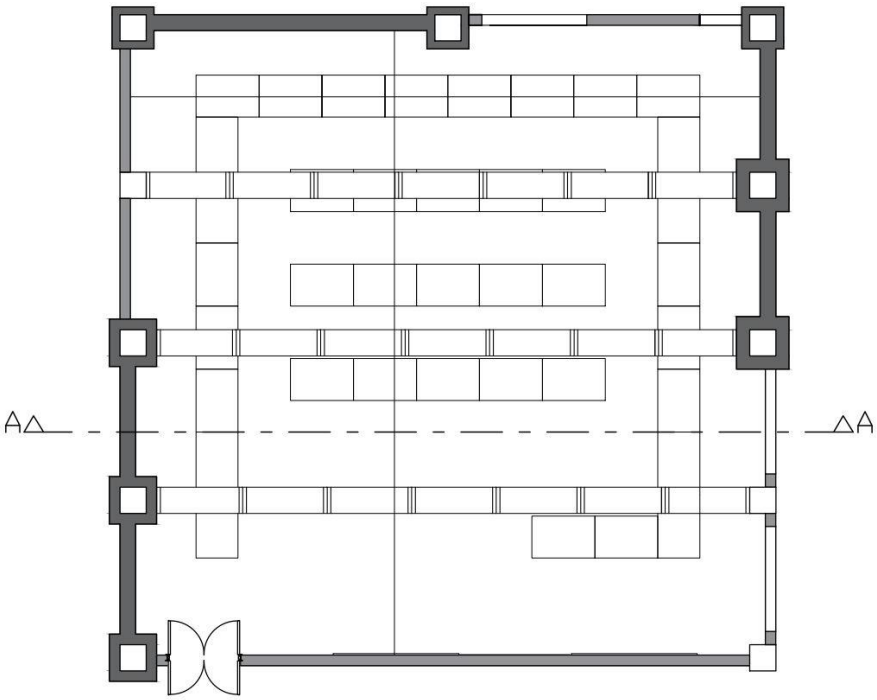


Figure 3.6. The plan of studio A206.

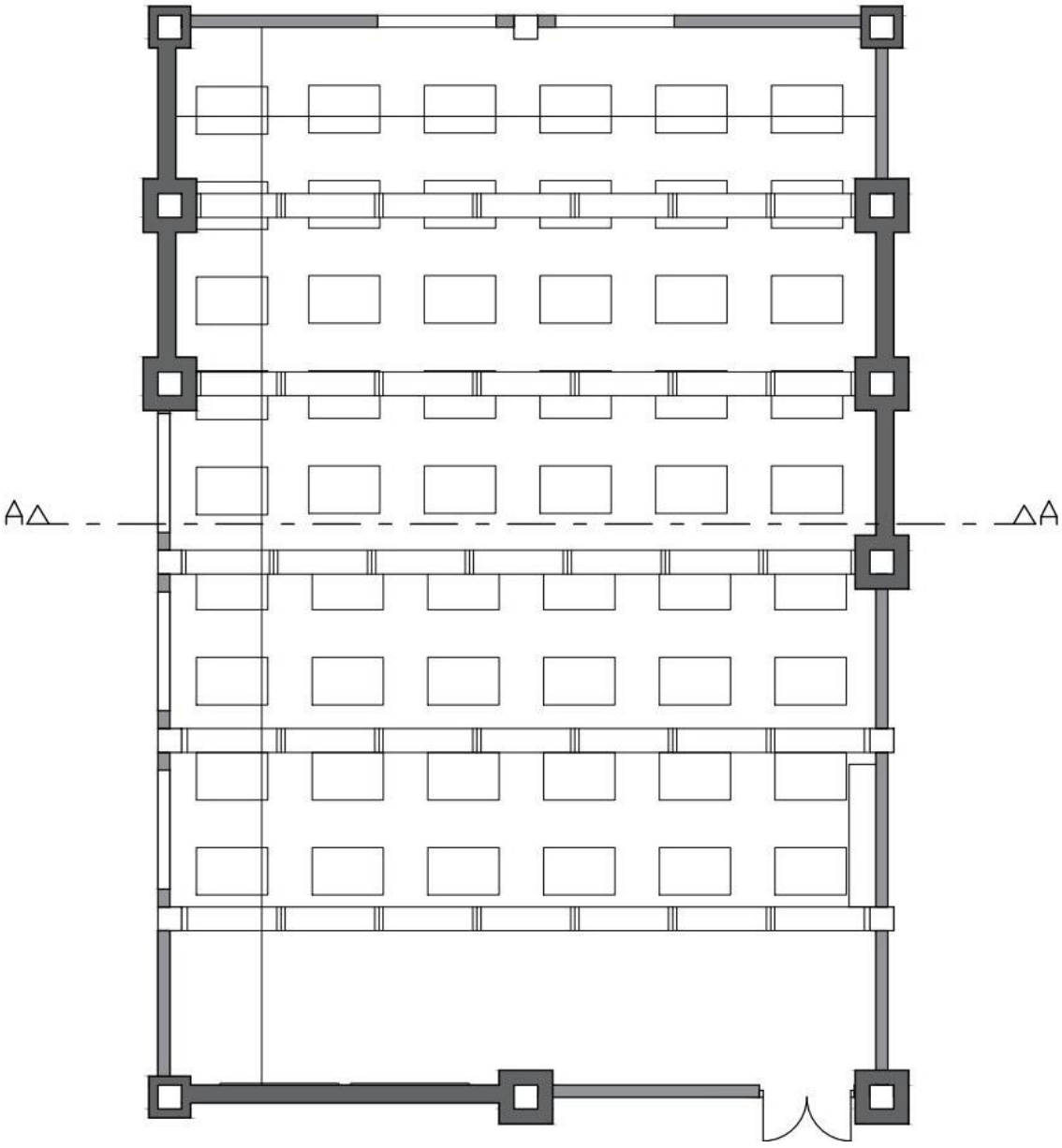


Figure 3.7. The plan of studio B208.

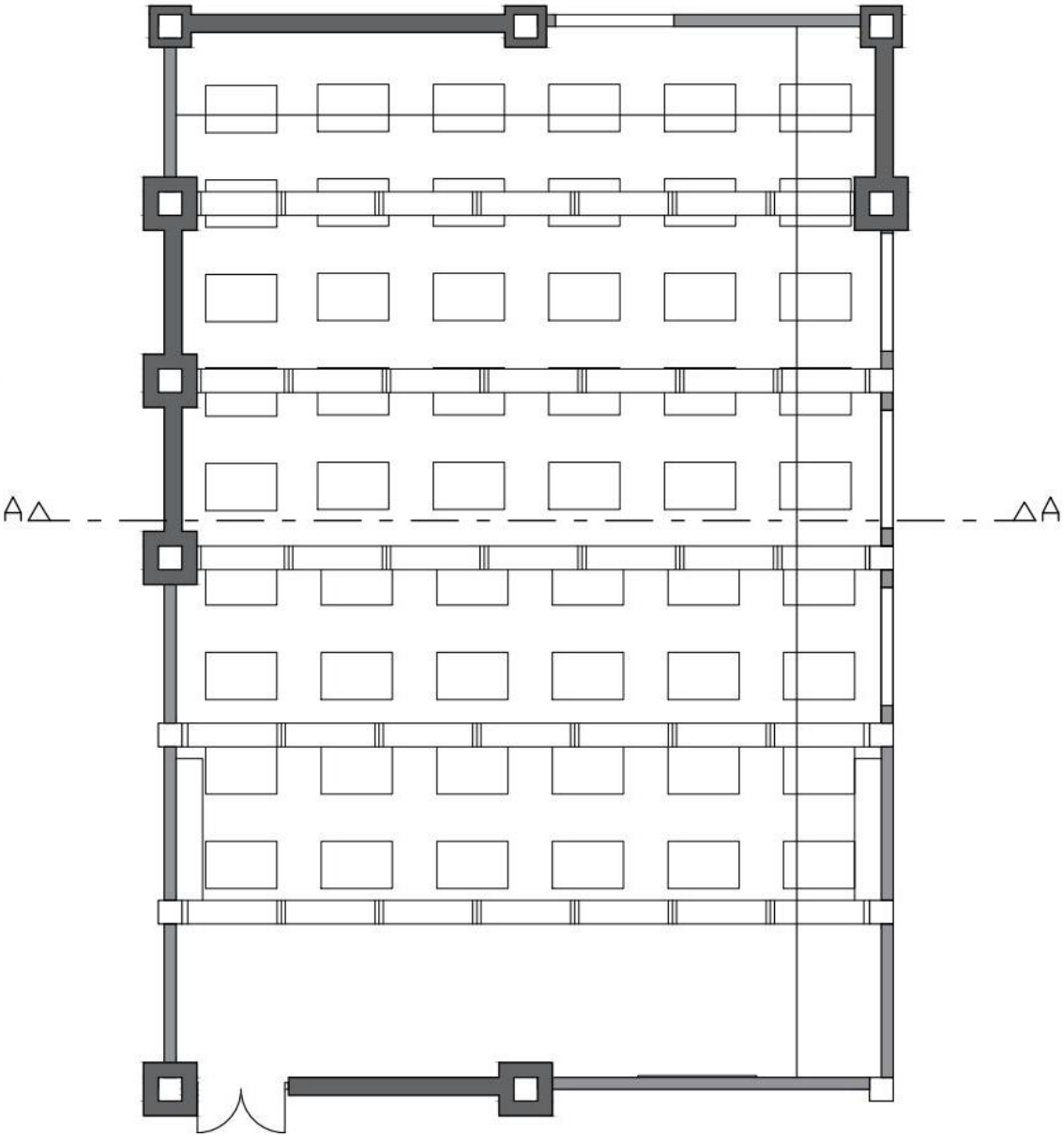


Figure 3.8. The plan of studio B207.

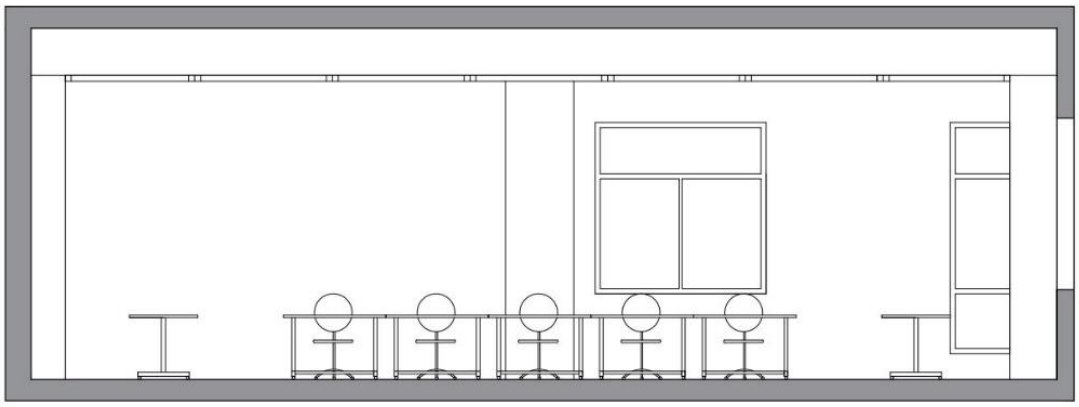


Figure 3.9. Section A of studio A206.

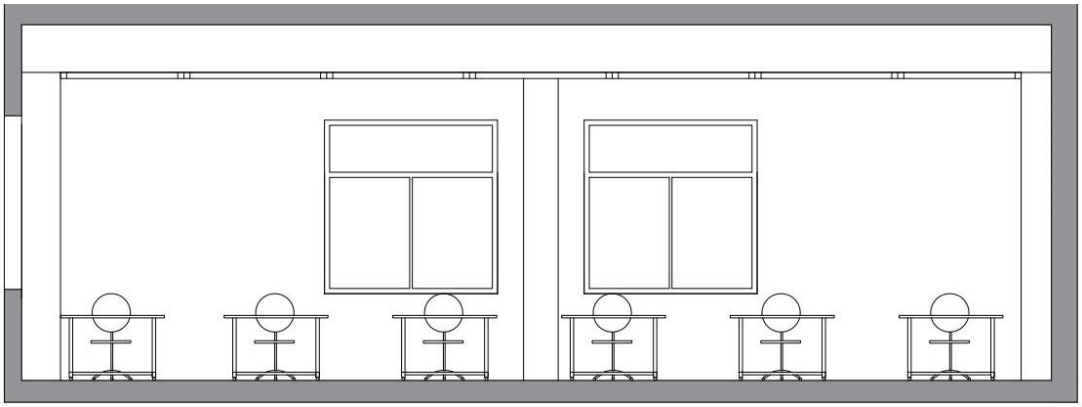


Figure 3.10. Section A of studio B208.

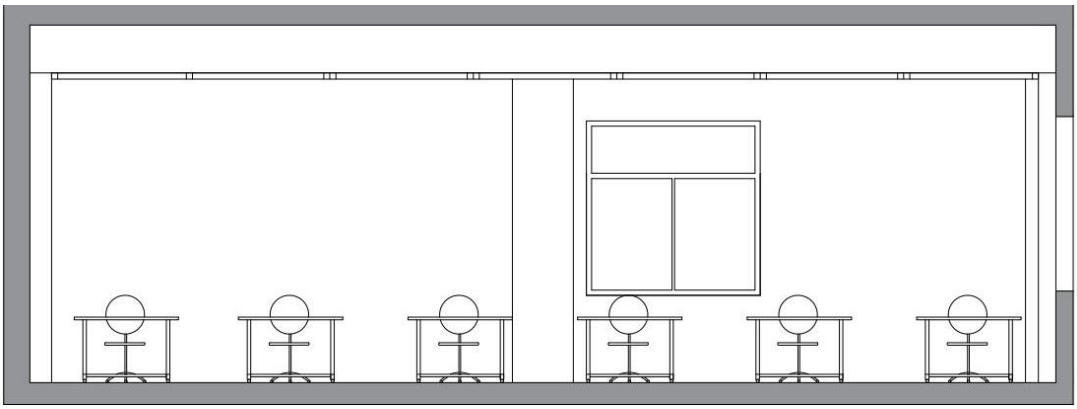


Figure 3.11. Section A of studio B207.

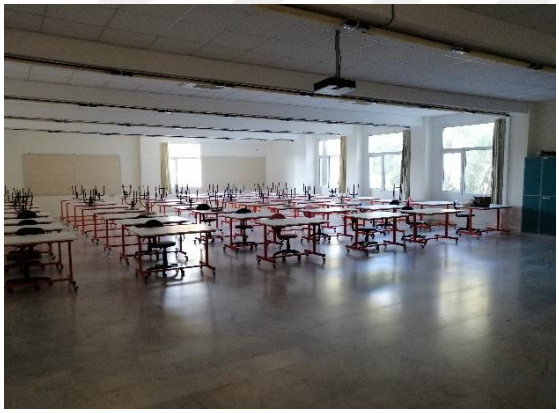
The interior views of the studios are shown in the figure below. The photos were taken in two conditions; 1) the curtains were open, and the lamps were switched off to observe daylight illuminance only, and 2) curtains were open and lamps were switched on to observe general illumination level inside the studios.

a) A206 (only daylight)

b) A206 (with daylight and artificial light)

c) B208 (only daylight)

d) B208 (with daylight and artificial light)



e) B207 (only daylight)

f) B207 (with daylight and artificial light)

Figure 3.12. Interior views of studio *a) A206 (only daylight), b) A206 (with daylight and artificial light), c) B208 (only daylight), d) B208 (with daylight and artificial light), e) B207 (only daylight), and f) B207 (with daylight and artificial light)* (Photograph by Merve Durgut).

3.1.3. User Profile

Information about users were obtained via survey questions. The users of studio A206 are third-grade architecture students. The class size is 39. Among these students, 10 of them responded to survey questions which is 25.64% of the class size. 60% of the responders is female and 40% is male. The average age is 22 years old. 60% of them spend more than 16 hours and 40% spend 12-16 hours per week in this studio. The users of studio B208 and B207 are second-grade architecture students. The total class size is 54 students; however, the students are distributed to studio B208 and B207. In B208, there are 36 students and in B207 there are 18 students. Among 36 students in B208, 22 of them responded to survey questions which corresponds to 61% of the studio. 68% of the responders is female and 32% is male. The average age is 21 years old. 55% of them spend more than 16 hours, 41% spend 12-16 hours, and 4% spend 12 hours per week in this studio. In studio B207, among 18 students, 13 of them responded to survey questions which corresponds to 72% of the studio. 54% of the responders is male and 46% is female. The average age is 21 years old. 69% of them spend more than 16 hours, 23% spend 12-16 hours, and 8% spend 12 hours per week in this studio.

3.2. Methods

Field measurements and survey were utilized for the purpose of this study. The measurements show if the lighting conditions of studios match the standards and if they meet the visual comfort of the students. The survey helps investigate the effects of lighting conditions on visual comfort, satisfaction, and motivation levels of architecture students by examining the perception of users from their own perspective. The data results obtained from survey and field measurements were examined comparatively to understand how different lighting conditions affect the perception and feelings of the users.

3.2.1. Field Measurements

Field measurements were conducted to evaluate both daylight illuminance and general illumination levels inside the studios. The measurements were conducted in three

studios simultaneously on 5th of March at 11:00 am and 4:00 pm considering the school day hours. The sky was overcast at 11:00 am in the morning; later in the afternoon, it was partially cloudy at 4:00 pm. The morning hour of 11:00 am was selected to observe morning daylight and 4:00 pm was selected to observe afternoon daylight as it comes close to evening and end of the school day. The measurements were made in two conditions; 1) while the curtains were open and artificial light sources were off (to determine only daylight illumination level), 2) while the curtains were open and artificial light sources were on (to determine general illumination level).

In studio A206, 10 points were determined and in B208 and B207 20 points were determined as measurement points. Studio layout, seating arrangements, artificial light sources and window positions were determinant factors while deciding on measurement points. In studio A206, the students' seating was arranged as U-shape and in B208 and B207 the seating arrangement could vary in different days or hours during a day; however, generally a more regular order followed like a grid system. 10 points in A206 were determined in accordance with the U-shape seating arrangement and 20 points in B208 and B207 were determined according to a grid system that was created considering the lamps' position and studio layout. The illumination levels were measured with a light meter. By averaging the measured illumination levels at determined points, the average illumination levels were calculated in each studio.

The studios were divided into sections as A, B, C, D, and E according to the window positions and illumination levels. Section A refers to window side, section B is the center of the studio, section C is the wall side, section D is the back of the studio (wall side) and section E is the back of the studio (window side). In studio A206, the seating arrangement starts 1.8m far from the board, in B208 the distance between the seating and board is 3.5m and it is approximately 6m in studio B207. In studio B207, students' seating starts around 5m far from the board because the first window of the west façade is positioned on that point. Along 5m, there is no window, and the area is too dark. While calculating the average illumination levels of the sections, the points that remain within the seating area are considered. The average illumination levels of the sections were calculated by averaging the measured illumination levels at these points on each section.

The figures below show the sections and the measured illumination levels in each studio for the two conditions mentioned above to measure: 1) only daylight illumination levels, 2) general illumination levels which consist of daylight and artificial light.

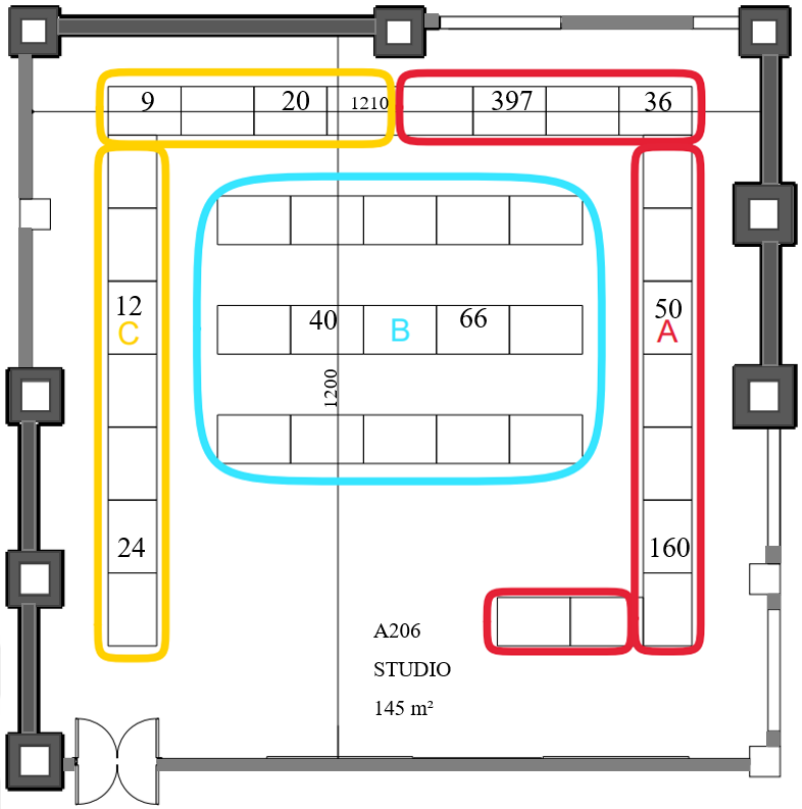


Figure 3.13.Daylight illumination levels at measured points in studio A206 at 11:00 am.

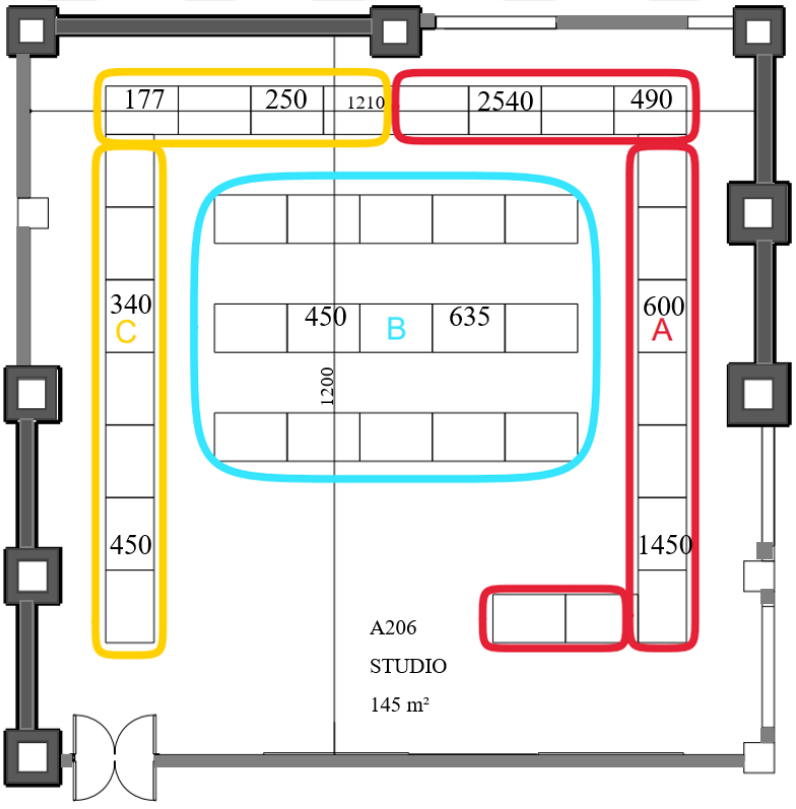


Figure 3.14. The general illumination levels at measured points in studio A206 at 11:00 am.

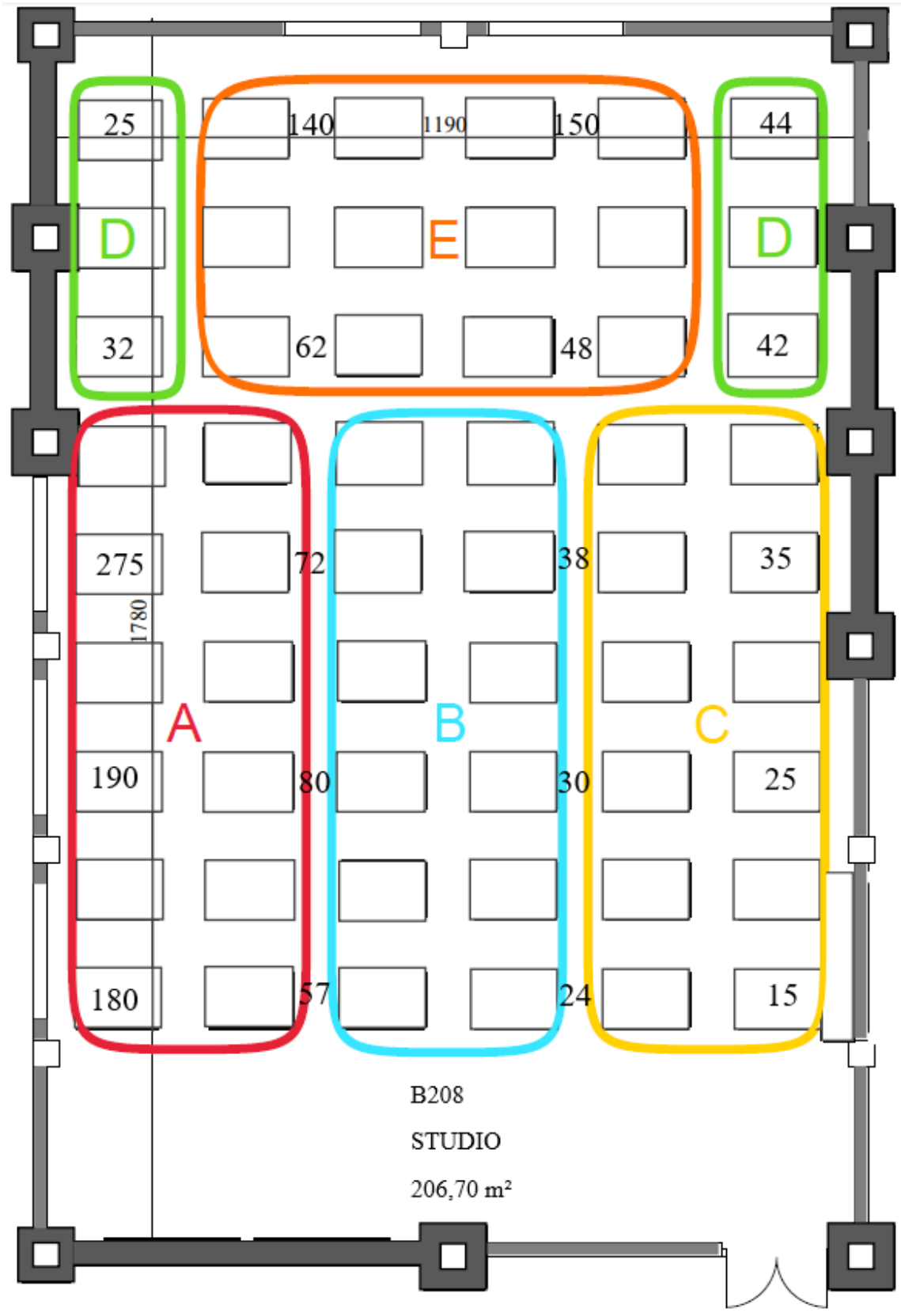


Figure 3.15. Daylight illumination levels at measured points in studio B208 at 11:00 am.

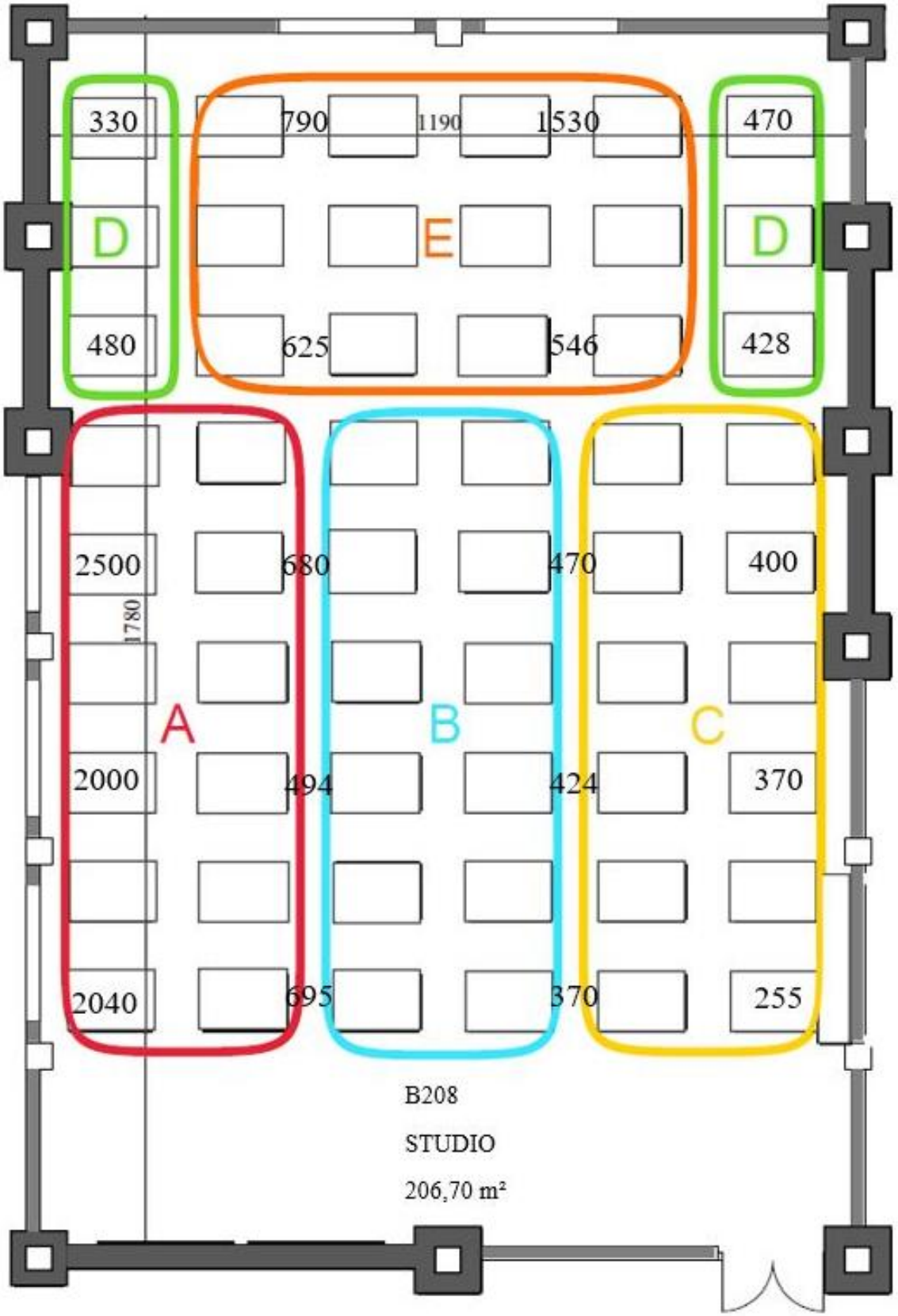


Figure 3.16. The general illumination levels at measured points in studio B208 at 11:00 am.

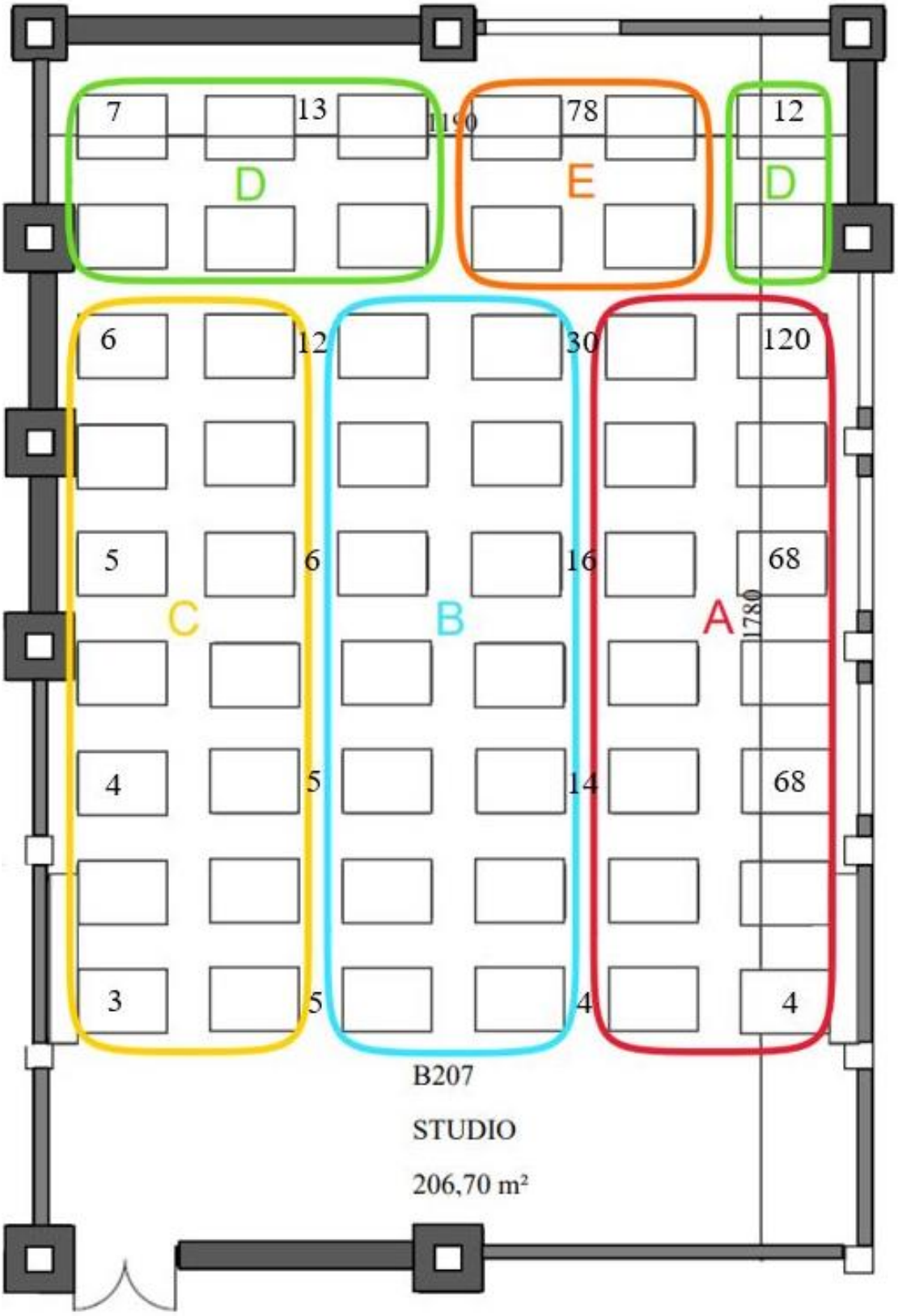


Figure 3.17. Daylight illumination levels at measured points in studio B207 at 11:00 am.

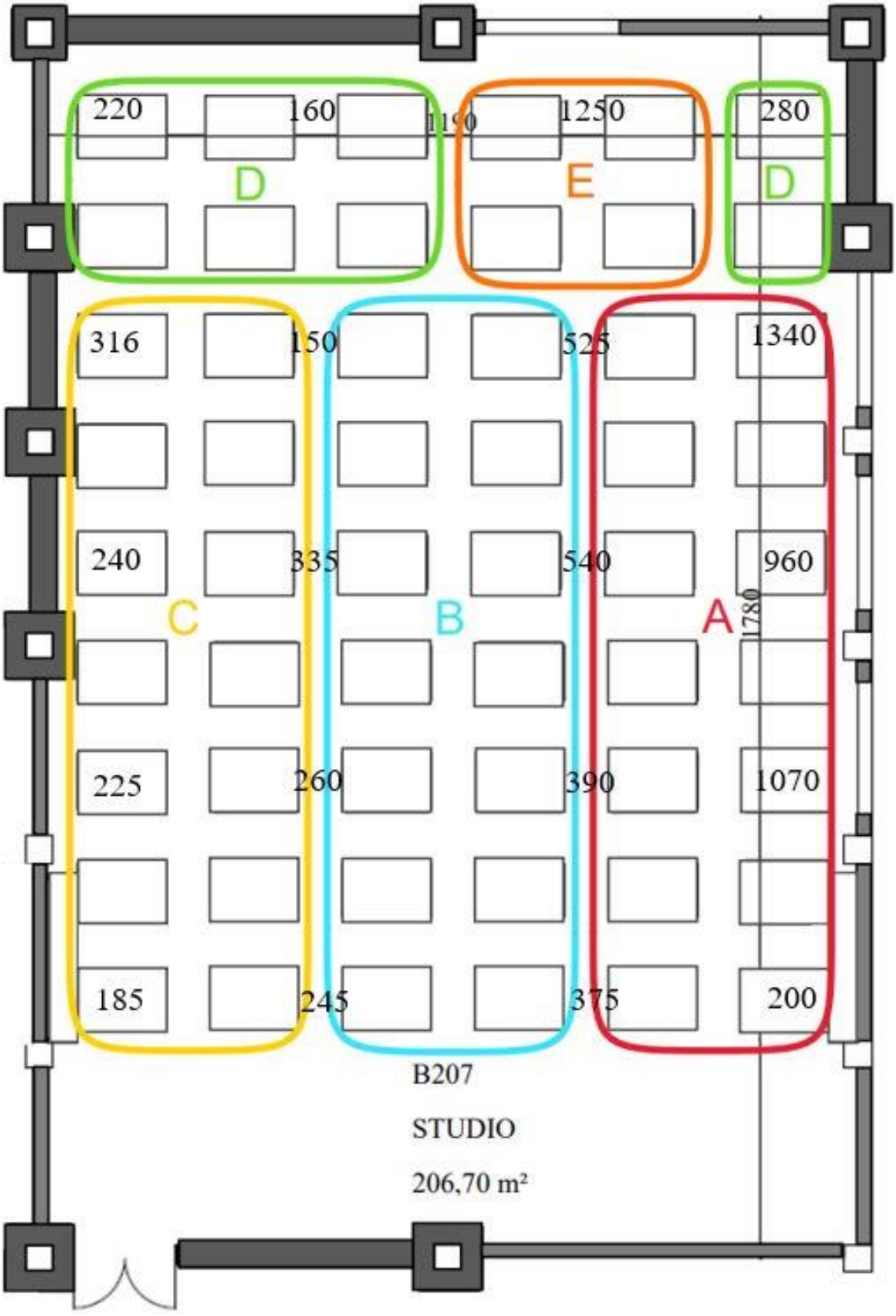


Figure 3.18. The general illumination levels at measured points in studio B207 at 11:00 am.

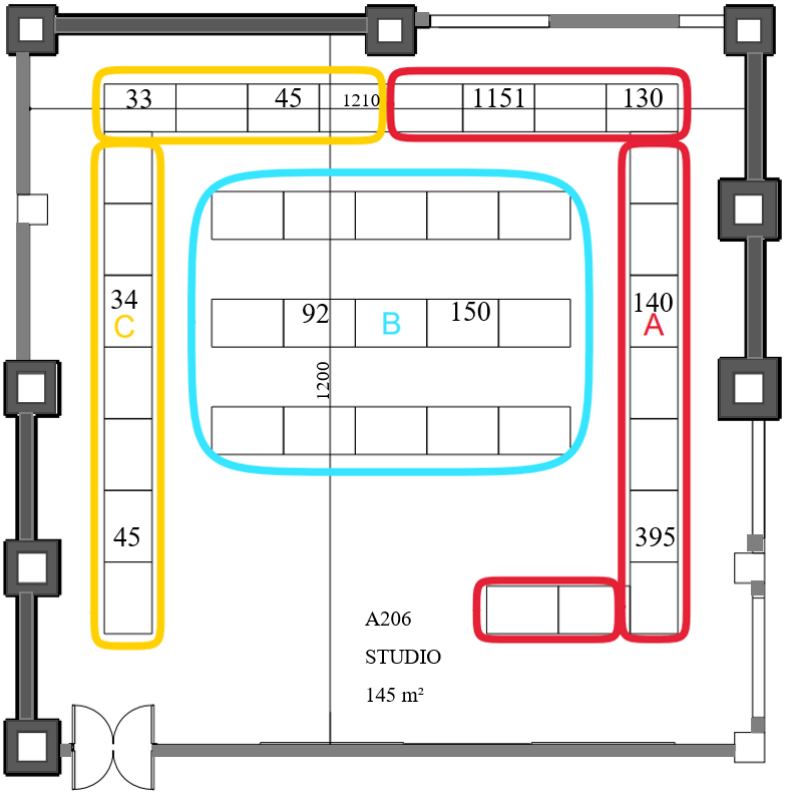


Figure 3.19. Daylight illumination levels at measured points in studio A206 at 4:00 pm.

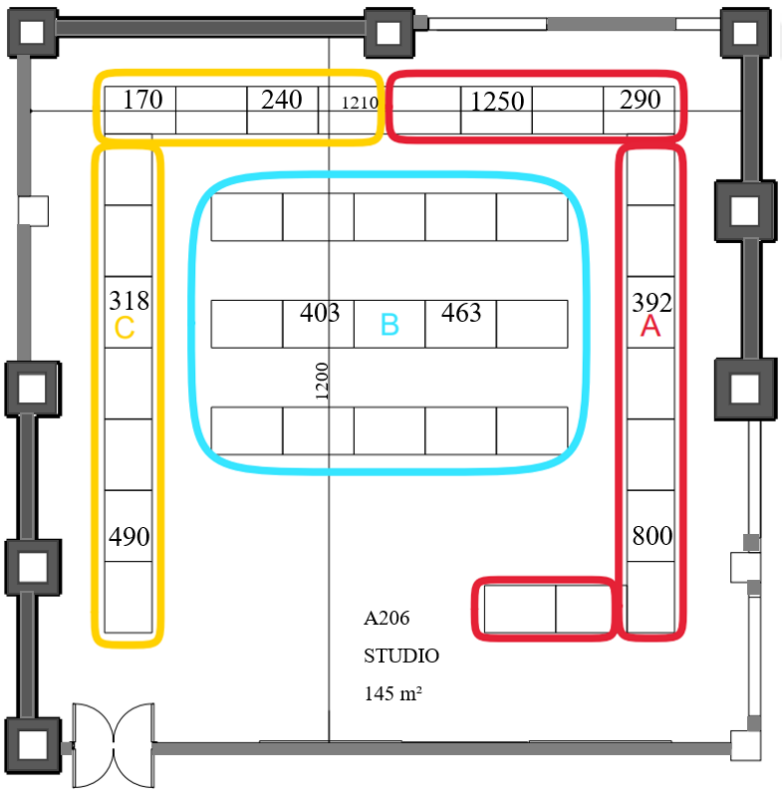


Figure 3.20. The general illumination levels at measured points in studio A206 at 4:00 pm.

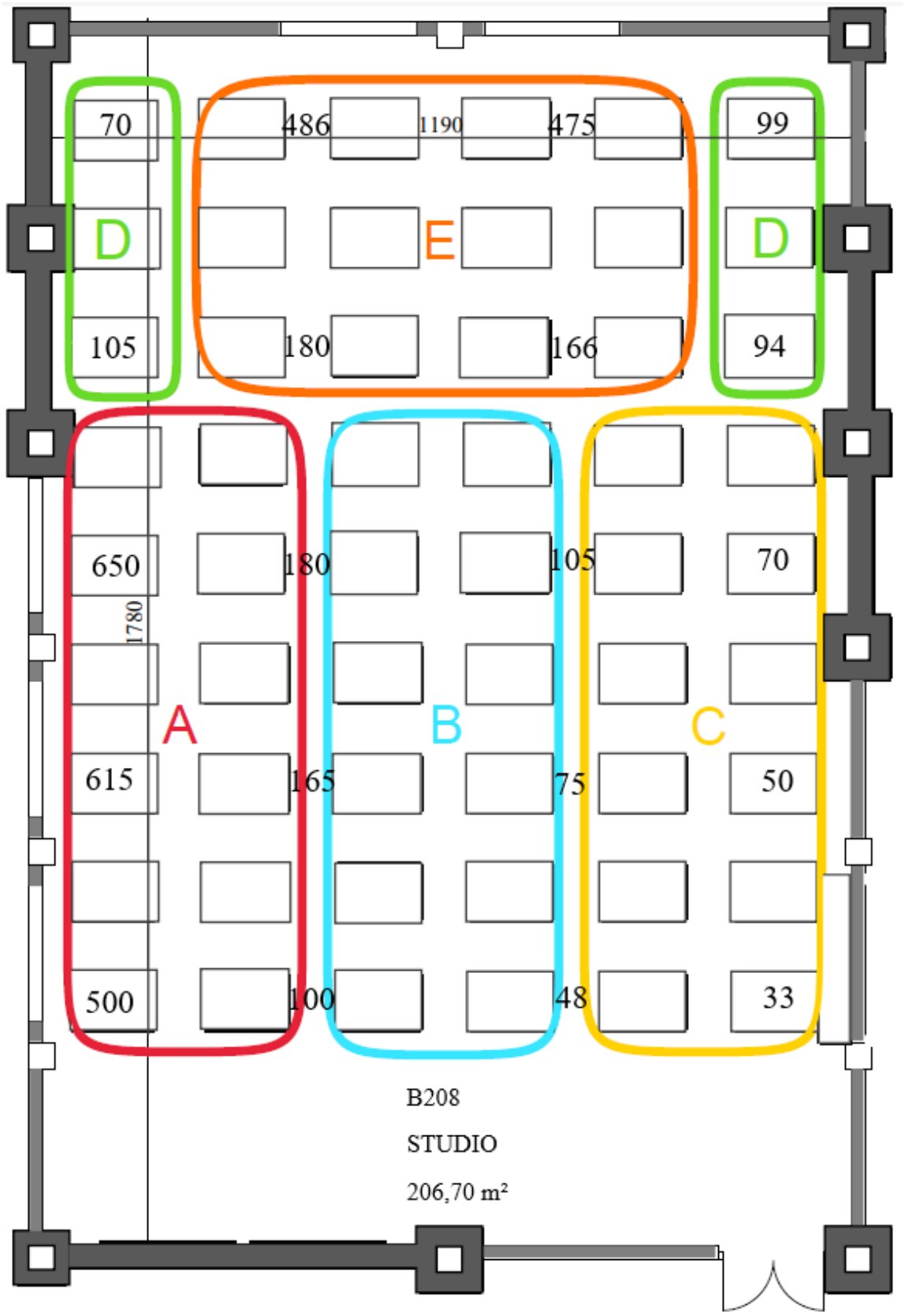


Figure 3.21. Daylight illumination levels at measured points in studio B208 at 4:00 pm.

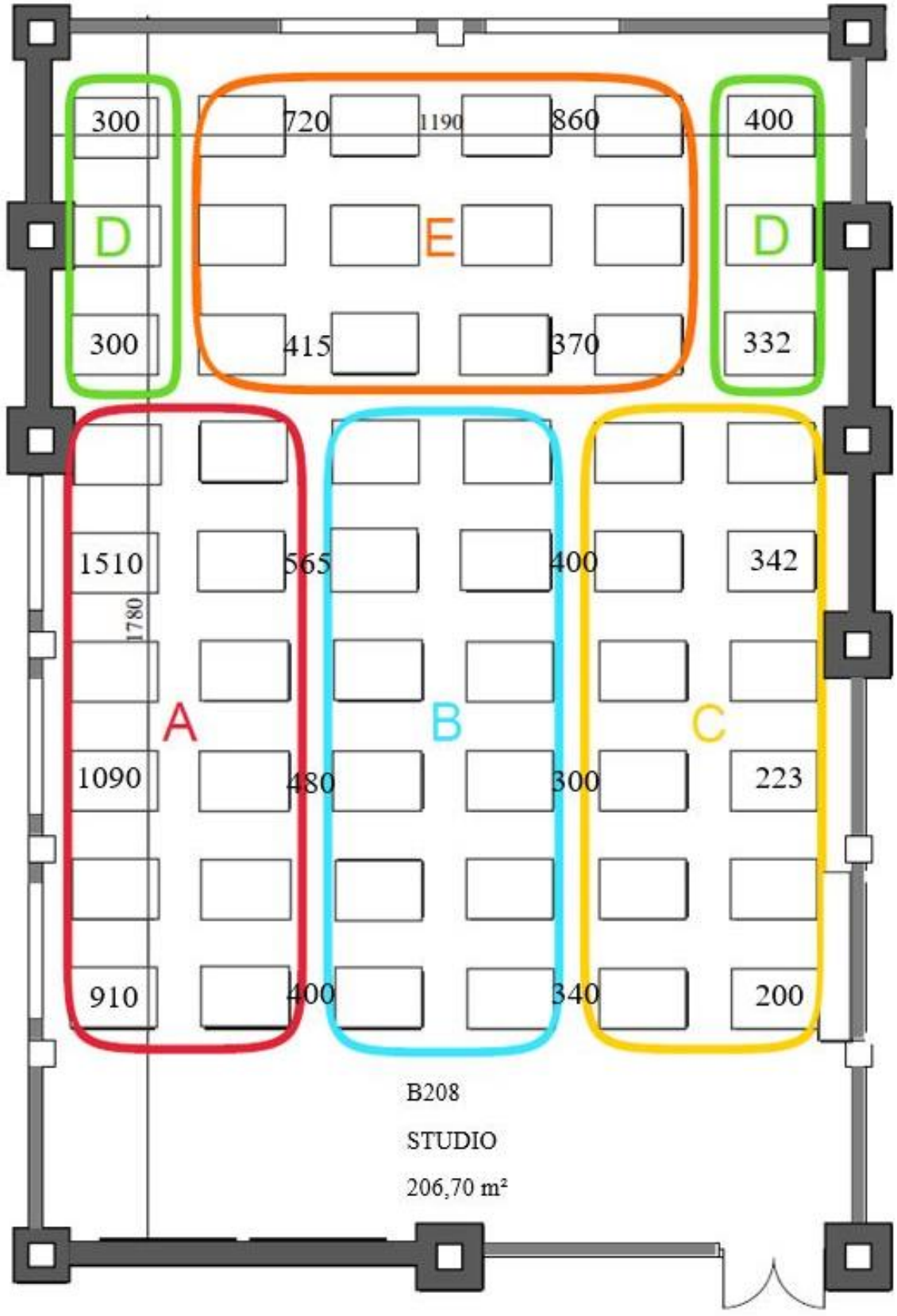


Figure 3.22. The general illumination levels at measured points in studio B208 at 4:00 pm.

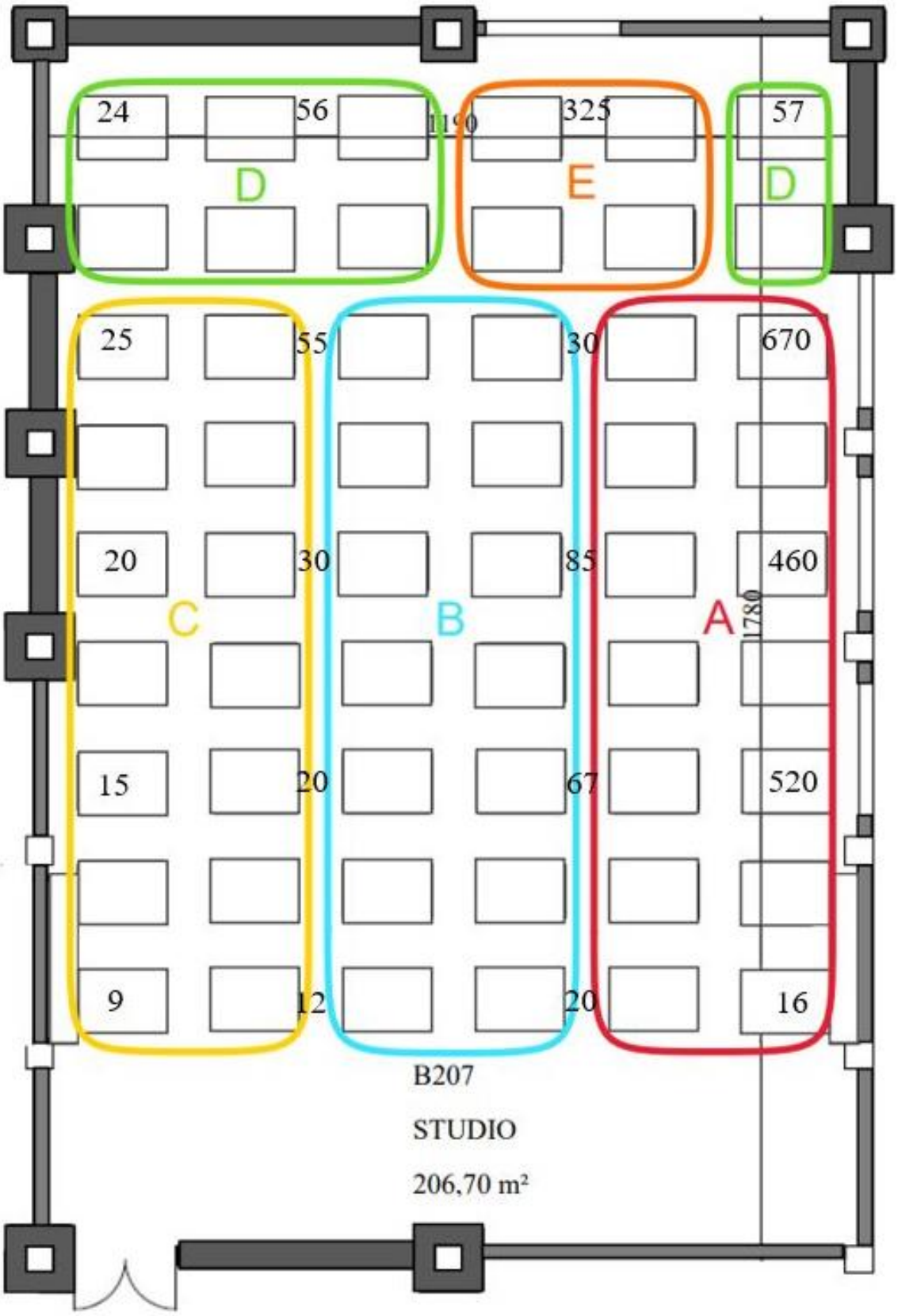


Figure 3.23. Daylight illumination levels at measured points in studio B207 at 4:00 pm.

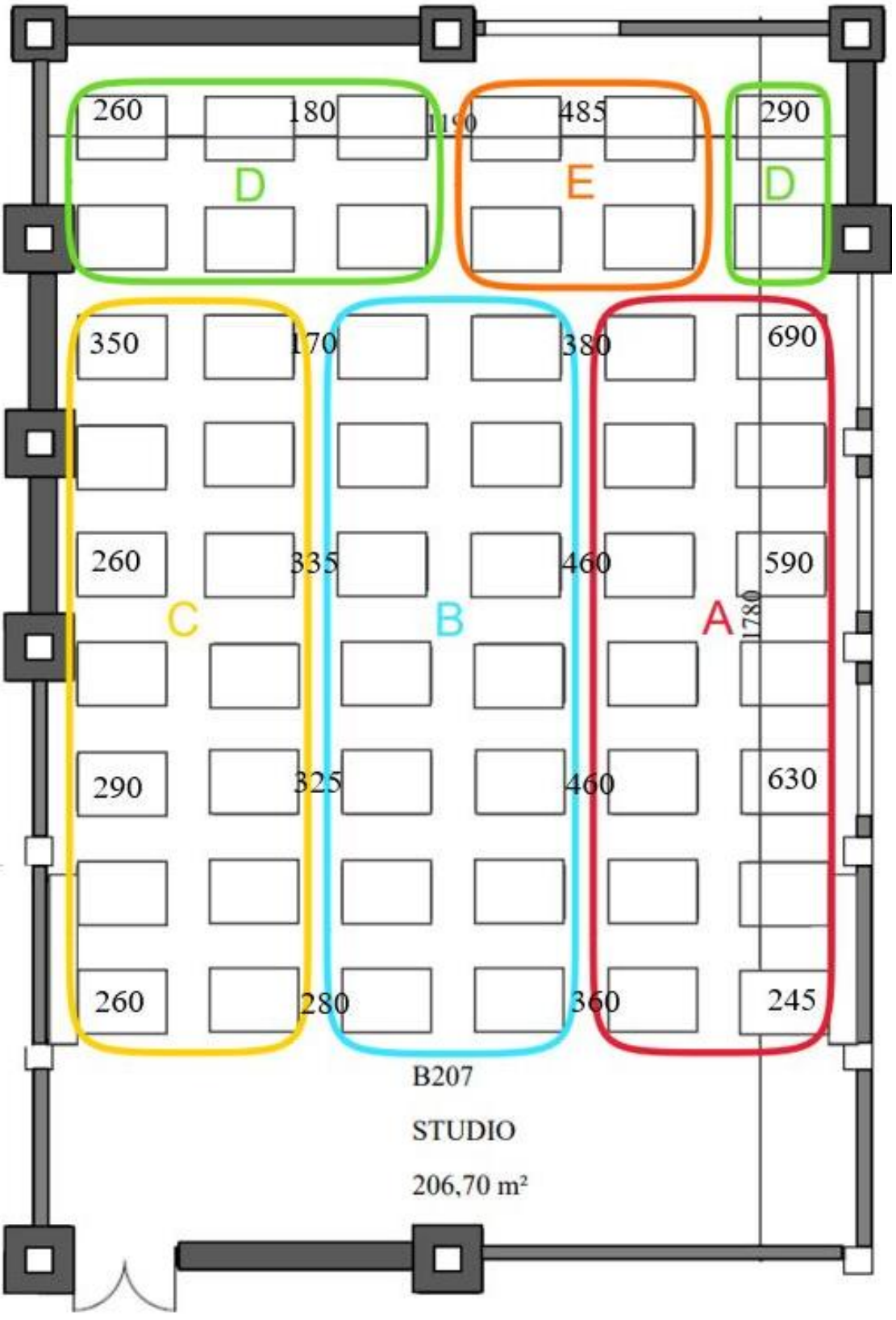


Figure 3.24. The general illumination levels at measured points in studio B207 at 4:00 pm.

3.2.2. Survey Design

A multiple-sectioned survey was prepared based on the objectives of the study as well as the literature regarding the effects of lighting conditions on visual comfort, satisfaction, and motivation levels. Various types of questions were included in the survey such as yes-no questions, multiple choice questions, Likert-scale, matrix questions, and fill-in-the-blank questions. The survey was administered to the students of three studios. It was prepared and applied via Surveey which is an online survey system in which you can create surveys and publish through links or codes. In the present study, after the questions were prepared on this system, the links of surveys were sent to students via email. In A206 10, in B207 13, and in B208 22 students responded to the survey. In total, 45 students in all three studios participated in the survey. The students were separated into groups based upon their seating arrangement according to the section they generally sit; A (window side), B (center of the studio), C (wall side), D (back of the studio [wall side]) and E (back of the studio [window side]). 6 people from section A, 1 person from section B, and 3 people from section C responded to survey questions in studio A206. 5 people from section A, 3 people from section B, 8 people from section C,4 people from section D and 2 people from section E participated in the survey in studio B208. 4 people from section A, 1 person from section B, 1 person from section C, 3 people from section D and 4 people from section E responded to survey questions in studio B207. At the beginning of the survey, participants were informed about the objectives of the study. The participants were requested to answer the survey questions according to the section they generally sit. For this purpose, plan schemes of their studios were given to them in the first question and they were asked select the section they usually sit and answer the remaining survey questions according to their section. That is why, each studio has its own survey as their plan schemes are different. Except for the first question, the remaining questions are the same. Many of the questions were obligatory, thus the participants could not move onto the question without answering the previous one.

The structure of the survey is composed of four sections; 1) Section A: Lighting Conditions, 2) Section B: Visual Comfort and Satisfaction, 3) Section C: Motivation Level, and 4) Section D: Personal Information. In section A, the aim was to obtain data related to the perception of the users regarding lighting conditions in their own studio

environments. In section B, the purpose was to obtain data regarding the visual comfort and satisfaction of the students within these lighting conditions. In section C, it was aimed to collect data about how these lighting conditions affect students' motivation levels. In section D, personal information regarding age, gender, and how many hours they spend in their studios were asked. Except the first question that the seating section was asked, there are 5 main questions and 2 sub-questions in section A, 4 main questions and 1 sub-question in section B, 4 questions in section C, and 3 questions in section D. In total, there are 17 main questions and 3 sub-questions.

The questions were directed to evaluate both the lighting conditions in their studios generally and in their study areas specifically. They were requested not only to evaluate the current lighting conditions they have in their studios, but also to indicate the importance of lighting conditions for themselves in terms of their visual comfort, satisfaction, and motivation levels.

In the process of analyzing the data obtained from survey questions, Surveey system and Excel software were used. Surveey system enables users to both prepare survey questions online and view the results, and also to export the data to analysis software programs. Thus, the data obtained from Surveey system was exported to Excel. For data analysis, arithmetic mean and percentage were used to represent statistics and graphics were prepared in Excel for the presentation of data results.

CHAPTER 4

FINDINGS

In this section, data obtained from survey and measurements will be analyzed and explained. A survey was administered to the students in three studios. In A206, ten students responded to the survey, in B207 thirteen, and in B208 twenty-two. The survey is composed of four sections including perceptions of lighting conditions, visual comfort and satisfaction, and motivation levels, and personal information.

The students were separated into groups based upon their seating arrangement; A (window side), B (center of the studio), C (wall side), D (back of the studio [wall side]) and E (back of the studio [window side]). There are 6 people in section A,1 person in section B and 3 people in section C in studio A206. There are 5 people in section A, 3 people in section B, 8 people in section C,4 people in section D and 2 people in section E in studio B208. There are 4 people in section A, 1 person in section B, 1 person in section C, 3 people in section D and 4 people in section E in studio B207. The participants were requested to answer the survey questions according to the section they generally sit as shown in Figures 3.5.-3.16. The measurements were made in three studios simultaneously on the 5th of March at 11:00 am and 4:00 pm. The sky was overcast at 11:00 am and partially cloudy at 4:00 pm. Measurements were conducted to evaluate the level of daylight illumination inside the studio as well as the level of general lighting illumination. Thus, the measurements were made in two conditions; 1) while the curtains are open and artificial light sources are off, 2) while the curtains are open and artificial light sources are on (see Figure 3.4.).

For data analysis, arithmetic mean and percentage were used to represent statistics. Surveey system and Excel were used for analysis.

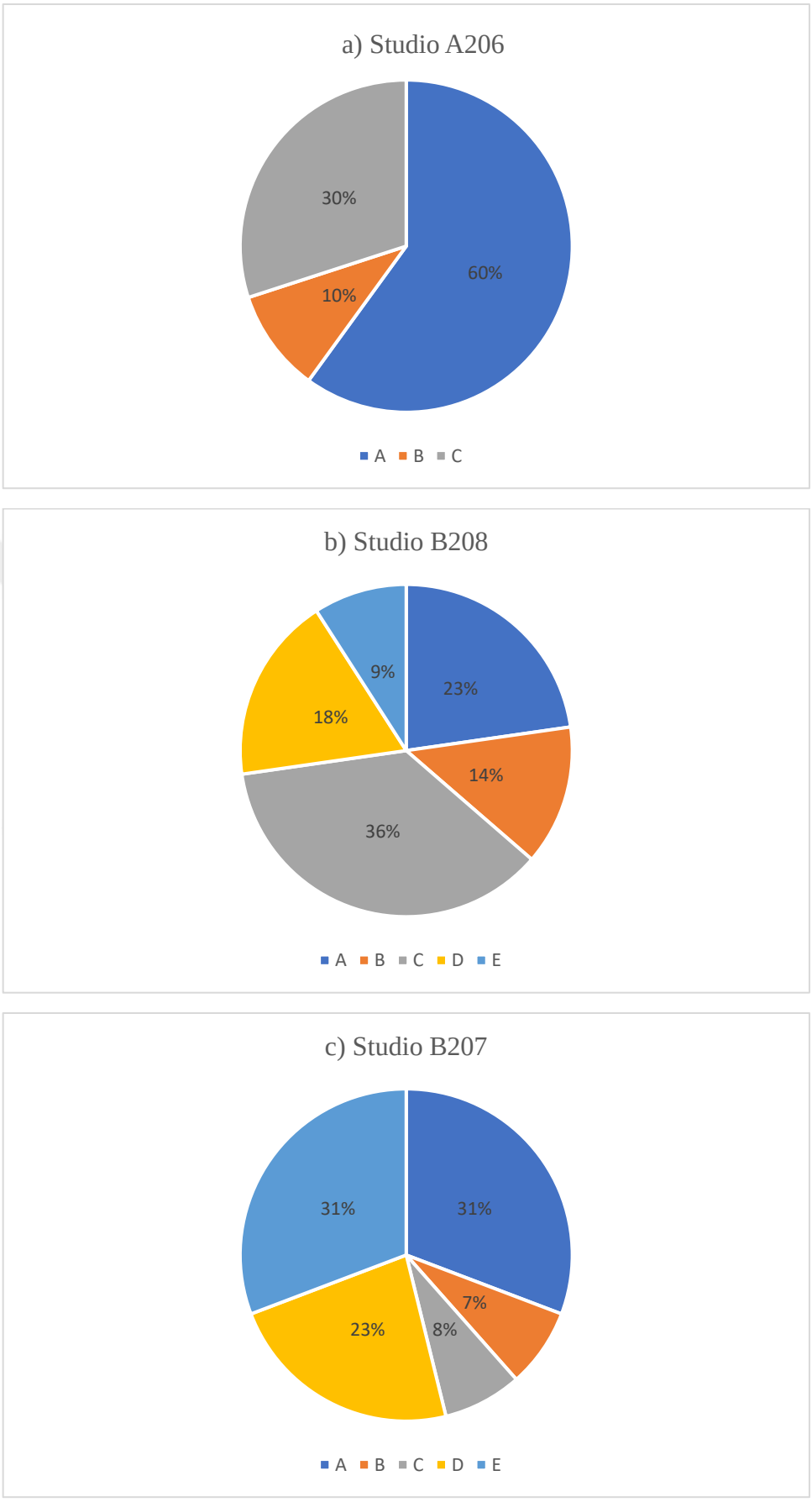


Figure 4.1. Ratio of the groups in studio a) A206, b) B208, c) B207.

In studio A206, 60% of the participants is in group A (window side), 10% of them is in group B (center of the studio) and 30% of them is in group C (wall side). The number of the students is higher in group A, so it will be the dominant group in terms of the answers given to the general questions.

In studio B208, 23% of the participants is in group A (window side), 14% of them is in group B (center of the studio), 36% is in group C (wall side), 18% is in group D (back of the studio [wall side]) and 9% of them is in group E (back of the studio [window side]). Since the number of the participants is higher in group C, it will be the dominant group in terms of the answers given to the general questions.

In studio B207, 31% of the participants is in group A (window side), 7% of them is in group B (center of the studio), 8% is in group C (wall side), 23% is in group D (back of the studio [wall side]) and 31% of them is in group E (back of the studio [window side]). Since the number of the students is higher in group A and E, they will be the dominant groups in terms of the answers given to the general questions.

4.1. Section A: Lighting Conditions

Part A of the survey included 5 question items regarding the general lighting conditions in the studios. This section will present participants' responses to each survey item along with explanations.

4.1.1. Survey Item 1: General lighting conditions in the studios

Q1: *"1) Do you think the general lighting in the studio is sufficient? If not, what do you think is the reason behind it?"*

The first question of section A of the survey is aimed at exploring participants' perceptions regarding the general lighting conditions in the studios, whether they find it sufficient or insufficient. First, the measurement results for each studio will be presented followed by an explanation of the responses to this particular question.

4.1.1.1. Studio A206-Measurement and Survey results

Illumination levels of daylight and general lighting were measured on March 5 at 11:00 am and 4:00 pm in 10 points of the studio. Table 4.1. indicates the measurement results.

Table 4.1. Illumination levels of daylight and general lighting.

Hour	Illumination level of daylight	Illumination level of general lighting
11:00	81 lx	738 lx
16:00	222 lx	482 lx

According to the measurements, the illumination level of the studio in general is 738 lx at 11:00 am and 482 lx at 4:00 pm. Considering the standards-which is 500-750 lx for the studios (CIBSE, 1994)- it is quite acceptable for an architectural design studio. However, while 90% of the students in A206 indicated that the general lighting of the studio is not sufficient, 10% find the lighting conditions as sufficient. Most of the participants are in group A in this studio. Considering the fact that group A faces the rest of the class like group B and C it is possible that they perceive less illumination. Thus, they might be affected by the luminous environment of the rest of the class.

Table 4.2. Illumination levels of daylight and general lighting by groups.

	Section	Illumination level of daylight	Illumination level of general lighting
11.00	A	**161 lx**	**1270 lx**
	B	**53lx**	**543 lx**
	C	**16lx**	**289 lx**
16.00	A	**454 lx**	**683 lx**
	B	**121 lx**	**433 lx**
	C	**39 lx**	**305 lx**

As Table 4.2. shows, in group A, the average illumination level is 1270 lx at 11:00 am and 683 lx at 4:00 pm, while in group B it is 543 lx at 11:00 am and 433 lx at 4:00 pm and in group C it decreases to 289 lx at 11:00 am and to 305 lx at 4:00 pm which is very low considering the international standards.

Survey Item 1: "1) Do you think the general lighting in the studio is sufficient? If not, what do you think is the reason behind it?"

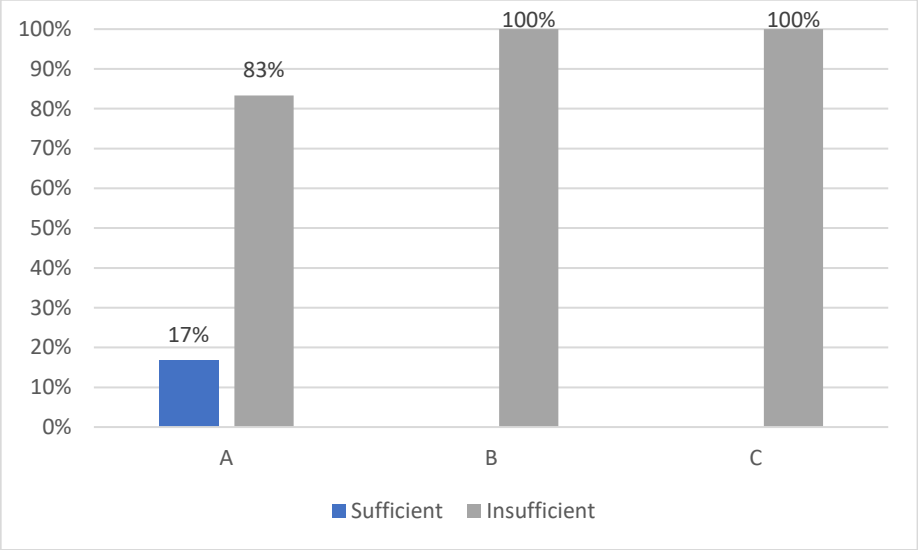


Figure 4.2. Perceptions regarding general lighting conditions in A206 by groups.

As Figure 4.2. shows, 83% of the participants in group A and 100% in group B and C find the lighting in the studio insufficient, while 17% of group A find the lighting sufficient.

In the second part of this question, the participants were given four options such as "the amount of light sources", "the type of light resources", "insufficient daylight" and "other (please explain) and asked to indicate their reason for the insufficiency of lighting. According to the results, 78% of the participants stated that insufficient daylight is the reason behind it, while 33% indicated that the reason behind insufficient lighting in the studio is the type of the light sources. The illumination level of daylight inside the studio is 81 lx at 11:00 am and 222 lx at 4:00 pm. As it is seen, daylight illumination level is quite low in the studio. It is clear that, even in some sections, lighting meets the standards, but students do not perceive it as enough because of the lack of daylight. That is why most of the students indicated that the insufficient daylight as the primary reason behind the insufficient lighting.

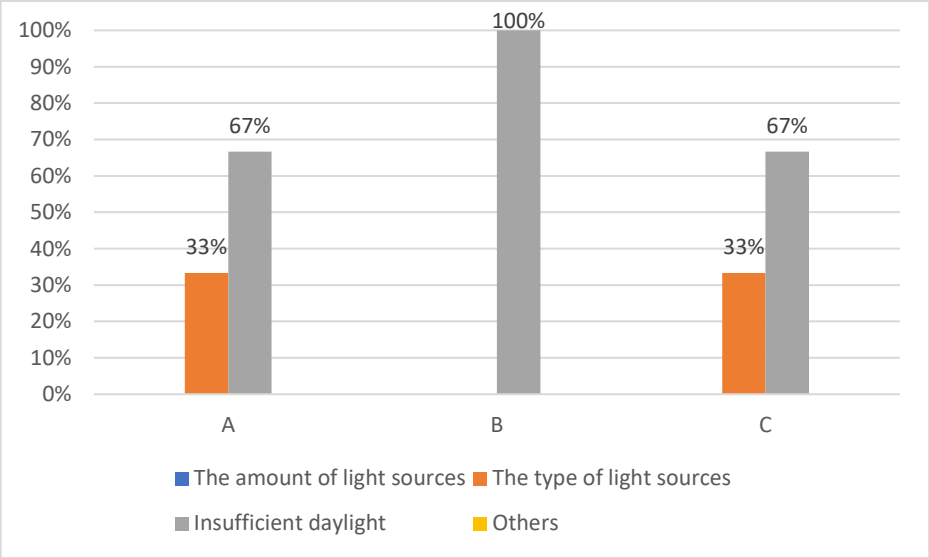


Figure 4.3. The evaluation of the reasons behind insufficient lighting in studio A206.

The 67% of group A, indicated that the reason behind insufficient lighting is insufficient daylight while 33% stated that the reason is the type of light sources. The 100% of group B, indicated that the reason behind insufficient lighting is insufficient daylight. In group C, 67% of the students indicated that the reason behind insufficient lighting is insufficient daylight while 33% of the students indicated that it is because of the type of the light sources.

In section A, the daylight illumination level is 161 lx at 11:00 am and 454 lx at 4:00 pm. In section B, the daylight illumination level is 53 lx at 11:00 am and 121 lx at 4:00 pm. In section C, the daylight illumination level is 16 lx at 11:00 am and 39 lx at 4:00 pm. For both measurements in all sections, they are under the standards.

Even though the general lighting inside the studio meets the standards, almost all the students indicated that the lighting is not sufficient inside the studio. They stated insufficient daylight as the primary reason behind it. Considering the measurements, the average daylight illumination inside the studio is 81 lx at 11:00 am and 222 lx at 4:00 pm. In both measurements, it is very low and can not meet the standard illumination level without the help of artificial lighting.

4.1.1.2. Studio B208-Measurement and Survey results

Illumination levels of daylight and general lighting were measured on March 5 at 11:00 am and 4:00 pm in 20 points of the studio. Table 4.3. indicates the measurement results.

Table 4.3. Illumination levels of daylight and general lighting.

Hour	Illumination level of daylight	Illumination level of general lighting
11:00	78 lx	795 lx
16:00	213 lx	523 lx

According to the measurements, the illumination level of the studio in general is 795 lx at 11:00 am and 523 lx at 4:00 pm. According to the survey results, 59% of the students indicated that the general lighting of the studio is not sufficient, while 41% find the lighting sufficient. Considering the standards which is 500-750 lx for the studios (CIBSE, 1994), it meets the standards for an architectural design studio. However, more than half of the students find it insufficient. 36% of the participants are from group C and 18% of them are from group D which means 54% of the participants are from the sections that have less illumination inside the studio. This may cause an increase in percentage for the answer “insufficient”.

Table 4.4. Illumination levels of daylight and general lighting by sections.

	Section	Illumination level of daylight	Illumination level of general lighting
11.00	A	**142 lx**	**1402 lx**
	B	**50 lx**	**522 lx**
	C	**28 lx**	**382 lx**
	D	**36 lx**	**427 lx**
	E	**100 lx**	**873 lx**
16.00	A	**368 lx**	**826 lx**
	B	**112 lx**	**414 lx**
	C	**64 lx**	**301 lx**
	D	**92 lx**	**333 lx**
	E	**327 lx**	**591 lx**

According to Table 4.4., in section A, the average illumination level is 1402 lx at 11:00 am and 826 lx at 4:00 pm. In section B, it is 522 lx at 11:00 am and 414 lx at 4:00 pm. In section C, it is 382 lx at 11:00 am and 301 lx at 4:00 pm. In section D, it is 427 lx at 11:00 am and 333 lx at 4:00 pm and in section E, it is 873 lx at 11:00 am and 591 lx at 4:00 pm. Considering the daylight illuminance in all sections, section A has the highest daylight illuminance at 4:00 pm.

Survey Item 1: *"1) Do you think the general lighting in the studio is sufficient? If not, what do you think is the reason behind it?*

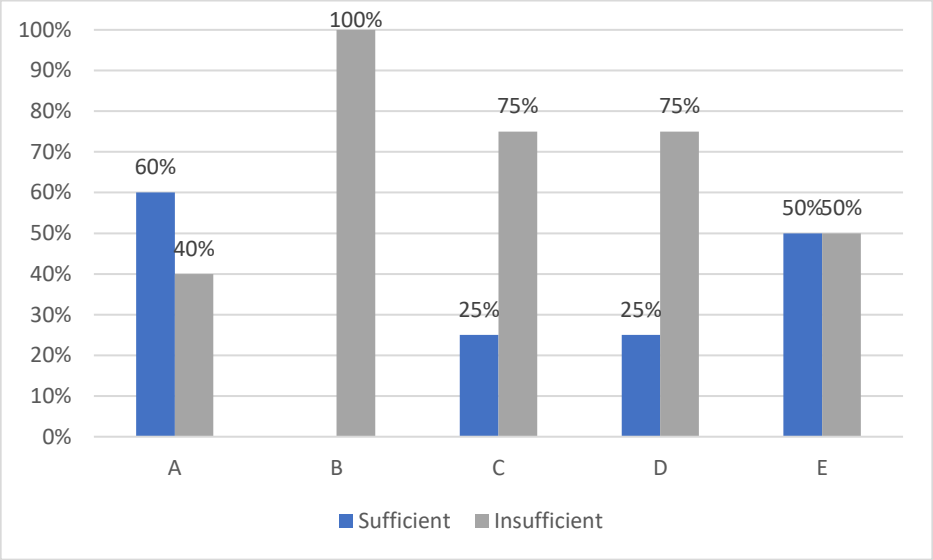


Figure 4.4. Perceptions regarding general lighting conditions in B208 by groups.

As parallel to the results of the measurements, 60% of group A found the lighting sufficient and 40% of them indicated as insufficient. 100% of group B indicated that it is insufficient. 75% of group C find it insufficient while 25% of them indicated as sufficient. 75% of group D indicated as insufficient as well while 25% find it sufficient. As for Group E, half of the students indicated that the lighting is sufficient while the other half found it insufficient.

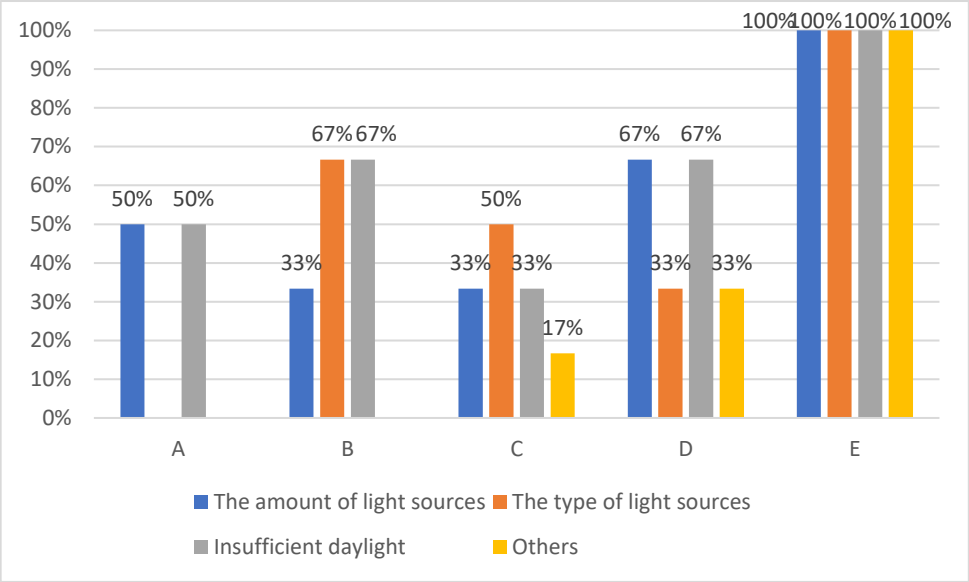


Figure 4.5. The evaluation of the reasons behind insufficient lighting in studio B208.

Based upon the results, 62% of the students in total indicated that the reason behind insufficient lighting inside the studio is insufficient daylight while 54% stated that the reason is the type of the light sources and the amount of the light sources. Only 23% of the students indicated other reasons stating that; 1) “most of the artificial light sources are not working and they are not changed with the new ones”, 2) “light bulbs fail frequently”, 3) “even when I sit next to the window, particularly when it is cloudy, I cannot see well while I am making technical drawings.”

More specifically, 50% of group A indicated that the reason behind insufficient lighting is insufficient daylight while the other half stated that the reason is the amount of the light sources. The 67% of group B stated that the reason is the type of the light sources and insufficient daylight while 33% stated that the reason is the amount of the light sources. The 50% of group C, indicated that the reason behind insufficient lighting is the type of the light sources, 33% stated that it is because of the amount of the light sources and the insufficient daylight. 17% of them indicated as others. In group D, the 67% of the students stated as insufficient daylight and the amount of the light sources while 33% of them indicated as others and the type of the light sources. Group E indicated that all the options cause insufficient lighting inside the studio on an equal basis.

The illumination level of daylight inside the studio is 78 lx at 11:00 am and 213 lx at 4:00 pm. As it is seen, daylight illuminance is very low in the studio. It is clear that even in some sections the lighting meets the standards, the students do not think it is enough

because of the lack of daylight. That is why, most of the students indicated that the insufficient daylight as the primary reason for the insufficient lighting. The type of light sources and the amount of light sources are also very important as secondary reasons.

4.1.1.3. Studio B207-Measurement and Survey results

Illumination levels of daylight and general lighting were measured on March 5 at 11:00 am and 4:00 pm in 20 points of the studio. Table 4.5. indicates the measurement results.

Table 4.5. Illumination levels of daylight and general lighting.

Hour	Illumination level of daylight	Illumination level of general lighting
11:00	24 lx	463 lx
16:00	126 lx	365 lx

According to the measurements, the illumination level of the studio is 463 lx at 11:00 am and 365 lx at 4:00 pm. According to the survey results, 54% of the students indicated that the general lighting of the studio is not sufficient, while 46% find the lighting sufficient. Considering the standards-which is 500-750 lx (CIBSE, 1994) for the studios- it is under the standards for an architectural design studio.

Table 4.6. Illumination levels of daylight and general lighting by sections.

	Section	Illumination level of daylight	Illumination level of general lighting
11.00	A	**53 lx**	**804 lx**
	B	**14 lx**	**367 lx**
	C	**6 lx**	**254 lx**
	D	**11 lx**	**220 lx**
	E	**78 lx**	**1250 lx**
16.00	A	**322 lx**	**535 lx**
	B	**65 lx**	**355 lx**
	C	**28 lx**	**288 lx**
	D	**46 lx**	**243 lx**
	E	**325 lx**	**485 lx**

In section A, the average illumination level is 804 lx at 11:00 am and 535 lx at 4:00 pm. In section B, it is 367 lx at 11:00 am and 355 lx at 4:00 pm. In section C it is 254 lx at 11:00 am and 288 lx at 4:00 pm. In section D it is 220 lx at 11:00 am and 243 lx at 4:00 pm and in section E, it is 1250 lx at 11:00 am and 485 lx at 4:00 pm.

Survey Item 1: *"1) Do you think the general lighting in the studio is sufficient? If not, what do you think is the reason behind it?"*

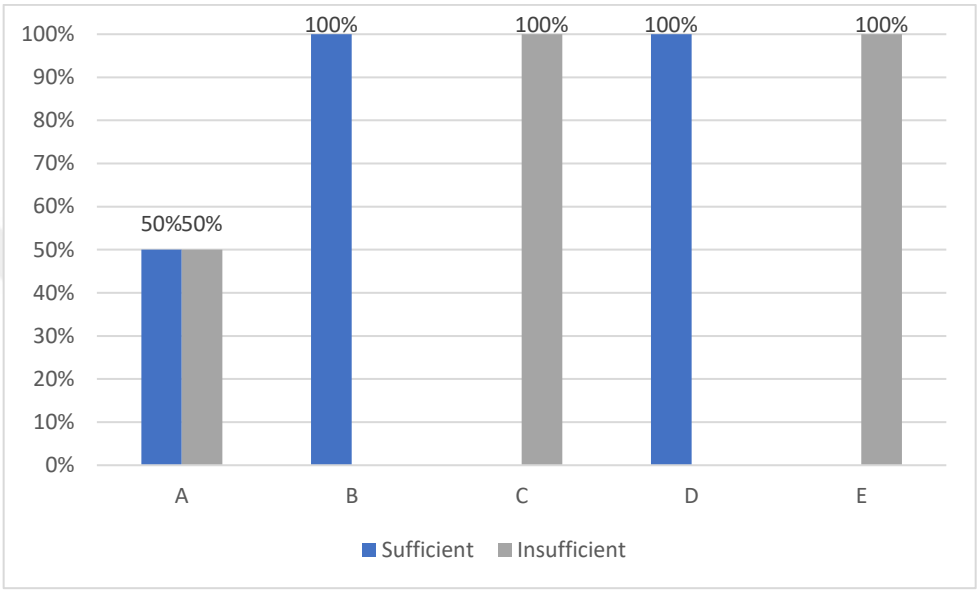


Figure 4.6. Perceptions regarding general lighting conditions in B207 by groups.

As Figure 4.6. shows, 50% of group A finds the lighting is sufficient while the other half of the students find it insufficient. 100% of group B and group D indicated that it is sufficient while 100% of group C and group E indicated as insufficient.

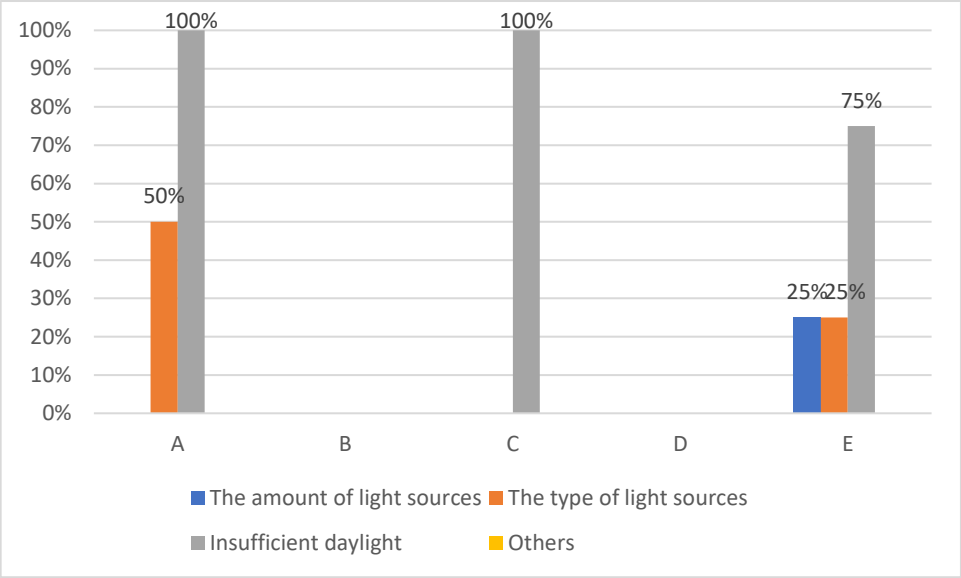


Figure 4.7. The evaluation of the reasons behind insufficient lighting in studio B207.

In total, 86% of the students in studio B207 indicated that the reason behind insufficient lighting inside the studio is insufficient daylight while 29% stated that the reason is the type of the light sources. Only 14% of the students indicated that it is because of the amount of the light sources.

More specifically, 100% of group A, indicated that the reason behind insufficient lighting is insufficient daylight and 50% indicated that the reason is the type of the light sources. The 100% of group C, stated that the reason is the insufficient daylight. 75% of group E, indicated that insufficient daylight causes insufficient lighting conditions as well, while 25% also stated that the amount and the type of the light sources cause insufficient lighting.

In sum, as the measurement results also indicate (average daylight: 24 lx at 11 am and 126 lx at 4:00 pm), the studio has a huge problem in terms of providing sufficient daylight. Therefore, most of the students indicated that the insufficient daylight is the primary reason behind the insufficient lighting.

Comparing the results of all the three studios, it is inferred that studio A206 is the most insufficient one in terms of lighting conditions inside the studio. Studio B208 and B207 lack sufficient lighting conditions. The average illumination level in studio A206 and B208 are closer to each other, however, when compared section by section B208 has more illumination than A206. B207 has the same dimensions with B208; however, its

main facade is facing the west and thus it cannot get enough daylight during the studio hours. It is expected that B208 needs to have the highest sufficiency level, but because most of the participants are from section C and D which have very poor lighting, the general sufficiency decreases with the effect of those sections. It is also important to note that the seating arrangement has a huge impact on the evaluation process. For instance, in studio A206, group A finds the lighting inside the studio insufficient; because the studio is small, section C and B which are darker are closer to section A, so group A perceives the lighting as insufficient. Studio B207 is the least advantageous studio in terms of both daylight illumination level and general illumination level as the levels are under the standards. Likewise, the students also indicate that they do not find the illumination level enough.

Therefore, even though the illumination level of the studio meets the standards with the help of artificial lighting, when daylight illuminance is not sufficient, the students directly perceive as lighting as not good enough. Especially, in studio A206 and B207, insufficient daylight has been found to be the most significant reason for insufficient lighting.

4.1.2. Survey item 2: Illumination levels

In question 2 of this section, the participants were asked to evaluate the illumination levels: a) of artifical lighting, b) on the desk while making model, technical drawing, reading and writing, c) on their computer screen while studying and d) on the projection screen during presentations. The options included “too bright”, “bright”, “normal”, “dim” and “too dim.”

4.1.2.1 Illumination levels of artificial lighting

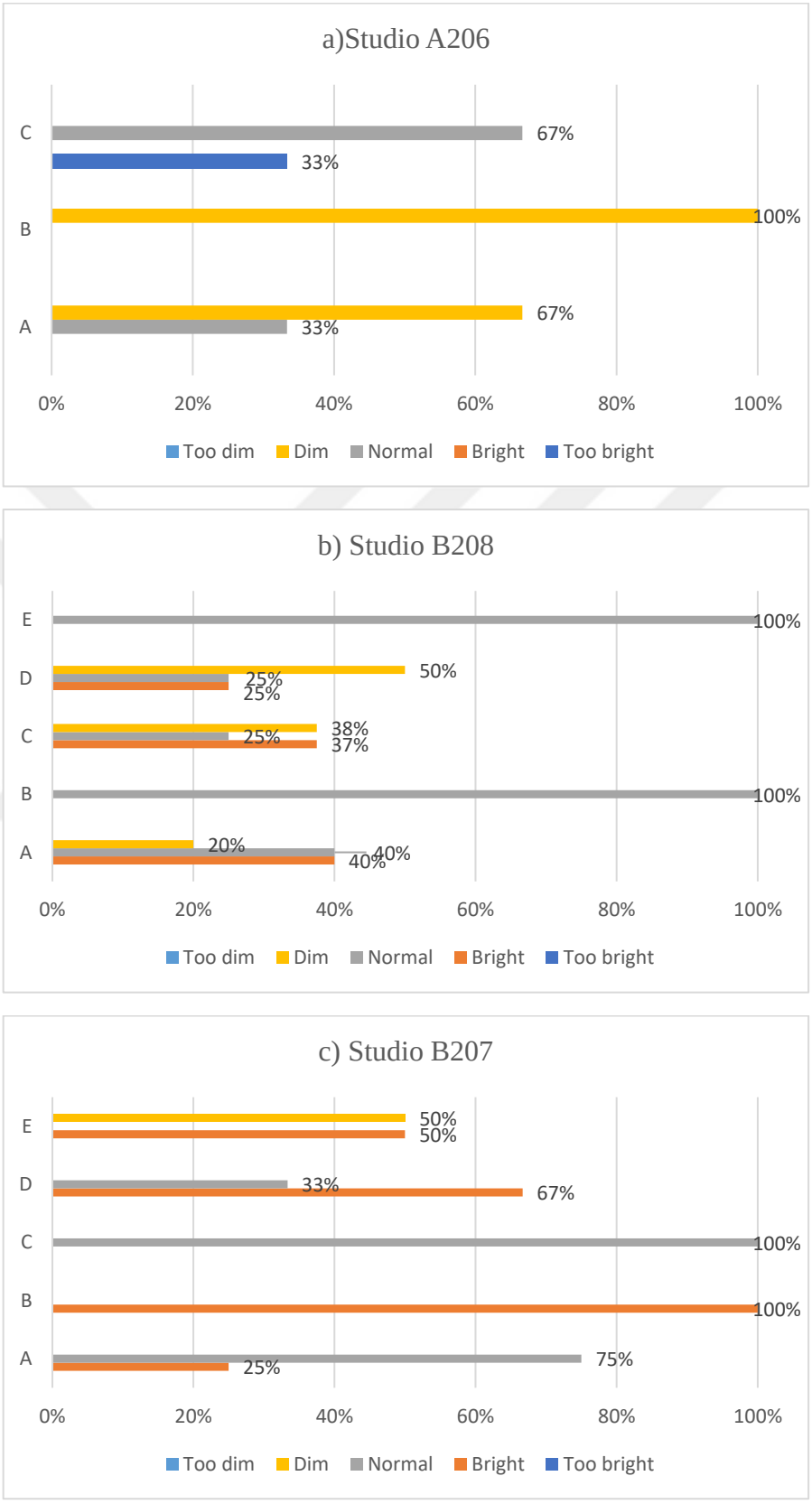


Figure 4.8. The evaluation of the artificial lighting illumination level of studio a) A206, b) B208, c) B207.

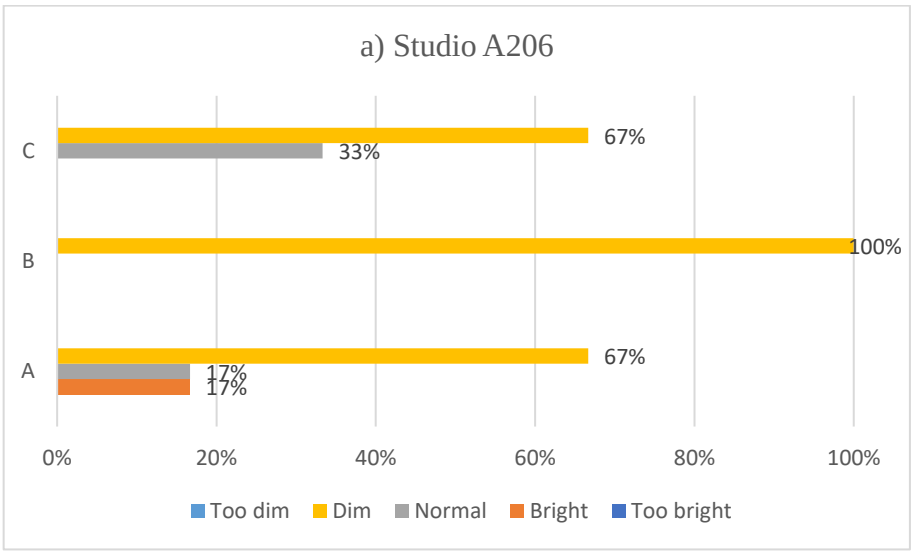
In studio A206, 67% of group A found the illumination level of the artificial lighting dim, while 33% indicated as normal. 100% of group B stated that it is dim. 67% of group C indicated as normal while 33% as too bright.

In studio B208, 40% of group A found the illumination level of the artificial lighting bright, the other 40% indicated as normal and 20% as dim.100% of group B found it normal. 37% of group C indicated as bright, 25% as normal and 38% as dim. 50% of group D found the illumination level of the artificial lighting dim while 25% indicated as normal and other 25% as bright. 100% of group E found it normal.

In studio B207, 75% of group A found the illumination level of the artificial lighting normal while 25% indicated as bright. 100% of group B found it bright.100% of group C indicated as normal. 67% of group D stated that it is bright while 33% indicated as normal. Half of group E found it bright while the other half indicated as dim.

A greater number of the students in studio B207 found the illumination level of the artificial lighting bright and normal comparing to the other studios. This is the studio with the least daylight illumination level.This might be the reason behind these results.Because the average daylight illumination is less in this studio, they perceive as if the artificial lighting is more.

4.1.2.2 Illumination level on the desk while making model



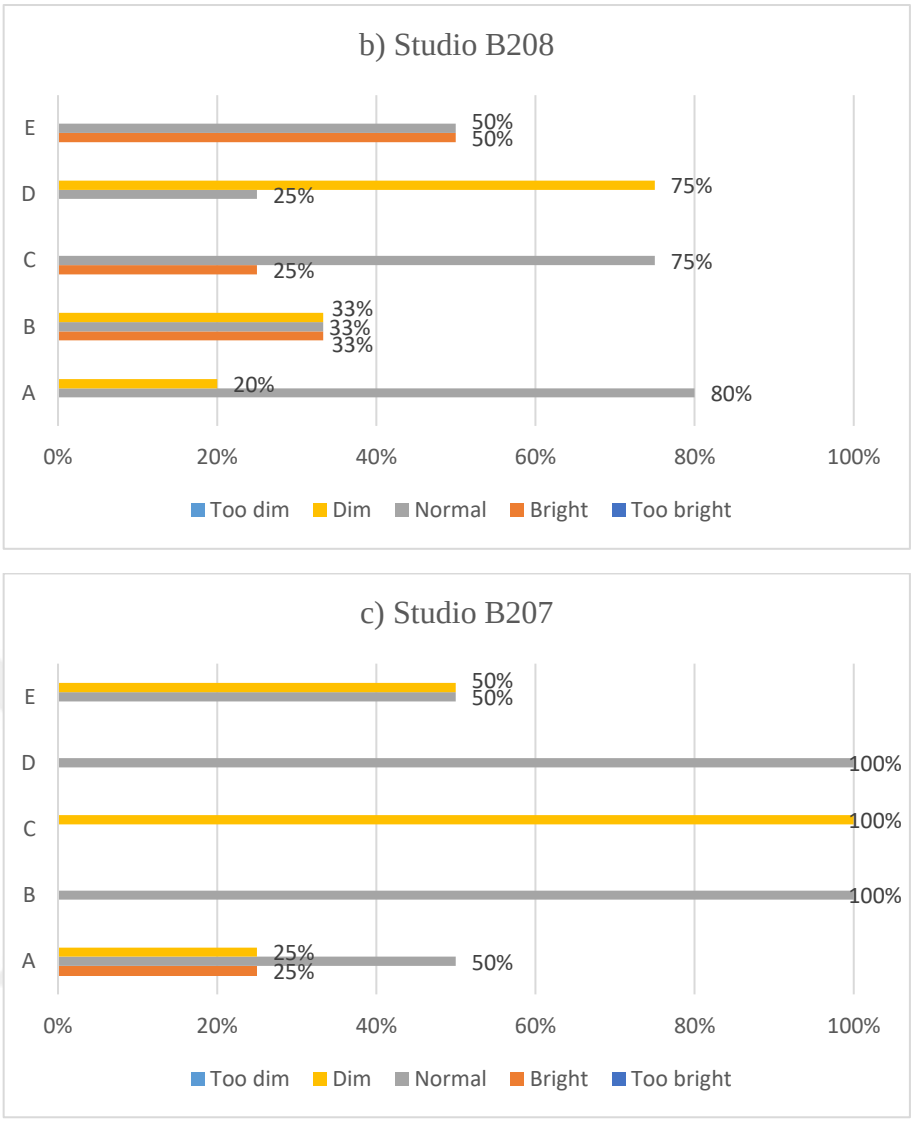


Figure 4.9. The evaluation of the illumination level on the desk while making model by the students of studio a) A206, b) B208, c) B207.

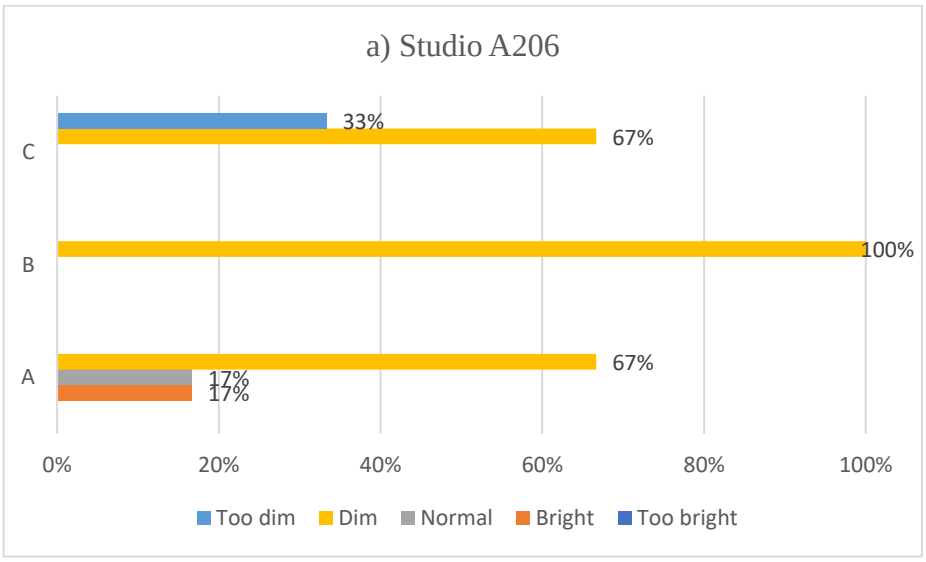
In studio A206, 67% of group A found the illumination level on the desk while making model dim,17% indicated as normal and 17% as bright. 100% of group B found it dim. 67% of group C found it dim and 33% normal.

In studio B208, 80% of group A found the illumination level on the desk while making model normal and 20% indicated as dim. 33% of group B indicated as bright , 33% as normal and 33% as dim. 75% of group C indicated as normal, 25% as bright. 75% of group D found it dim, while 25% indicated as normal. Half of group E found it bright while the other half indicated as normal.

In studio B207, 50% of group A found the illumination level on the desk while making model normal, 25% indicated as bright and 25% as dim. 100% of group B indicated as normal. 100% of group C indicated as dim. 100% of group D found it normal. Half of group E found it normal, while the other half indicated as dim.

According to the standards, the illumination level must be between 500-1000 lx (IESNA, 2000) for model making. In A206 group C, in B208 group C and D, and in B207 group B,C, and D are below the standards. However, in A206 all the groups found the illumination level while model making dim with a very high percent. In B208, most of the students in group A, B and E, found it normal and bright and group D found it dim as expected. Only the results of group C is unexpected considering the illumination level in their study area which is 382 lx and 301 lx. Individual differences were observed for group C. In B207, most of group A and half of group E found that the illumination level on the desk while making model is normal. 100% of group C found it dim as expected according to the meausrements. However, all of the students in group B and group D found it normal unexpectedly. Individual differences were observed in those evaluations.

4.1.2.3 Illumination level on the desk while making technical drawing



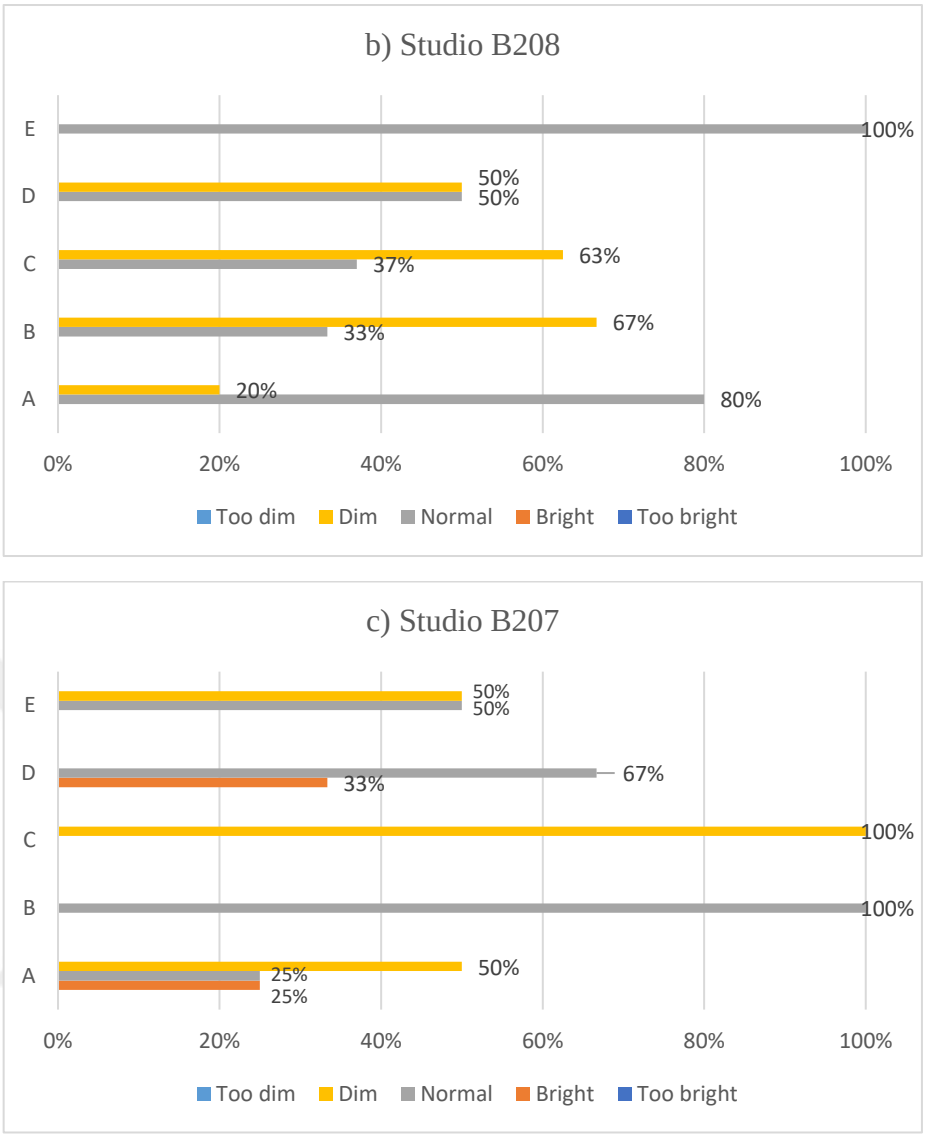


Figure 4.10. The evaluation of the illumination level on the desk while making technical drawing by the students of studio a) A206, b) B208, c) B207.

In studio A206, 67% of group A found the illumination level on the desk while making technical drawing dim, 17% as normal and 17% as bright. 100% of group B found it dim. 67% of group C found it dim and 33% indicated as too dim.

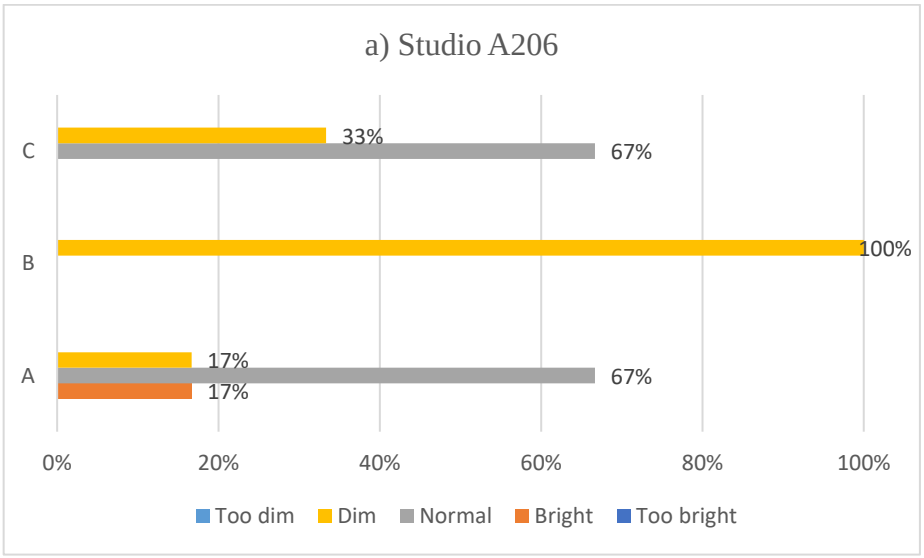
In studio B208, 80% of group A found the illumination level on the desk while making technical drawing as normal, 20% as dim.67% of group B found it dim, 33% indicated as normal. 63% of group C found it dim and 37% indicated as normal. Half of group D found it normal and the other half found it dim. 100% of group E indicated as normal.

In studio B207, 50% of group A found the illumination level on the desk while making technical drawing as dim, 25% as normal and 25% as bright. 100% of group B indicated

as normal. 100% of group C indicated as dim. 67% of group D found it normal, 33% indicated as bright. Half of group E found it normal while the other half indicated as dim.

According to the standards, the minumum illumination level must be 750 lx (CIBSE, 1994) for technical drawings. In studio A206, section B and C, in studio B208 and B207 section B, C, and D are below the standards. In sum, it can be inferred that according to the most of the students of A206, the illumination level on the desk while making technical drawing is dim. According to the measurements, section A is under the standards at 4:00 pm. Thus, these evaluations are expected considering the measurement results. In studio B208, most of the students of group A and E indicated that the illumination level on the desk while making technical drawing is normal. On the other hand, group B, C and half of group D found it dim while the other half of the D indicated as normal. These evaluations are also expected considering the measurement results. In studio B207, most of the students of group A and all the group C evaluated the illumination level on the desk while making technical drawing as dim. Group B and D mostly stated that it is normal. Half of group E found it normal while the other half indicated as dim. Individual differences were observed for group B and D in B207.

4.1.2.4 Illumination level on students' desks while reading and writing



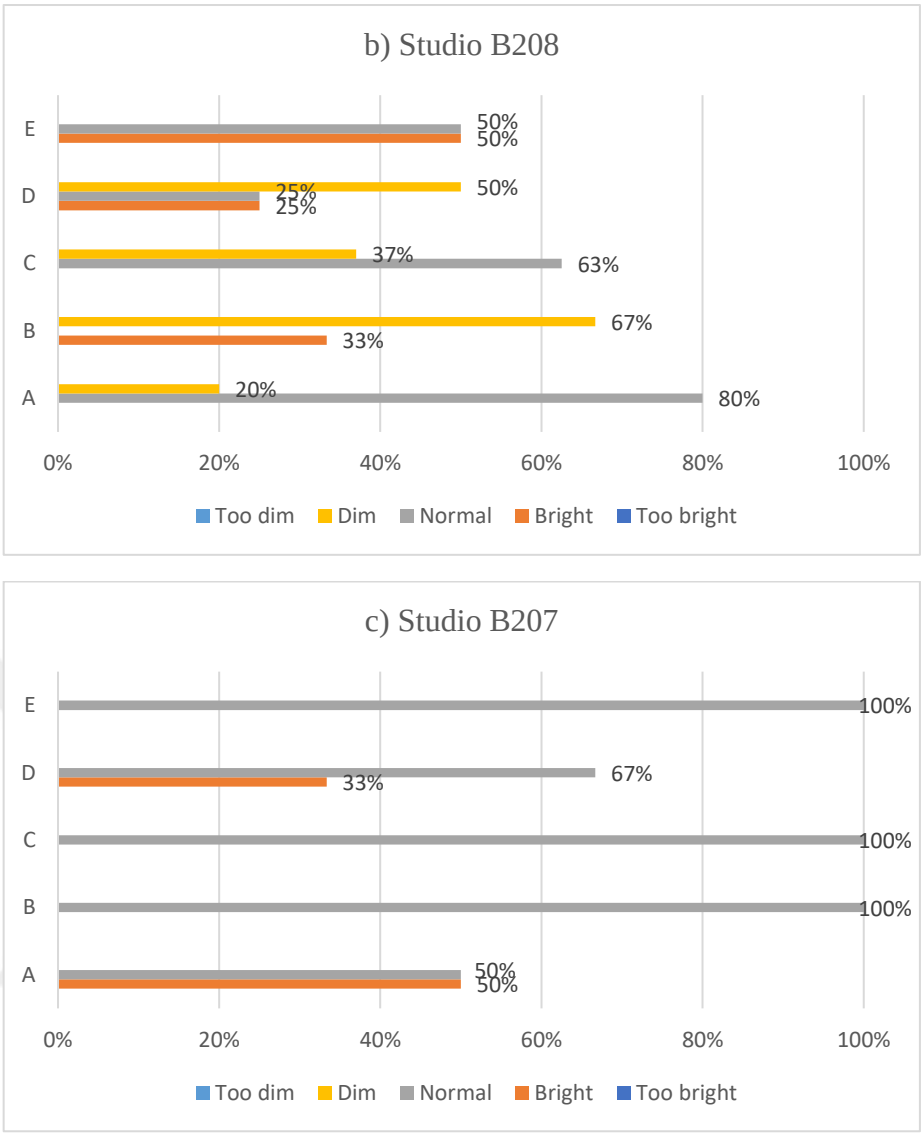


Figure 4.11. The evaluation of the illumination level on the desk while reading and writing by the students of studio a) A206, b) B208, c) B207.

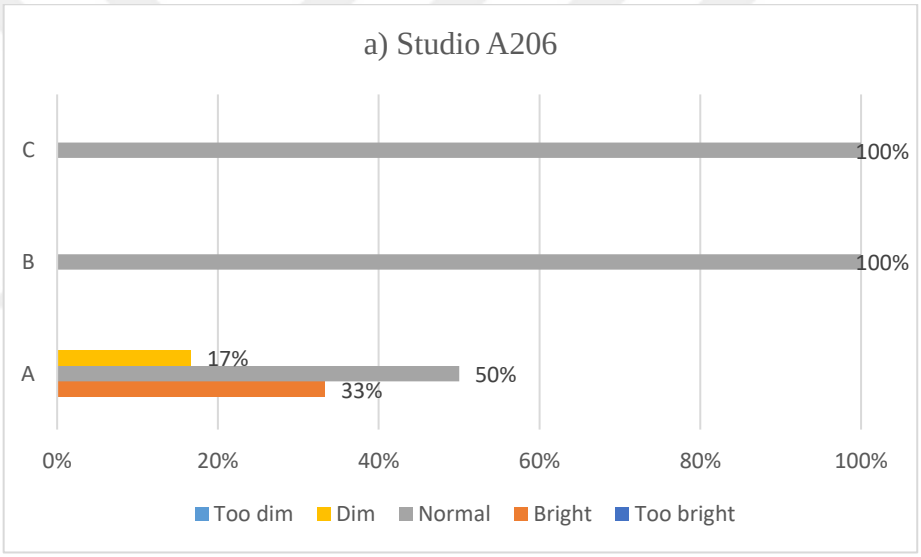
In studio A206, 67% of group A found the illumination level on the desk while reading and writing normal, 17% indicated as bright and 17% as dim. 100% of group B found it dim. 67% of group C found it normal, 33% indicated as dim.

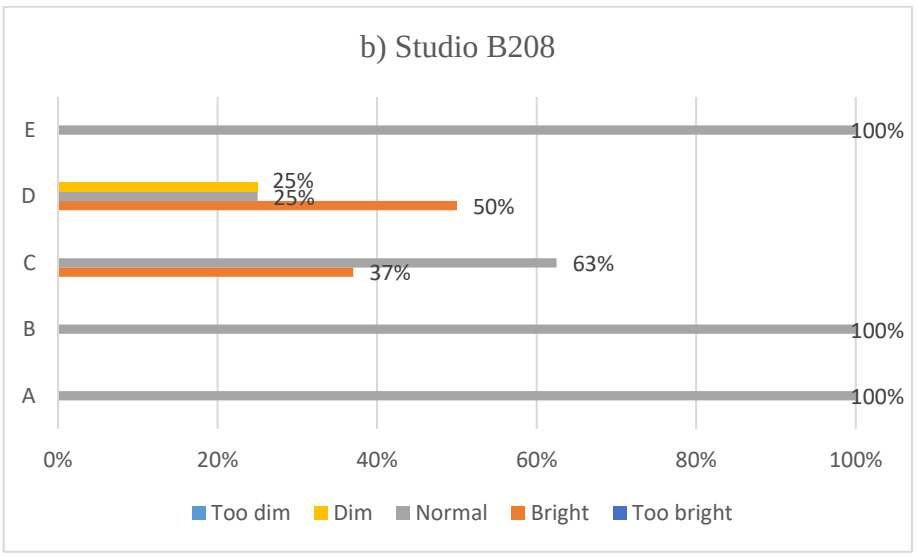
In studio B208, 80% of group A found the illumination level on the desk while reading and writing normal, 20% indicated as dim. 67% of group B found it dim, 33% indicated as bright. 63% of group C indicated as normal and 37% as dim. 50% of group D found it dim, 25% indicated as normal and 25% as bright. Half of group E indicated as bright and the other half as normal.

In studio B207, 50% of group A found the illumination level on the desk while reading and writing normal while the other 50% indicated as bright. 100% of group B and C found it normal. 67% of group D indicated as normal and 33% as bright.100% of group E found it normal.

According to the standards, the illumination level must be 300-500 lx (CIBSE, 1994) while reading and writing. Most of the students in all studios found the illumination level on the desk while reading and writing normal. In B207, section C and D are under the standards but they are pretty much close. Group C and D indicated as the illumination level normal while reading and writing.

4.1.2.5 Illumination level on students' computer screen





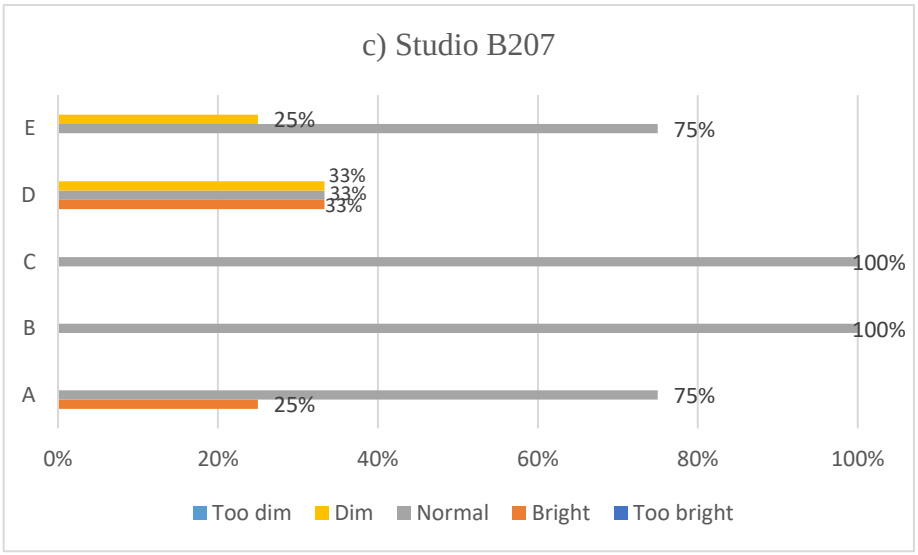


Figure 4.12. The evaluation of the illumination level while studying with computer by the students of studio a) A206, b) B208, c) B207.

In studio A206, 50% of group A found that the illumination level on the computer screen while studying is normal, 33% indicated as bright and 17% as dim. 100% of group B and C found it normal.

In studio B208, 100% of group A and B found that the illumination level on the computer screen while studying is normal. 63% of group C indicated as normal and 37% as bright. Half of group D indicated as bright, 25% as normal and 25% as dim. 100% of group E indicated as normal.

In studio B207, 75% of group A found the illumination level on the computer screen while studying normal and 25% indicated as bright. 100% of group B and C found it normal. 33% of group D found it bright, 33% indicated as normal and 33% as dim. 75% of group E found it normal and 25% indicated as dim.

According to the standards, the minumum illumination level must be 300 lx while studying with computer. In addition, for CAD drawings, it can increase to 500 lx (CIBSE, 1994). According to the meauserements, the avarage illumination level of section D in B207 is around 250 lx which is below the standards. 33% of group D evaluated the illumination level on the computer screen as normal, 33% as bright, and 33% as dim.

In sum, it can be inferred that according to the most of the students in all three studios, the illumination level on the computer screen while studying with computer is normal.

4.1.2.6 Illumination level on the projection screen during presentations

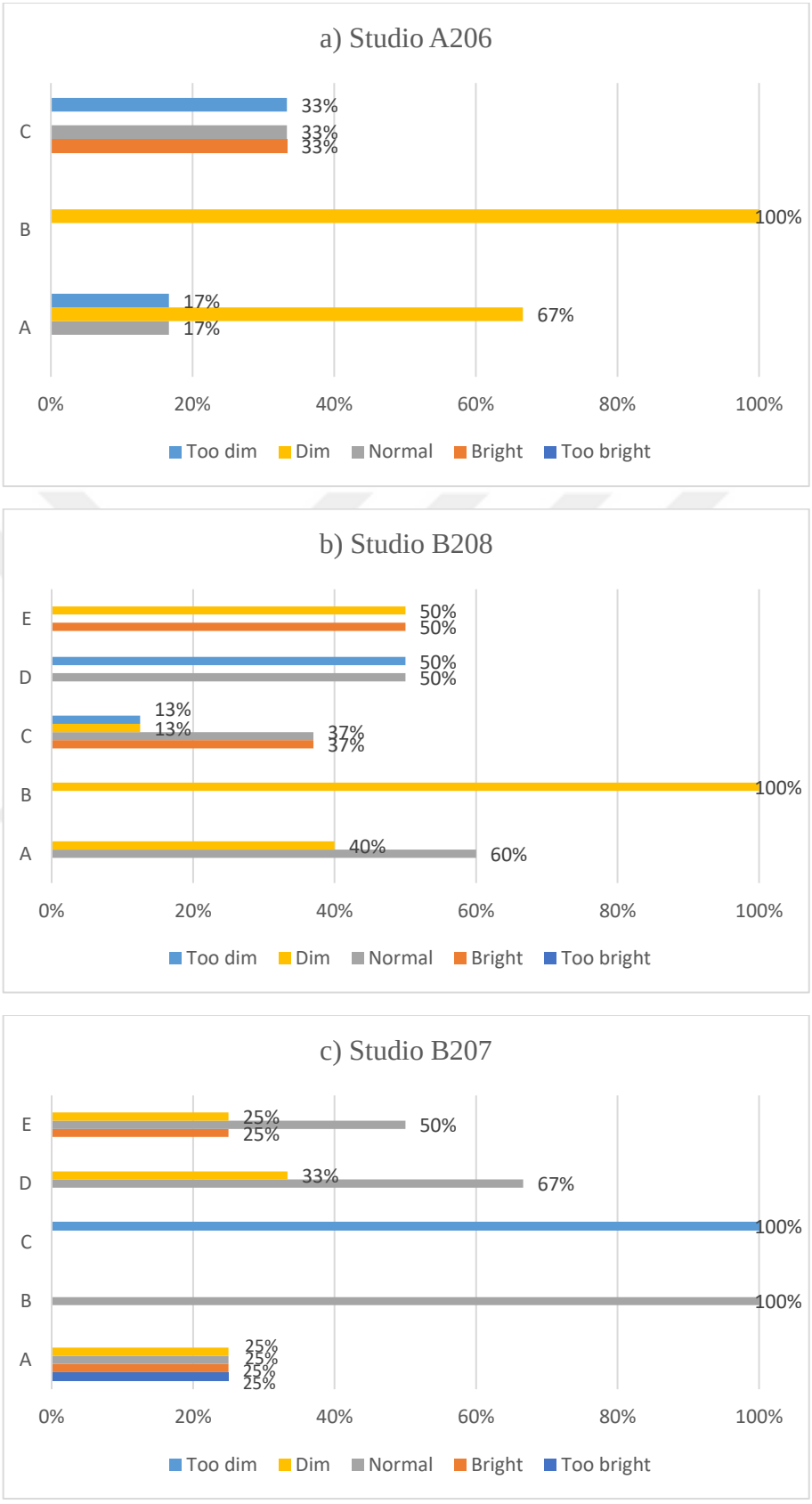


Figure 4.13. The evaluation of the illumination level on the projection screen during presentations by the students of studio a) A206, b) B208, c) B207.

In studio A206, 67% of group A and 100% of group B found that the illumination level on the projection screen during presentations is dim. 33% of group C indicated as bright, the other 33% as normal, and rest of the group as too dim.

In studio B208, 60% of group A found the illumination level on the projection screen during presentations normal. 100% of group B indicated that it is dim. 37% of group C found it bright, while the other 37% stated that it is normal. 13% of group C indicated that it is dim and the other 13% stated that it is too dim.While half of group D found it normal the other half stated that it is too dim. 50% of group E indicated that it is bright while the other half found it dim.

In B207, 25% of group A found that the illumination level on the projection screen during presentations is too bright and 25% found it bright. On the other hand, 25% of group A indicated that it is normal while the other 25% found it dim. 100% of group B indicated that it is normal. 100% of group C found it too dim. 67% of group D and 50% of group E indicated that it is normal.

4.1.3 Survey item 3 : Importance of the presence of windows in the studio(s) in terms of daylight illumination

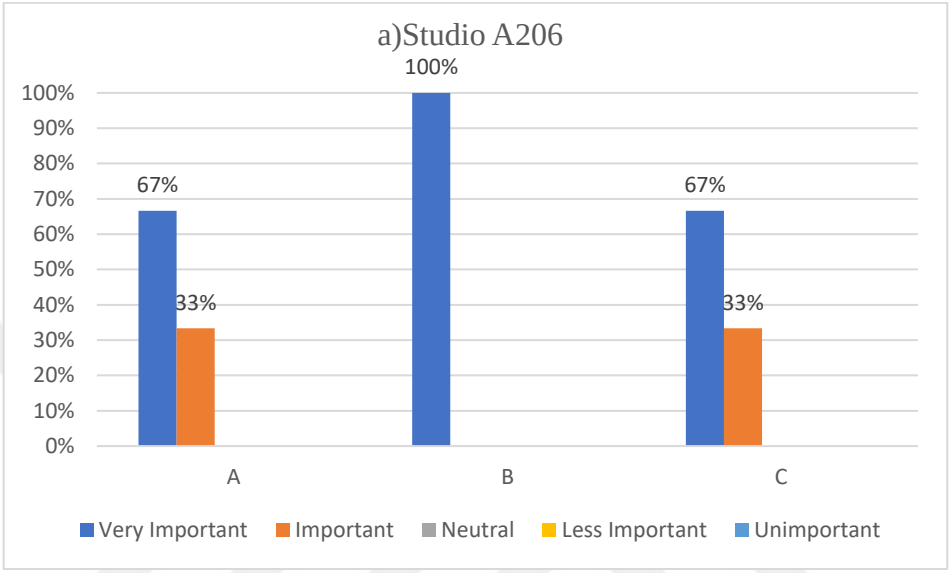
Q3: *"How important is it to have windows in the studio to benefit from daylight?"*
In question 3 of this section of the survey, participants were asked to evaluate the importance of having windows in a studio in terms of benefiting from daylight. The options included "very important", "important", "neutral", "less important", and "unimportant."

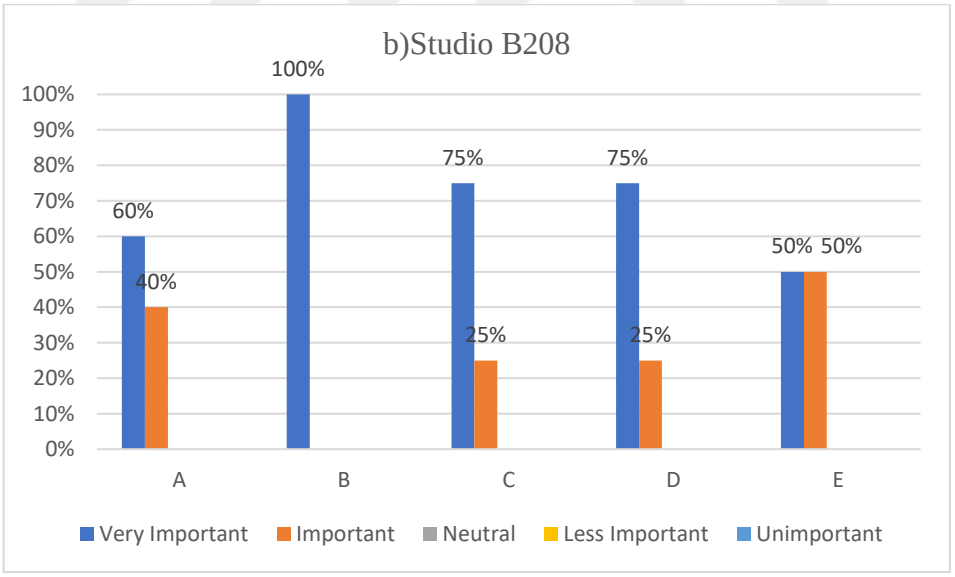
Table 4.7. The importance of daylight illumination to benefit from.

	Very Important (%)	Important (%)	Neutral (%)
A 206	%70	%30	
B207	%54	%31	%15
B208	%73	%27	

As Table 4.7. shows, in studio A206, 70% of the students indicated that daylight illumination is very important to benefit from while 30% indicated as it is important.In studio B208, 73% of the students indicated that daylight illumination is very important to

benefit from while 27% indicated as it is important. In studio B207, 54% of the students indicated that daylight illumination is very important to benefit from while 31% indicated as it is important and 15% as neutral. The results indicate that it is important to have windows in the studio in order to benefit from daylight.





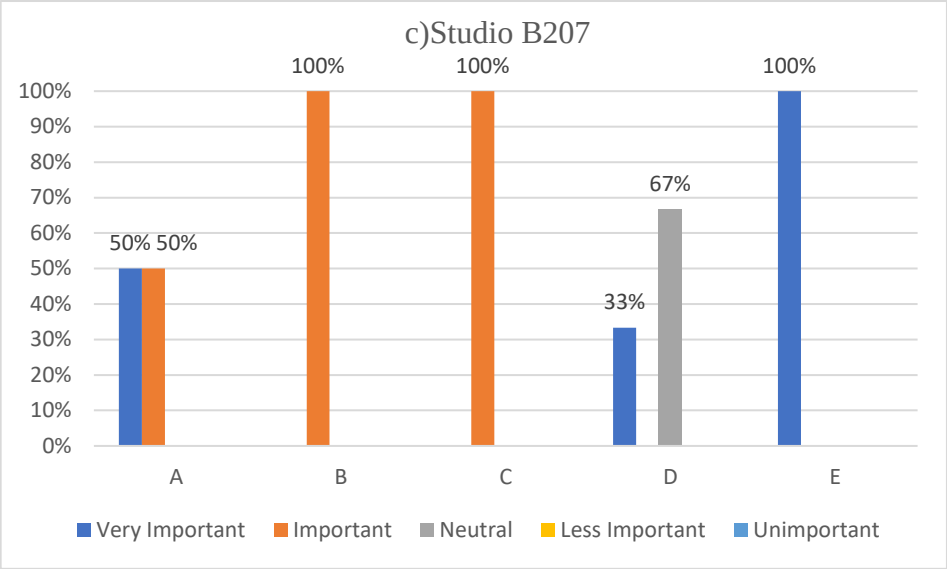


Figure 4.14. The evaluation of the importance of daylight illumination to benefit from by groups in studio a) A206, b) B208, c) B207.

In studio A206, 67% of the participants in group A indicated that daylight illumination is very important to benefit from daylight while 33% indicated that it is important.100% of group B indicated as “very important” 67% of group C indicated as “very important” and 33% as important.

In studio B208, 60% of group A stated that daylight illumination is “very important” to benefit from daylight and 40% indicated as “important.” 100% of group B indicated as “very important.” 75% of group C and D indicated as “very important” and 25% as “important.” 50% of group E indicated as “very important” and 50% as “important.”

In studio B207, 50% of group A indicated that daylight illumination is very important to benefit from while the other half indicated as important. 100% of group B and C indicated as important. 67% of group D indicated as neutral and 33% as very important. 100% of group E indicated as very important.

According to the results from all three studios, it is “very important” to have windows in the studio in order to benefit from daylight.

4.1.4 Survey item 4: The use of artificial lighting in the studios

Q4: *“How often do you use artificial lighting inside the studio? If you use artificial lighting frequently, what is the reason behind it? (e.g. insufficient daylight, glare resulting from daylight, other (please indicate)”*

In question 4 of Section A, participants were first asked about their frequency of usage of artificial light sources. The options included “always”, “often”, “sometimes”, “rarely”, and “never.”

Table 4.8. The frequency of the usage of the artficial light sources.

	Always (%)	Often (%)	Sometimes (%)	Rarely (%)
A 206		%90	%10	
B207	%15	%62	%8	%15
B 208	%18	%59	%18	%5

As Table 4.8. indicates, in studio A206, 90% of the students indicated that they *often* use the artificial lighting, 10% stated that they *sometimes* use it. Considering the daylight illumination inside the studio, which is 81 lx at 11:00 am and 222 lx at 4:00 pm, it is inevitable to use artificial light sources.

In studio B208, 59% of the students indicated that they *often* use the artficial lighting, whereas 18% stated that they *always* use it. 18% of them stated that they *sometimes* use it and 5% indicated as *rarely*. Considering the daylight illumination inside the studio, which is 78 lx at 11:00 am and 213 lx at 4:00 pm, a great majority of the students utilize artificial light sources.

In studio B207, 62% of the students indicated that they *often* use the artficial lighting and 15% stated that they *always* use it. 8% of them stated that they *sometimes* use it and 15% indicated as *rarely.* Since the daylight illumination inside the studio is very low (24 lx at 11:00 am and 126 lx at 4:00 pm), the students prefer to use artificial light sources.

In the second part of this question, the students were asked to indicate their reason(s) for using artifical lighting. The variables included “insufficent daylight”, “glare as a result of daylight” and “other.” For this sub-question, the students could choose more than one option. Table 4.9. below shows the percentages for each variable in each class:

Table 4.9. Reasons for using artifical lighting.

Variable(s)	Class		
	A206 (%)	B208 (%)	B207 (%)
Insufficient daylight	90%	55%	46%
Glare resulting from daylight	20%	36%	46%
Other	10%	9%	15%

In studio A206, 90% of the students stated that they need artificial lighting because of insufficient daylight, while 20% of them stated that it is because of the glare resulting from daylight. The participant who indicated as “other” stated that; “Daylight causes some problems about the visibility of computer screens.” This statement is also related with the glare resulting from daylight.

In studio B208, 55% of the students reported that the reason why they use artificial lighting is the lack of daylight, whereas 36% of them indicated their reason as the glare resulting from daylight. 9% of the students indicated as “other.” Those participants stated that: 1) “Daylight is not distributed to the studio uniformly and thus there are well lit spaces and dark spaces throughout the studio”, 2) “It is because we generally study at nights”.

In studio B207, 46% of the students indicated the reason as insufficient daylight while 46% of them stated that it is because of the glare resulting from daylight. 15% of the students chose “other.” Those participants stated that: 1) “Because we stay until the morning to study, we use artificial lighting for the whole night”, 2) “I use artificial lighting at nights.”

For all three studios, insufficient daylight is the primary reason for the usage of artificial lighting. However, for the participants in studio B207 and B208, glare also plays a significant role. One of the statement as “other” in B208, indicated that daylight is not distributed uniformly throughout the studio; so even there are well lit spaces, they have to use the artificial light sources for the rest of the class as a result of the lack of enough daylight illumination.

More precisely, studio A206 takes daylight from its east and north facades. Studio B208 has east and south facades and its openings are larger than A206. Studio B207 has west and south facade and its openings are larger than A206 and equal to B208. The west, south and east facades are the ones that make it hard to control the illumination. For this reason, the percentages of “the glare resulting from daylight” is very high in studio B208 and B207. It is even equal to that of “insufficient daylight” in B207.

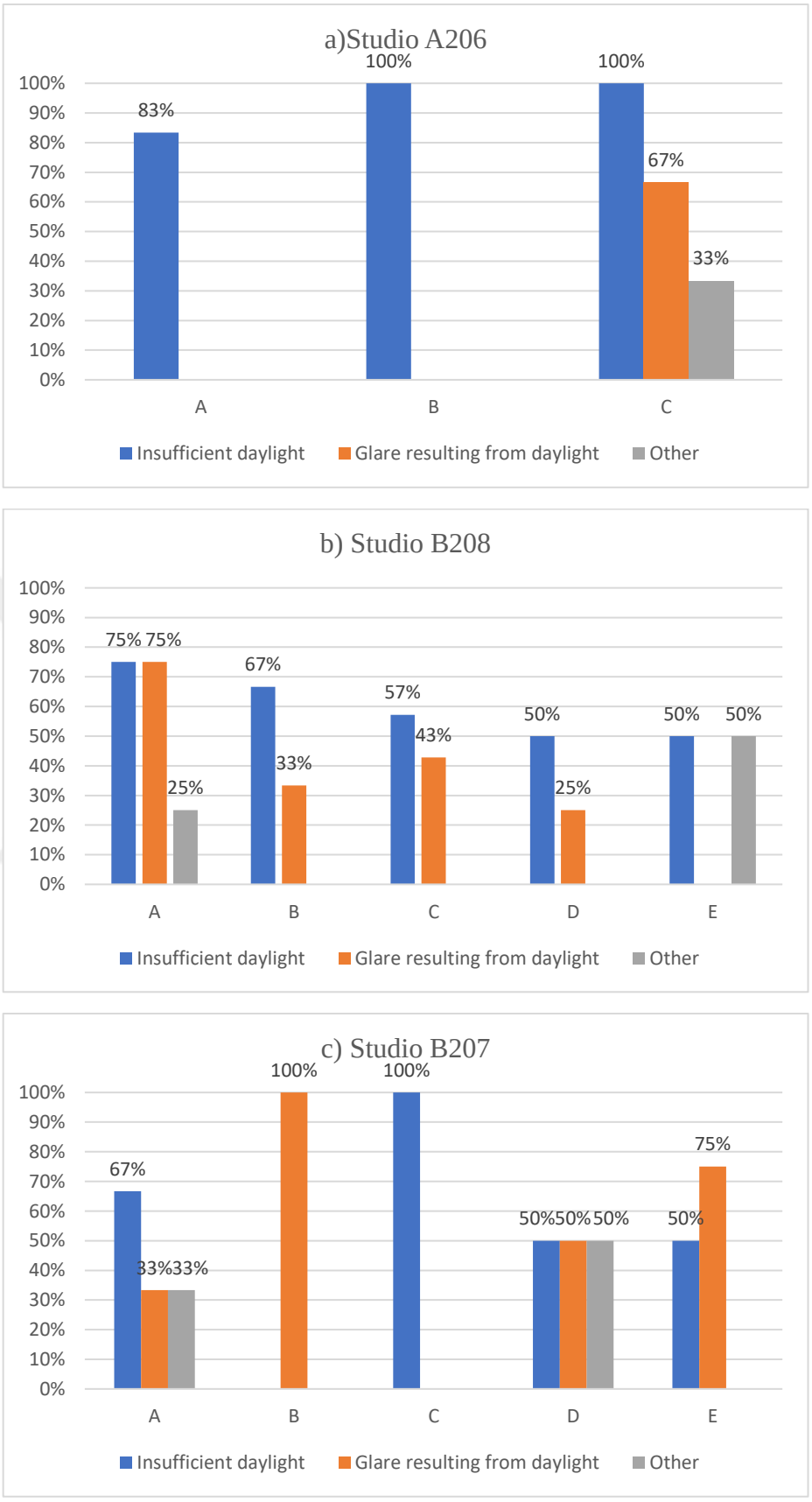


Figure 4.15. The evaluation of the frequency of the usage of the artficial light sources by the students of the studio a) A206, b) B208 and c) B207.

In studio A206, 83% of group A indicated that the reason they use artificial lighting frequently is insufficient daylight. 100% of group B indicated as insufficient daylight as well. Similarly, 100% of group C indicated as insufficient daylight; as a secondary reason, they chose "glare that results from daylight." 33% of the participants in this group indicated another reason: "Daylight causes some problems about the visibility of computer screens." This is also related with the glare resulting from daylight.

Since the students had the option of choosing more than one variable in this question, in studio B208, 75% of group A stated that both insufficient daylight and glare resulting from daylight are the primary reasons for the usage of artificial lighting frequently. 25% of them indicated other reasons. The participant who responded as "other" stated that; 1) "Daylight is not distributed to the studio uniformly and thus there are well lit spaces and dark spaces throughout the studio". 67% of group B indicated as insufficient daylight, 33% as glare resulting from daylight. 57% of group C, indicated as insufficient daylight,43% as glare resulting from daylight. 50% of group D, indicated as insufficient daylight,25% as glare resulting from daylight. 50% of group E, indicated as insufficient daylight, 50% indicated as other. The participant who responded as "other" stated that; 2) "It is because we generally study at nights". The reasons indicated as "other" are related to the insufficiency of daylight as well as non-existence of daylight.

In studio B207, 67% of group A reported that insufficient daylight is the primary reason for using artificial lighting frequently, while 33% indicated as glare resulting from daylight and 33% indicated as other. 100% of group B indicated as glare resulting from daylight and 100% of group C indicated as insufficient daylight. As for group D, all the options share an equal ratio as 50%. 75% of group E chose glare resulting from daylight, while 50% selected insufficient daylight. The participants who indicated as "other" stated that; 1) "Because we stay until the morning to study, we use artificial lighting for whole night." 2) "I use artificial lighting at nights." These statements are related to non-existence of daylight.

4.1.5 Survey item 5: Perceptions of the illumination levels of the surrounding area

Q5: "*When you raise your head from your desk, how does the surrounding seem to you?"*

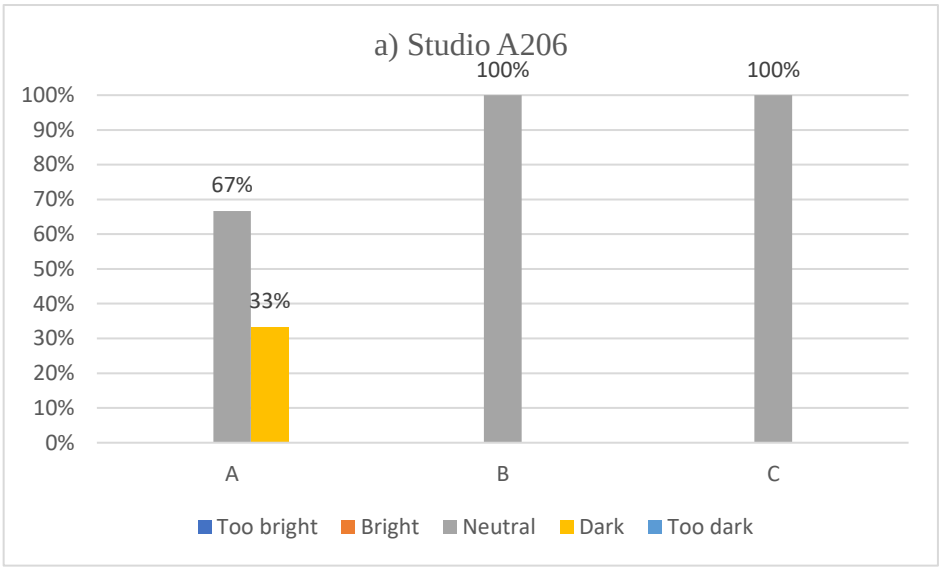
In this section of the survey, the participants were asked how the surrounding area seems when they raise their heads from their desks. The options included “too bright”, “bright”, “neutral”, “dark”, and “too dark." Table 4.10. shows their perceptions as regards the illumination levels:

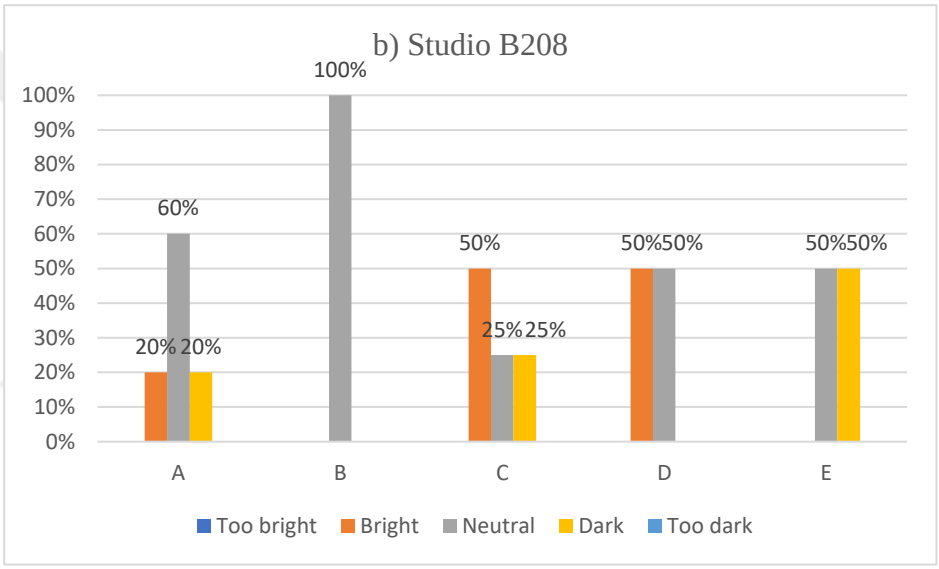
Table 4.10. The perceptions regard the illumination levels.

	Too Bright (%)	**Bright (%)**	**Neutral (%)**	**Dark (%)**	**Too Dark (%)**
A 206			%80	%20	
B 207		%23	%69	%8	
B 208		%32	%50	%18	

In studio A206, 80% of the students mentioned that when they raise their head from their desk, the surrounding seems *neutral* while 20% said it is *dark*. In studio B208, 50% of the students chose *neutral,* while the remaining 32% chose *bright* and 18% *dark.* In studio B207, while 69% of the students selected *neutral*, 23% of them indicated as *bright* and 8% as *dark.*

The majority of the students in A206 chose the option “neutral” for their luminous surrounding; in other words, they believe that studio A206 has balanced lighting. In B208, on the other hand, only half of the students indicated as neutral for their luminous surrounding; however, a relativel high percentage of students stated that it is bright, while the remaining 18% percent indicated as dark. The students in B207 mostly indicated as neutral for their luminous surrounding, but there are some students who said it is bright and dark. Thus, in both B207 and B208, there are some spaces that are well lit but also some areas with poor lighting.





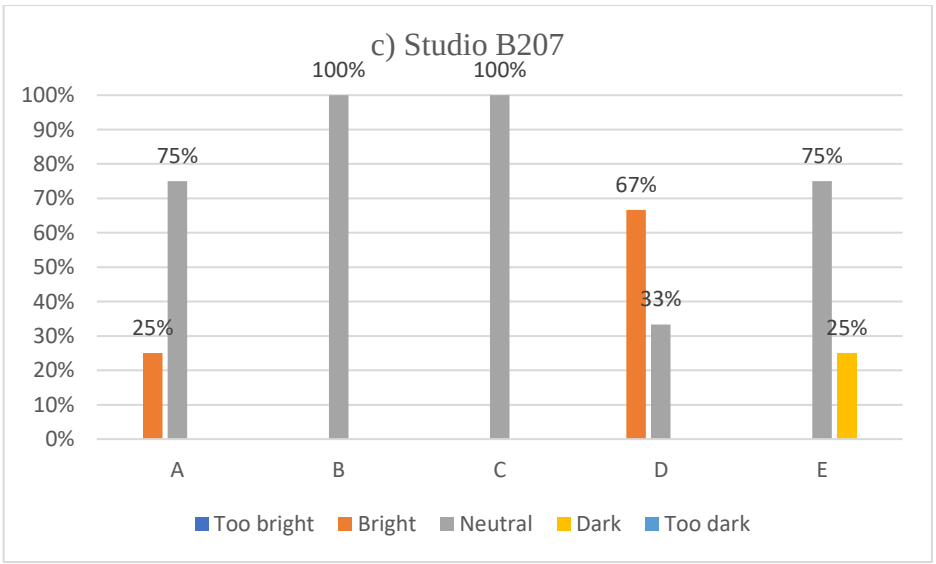


Figure 4.16. Perceptions of the illumination levels of the surrounding area in studio a) A206, b) B208, c) B207.

In studio A206, 67% of group A reported that when they raise their heads from their desks, the surrounding environment seems neutral, while 33% indicated as dark. 100% of group B and C indicated as neutral.

In studio B208, 60% of group A indicated that when they raise their head from their desk, the surrounding environment seems neutral while 20% indicated as bright and 20% as dark. 100% of group B indicated as neutral. 50% of group C indicated as bright, 25% as neutral and 25% as dark. 50% of group D indicated as bright and 50% as neutral. 50% of group E indicated as neutral and 50% as dark.

In studio B207, 75% of group A reported neutral while 25% stated as bright. 100% of the participants in both group B and C indicated as neutral. 67% of group D indicated as bright and 33% as neutral. This could be the case because group D has the lowest illumination level in their study area. 75% of group E reported neutral while 25% as dark.

As a result, in all studios, 100% of the participants in group B (which is in the center of the studios) stated as neutral. This is because they are in the center and when they raise their heads from their desks, they see both section A and C -which are in the both sides of section B- as dark and bright. 50% of group C and D in B208, indicated as bright which is because in section C the illumination level is much lower compared to the other sections. Thus, they may perceive their surroundings as brighter. Group D is very close to group E; this can affect their perception about brightness as well. 50% of them indicated as neutral. Group D has more balanced lighting compared to the other sections and this may be the reason behind their choice. 50% of group E mentioned that it is dark which is because section E has a higher illumination level compared to the other sections except for A, thus they may perceive their surroundings as darker. Section E also has a different perspective as they see A, B, and C sections because they are in the back side. This can be the reason for those who remained neutral. Group A, B, C, and E in B207 indicated as neutral with high percentages. Group B may have selected the option “neutral” with the same reason as group B in B208. Section B and section D are very close to section C and the illumination levels of these three sections are close to each other. That is why group C may have responded as neutral. Group D mostly stated as

bright; because their section has the least illumination, they may perceive as if their surrounding is brighter.

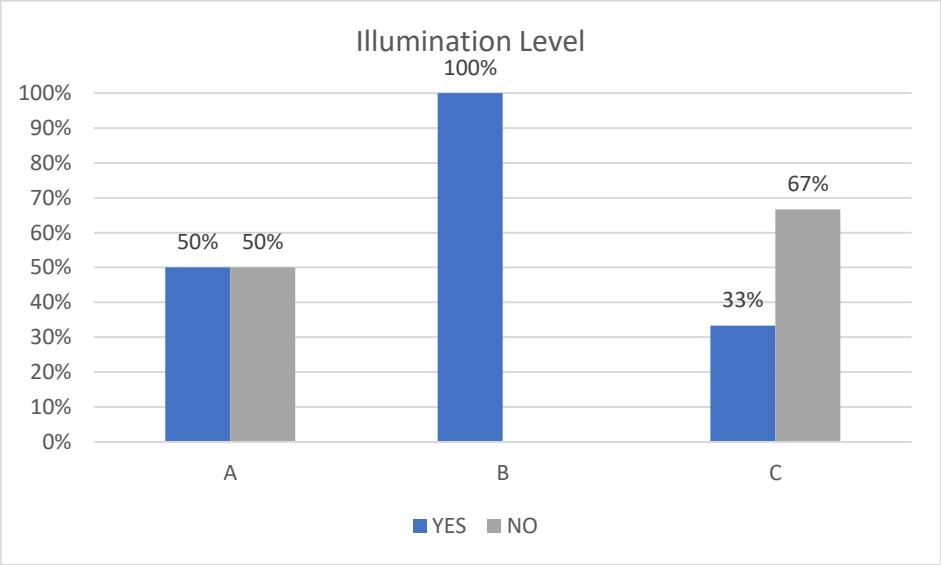
4.2. Section B: Visual Comfort and Satisfaction

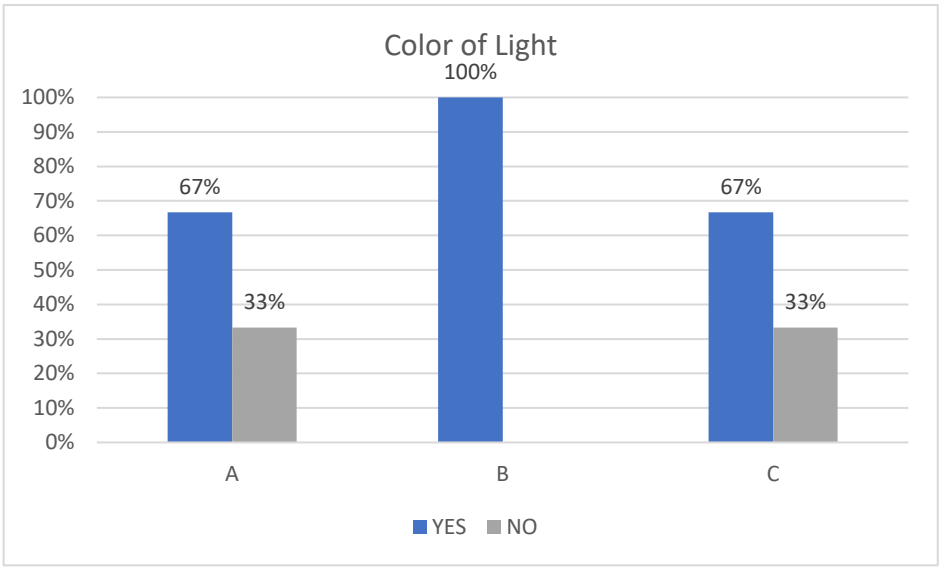
4.2.1 Survey item 1: The evaluation of the lighting conditions in terms of visual comfort

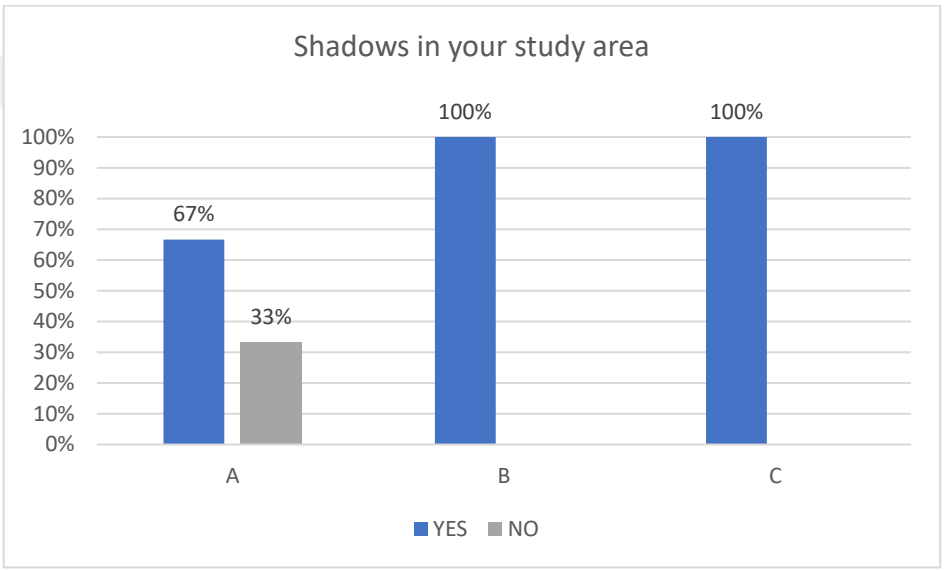
Q1: "*Do the following elements prevent you while you are studying? If there is glare, what do you think is the reason behind it?"*

In the first question of this section, the participants were asked to evaluate the lighting conditions in terms of their visual comfort: a) illumination level, b) color of light c) shadows in their study area, d) glare.

In the second part of this question, the students were asked to indicate if there is glare,what is the reason behind it. The variables included "artificial light sources", "daylight", "material reflectance" and "other." For this sub-question, the students could choose more than one option.







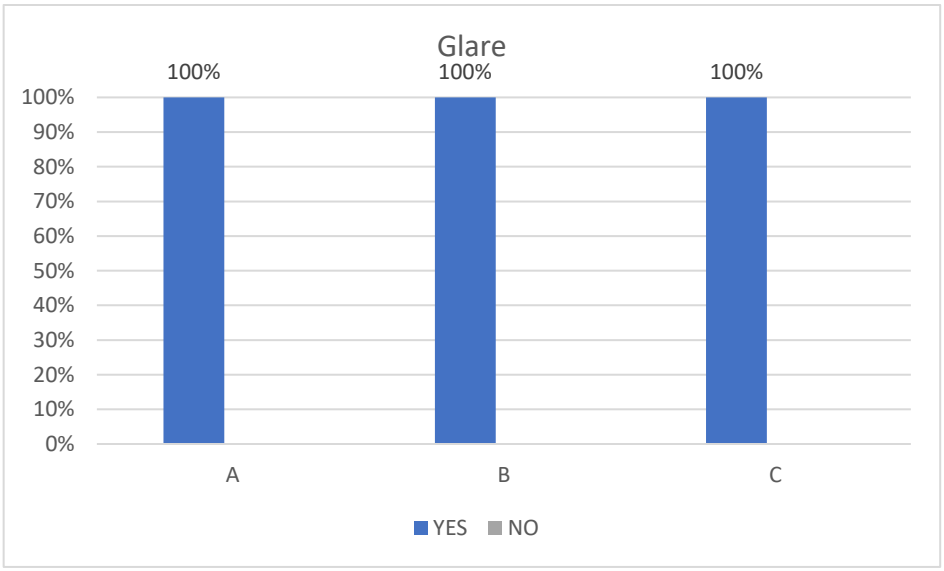


Figure 4.17. The evaluation of the lighting conditions in terms of visual comfort in studio A206; a) illumination level, b) color of light, c) shadows in their study area, d) glare.

50% of group A suggested that the illumination level prevents them while studying, while the other half stated that it does not. 100% of group B mentioned that it does. 67% of group C also stated that it does while 33% said it does not. According to the standards, the illumination level must be between 500-750 lx for the studios (CIBSE, 1994). The illumination level in section A is above the standards at 11:00 am and meets the standards at 4:00 pm. In section B, it meets the standards at 11:00 am and is under the standards at 4:00 pm. In section C, it is under the standards for both measurements. However, 67% of group C responded that the illumination level does not prevent them while studying. Individual differences were observed in group C.

67% of group A indicated that the color of light prevents them while studying, whereas 33% said that it does not. 100% of group B stated that it does. 67% of group C reported that it does, while 33% stated that it does not. Most of the participants of all the groups indicated that the color of light prevents them while studying.

67% of group A stated that the shadows in their study area prevents them while studying, whereas 33% indicated that it does not. 100% of group B and C reported that it does. Group B and group C have darker sections comparing to group A. That is why all of them indicated as it does while there are some students in group A who stated that it does not.

100% of group A, B, and C reported that glare prevents them while studying.

"If there is glare, what do you think, is the reason behind it?"

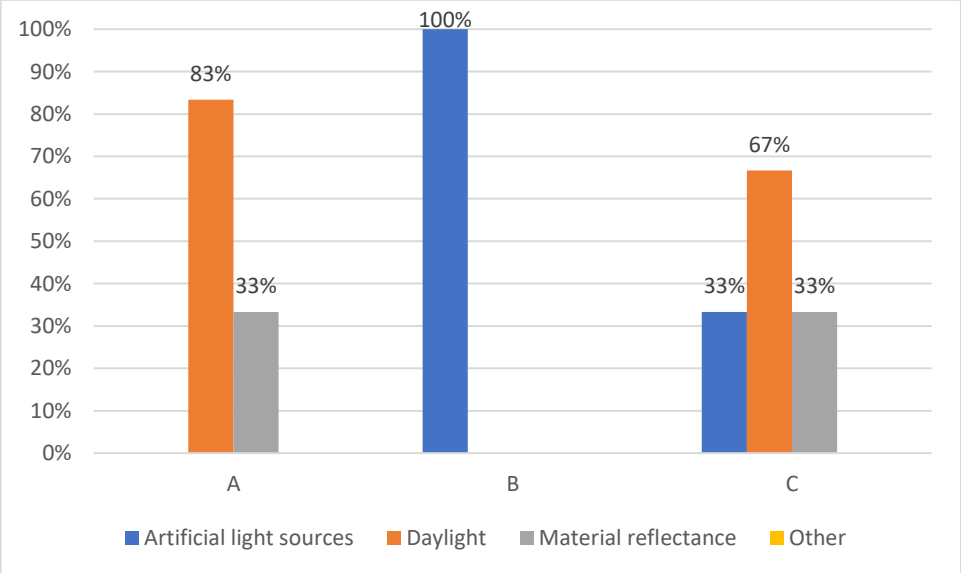
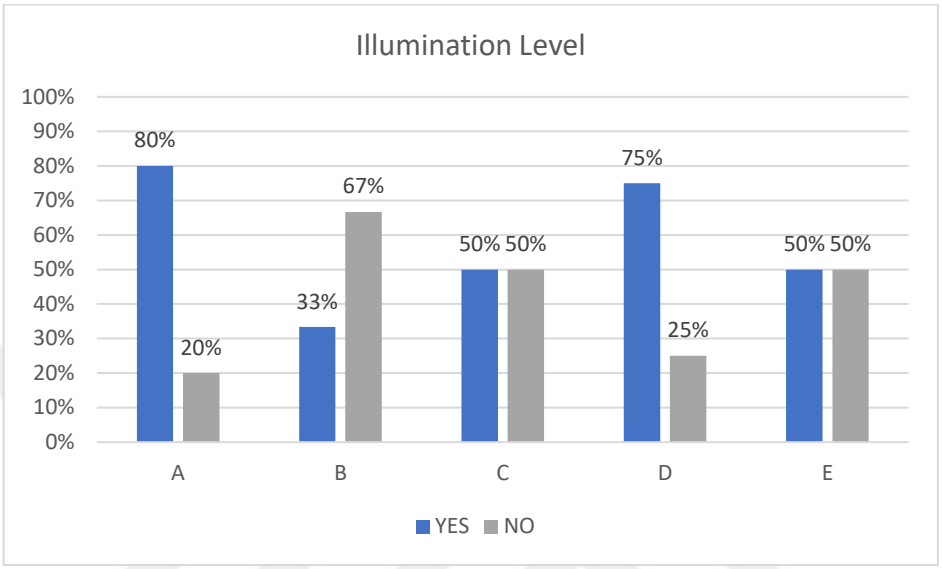
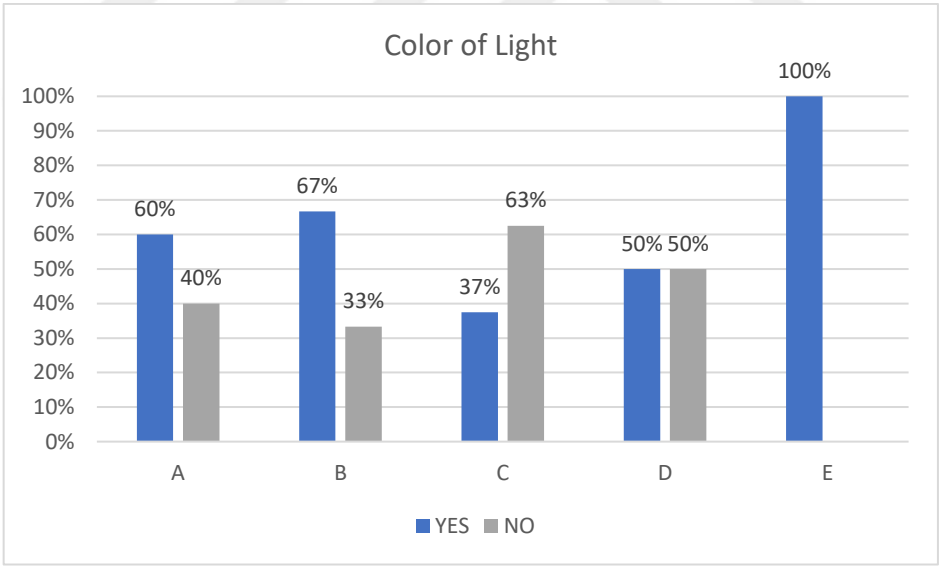
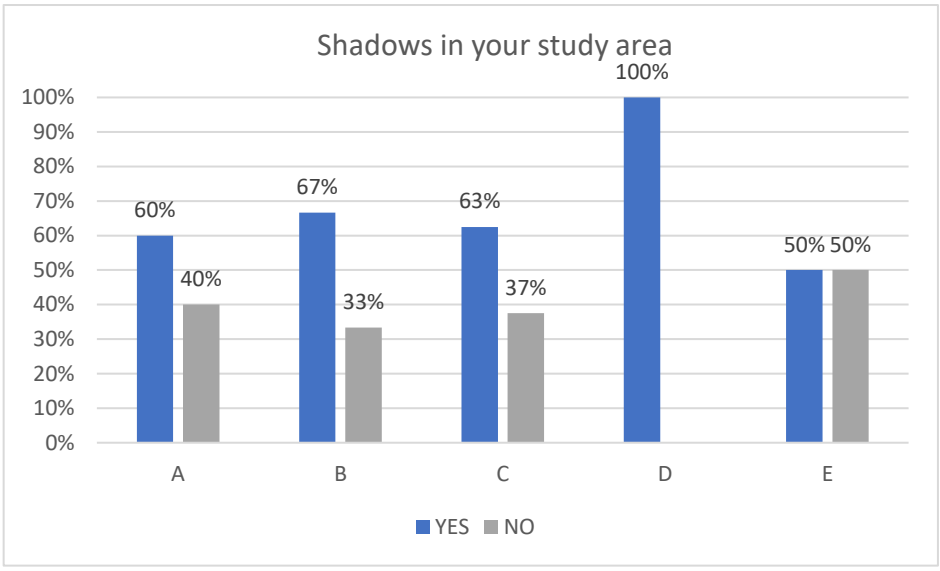


Figure 4.18. The evaluation of the source of glare by the students of studio A206.

70% of the students stated that the reason behind glare is daylight, 30% indicated as material reflectance and 20% as artificial light sources. 83% of group A indicated that the reason behind glare is daylight, 33% as material reflectance. 100% of group B indicated as artificial light sources. 67% of group C indicated as daylight, 33% as artificial light sources, and 33% as material reflectance.







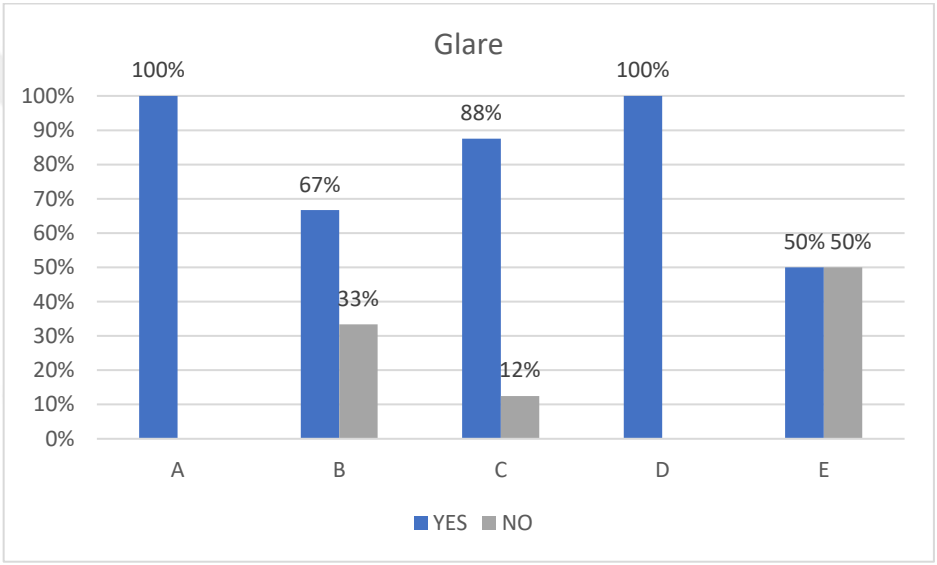


Figure 4.19. The evaluation of the lighting conditions in terms of visual comfort in studio B208; a) illumination level, b) color of light c) shadows in their study area, d) glare.

80% of group A suggested that the illumination level prevents them while studying, while 20% indicated as it does not. 67% of group B indicated as it does not, 33% as it does. 50% of group C indicated as it does while the other 50% as it does not. 75% of group D indicated as it does and 25% as it does not. 50% of group E indicated as it does and 50% as it does not. According to the standards, the illumination level must be between 500-750 lx for the studios (CIBSE, 1994). The illumination level in section A is above the standards in both measurements, section B meets the standards at 11:00 am and under the standards at 4:00 pm. Section C and D do not meet the standards for both measurements. Section E is above the standards at 11:00 am and meets the standards at 4:00 pm.

60% of group A reported that the color of light prevents them while studying, whereas 40% stated that it does not. 67% of group B indicated as it does and 33% as it does not. 63% of group C indicated as it does not, 37% as it does. 50% of group D indicated as it does and 50% as it does not. 100% of group E said it does. Most of the participants of all the groups responded that the color of light prevents them while studying.

60% of group A indicated that the shadows in their study area prevents them while studying, 40% as it does not. 67% of group B said it does and 33% stated that it does not. 63% of group C indicated as it does, 37% as it does not. 100% of group D said it does. 50% of group E responded that it does and 50% said it does not. Most of the students in all groups indicated that the shadows in their study area prevents them while studying.

100% of group A reported that glare prevents them while studying. 67% of group B indicated that it does and 33% as it does not. 88% of group C mentioned that it does and 12% said it does not. 100% of group D stated that it does. 50% of group E indicated as it does and 50% as it does not. Most of the students in all groups stated that glare prevents them while studying.

"If there is glare, what do you think, is the reason behind it?"

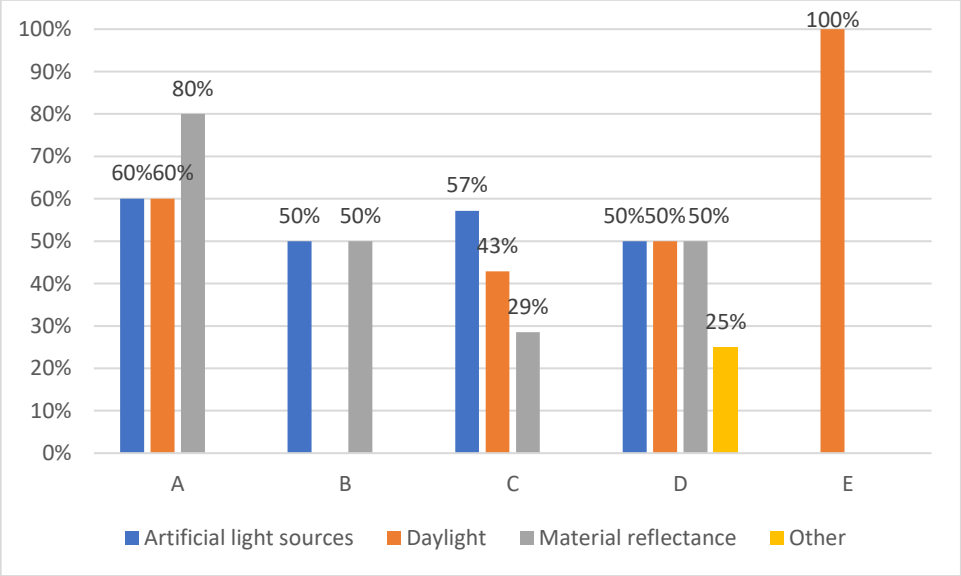
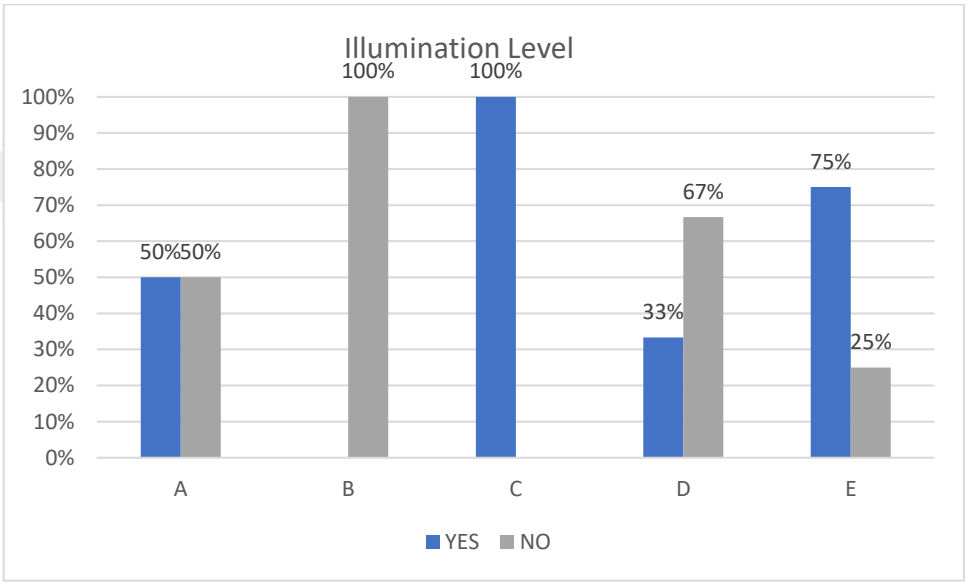
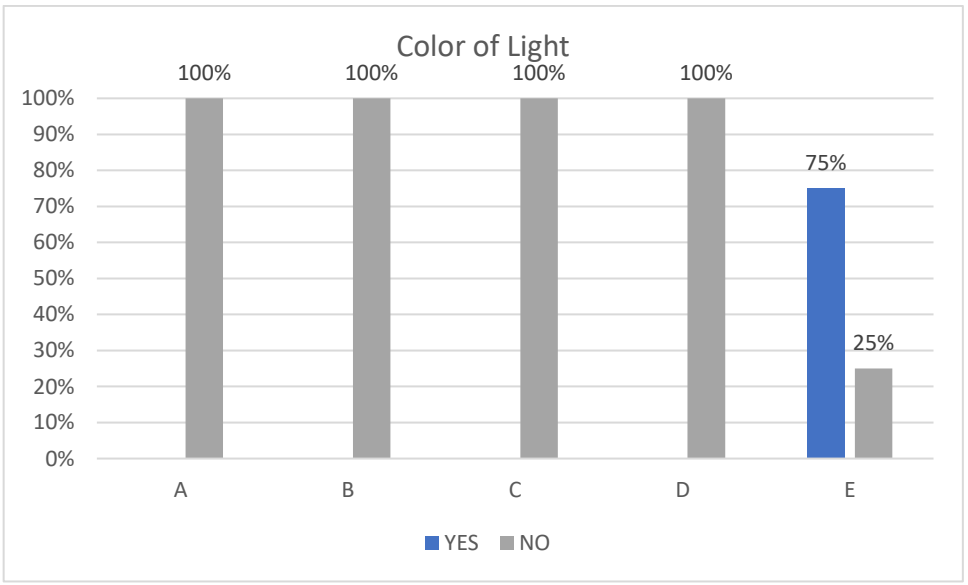


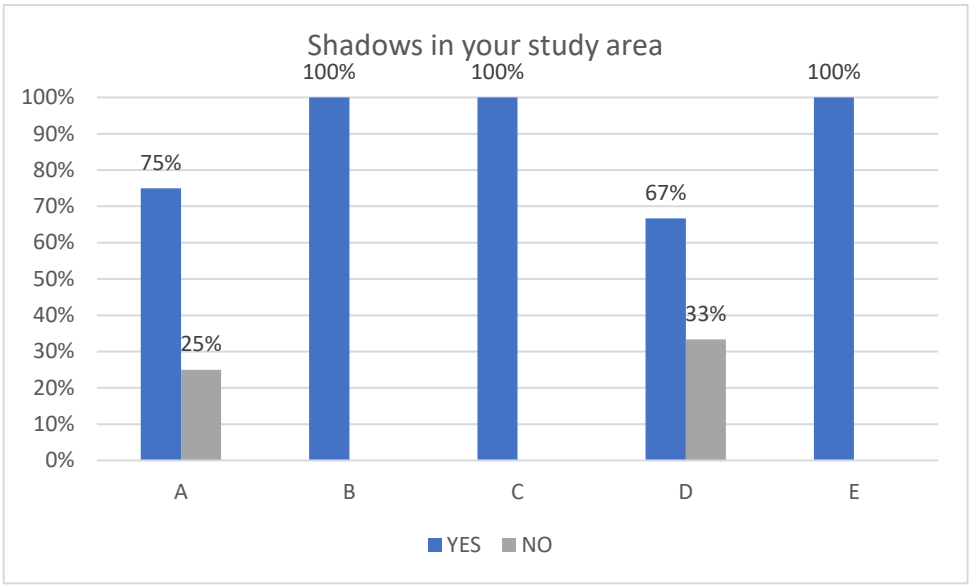
Figure 4.20. The evaluation of the source of glare by the students of studio B208.

53% of the students reported that the reason behind glare is artificial light sources, 47% indicated as daylight and material reflectance and 5% as other. 60% of group A indicated that the reason behind glare is daylight and artificial light sources, 80% as material

reflectance. 50% of group B indicated as artificial light sources and material reflectance. 57% of group C responded as artificial light sources, 43% as daylight, and 29% as material reflectance. 50% of group D indicated as artificial light sources, daylight, and material reflectance, while 25% responded as other. The student who responded as other stated that “My eyes get tired because of the artificial lighting in such a busy working environment”. This statement is also related with the artificial light sources. 100% of group E indicated as daylight.







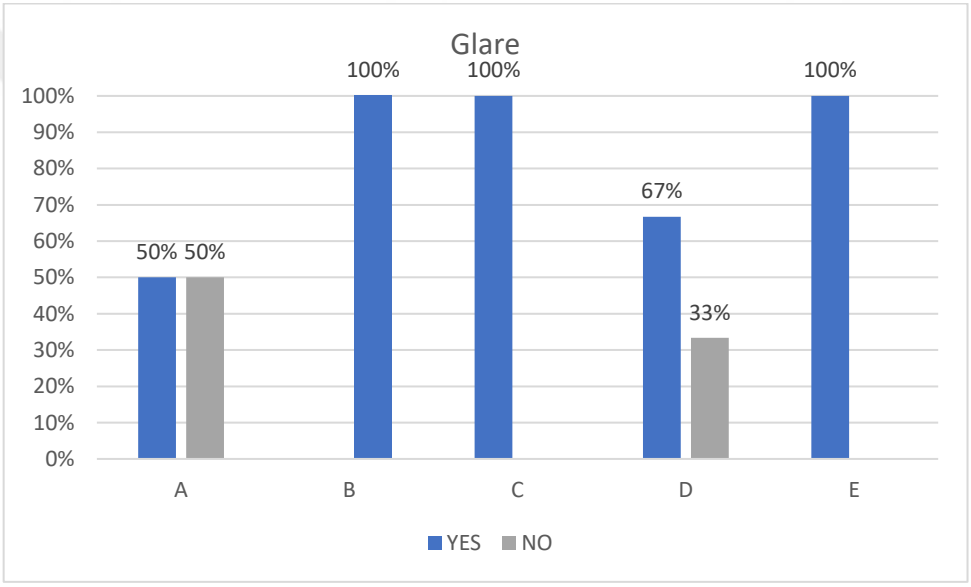


Figure 4.21. The evaluation of the lighting conditions in terms of visual comfort in studio B207; a) illumination level, b) color of light c) shadows in their study area, d) glare.

50% of group A suggested that the illumination level prevents them while studying, whereas 50% stated that it does not. 100% of group B said it does not. 100% of group C reported that it does. 67% of group D indicated as it does not and 33% as it does. 75% of group E indicated as it does and 25% as it does not. According to the standards, the illumination level must be between 500-750 lx for the studios (CIBSE, 1994). The illumination level in section B, C, and D is under the standards. However, while group C stated that the illumination level prevents them during studying, group B and D stated that it does not prevent them. Individual differences were observed for group B and D.

100% of group A, B, C, and D reported that the color of light does not prevent them while studying. 75% of group E indicated as it does and 25% as it does not. Most of the students stated that the color of light does not prevent them while studying.

75% of group A indicated that the shadows in their study area prevents them while studying, 25% as it does not. 100% of group B and C stated that it does. 67% of group D said it does, while 33% reported that it does not. 100% of group E responded that it does. Almost all the students stated that the shadows in their study area prevents them while studying. Because B207 has the lowest daylight illumination and general illumination level compared to the other studios, there are very dark areas inside the studio. Thus, the percentages are higher in B207.

50% of group A suggested that glare prevents them while studying and 50% said that it does not. 100% of group B and C reported that it does. 67% of group D indicated that it does and 33% stated that it does not. 100% of group E responded that it does. Most of the students indicated that glare prevents them while studying.

"If there is glare, what do you think, is the reason behind it?"

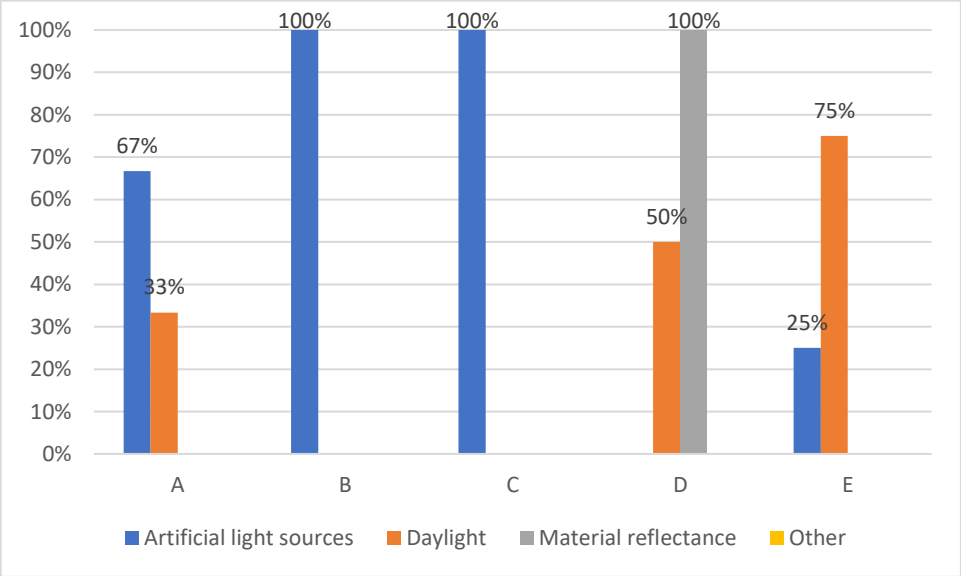


Figure 4.22. The evaluation of the source of glare by the students of studio B207.

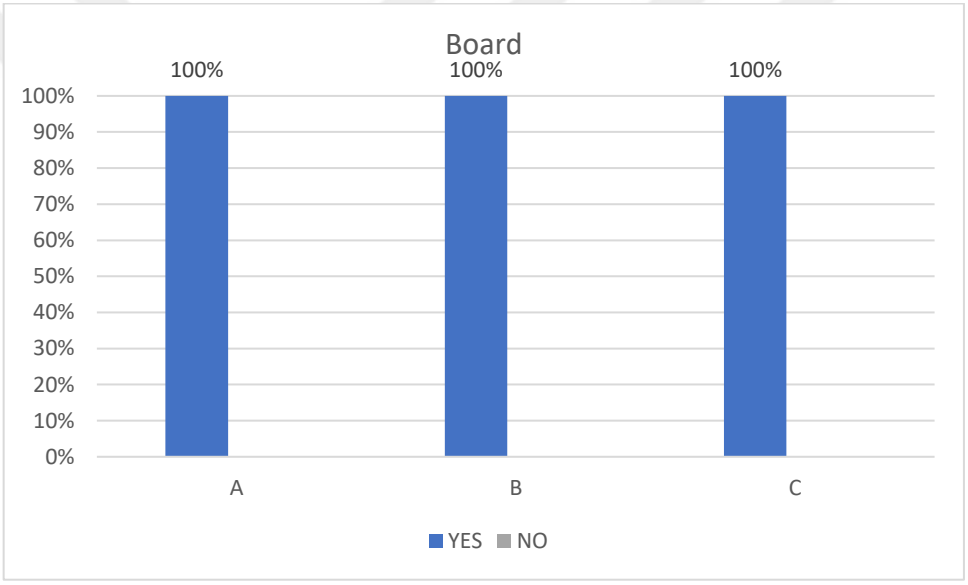
56% of the students indicated that the reason behind glare is artificial light sources and daylight, while 22% indicated as material reflectance. 67% of group A indicated that the reason behind glare is artificial light sources and 33% indicated as daylight. 100% of group B and C responded that the reason is artificial light sources.100% of group D

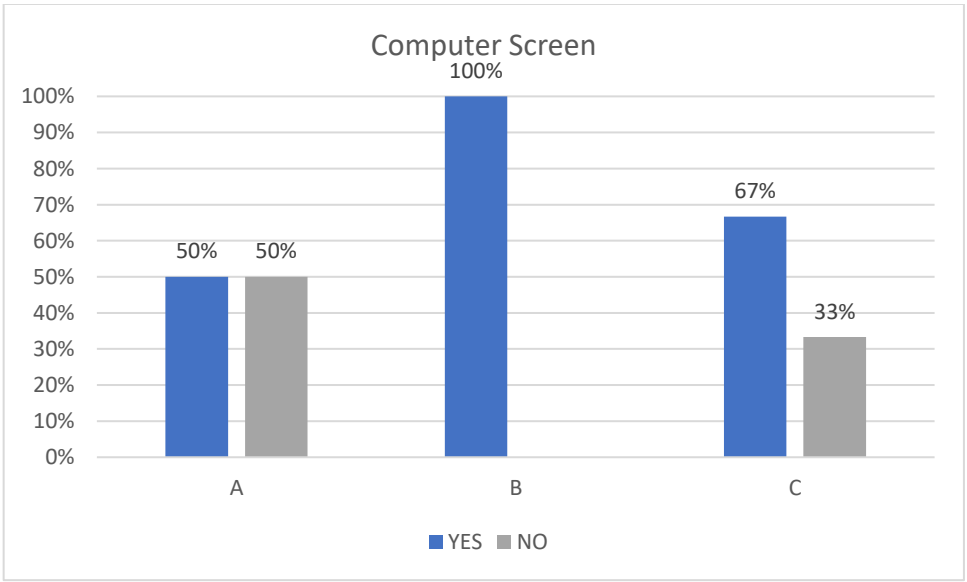
indicated as material reflectance and 50% as daylight. 75% of group E stated that the reason is daylight, while 25% indicated as artificial light sources.

4.2.2 Survey item 2: The evaluation of the existence of glare on surfaces/students' study areas

Q2: ***"****Did you notice any glare on the .....?"*

In the second question of this section, the participants were asked to evaluate the existence of glare on surfaces and their study areas: a) board, b) computer screen, c) desk, d) projection screen.





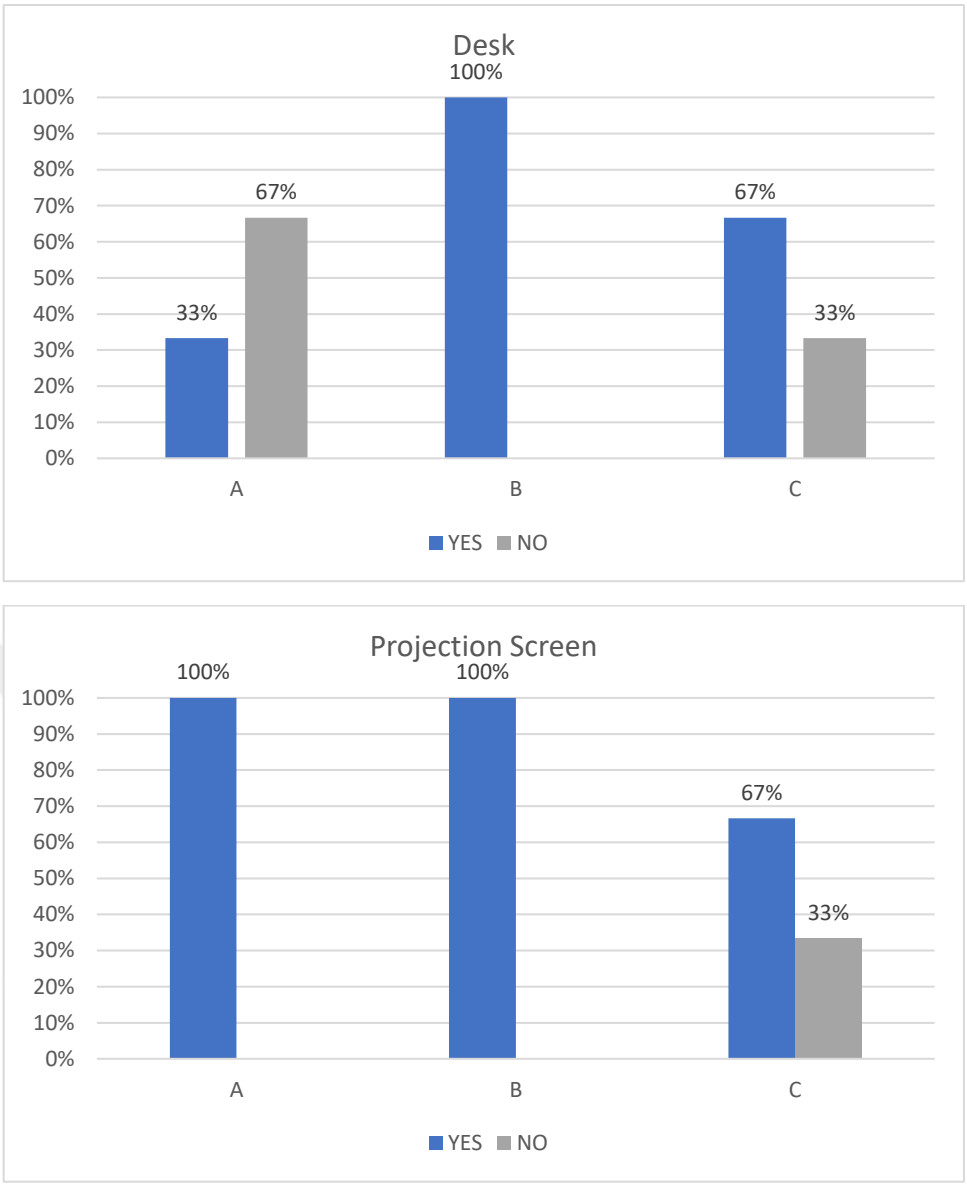


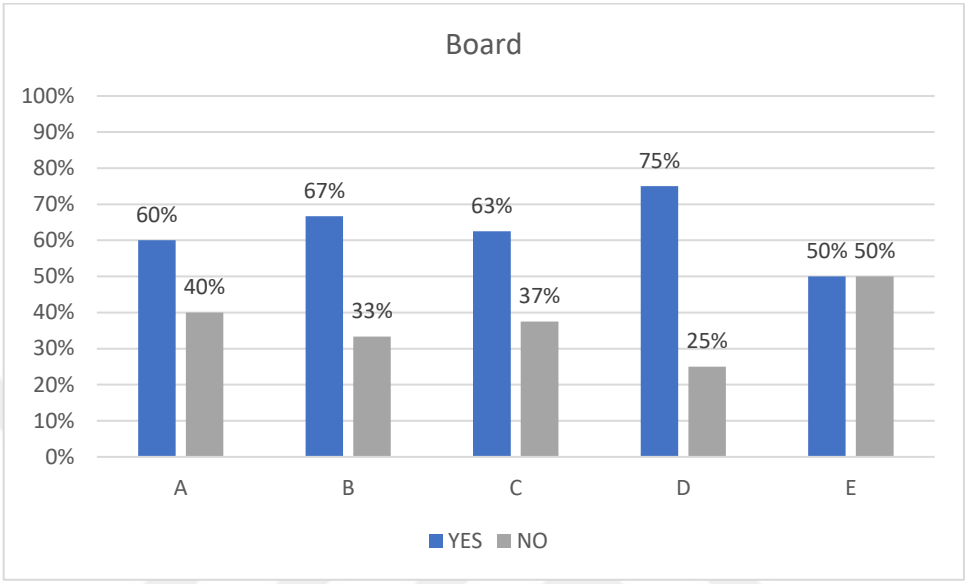
Figure 4.23. The evaluation of the existence of glare on) board, b) computer screen, c) desk, d) projection screen in studio A206.

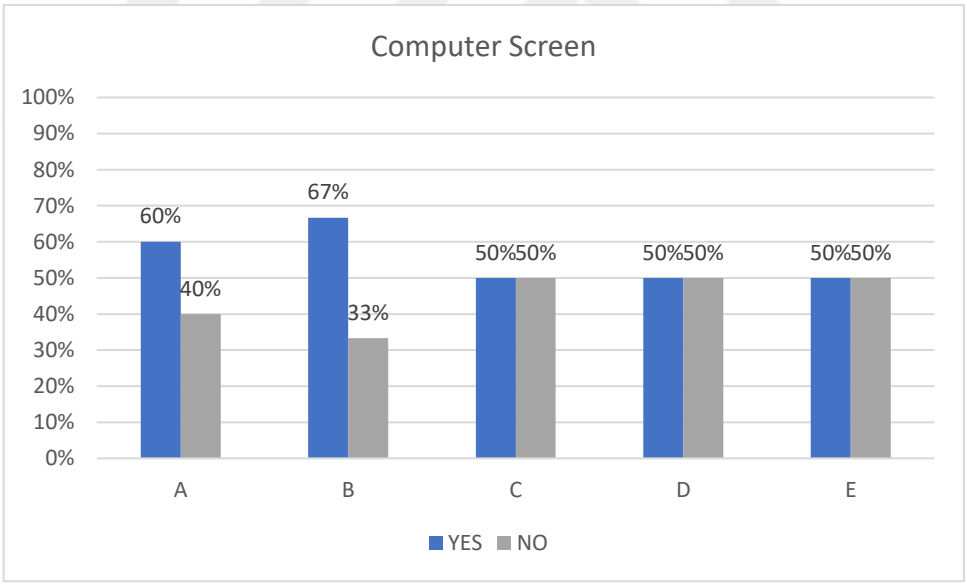
All the students reported that there is glare on the board.

50% of group A stated that there is glare on their computer screen while the other half indicated as there is not. 100% of group B said that there is glare. 67% of group C indicated as there is glare while 33% as there is not.

67% of group A reported that there is no glare on their desks, while 33% indicated as there is. 100% of group B responded that there is glare on their desks. 67% of group C indicated as there is, while 33% as there is not.

100% of group A and B stated that there is glare on the projection screen. 67% of group C also indicated as there is, while 33% stated that there is no glare on the projection screen.





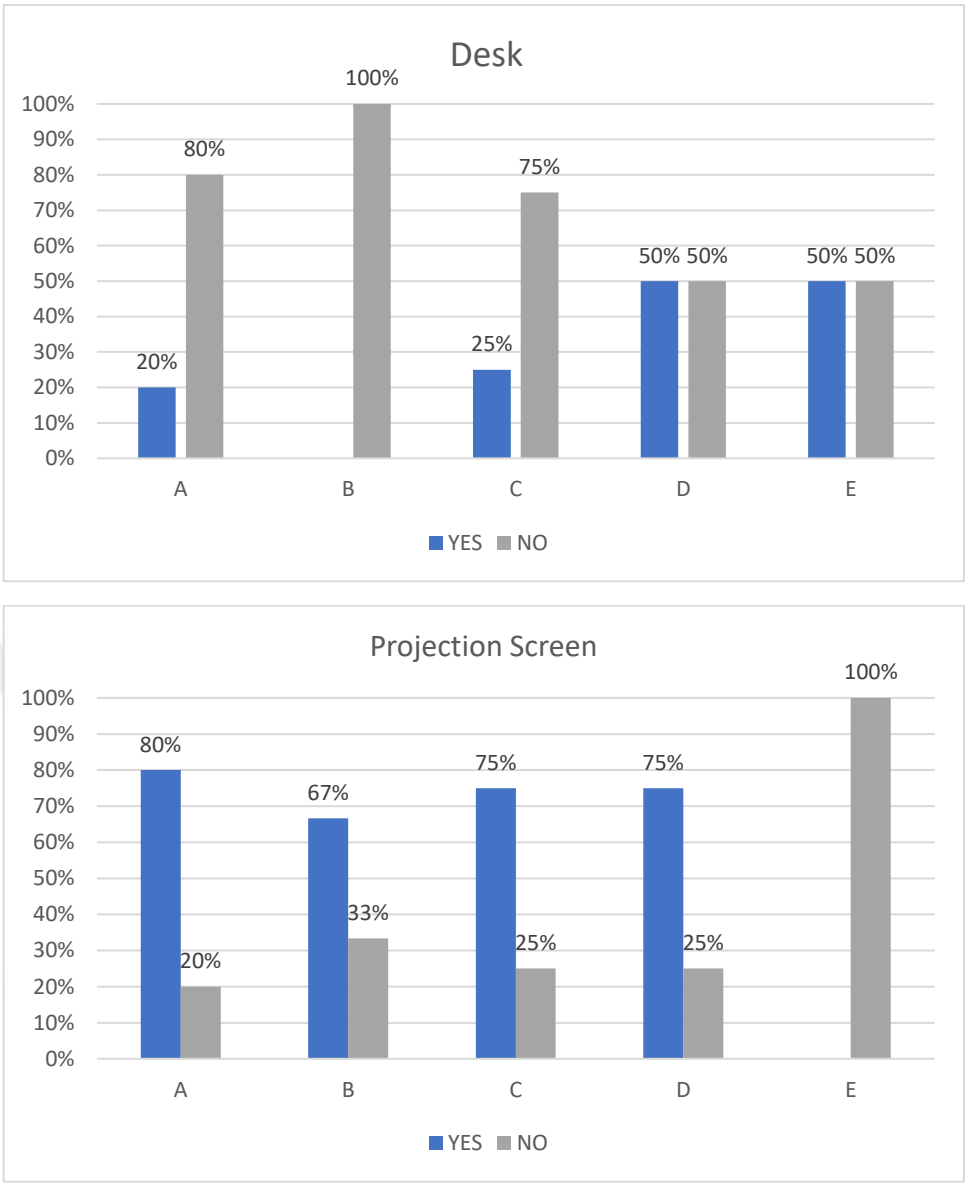


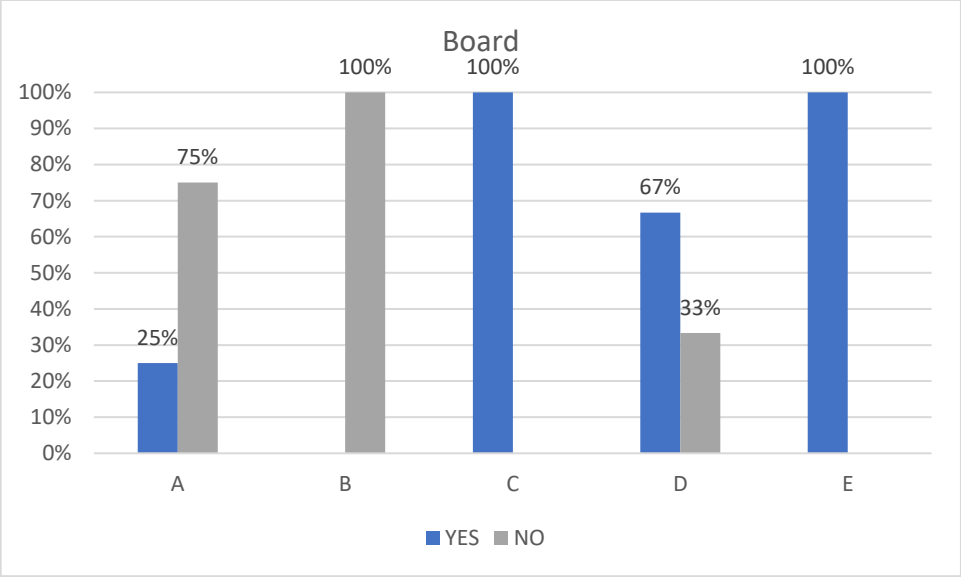
Figure 4.24. The evaluation of the existence of glare on) board, b) computer screen, c) desk, d) projection screen in studio B208.

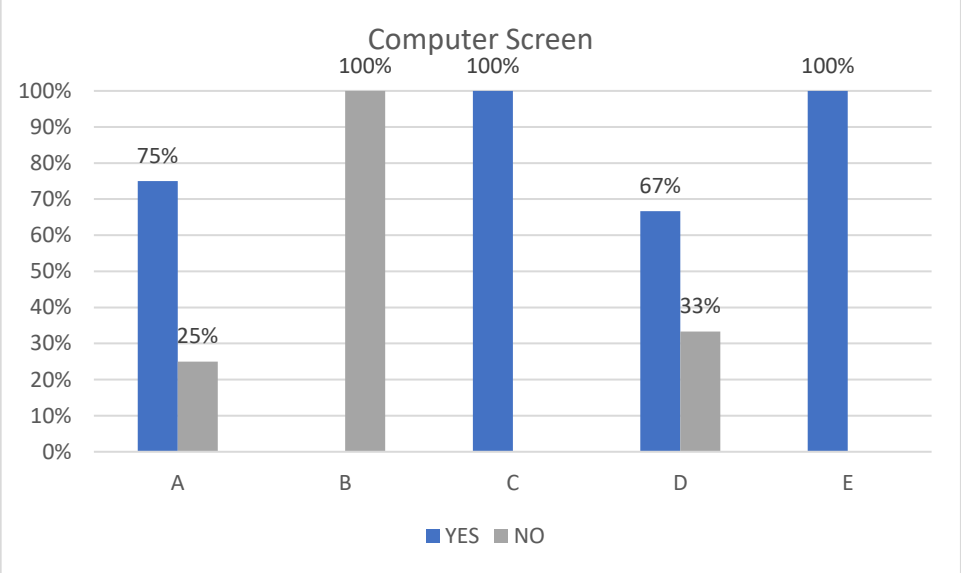
60% of group A reported that there is glare on the board, while 40% indicated as there is not. 67% of group B stated that there is, while 33% said that there is not. 63% of group C indicated as there is and 37% as there is not. 75% of group D stated that there is, while 25% said that there is not. 50% of group E indicated as there is and 50% as there is not.

60% of group A stated that there is glare on their computer screen, while 40% indicated as there is not. 67% of group B indicated that there is and 33% as there is not. 50% of group C indicated as there is, 50% as there is not. 50% of group D indicated as there is, 50% as there is not. 50% of group E said that there is, while 50% stated that there is not.

80% of group A indicated that there is no glare on their desks, 20% indicated as there is. 100% of group B stated that there is not. 75% of group C indicated as there is not, 25% as there is. 50% of group D indicated as there is and 50% as there is not. 50% of group E reported that there is glare on their desks, while 50% stated that there is not.

80% of group A responded that there is glare on the projection screen, while 20% stated that there is not. 67% of group B indicated as there is, 33% as there is not. 75% of group C indicated as there is, 25% as there is not. 75% of group D responded that there is, while 25% indicated as there is not. 100% of group E stated that there is not.





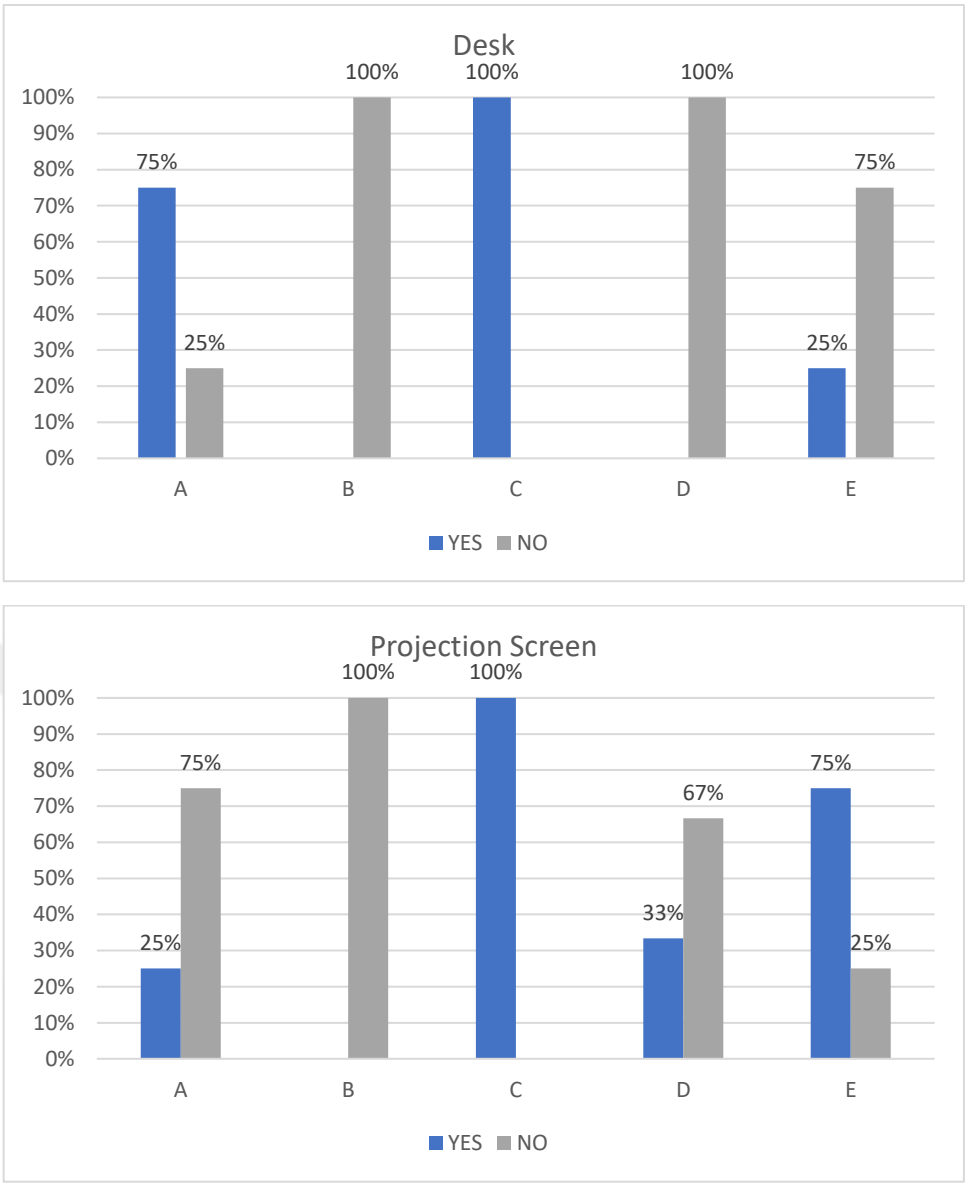


Figure 4.25. The evaluation of the existence of glare on) board, b) computer screen, c) desk, d) projection screen in studio B207.

75% of group A reported that there is no glare on the board, while 25% indicated as there is. 100% of group B stated that there is not. 100% of group C indicated as there is. 67% of group D indicated as there is, 33% as there is not. 100% of group E responded that there is glare on the board.

75% of group A stated that there is glare on their computer screen, while 25% indicated as there is not. 100% of group B reported that there is not. 100% of group C indicated as there is. 67% of group D indicated as there is, 33% indicated as there is not. 100% of group E indicated as there is.

75% of group A reported that there is glare on their desks, 25% indicated as there is not. 100% of group B said that there is no glare on their desks. 100% of group C stated that there is. 100% of group D indicated as there is not. 75% of group E indicated as there is not and 25% as there is.

75% of group A said that there is no glare on the projection screen, 25% indicated as there is. 100% of group B reported that there is not. 100% of group C indicated as there is. 67% of group D indicated as there is not, 33% as there is. 75% of group E indicated as there is, 25% as there is not.

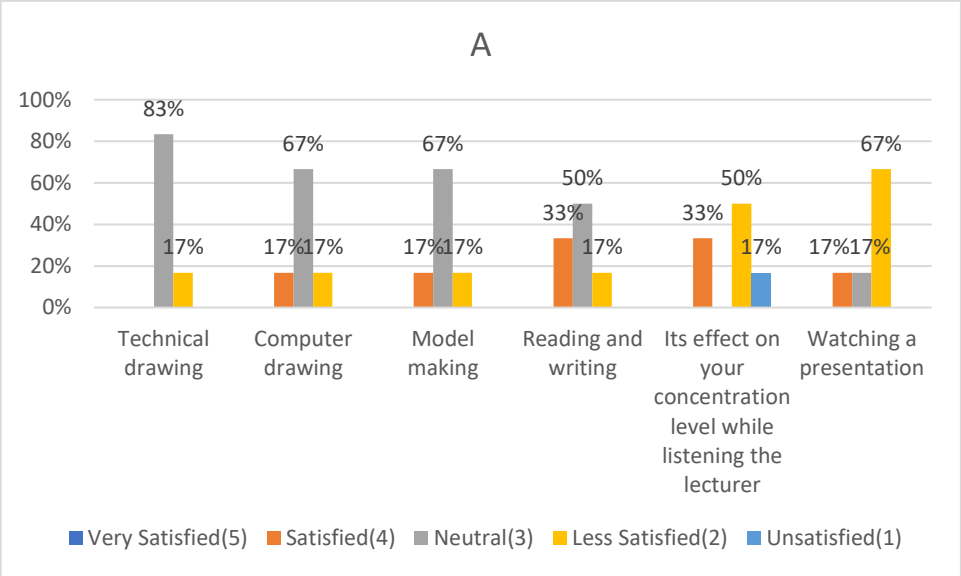
All the students in A206 and most of the students in B208 and B207 stated that there is glare on the board. Glare on the board is a very important visual problem. It may cause visibility problems while listening to the instructors when they use the board. It can have a negative impact on students' concentration levels. In studio A206 the window is much closer to the board, in B208 it is closer than B207.In B207, window is far from the board. Thus, while all the students in A206 stated as there is glare on the board, students in B208 made the same statement with high percentages, however the percentage is less in B207 compared the other two studios. Most of the students in all three studios also stated that there is glare on their computer screens. This may cause some visibility problems while studying with computer. The students also stated that there is glare on the projection screen with very high percentages. This is a very important problem because it may cause visibility problems while watching presentations. It can prevent students to concentrate to the presentations. Most of the students in all three studios did not indicate that there is glare on their desks.

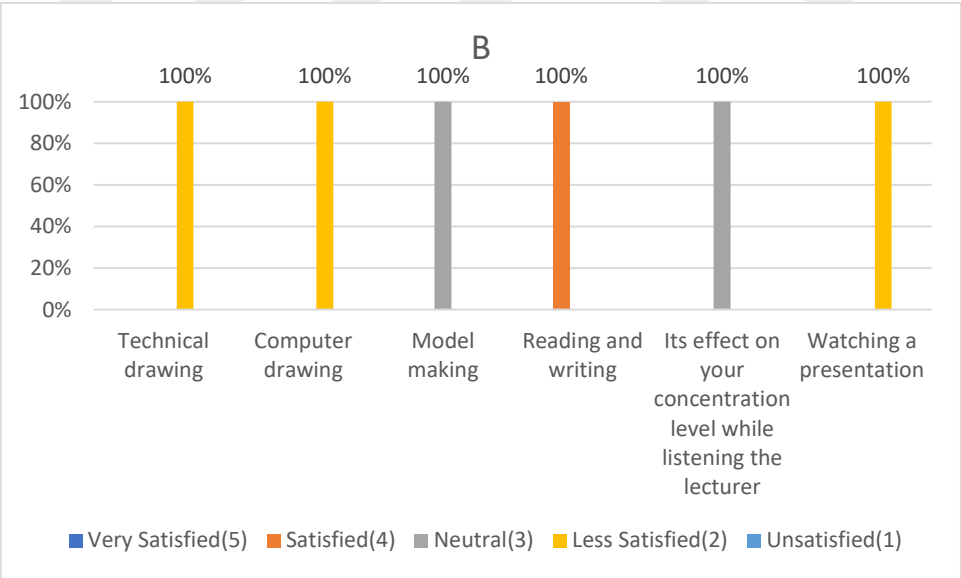
4.2.3 Survey item 3: The evaluation of the satisfaction levels of the students regarding the lighting conditions

Q3: "*Can you rate your satisfaction level with the lighting conditions between 1 to 5 according to each following task? (5-Very Satisfied, 4-Satisfied, 3-Neutral, 2-Less Satisfied, 1-Unsatisfied)"*

In question 3 of this section, the participants were asked to indicate their satisfaction levels regarding the lighting conditions of studios while working on such different tasks

as: a) technical drawing, b) computer drawing, c) making model, d) reading and writing and also its effect on their concentration levels while e) listening to the lecturer and f) watching a presentation. The options included “very satisfied (5)”, “satisfied (4)”, “neutral (3)”, “less satisfied (2)” and “unsatisfied (1).”





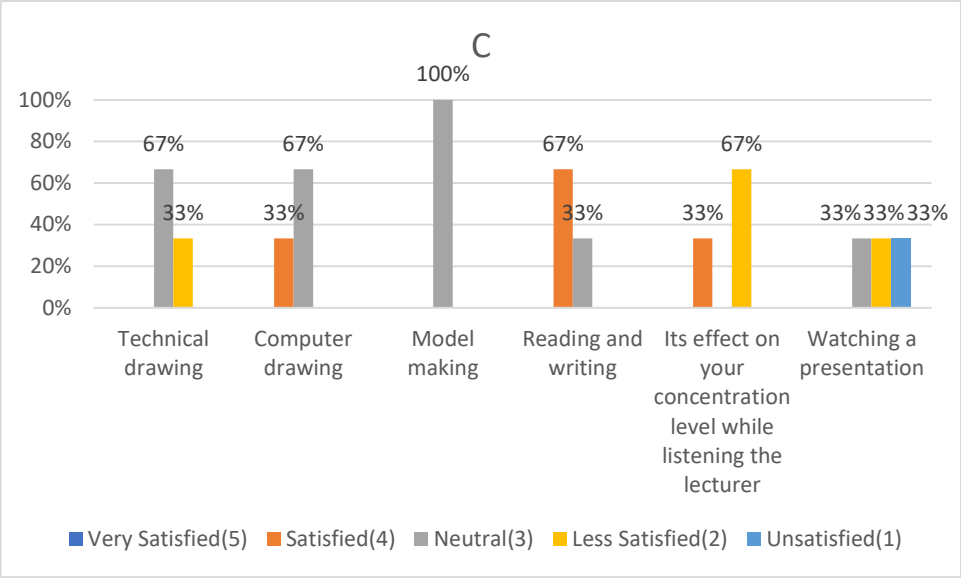


Figure 4.26. The satisfaction levels of group A, B and C regarding the lighting conditions in studio A206.

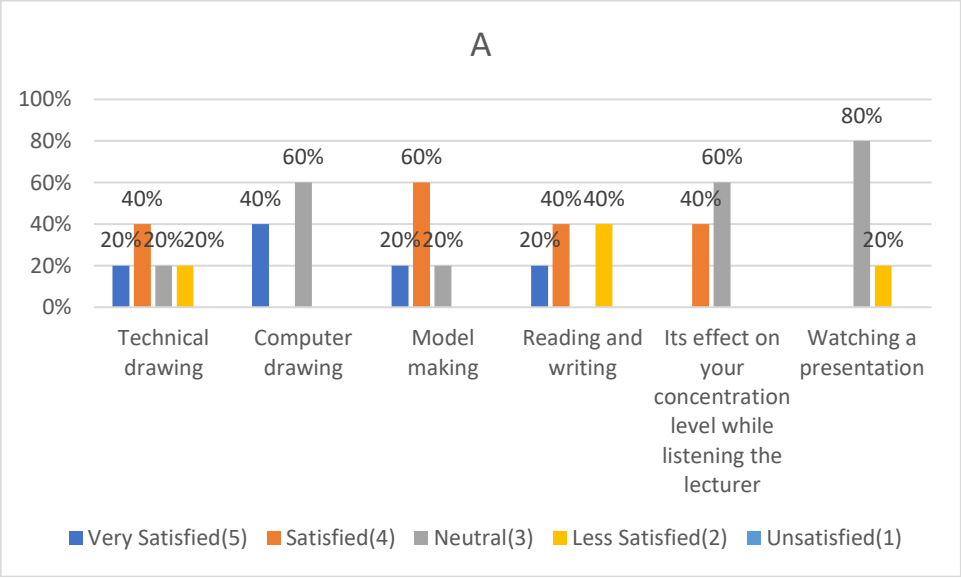
83% of group A indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings and 17% indicated as less satisfied. 67% of group A indicated as neutral for computer drawings, 17% indicated as less satisfied and 17% as satisfied. 67% of group A indicated as neutral for model making,17% indicated as less satisfied and 17% as satisfied. 50% of group A indicated as neutral for reading and writing, 33% indicated as satisfied and 17% as less satisfied. 50% of group A indicated as less satisfied for their concentration levels while listening the lecturer, 33% indicated as satisfied and 17% as unsatisfied. 67% of group A indicated as less satisfied for watching presentations, 17% as neutral and 17% as satisfied.

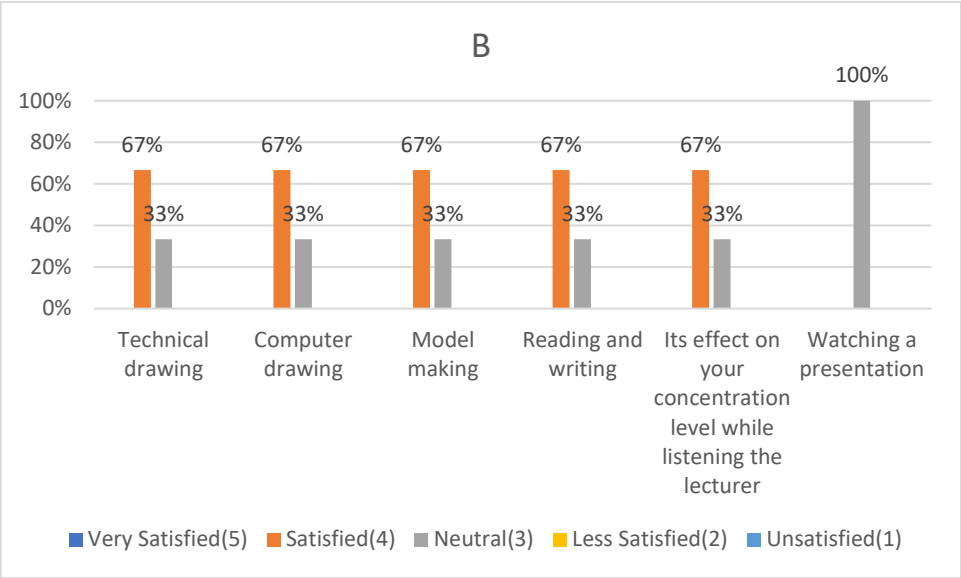
100% of group B indicated as less satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, computer drawings and watching presentations. 100% of group B indicated as neutral for model making and their concentration levels while listening the lecturer.100% of group B indicated as satisfied for reading and writing.

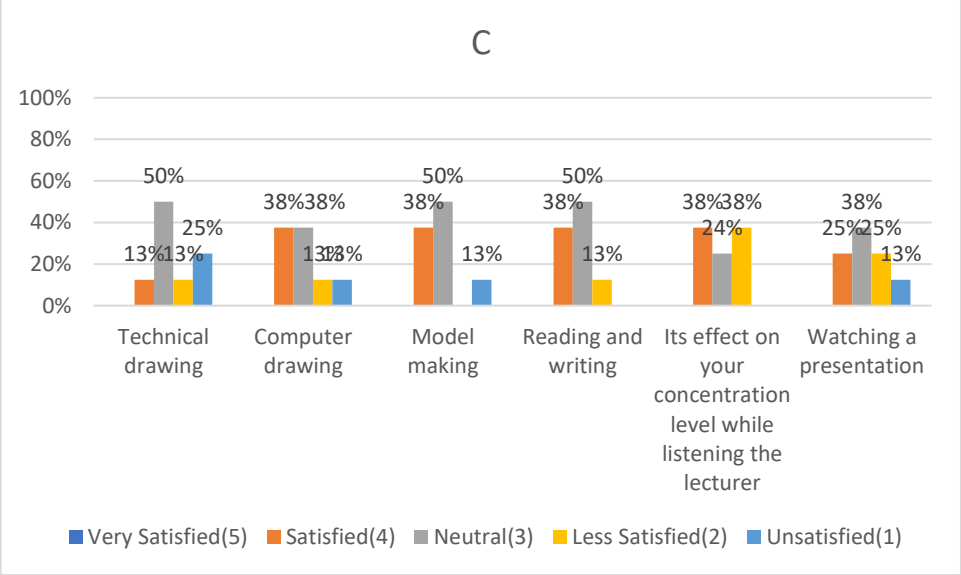
67% of group C indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings and 33% indicated as less satisfied. 67% of group C indicated as neutral for computer drawings, 33% indicated as satisfied. 100% of

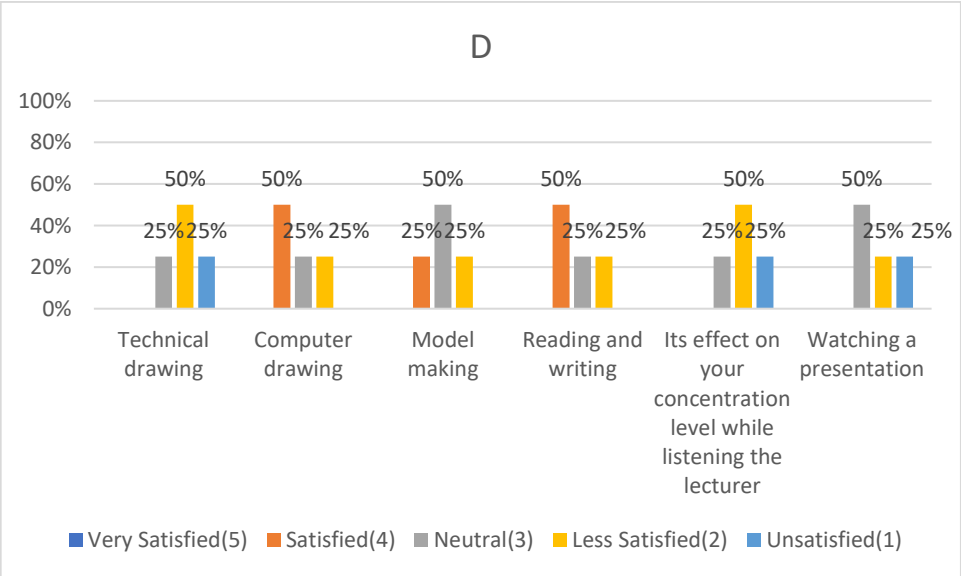
group C indicated as neutral for model making. 67% of group C indicated as satisfied for reading and writing,33% indicated as neutral. 67% of group C indicated as less satisfied for their concentration levels while listening the lecturer,33% indicated as satisfied. 33% of group C indicated as neutral for watching presentations,33% as less satisfied and 33% as unsatisfied.

Thus, based upon the results, in studio A206, the satisfaction level of the students is mostly neutral regarding model making, computer drawing and technical drawing tasks. Only group B indicated “less satisfied” for computer drawing and technical drawing tasks. Group B found illumination level “normal” while studying with computer; however, they also state that there is glare on their computer screen. This might be the reason behind dissatisfaction of group B regarding computer drawing task. They find the illumination level dim for technical drawing; as parallel to their statement, group B is less satisfied with the lighting for technical drawing task. The students are mostly satisfied regarding lighting conditions for reading and writing. Many of them stated as “less satisfied” and “unsatisfied” regarding lighting conditions for watching presentations as well as its effects on their concentration levels while listening to the lecturer. A great majority of the students in this studio indicated that there is glare on the board and projection screen and that glare prevents them while studying. Glare may cause visual discomfort and thus concentration problems. Therefore, it is understandable that their concentration was negatively affected by the impact of glare.




B
100%
80%
60%
40%
20%
0%
67%
33%
100%
Technical drawing
Computer drawing
Model making
Reading and writing
Its effect on your concentration level while listening the lecturer
Watching a presentation
Very Satisfied(5)
Satisfied(4)
Neutral(3)
Less Satisfied(2)
Unsatisfied(1)


C
100%
80%
60%
40%
20%
0%
50%
25%
13%
38%
24%
Technical drawing
Computer drawing
Model making
Reading and writing
Its effect on your concentration level while listening the lecturer
Watching a presentation
Very Satisfied(5)
Satisfied(4)
Neutral(3)
Less Satisfied(2)
Unsatisfied(1)


D
100%
80%
60%
40%
20%
0%
50%
25%
Technical drawing
Computer drawing
Model making
Reading and writing
Its effect on your concentration level while listening the lecturer
Watching a presentation
Very Satisfied(5)
Satisfied(4)
Neutral(3)
Less Satisfied(2)
Unsatisfied(1)

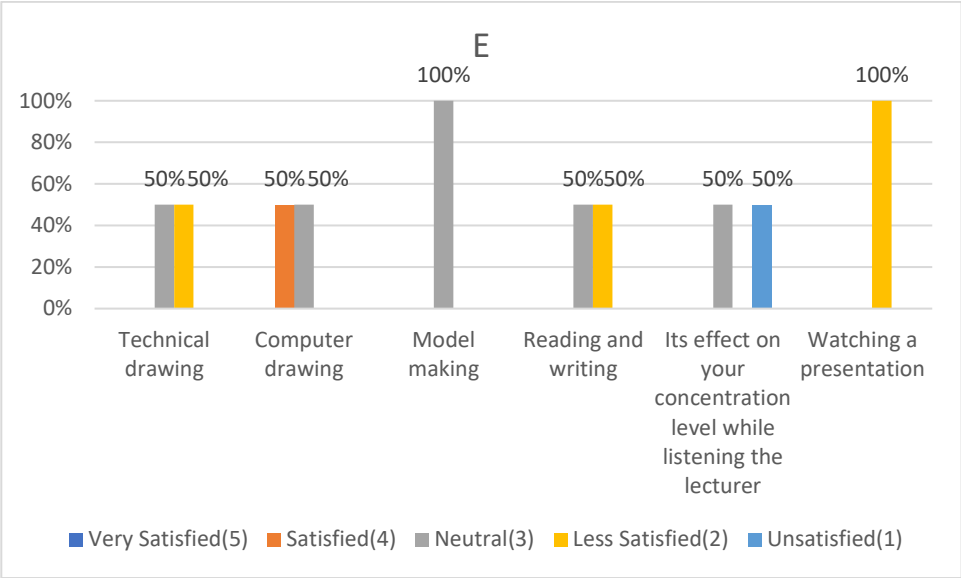


Figure 4.27. The satisfaction levels of group A, B, C, D and E regarding the lighting conditions in studio B208.

40% of group A indicated as satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, 20% indicated as very satisfied, 20% as neutral and 20% as less satisfied. 60% of group A indicated as neutral for computer drawings, 40% as very satisfied. 60% of group A indicated as satisfied for model making, 20% as very satisfied and 20% as neutral. 40% of group A indicated as satisfied for reading and writing, 40% as less satisfied and 20% as very satisfied. 60% of group A indicated as neutral for their concentration levels while listening the lecturer, 40% indicated as satisfied. 80% of group A indicated as neutral for watching presentations, 20% as less satisfied.

67% of group B indicated as satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, computer drawings, model making and reading and writing,33% neutral. 67% of group B indicated as satisfied for their concentration levels while listening the lecturer,33% as neutral.100% of group B indicated as neutral for watching presentations.

50% of group C indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings, 25% indicated as unsatisfied, 13% as less satisfied and 13% as satisfied. 38% of group C indicated as neutral for computer

drawings, 38% indicated as satisfied, 13% as less satisfied and 13% as unsatisfied. 50% of group C indicated as neutral for model making,38% as satisfied and 13% as unsatisfied. 50% of group C indicated as neutral for reading and writing, 38% as satisfied and 13% as less satisfied. 38% of group C indicated as less satisfied for their concentration levels while listening the lecturer, 38% as satisfied and 24% as neutral. 38% of group C indicated as neutral for watching presentations, 25% as satisfied, 25% as less satisfied and 13% as unsatisfied.

50% of group D indicated as less satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, 25% indicated as unsatisfied and 25% as neutral. 50% of group D indicated as satisfied for computer drawings ,25% as neutral and 25% as less satisfied. 50% of group D indicated as neutral for model making, 25% as satisfied and 25% as less satisfied.50% of group D indicated as satisfied for reading and writing, 25% as neutral and 25% as less satisfied. 50% of group D indicated as less satisfied for their concentration levels while listening the lecturer, 25% indicated as unsatisfied and 25% as neutral. 50% of group D indicated as neutral for watching presentations, 25% indicated as less satisfied and 25% as unsatisfied.

50% of group E indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings, 50% indicated as less satisfied. 50% of group E indicated as satisfied for computer drawings, 50% indicated as neutral.100% of group E indicated as neutral for model making. 50% of group E indicated as neutral for reading and writing, 50% indicated as less satisfied. 50% of group E indicated as neutral for their concentration levels while listening the lecturer, 50% indicated as unsatisfied. 100% of group E indicated as less satisfied for watching presentations.

In studio B208, the satisfaction levels differ according to each group and task. Considering the responses to the second question of the lighting conditions section, the responses are parallel to each other between those two questions.

Group A mostly find illumination level normal for all tasks. As parallel to their statements, they are satisfied with technical drawing, model making and reading/writing tasks. However, 60% of them selected the option “neutral” for computer drawing. 60%

of group A stated that there is glare on their computer screens. This might be the reason why they stated “neutral” for computer drawing task.

67% of group B stated that the illumination level does not prevent them while studying. That is why, even they indicated as dim for technical drawing and reading/writing tasks, they stated that they are satisfied with the lighting conditions regarding those tasks.

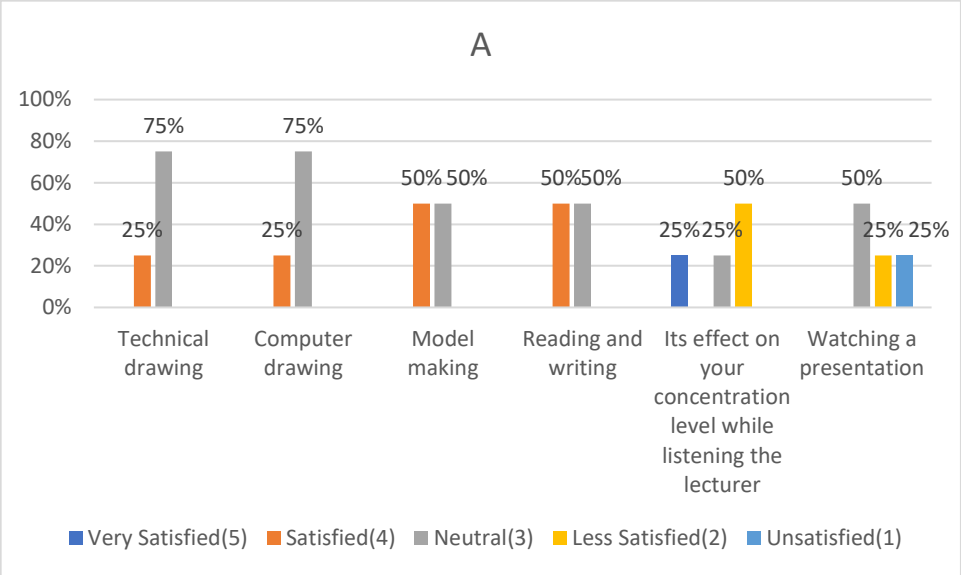
Group C mostly found the illumination level normal for all the tasks except technical drawing. They mostly stated as neutral and some of them as satisfied for their satisfaction levels regarding each task. As for technical drawings, a significant number of students stated that they are not satisfied with the lighting conditions.

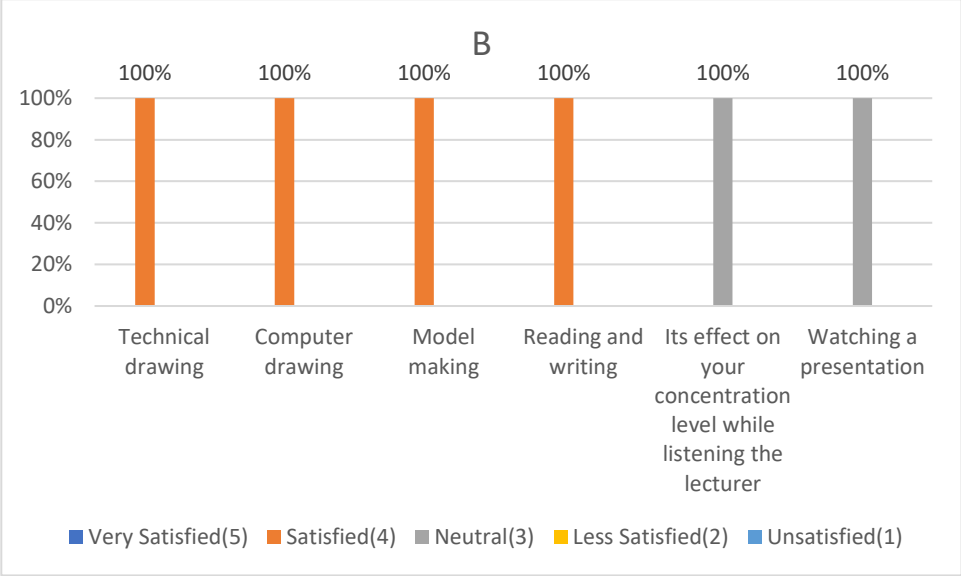
The responses of group D are pretty much parallel with their evaluation regarding the illumination levels. It has been observed that while some of the students find the illumination dim or normal, they remained with the option neutral for their satisfaction levels.

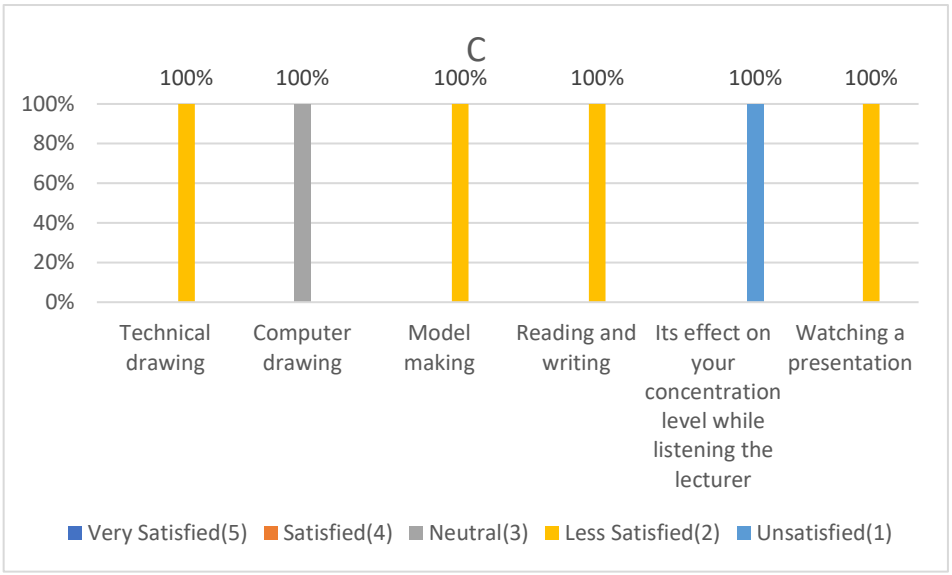
Group E also responded to this question as parallel to their illumination level perception. They remained neutral for some of the tasks for which they indicated the illumination level as “normal” and “bright.” For reading and writing tasks, half of them stated that the illumination was “bright” while the other half indicated as “normal.” The participant who stated as bright, reported as less satisfied for his/her satisfaction level. It was observed that the high level of light caused dissatisfaction for the participant. All of the participants in group E stated as “normal” for the illumination level regarding technical drawing tasks. However, half of them indicated as “less satisfied” regarding this task. They reported that there is glare on the desk in the previous question. The glare on the desk might be the reason behind dissatisfaction of the participants.

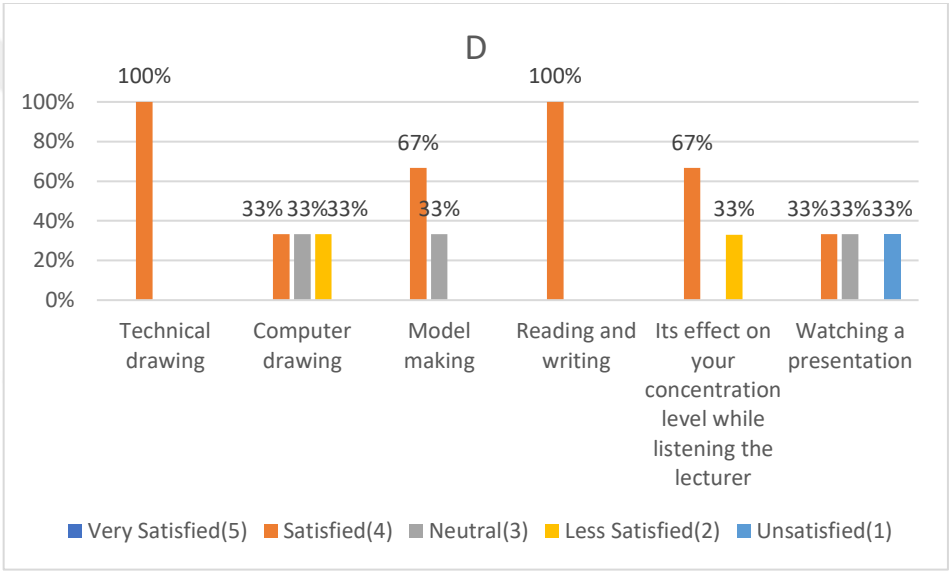
For watching presentations, most of the students stated as neutral and there are some participants who indicated as “less satisfied” with a significant percentage. Most of the students also find the illuminance on projection screen as “dim.” The students also reported that there is glare on the projection screen. Generally, the students are “neutral” or “less satisfied” regarding the effects of lighting conditions on their concentration levels while listening to the lecturer.

Group A is the only group that was found to be “very satisfied” with significant percentages for all tasks. Because the illumination level in their section is above 800 lx during the entire day (11:00-16:00), they do not face problems regarding lighting insufficiency. They have the maximum illumination and daylight illuminance in all sections of all three studios. They also indicated as “normal” for the illumination levels in their section regarding each task.









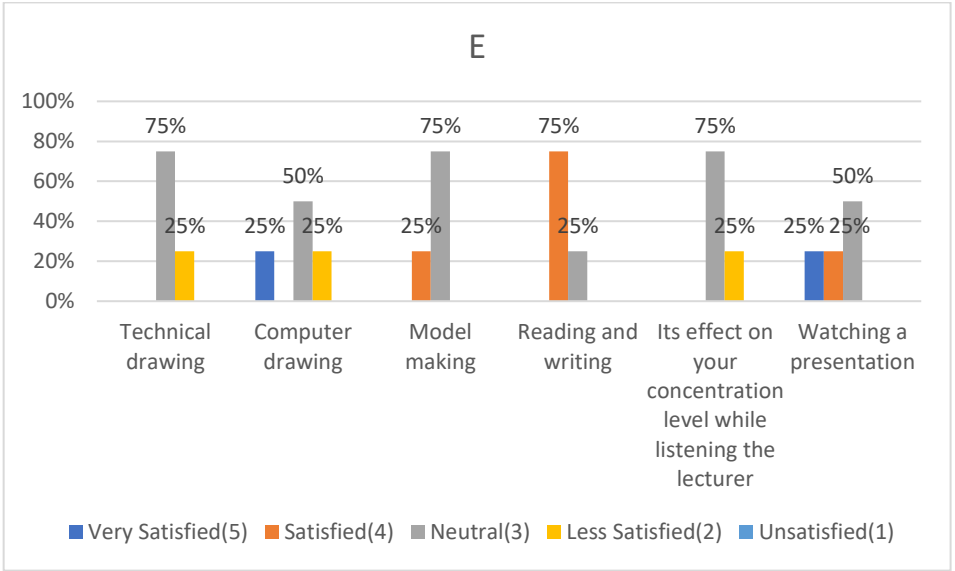


Figure 4.28. The satisfaction levels of group A, B, C, D and E regarding the lighting conditions in studio B207.

75% of group A indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings and computer drawings, 25% indicated as satisfied. 50% of group A indicated as satisfied for model making and reading and writing, 50% indicated as neutral. 50% of group A indicated as less satisfied for their concentration levels while listening the lecturer, 25% indicated as neutral and 25% as very satisfied. 50% of group A indicated as neutral for watching presentations, 25% indicated as less satisfied and 25% as unsatisfied.

100% of group B indicated as satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, computer drawings, model making and reading and writing. 100% of group B indicated as neutral for their concentration levels while listening the lecturer and watching presentations.

100% of group C indicated as less satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings, model making, reading, and writing and watching presentations.100% of group C indicated as neutral for computer drawings. 100% of group C indicated unsatisfied for their concentration levels while listening the lecturer.

100% of group D indicated as satisfied in terms of their satisfaction levels regards to the lighting conditions during technical drawings. 33% of group D indicated as satisfied for computer drawings, 33% indicated as neutral and 33% as less satisfied. 67% of group D indicated as satisfied for model making, 33% indicated as neutral.100% of group D indicated as satisfied for reading and writing. 67% of group D indicated as satisfied for their concentration levels while listening the lecturer, 33% indicated as neutral. 33% of group D indicated as satisfied for watching presentations, 33% indicated as neutral and 33% as unsatisfied.

75% of group E indicated as neutral in terms of their satisfaction levels regards to the lighting conditions during technical drawings, 25% indicated as less satisfied. 50% of group E indicated as neutral for computer drawings, 25% indicated as very satisfied and 25% as less satisfied.75% of group E indicated as neutral for model making, 25% indicated as satisfied. 75% of group E indicated as satisfied for reading and writing, 25% indicated as neutral. 75% of group E indicated as neutral for their concentration levels

while listening the lecturer, 25% indicated as less satisfied. 50% of group E indicated as neutral for watching presentations, 25% indicated as satisfied and 25% as very satisfied.

In studio B207, the evaluation of the satisfaction level differs according to the groups and tasks. Considering the responses of the second question of the lighting conditions section, the responses are parallel to each other between those two questions.

Half of group A found the illumination "dim" for technical drawing, "normal" for computer studies and model making, "normal" and "bright" for reading and writing. Although half of the students indicated as "dim" for technical drawing, they mostly remained with the option "neutral." The participant who indicated as "bright" is satisfied regarding lighting conditions for this task. The students who indicated as "bright" are satisfied with lighting for reading/writing tasks as well. The ones who stated as "normal" for illumination levels stated as "neutral" for their satisfaction levels.

Group B found the illumination level "normal" for each task. As parallel to their statements, they are satisfied with lighting conditions for those tasks.

Group C found illumination level "dim" for technical drawing and model making. They indicated as "normal" for computer studies and reading/writing tasks. As parallel to their statements, they are "less satisfied" with lighting conditions for technical drawing and model making tasks. They stated as "neutral" for computer drawing and "less satisfied" for reading/writing tasks even they find illumination level "normal" for those tasks. Group C indicated that there is glare on their computer screens and desks and glare prevents them while studying. This may be the reason behind these statements.

Group D found the illumination level "normal" for each task except computer studies. For that task, they stated as "dim", "normal" and "bright" with an equal ratio. They are mostly satisfied with the lighting conditions for each task as parallel to their evaluations for the illumination levels.

Group E found the illumination level "dim" and "normal" for technical drawing and model making tasks with an equal ratio. They remained with the option "neutral" for those tasks with high percentages. For computer studies and reading/writing tasks, the

illumination was found to be “normal” for them. As parallel to their statements they are satisfied for reading/writing tasks. The reason for remaining with the option neutral for computer drawing task might be glare problem on their computer screens as they stated there is glare on their screens.

In general, the students are neutral regarding lighting conditions during presentations. The participants who indicated as “too bright”, “dim” and “too dim” are not satisfied. Generally, the students are neutral regarding the effects of lighting conditions on their concentration levels as well.

Section D has the least illumination level and section B does not meet the standards for some of the tasks like technical drawing and model making. However, in general, satisfaction and perception regarding to the illuminance in their surrounding area of group D and B is quite good. 67% of group D stated that the illumination level does not prevent them while studying. 33% of them also indicated that glare does not prevent them either. 33% of them stated that there is no glare on their computer screen and board, while the remaining 67% said that there is no glare on projection screen. All of them mentioned that there is no glare on the desk. Since most of them are not affected by the low illuminance in their study area and as they also do not observe glare on some surfaces, they are mostly satisfied with the lighting conditions in terms of their visual comfort and satisfaction. All the participants in group B stated that the illumination level does not prevent them while studying, and they observed no glare on the board, on their computer screen, desk, and projection screen. Examining the responses of these two groups, it has been found that they are satisfied with lighting conditions in their study area because illumination level does not prevent them even though the illuminance is low. Thus, individual differences have been observed regarding the perception of lighting in those two groups.

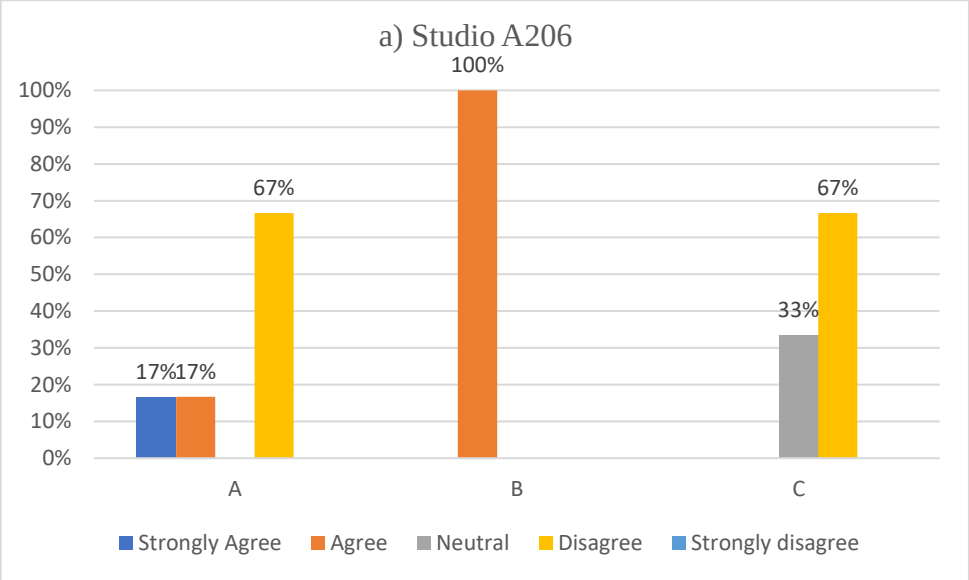
To sum up, when the students find the illumination level normal, bright, or dim, they may remain with the option neutral regarding their satisfaction levels. When the illumination is dim, they mostly indicate as less satisfied. When it is bright, they mostly indicate as they are satisfied. It is inferred that the illumination levels which exceed the standards do not disturb the students; on the contrary, the students may be satisfied with it. However, when the illumination level is low, they indicate as neutral or less satisfied for their satisfaction levels.

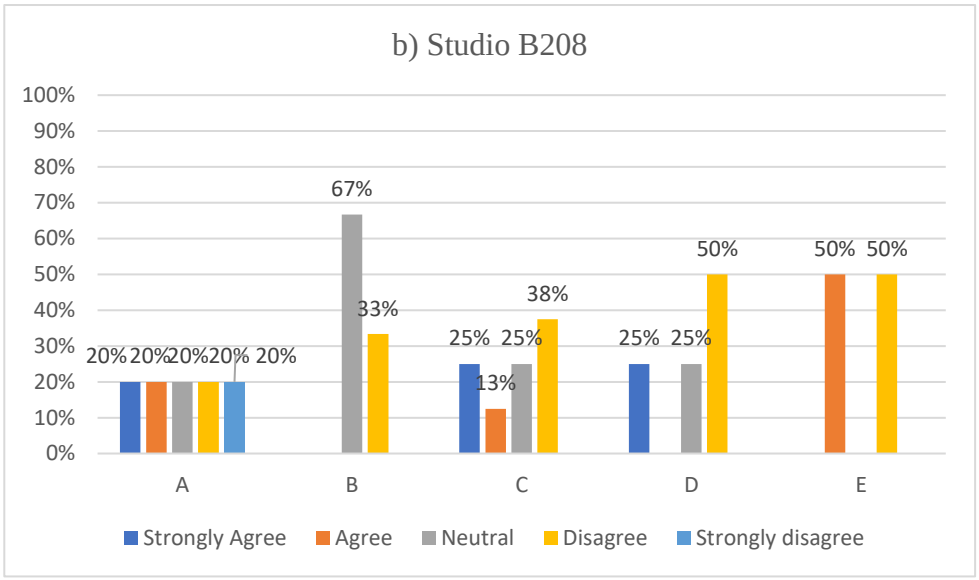
The results suggested that the responses of the participants regarding the evaluation of the illumination levels in question 2 of the lighting conditions section are parallel to their satisfaction levels regarding the lighting conditions. However, there are some cases when the students find the illumination enough but indicated as less satisfied. Those participants expressed some glare problems regarding the related tasks; thus, the reason behind their dissatisfaction might be glare. Therefore, glare could be a determining factor in their evaluation process of their satisfaction levels.

4.2.4 Survey item 4: The evaluation of the visual comfort and satisfaction of the students

In question 4 of this section, the participants were asked to respond to several questions to investigate their visual comfort and satisfaction levels regarding the lighting conditions; a) I do not like to study in this studio because of the lighting conditions, b) I do not like to study in this studio because of the lack of daylight and c) I do not like to study in this studio because of the artificial lighting conditions. The options included "strongly agree", "agree", "neutral", "disagree" and "strongly disagree."

a) "I do not like to study in this studio because of the lighting conditions".





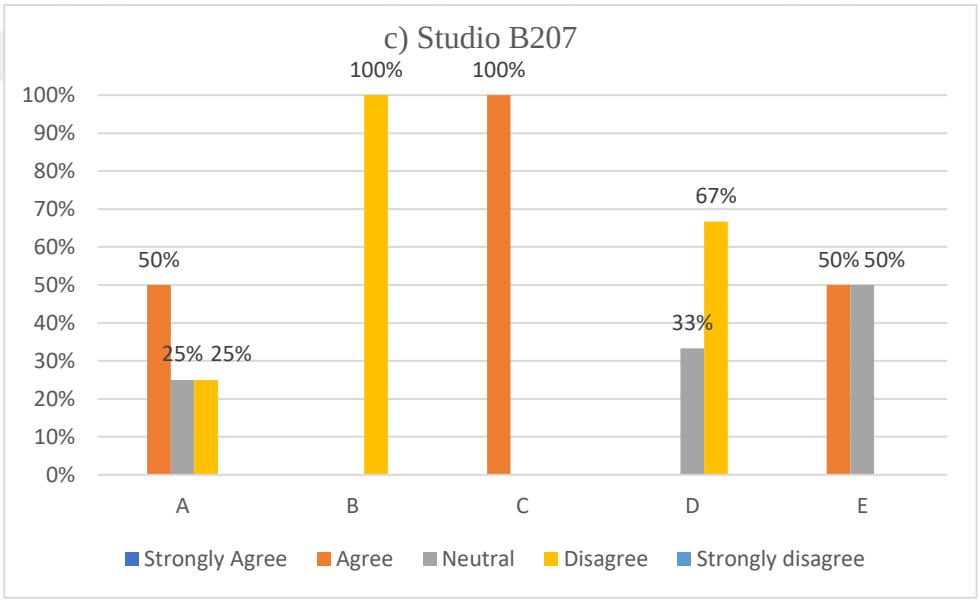


Figure 4.29. The effects of the lighting conditions on satisfaction of the students in studio a) A206, b) B208, c) B207.

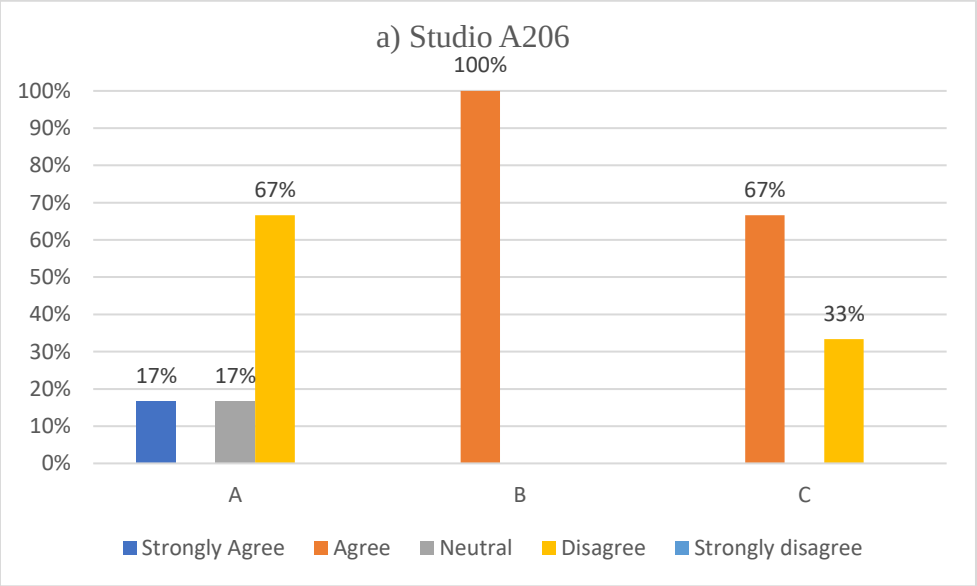
In studio A206, 67% of group A indicated as disagree, 17% as agree and 17% as strongly agree. 100% of group B indicated as agree. 67% of group C indicated as disagree, 33% as neutral.

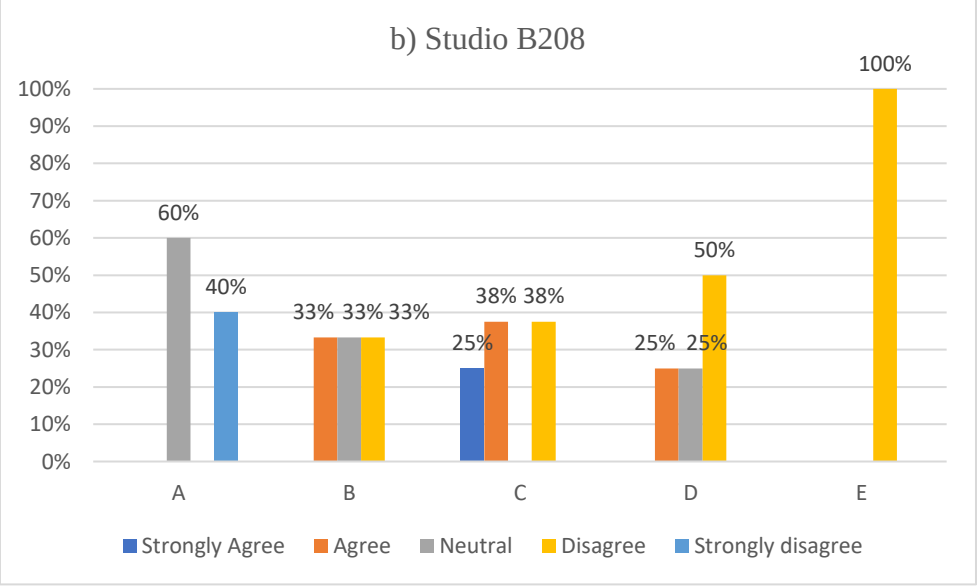
In studio B208, 20% of group A indicated as strongly agree, 20% as agree, 20% as neutral, 20% as disagree and 20% as strongly disagree. 67% of group B indicated as neutral, 33% as disagree. 38% of group C indicated as disagree, 25% as neutral, 25% as strongly agree and 13% as agree. 50% of group D indicated as disagree, 25% as neutral and 25% as

strongly agree. 50% of group E indicated as agree and 50% as disagree.

In studio B207, 50% of group A indicated as agree, 25% as neutral and 25% as disagree. 100% of group B indicated as disagree. 100% of group C indicated as agree. 67% of group D indicated as disagree, 33% as neutral. 50% of group E indicated as agree, 50% as neutral.

b) "I do not like to study in this studio because of the lack of daylight."





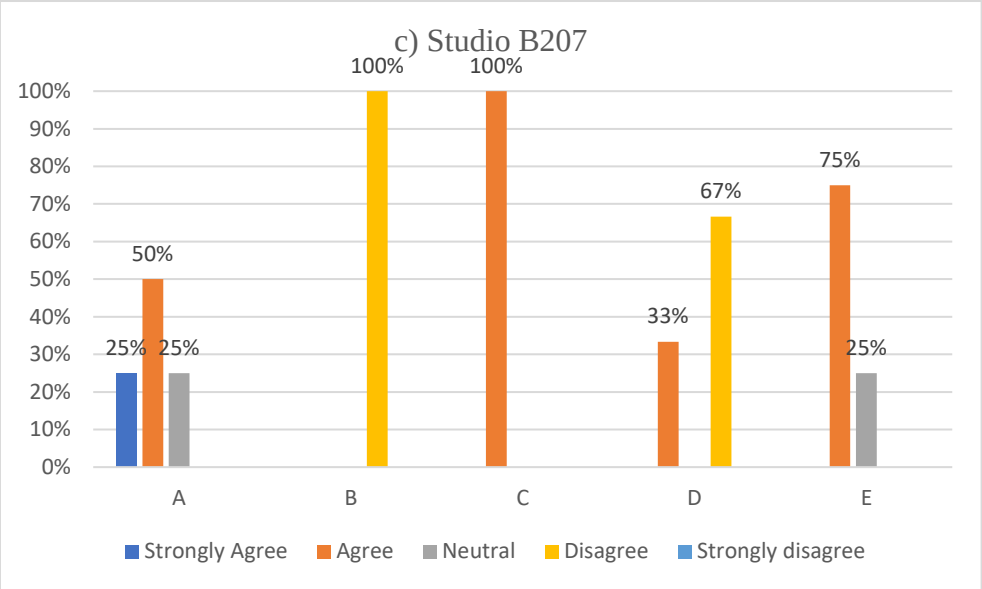


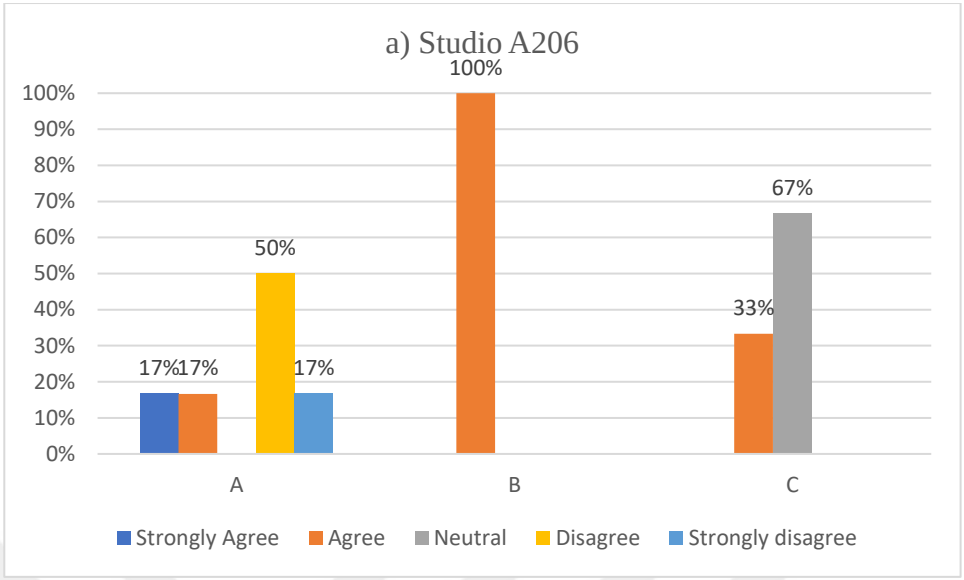
Figure 4.30. The effects of the lack of daylight on satisfaction of the students in studio a) A206, b) B208, c) B207.

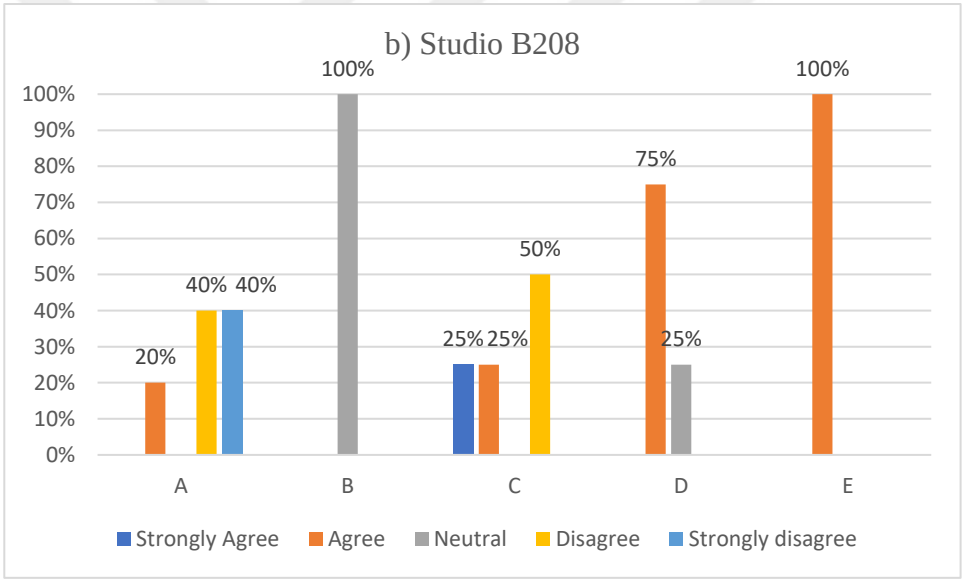
In studio A206, 67% of group A indicated as disagree, 17% as neutral and 17% as strongly agree. 100% of group B indicated as agree. 67% of group C indicated as agree, 33% as disagree.

In studio B208, 60% of group A indicated as neutral, and 40% as strongly disagree. 33% of group B indicated as agree, 33% as neutral and 33% as disagree. 38% of group C indicated as agree, 38% as disagree and 25% as strongly agree. 50% of group D indicated as disagree, 25% as neutral and 25% as agree. 100% of group E indicated as disagree.

In studio B207, 50% of group A indicated as agree, 25% as strongly agree and 25% as neutral. 100% of group B indicated as disagree. 100% of group C indicated as agree. 67% of group D indicated as disagree, 33% as agree. 75% of group E indicated as agree, 25% as neutral.

c) "I do not like to study in this studio because of the artificial lighting conditions."





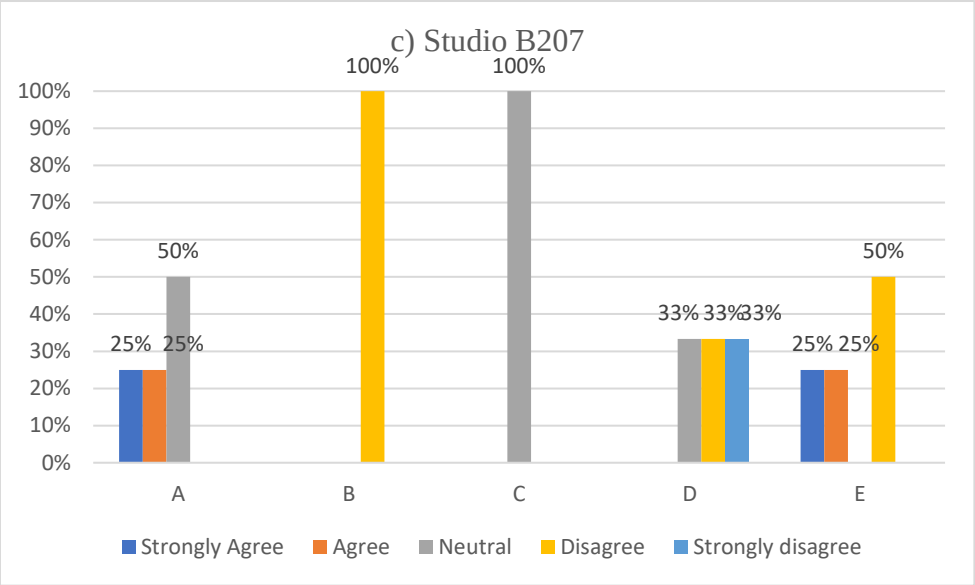


Figure 4.31. The effects of the artificial lighting conditions on satisfaction of the students in studio a) A206, b) B208, c) B207.

In studio A206, 50% of group A indicated as disagree, 17% as strongly disagree, 17% as strongly agree and 17% as agree. 100% of group B indicated as agree. 67% of group C indicated as neutral, 33% as agree.

In studio B208, 40% of group A indicated as strongly disagree, 40% as disagree, 20% as agree. 100% of group B indicated as neutral. 50% of group C indicated as disagree, 25% as agree and 25% as strongly agree. 75% of group D indicated as agree, 25% as neutral. 100% of group E indicated as agree.

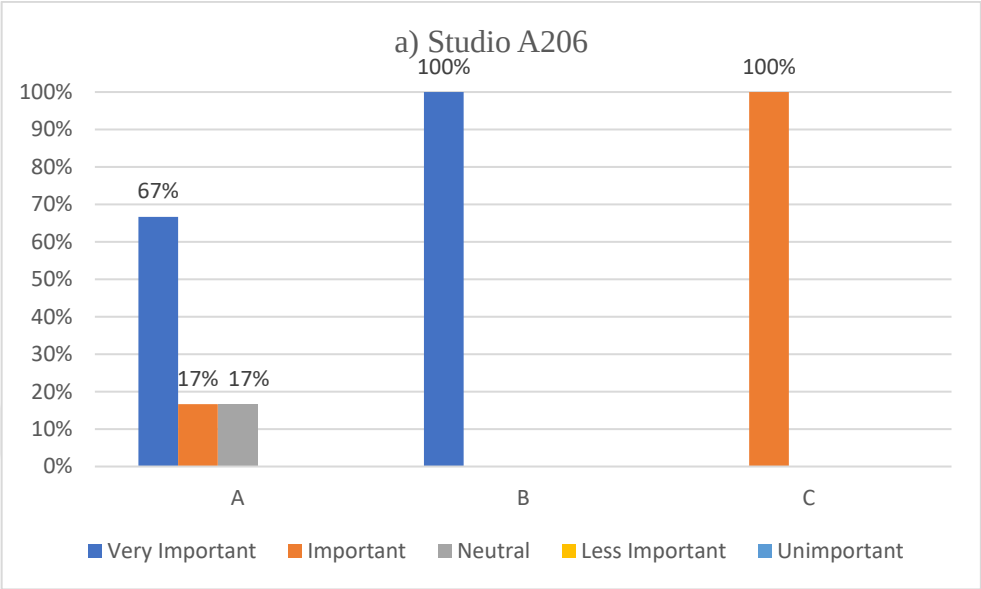
In studio B207, 50% of group A indicated as neutral, 25% as agree, and 25% as strongly agree. 100% of group B indicated as disagree. 100% of group C indicated as neutral. 33% of group D indicated as neutral, 33% as disagree, and 33% as strongly disagree. 50% of group E indicated as disagree, 25% as agree, and 25% as strongly agree.

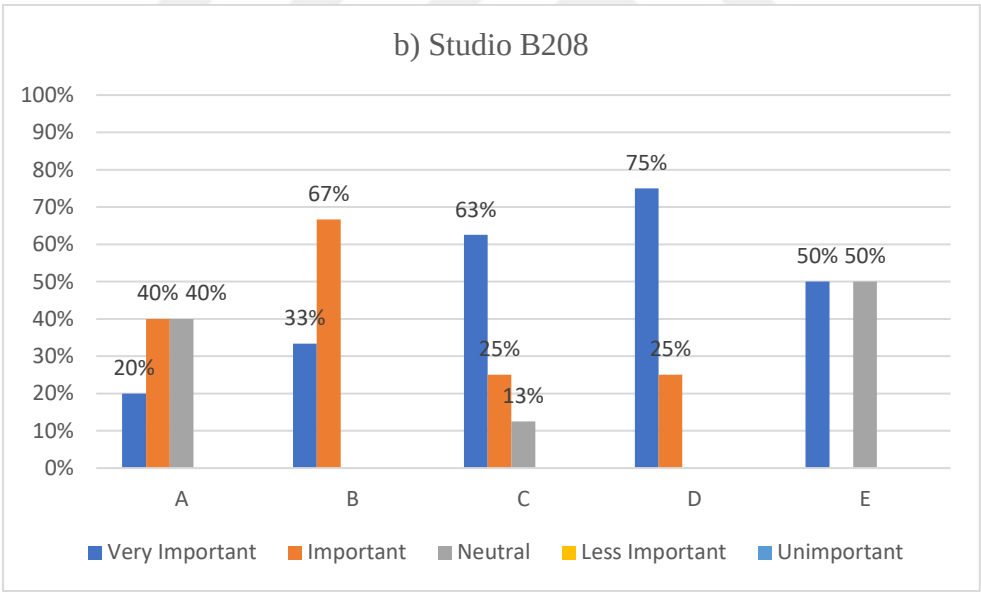
4.3. Section C: Motivation Level

4.3.1 Survey item 1 : The importance of lighting in terms of students' motivation levels

Q1: *"How important is lighting for your motivation level?"*

In the first question of this section of the survey, participants were asked to evaluate the importance of lighting for their motivation levels. The options included “very important”, “important”, “neutral”, “less important”, and “unimportant.”





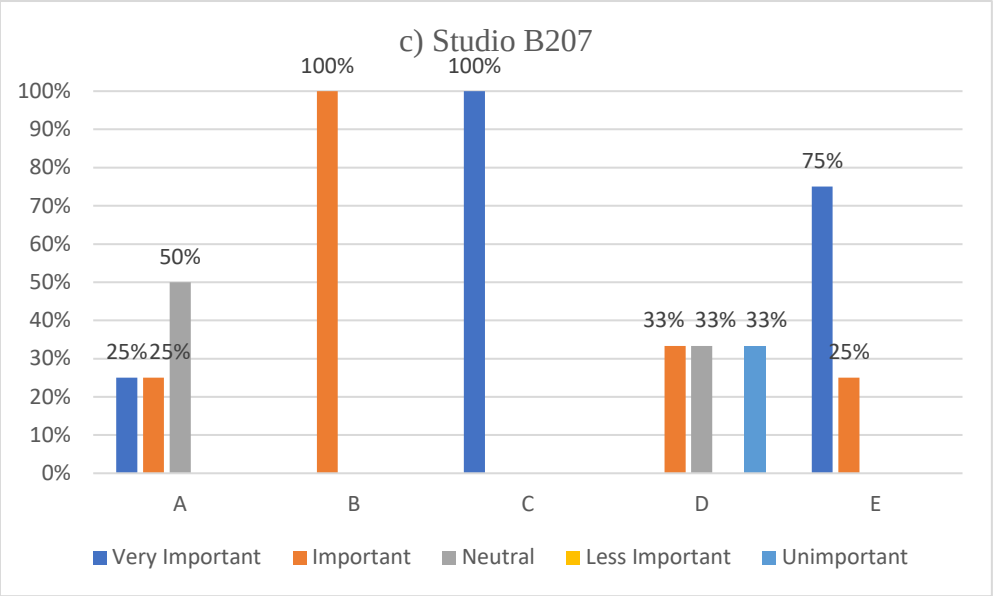


Figure 4.32. The importance of lighting for motivation levels of the students in studio a) A206, b) B208, c) B207.

In studio A206, 67% of group A indicated that lighting is very important in terms of their motivation levels, 17% indicated as important and 17% as neutral. 100% of group B indicated as very important. 100% of group C indicated as important.

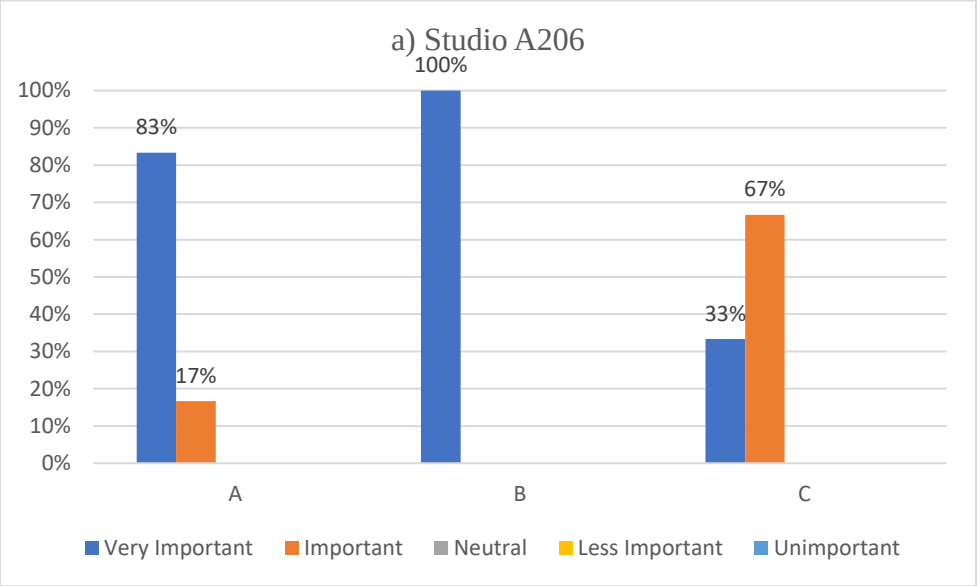
In studio B208, 40% of group A indicated that lighting is important in terms of their motivation levels, 40% indicated as neutral and 20% as very important. 67% of group B indicated as important, and 33% as very important. 63% of group C indicated as very important, 25% as important and 13% as neutral. 75% of group D indicated as very important, and 25% as important. 50% of group E indicated as very important, and 50% as neutral.

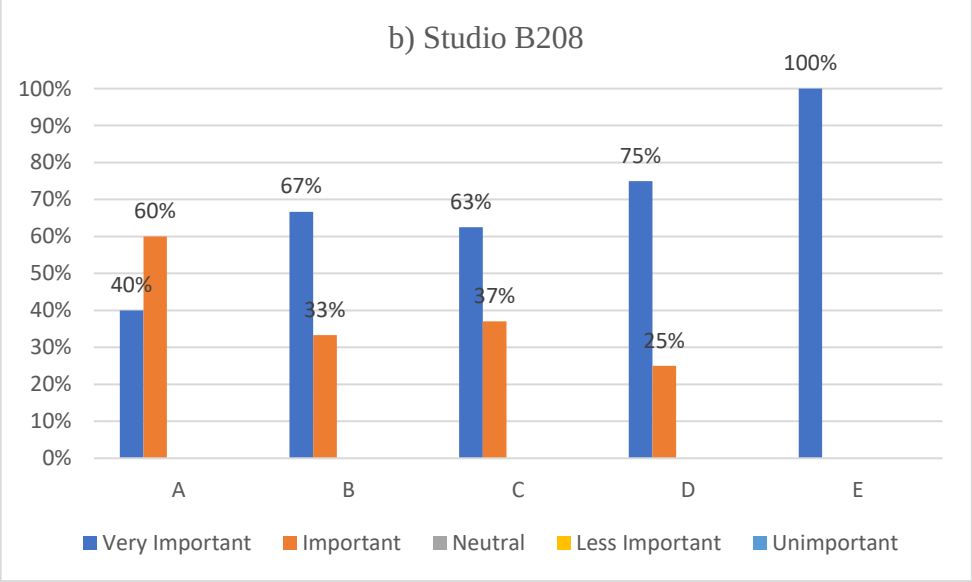
In studio B207, 50% of group A indicated that lighting is neither important nor unimportant in terms of their motivation levels, 25% indicated as important and 25% as very important. 100% of group B indicated as important. 100% of group C indicated as very important. 33% of group D indicated as important, 33% as neutral and 33% as unimportant. 75% of group E indicated as very important and 25% as important.

4.3.2 Survey item 2 : The importance of daylight in terms of students' motivation levels

Q2: *"How important for you to study in a studio with windows and daylight, from the side of your motivation level?"*

In the second question of this section of the survey, participants were asked to evaluate the importance of daylight for their motivation levels. The options included "very important", "important", "neutral", "less important", and "unimportant.





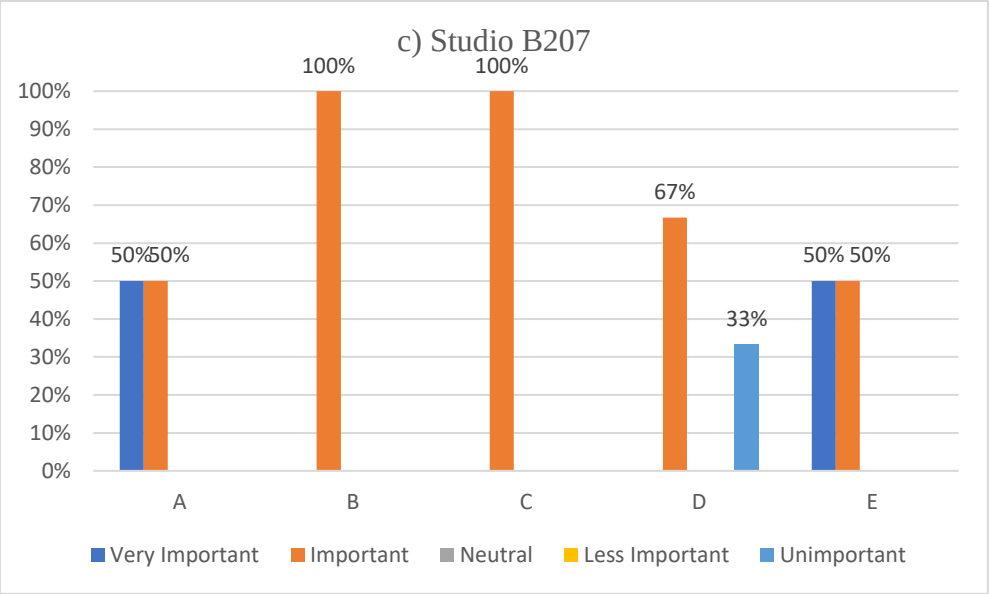


Figure 4.33. The importance of daylight for motivation levels of the students in studio a) A206, b) B208, c) B207.

In studio A206, 83% of group A indicated that it is very important to study in a studio with windows and daylight in terms of their motivation levels, and 17% indicated as it is important. 100% of group B indicated as very important. 67% of group C indicated as important, and 33% as very important.

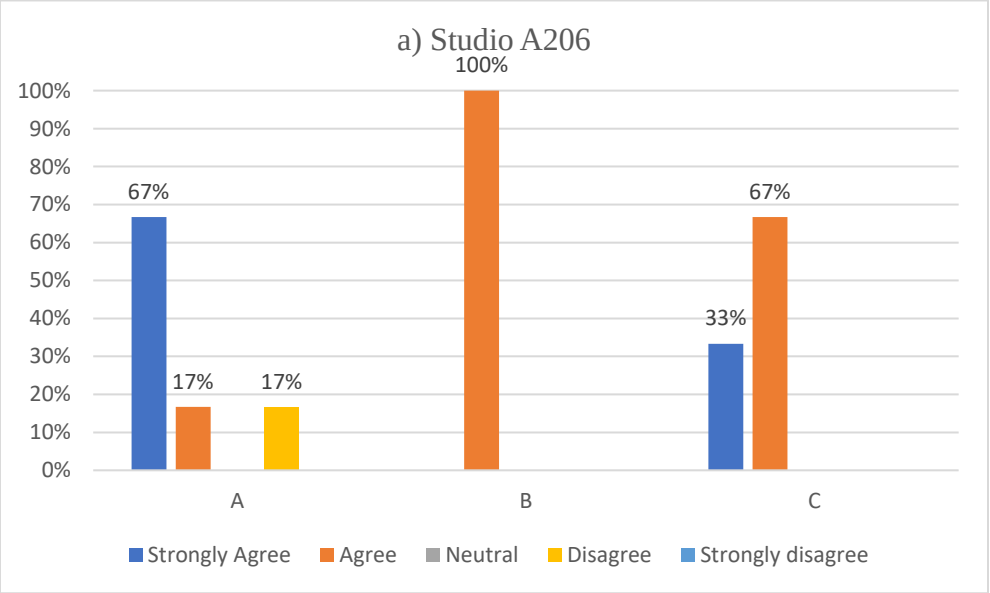
In studio B208, 60% of group A indicated that it is very important to study in a studio with windows and daylight in terms of their motivation levels, and 40% indicated as very important. 67% of group B indicated as very important, and 33% as important. 63% of group C indicated as very important, and 37% as important. 75% of group D indicated as very important, 25% as important. 100% of group E indicated as very important.

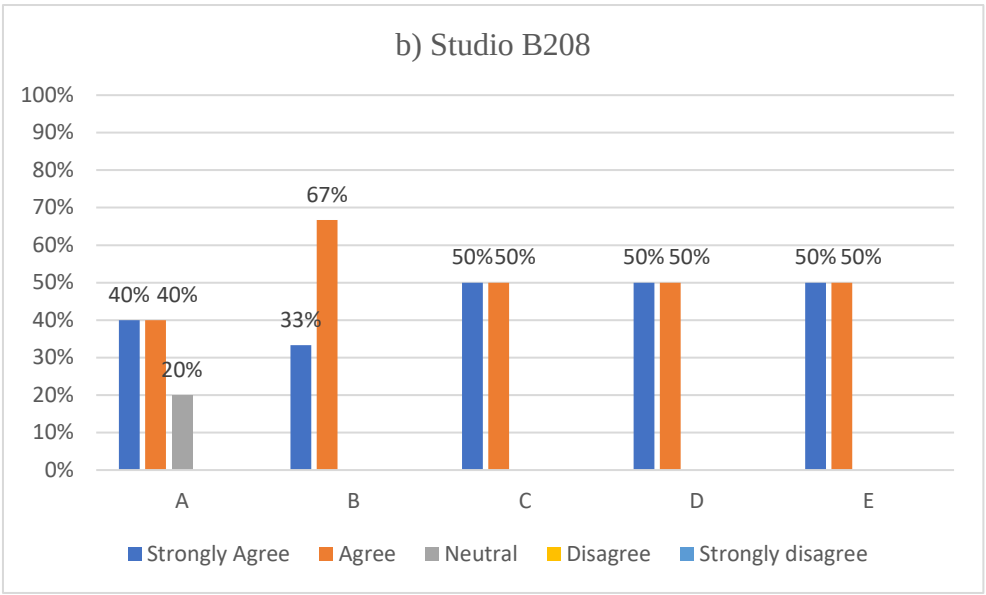
In studio B207, 50% of group A indicated that it is very important to study in a studio with windows and daylight in terms of their motivation levels, and 50% indicated as important. 100% of group B and C indicated as important. 67% of group D indicated as important, and 33% as unimportant. 50% of group E indicated as very important and 50% as important.

4.3.3 Survey item 3: The evaluation of the motivation levels of the students regarding the lighting conditions

In question 3 of this section, the participants were asked to respond to several questions to investigate their motivation levels regarding the lighting conditions; a) I believe daylight has a positive effect on my motivation level, b) I feel less alert, energetic and active especially in the mornings because of the lack of daylight, c) Seeing outside while studying has a positive impact on my motivation level, d) insufficient lighting in my study area makes me feel uncomfortable and demotivated, e) I believe glare in the surrounding area has a negative impact on my motivation level and f) I do not prefer to sit at the desks that are close to the window because of glare. The options included "strongly agree", "agree", "neutral", "disagree" and "strongly disagree."

a) "I believe daylight has a positive effect on my motivation level





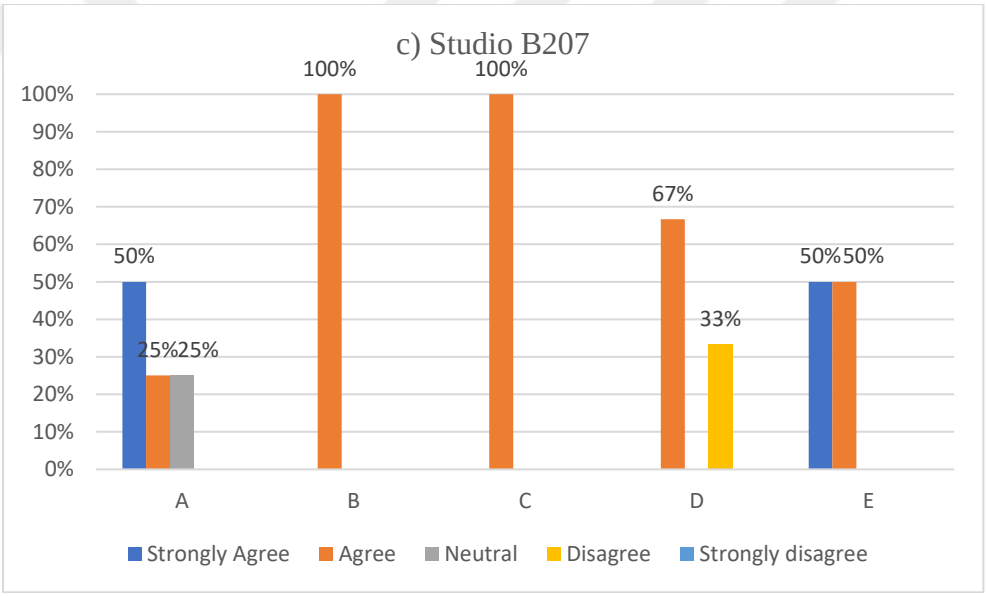


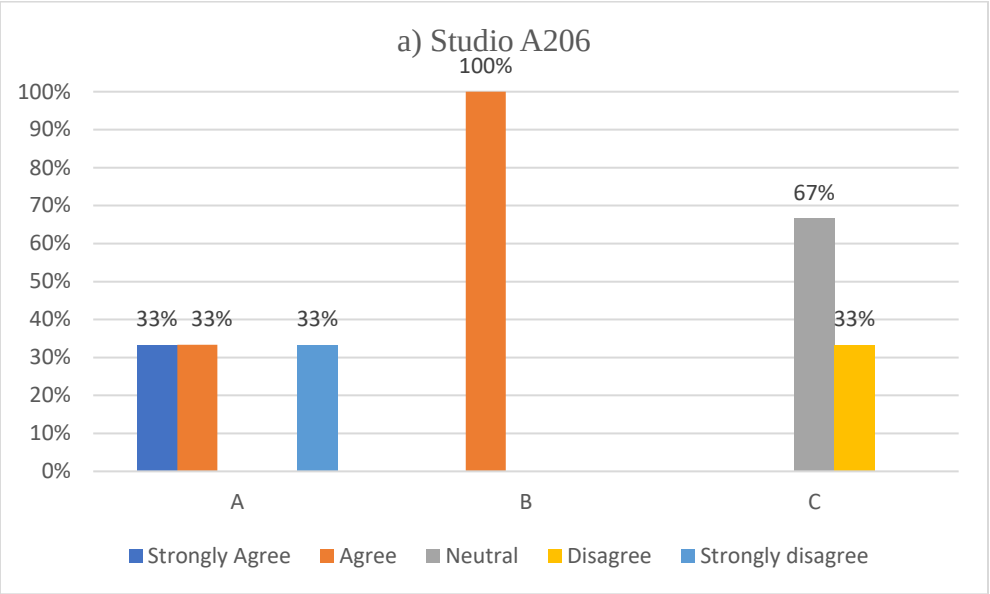
Figure 4.34. The effects of daylight on motivation levels of the students in studio a) A206, b) B208, c) B207.

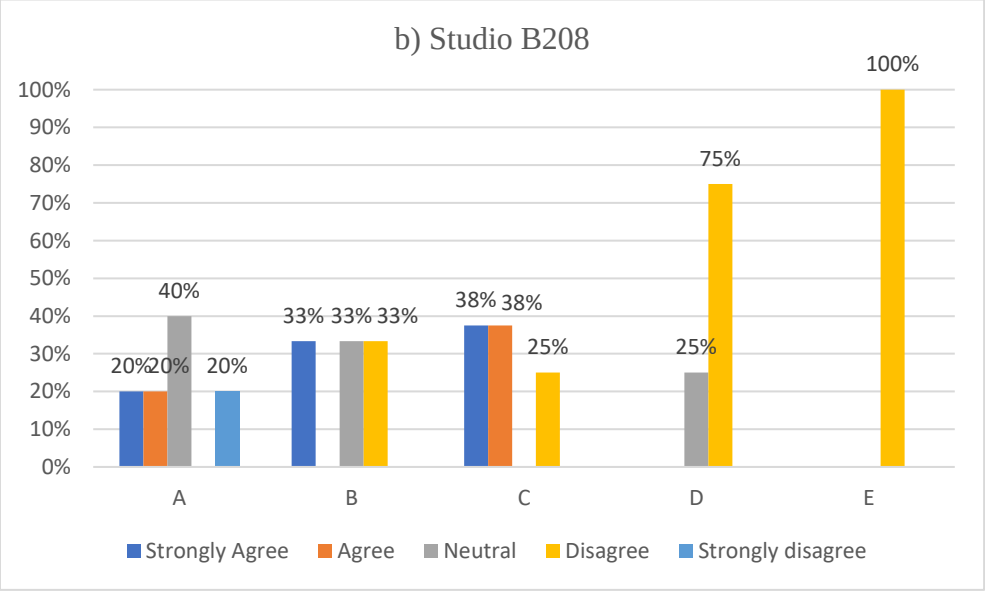
In studio A206, 67% of group A indicated as strongly agree, 17% as agree and 17% as disagree. 100% of group B indicated as agree. 67% of group C indicated as agree, and 33% as strongly agree.

In studio B208, 40% of group A indicated as strongly agree, 40% as agree, and 20% as neutral. 67% of group B indicated as agree, and 33% as strongly agree. 50% of group C, D and E indicated as strongly agree, and 50% as agree.

In studio B207, 50% of group A indicated as strongly agree, 25% as agree, and 25% as neutral. 100% of group B and C indicated as agree. 67% of group D indicated as agree, and 33% as disagree. 50% of group E indicated as strongly agree, and 50% as agree.

b) "I feel less alert, energetic and active especially in the mornings because of the lack of daylight"





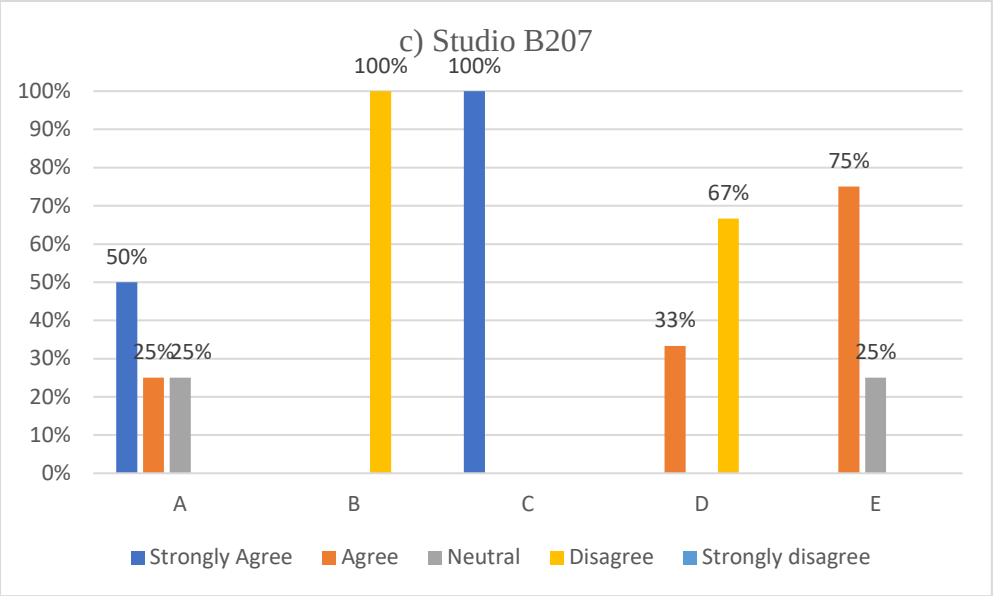


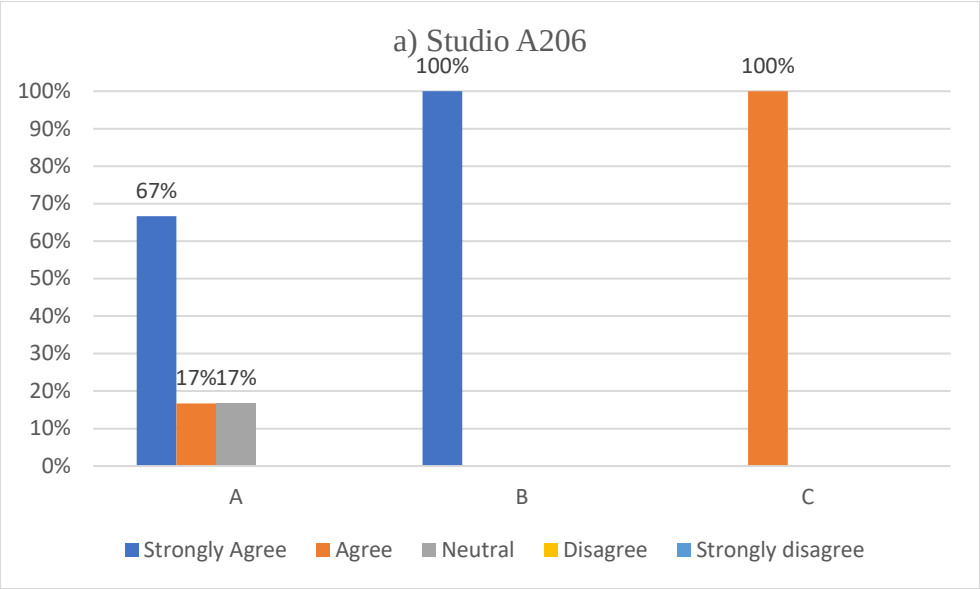
Figure 4.35. The effects of the lack of daylight on the students in studio a) A206, b) B208, c) B207.

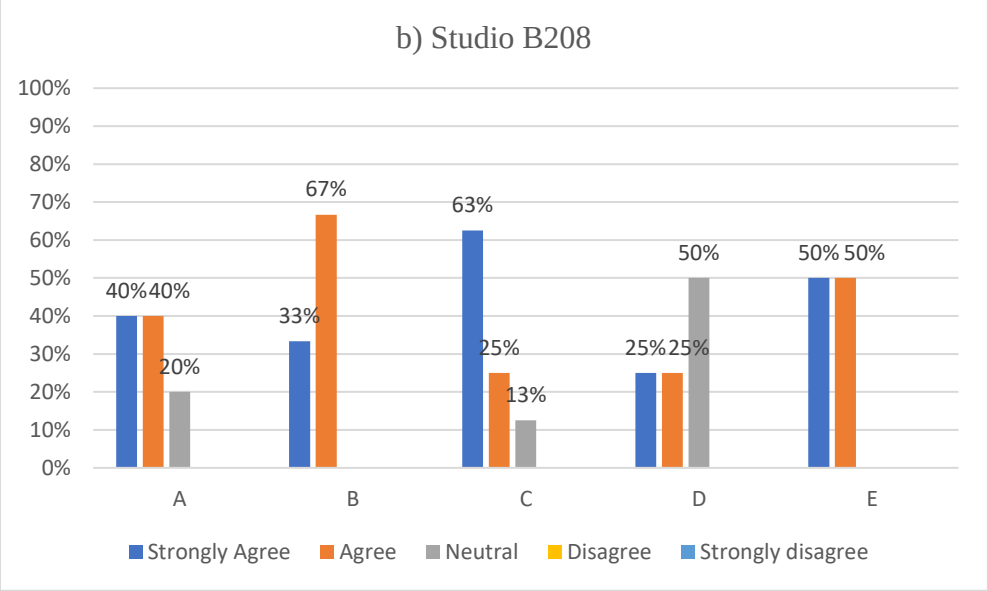
In studio A206, 33% of group A indicated as strongly agree, 33% as agree and 33% as strongly disagree. 100% of group B indicated as agree. 67% of group C indicated as neutral, and 33% as disagree.

In studio B208, 40% of group A indicated as neutral, 20% as strongly agree, 20% as agree, and 20% as strongly disagree. 33% of group B indicated as neutral, 33% as strongly agree, and 33% as disagree. 38% of group C indicated as strongly agree, 38% as agree, and 25% as disagree. 75% of group D indicated as disagree, and 25% as neutral. 100% of group E indicated as disagree.

In studio B207, 50% of group A indicated as strongly agree, 25% as agree, and 25% as neutral. 100% of group B indicated as disagree. 100% of group C indicated as strongly agree. 67% of group D indicated as disagree, and 33% as agree. 75% of group E indicated as agree, and 25% as neutral.

c) "Seeing outside while studying has a positive impact on my motivation level"





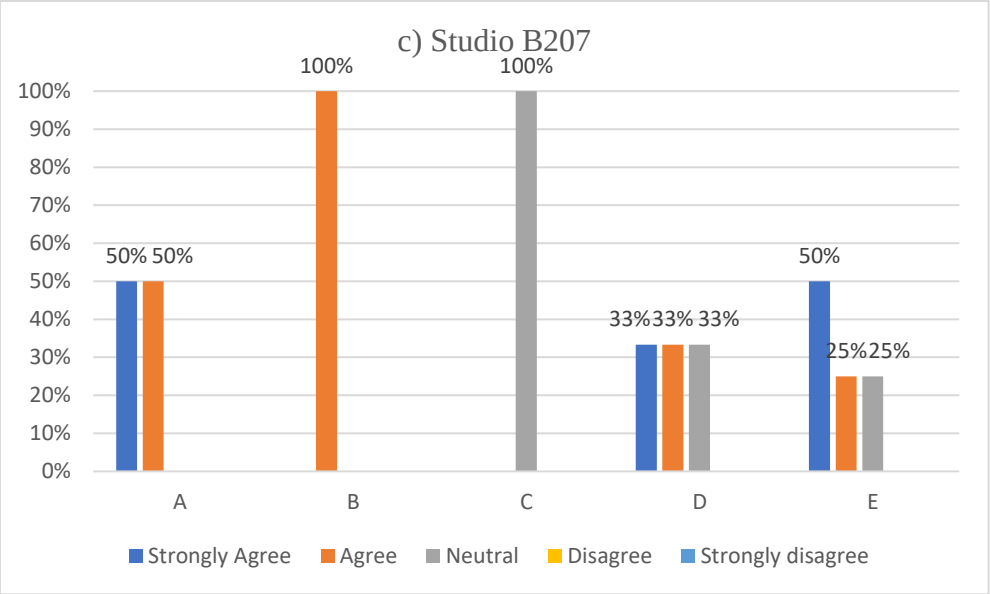


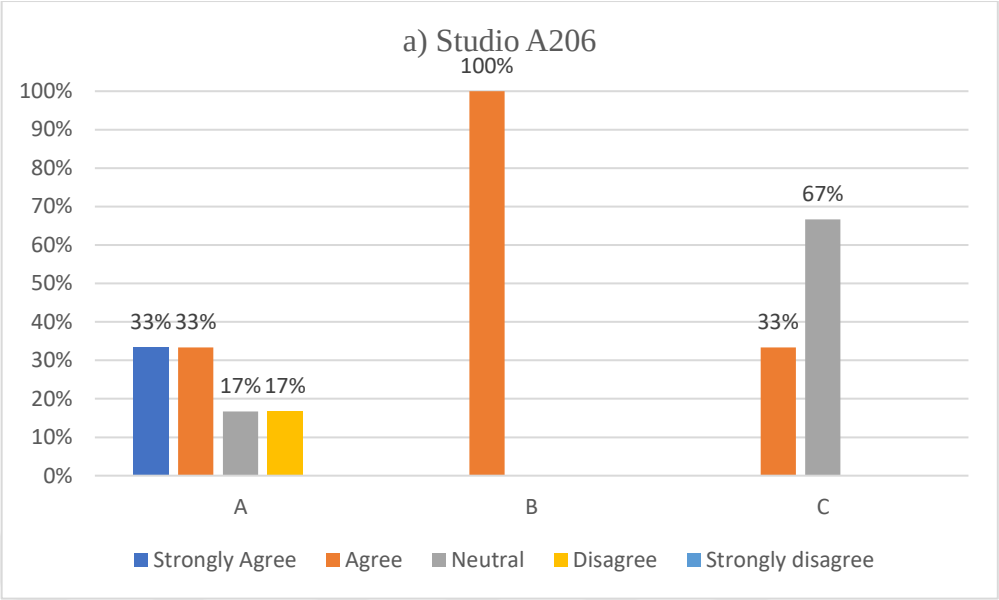
Figure 4.36. The effects of the outside view on the students' motivation levels in studio a) A206, b) B208, c) B207.

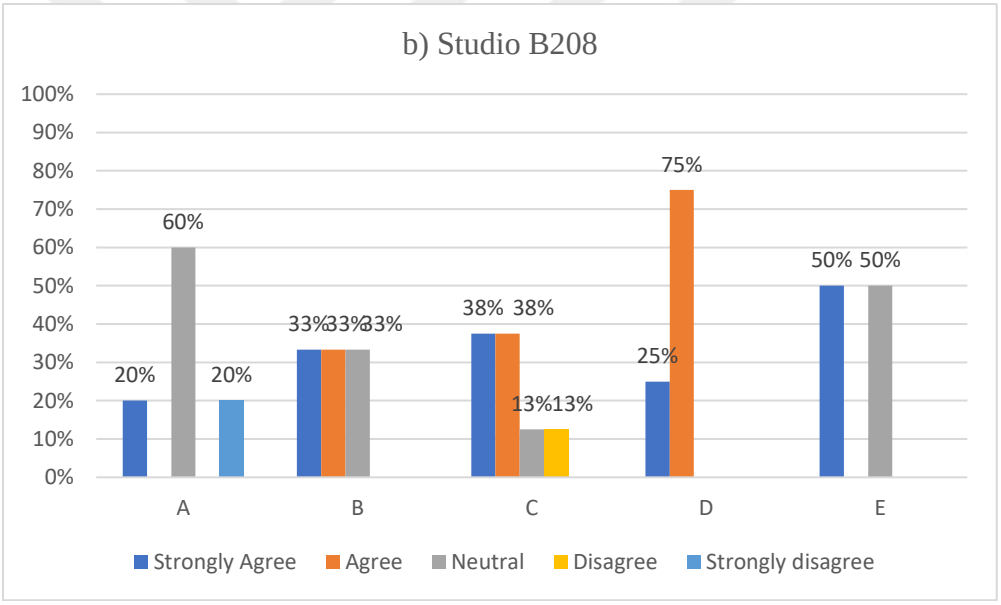
In studio A206, 67% of group A indicated as strongly agree, 17% as agree and 17% as neutral. 100% of group B indicated as strongly agree. 100% of group C indicated as agree.

In studio B208, 40% of group A indicated as strongly agree, 40% as agree, and 20% as neutral. 67% of group B indicated as agree, and 33% as strongly agree. 63% of group C indicated as strongly agree, 25% as agree, and 13% as neutral. 50% of group D indicated as neutral, 25% as agree, and 25% as strongly agree. 50% of group E indicated as strongly agree, and 50% as agree.

In studio B207, 50% of group A indicated as strongly agree, and 50% as agree. 100% of group B indicated as agree. 100% of group C indicated as neutral. 33% of group D indicated as strongly agree, 33% as agree, and 33% as neutral. 50% of group E indicated as strongly agree, 25% as agree, and 25% as neutral.

d) "Insufficient lighting in my study area makes me feel uncomfortable and demotivated"





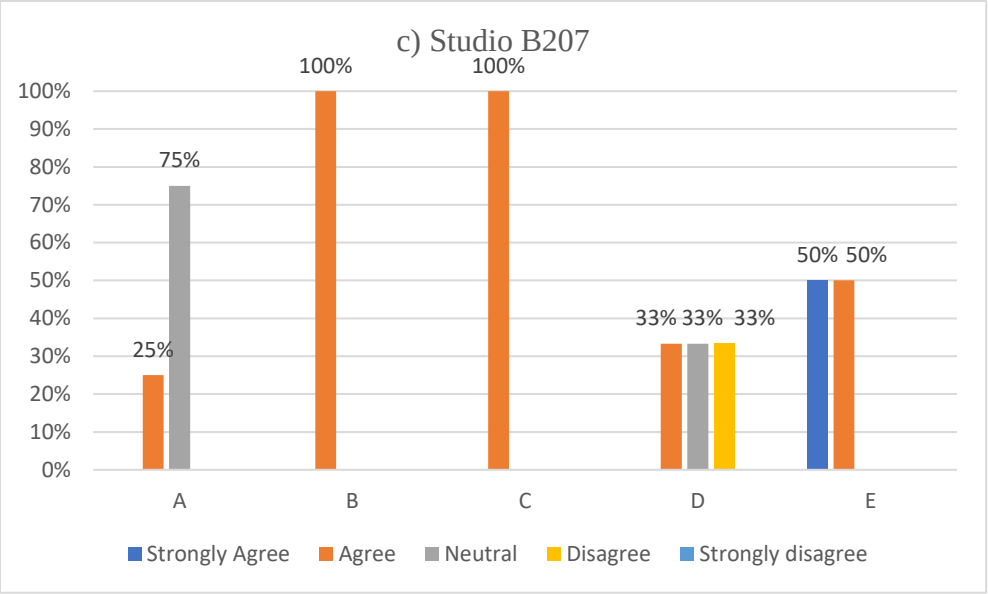


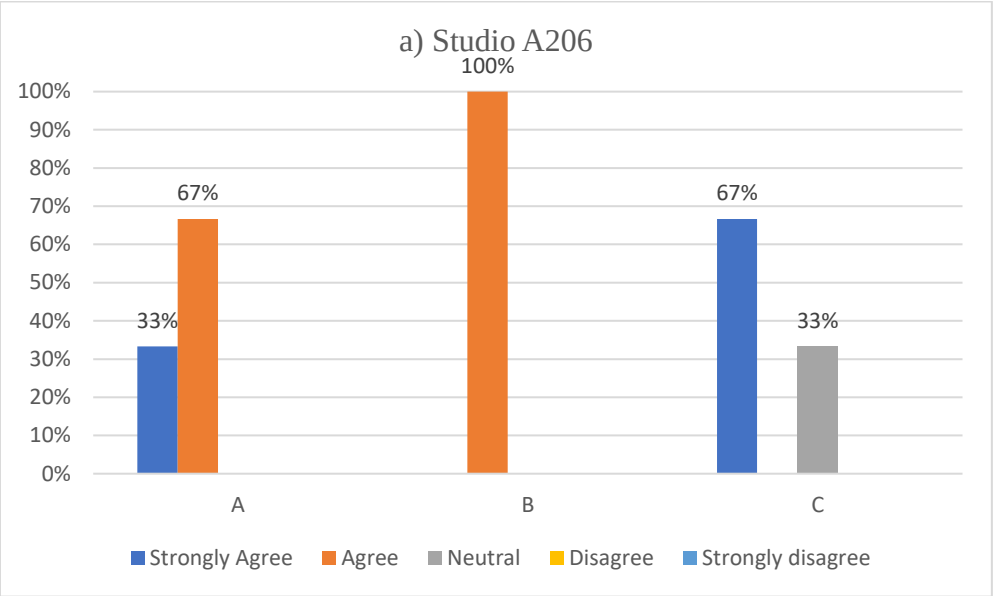
Figure 4.37. The effects of insufficient lighting on the students' comfort and motivation levels in studio a) A206, b) B208, c) B207.

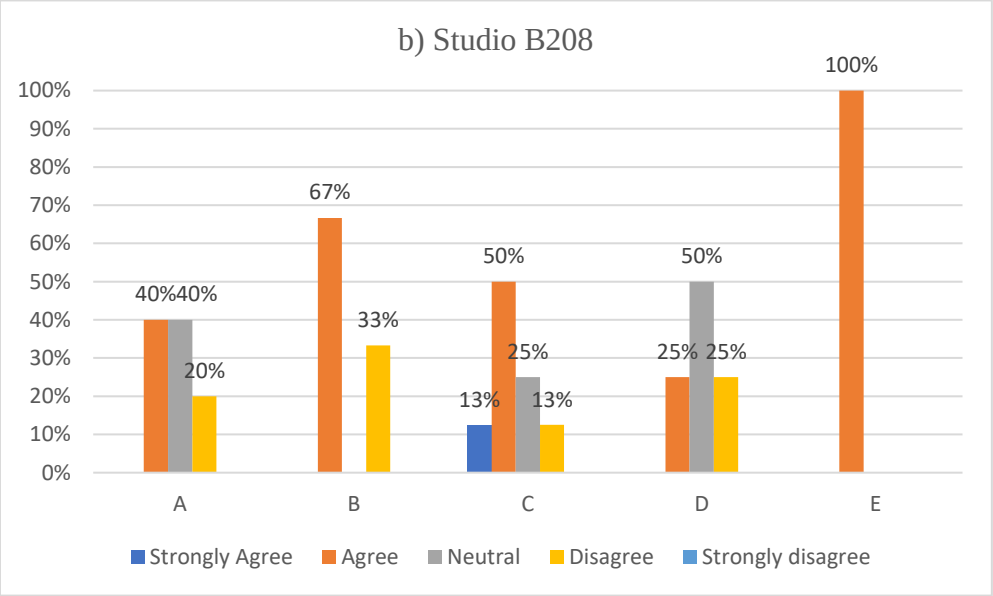
In studio A206, 33% of group A indicated as strongly agree, 33% as agree, 17% as neutral, and 17% as disagree. 100% of group B indicated as agree. 67% of group C indicated as neutral, and 33% as agree.

In studio B208, 60% of group A indicated as neutral, 20% as strongly agree, and 20% as strongly disagree. 33% of group B indicated as strongly agree, 33% as agree, and 33% as neutral. 38% of group C indicated as strongly agree, 38% as agree, 13% as neutral, and 13% as disagree. 75% of group D indicated as agree, and 25% as strongly agree. 50% of group E indicated as strongly agree, and 50% as neutral.

In studio B207, 75% of group A indicated as neutral, and 25% as agree. 100% of group B and C indicated as agree. 33% of group D indicated as agree, 33% as neutral, and 33% as disagree. 50% of group E indicated as strongly agree, and 50% as agree.

e) "I believe glare in the surrounding area has a negative impact on my motivation level."





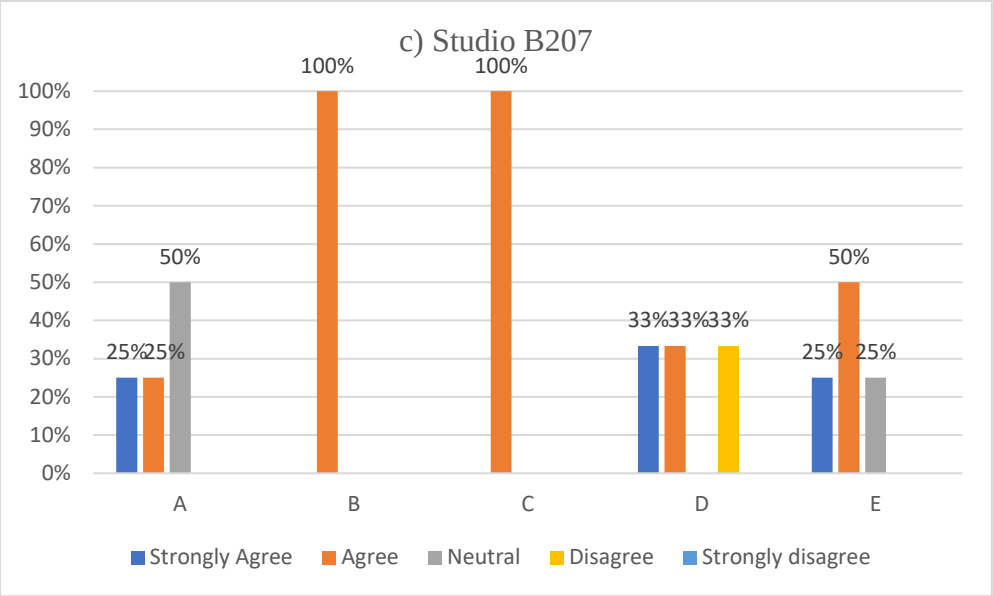


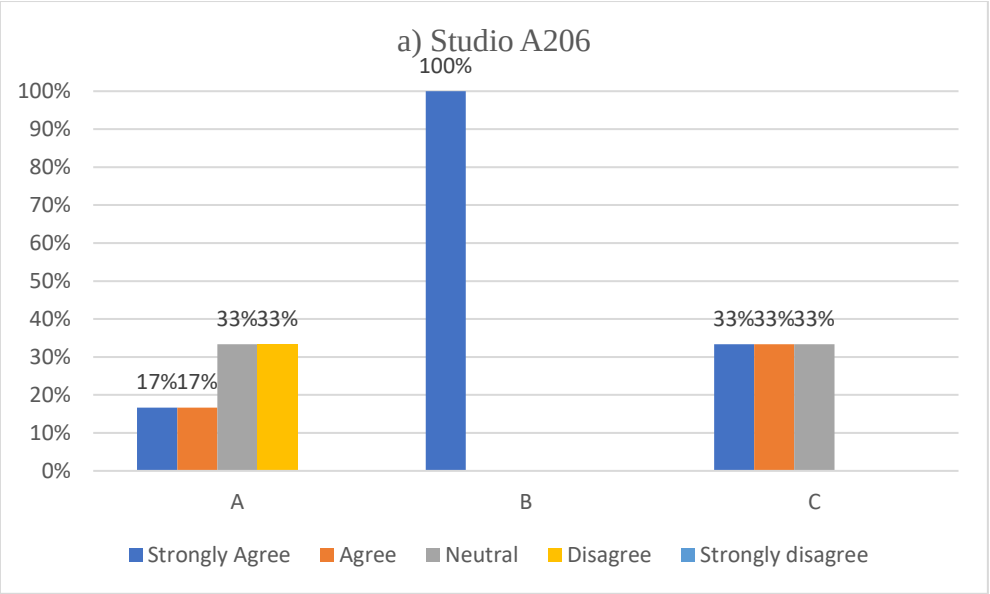
Figure 4.38. The effects of glare on the students' motivation levels in studio a) A206, b) B208, c) B207.

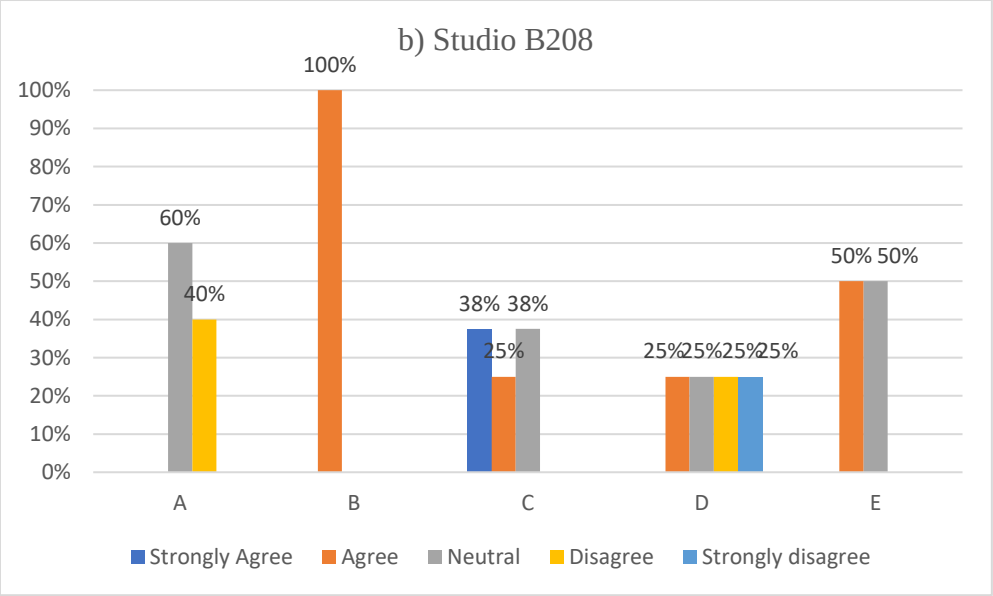
In studio A206, 67% of group A indicated as agree, and 33% as strongly agree. 100% of group B indicated as agree. 67 % of group C indicated as strongly agree, and 33% as neutral.

In studio B208, 40% of group A indicated as agree, 40% as neutral, and 20% as disagree. 67% of group B indicated as agree, and 33% as disagree. 50% of group C indicated as agree, 25% as neutral, 13% as strongly agree, and 13% as disagree. 50% of group D indicated as neutral, 25% as agree, and 25% as disagree. 100% of group E indicated as agree.

In studio B207, 50% of group A indicated as neutral, 25% as strongly agree, and 25% as agree. 100% of group B and C indicated as agree. 33% of group D indicated as strongly agree, 33% as agree, and 33% as disagree. 50% of group E indicated as agree, 25% as strongly agree, and 25% as neutral.

f) "I do not prefer to sit at the desks that are close to the window because of the glare."





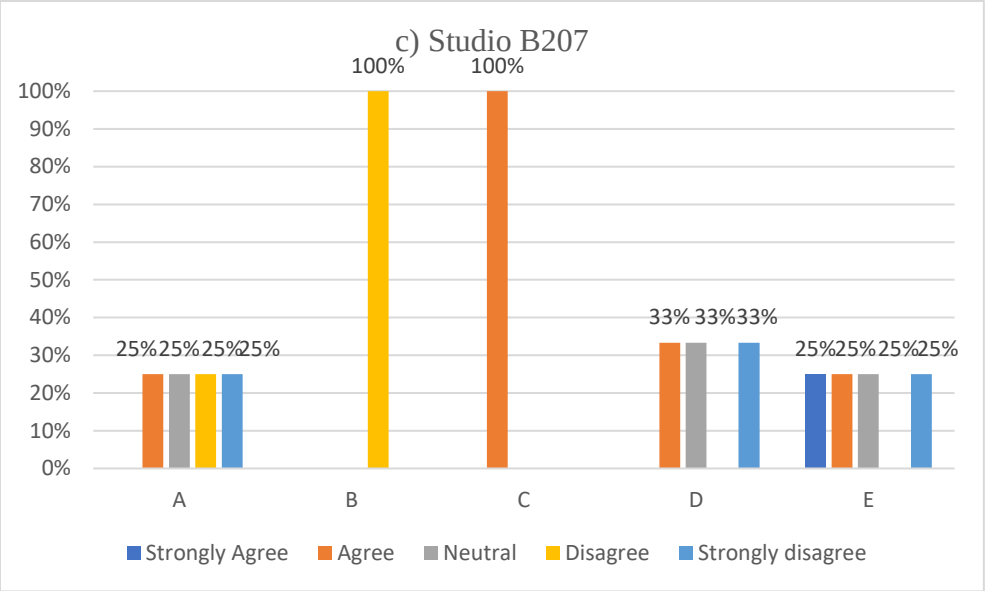


Figure 4.39. The effects of glare on the students' seating preferences in studio a) A206, b) B208, c) B207.

In studio A206, 33% of group A indicated as neutral, 33% as disagree, 17% as strongly agree, and 17% as agree. 100% of group B indicated as strongly agree. 33% of group C indicated as strongly agree, 33% as agree, and 33% as neutral.

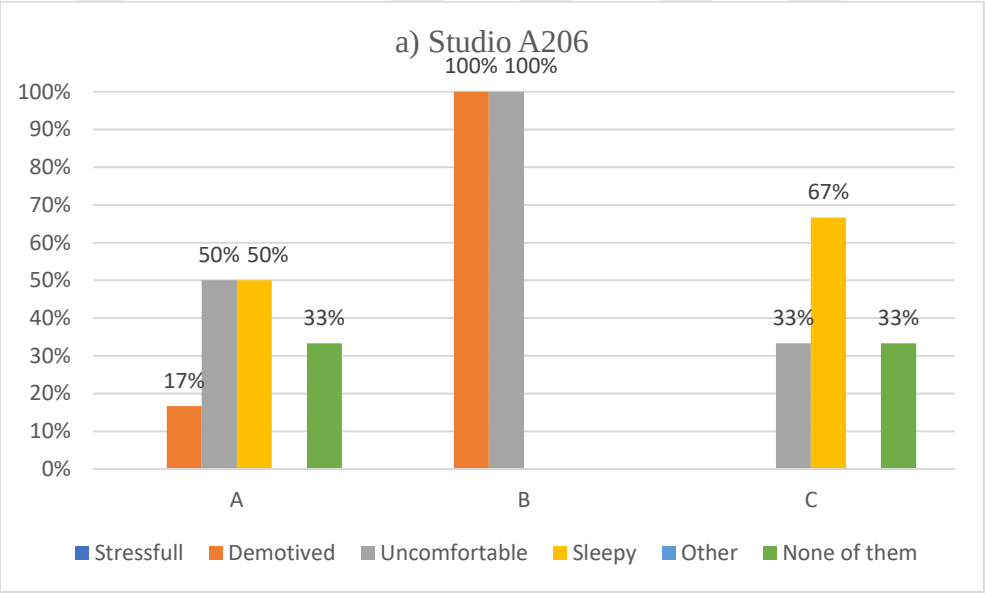
In studio B208, 60% of group A indicated as neutral, and 40% as disagree. 100% of group B indicated as agree. 38% of group C indicated as strongly agree, 38% as neutral, and 25% as agree. 25% of group D indicated as agree, 25% as neutral, 25% as disagree, and 25% as strongly disagree. 50% of group E indicated as agree, and 50% as neutral.

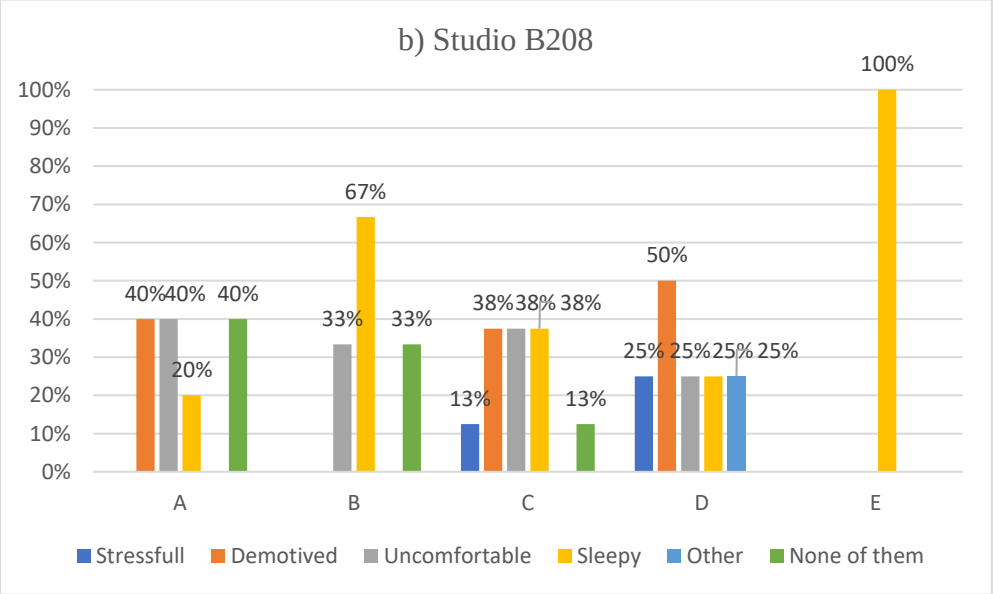
In studio B207, 25% of group A indicated as agree, 25% as neutral, 25% as disagree, and 25% as strongly disagree. 100% of group B indicated as disagree.100% of group C indicated as agree. 33% of group D indicated as agree, 33% as neutral, and 33% as strongly disagree. 25% of group E indicated as strongly agree, 25% as agree, 25% as neutral, and 25% as strongly disagree.

4.3.4 Survey item 4: The evaluation of the effects of lighting conditions on students' satisfaction and motivation levels

In the last question of this section, the participants were asked to indicate their feelings regards to the lighting conditions. The options included "stressfull", "demotivated", "uncomfortable","sleepy", "other" and "none of them." For this question, the students could choose more than one option.

Q4: "*Especially in the mornings, the lighting conditions make me feel.....(You may choose more than one option.)"*





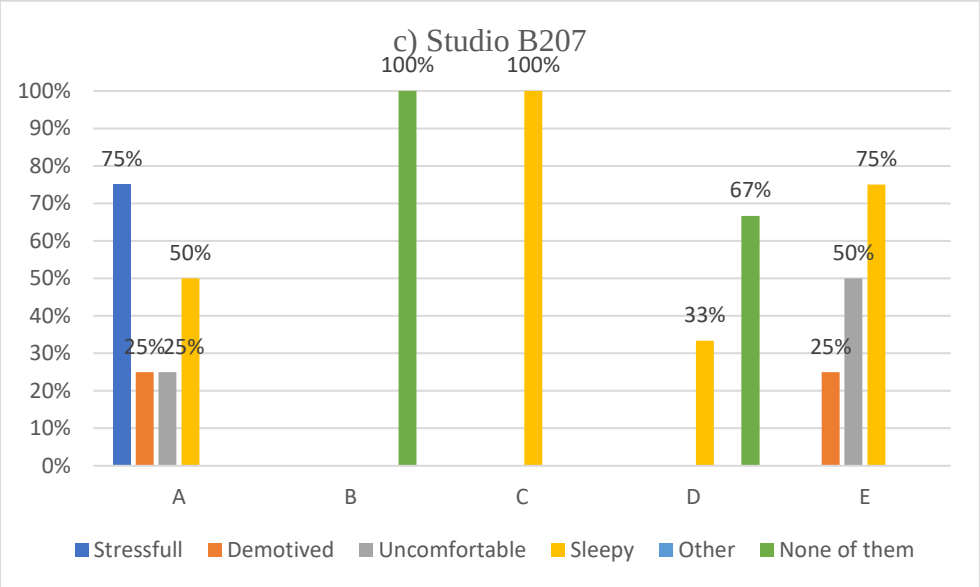


Figure 4.40. The effects of the lighting conditions on the students in studio a) A206, b) B208, c) B207.

In studio A206, 50% of group A indicated that the lighting conditions make them feel uncomfortable, 50% indicated as sleepy, 33% as none of them and 17% as demotivated. 100% of group B indicated as demotivated and uncomfortable. 67% of group C indicated as sleepy, 33% as uncomfortable, and 33% as none of them.

In studio B208, 40% of group A indicated that the lighting conditions make them feel demotivated, 40% indicated as uncomfortable, 40% as none of them, and 20% as sleepy. 67% of group B indicated as sleepy, 33% as uncomfortable, and 33% as none of them. 38% of group C indicated as demotivated, 38% as uncomfortable, 38% as sleepy, 13% as stressful, and 13% as none of them. 50% of group D indicated as demotivated, 25% as stressful, 25% as uncomfortable, 25% as sleepy, and 25% as other. The student who indicated as other stated that “daylight has a relaxing effect”. 100% of group E indicated as sleepy.

In studio B207, 75% of group A indicated that the lighting conditions make them feel stressful, 50% indicated as sleepy, 25% as demotivated, and 25% as uncomfortable. 100% of group B indicated as none of them. 100% of group C indicated as sleepy. 67% of group D indicated as none of them, and 33% as sleepy. 75% of group E indicated as sleepy, 50% as uncomfortable, and 25% as demotivated.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1. Discussion of Key Findings Regarding Lighting Conditions, Visual Comfort, and Satisfaction

The results from the study revealed that most of the students in all three studios found the lighting conditions insufficient. Considering the illumination levels in all three studios, B208 has the highest illumination, A206 is medium while B207 has the lowest. A wide variety of tasks are implemented during an entire day in an architectural design studio; since these tasks require different illumination levels, defining a standard illumination level and illuminating with stable lighting will not be proper for an architectural design studio. Studio B208 and A206 meet the standards for the entire day for some of the critical tasks; however, illumination level in studio B207 has been found to be insufficient. Generally, the students cited insufficient daylight as the reason behind insufficient lighting conditions. Even when the illumination was enough with the help of artificial lighting, they still indicated that lighting was insufficient because the amount of daylight was low. According to the group-based results, groups with less illumination and daylight illuminance were found to give negative responses regarding this evaluation. Studio B207, which has the least daylight illuminance, has the highest percentage in terms of the number of participants stating that insufficient daylight is the main reason behind insufficient lighting.

Other important factors that cause insufficient lighting conditions is the amount and type of light sources. Some of the participants indicated that light bulbs frequently fail, and that they are not working. This is a very big problem indicating that there is no consistency in artificial illumination levels inside the studios. In the evaluation process of illumination levels regarding each task, it has been observed that groups whose illumination levels are under the standards find the illumination dim, however, groups with illumination levels that are above the standards find it normal, which shows that the participants are more sensitive in terms of perceiving the lack of light than the excess of light. It is also inferred that glare is a major problem which prevents students while

studying in all three studios. The students mostly stated that there is glare on the board, projection screens and on the computers. On the other hand, the number of students that reported glare on their desk is low. The artificial light sources and daylight are the main reasons and material reflectance is the secondary reason for glare problem according to the participants.

Color of light is also another problem for the students as they state that it prevents them while studying. This problem is also related to the light sources. 70% of the students in A206 and 54% of the students in B208 indicated that color of light prevents them while studying. However, only 23% of the students in B207 stated that it prevents them. The light sources are the same, however, the perception of the color of light is quite subjective. As most of the students state that the color of light and glare prevent them from studying, they also state that shadows and illumination level constitute an impediment. Shadow is the other important problem for students. Particularly the groups with less illumination indicated shadow as a problem, with very high percentages. In comparison with the other two studios, B207 which has the least illumination is the one that is affected from shadows most. As daylight illuminance is not distributed to the studios uniformly, sudden changes in terms of illumination seem to occur. Some areas can be too dark, and some are bright or too bright, which suggests that not all students have adequate illumination for the tasks on which they study. Generally, illumination levels that are under the standards are annoying for the students. However, it depends on the perception of light by the students. Some of them indicate that illumination level does not prevent them, and those participants could be satisfied with the lighting in their section even if it is low. They are minority but some individual differences are observed regarding these participants. On the other hand, the high illumination levels are generally found normal rather than bright.

Comparing the measurement results and the responses from groups in all three studios, it has been inferred that group A in B208 is the group that is most pleased with the lighting conditions. They stated that illumination level normal for all the tasks, with very high percentages. They indicated that they are mostly satisfied with the lighting conditions. On the other hand, group C in B207 is the least satisfied one as they reported that the illumination level is either dim or too dim for most of the tasks. They also mentioned that they are not satisfied with the lighting conditions and that the lack of daylight and glare in their surrounding area have some negative impacts on them. Section A in B208 has 800-1400 lx during the day (11:00-16:00). Section C in B207 has 254-288 lx during the day (11:00-16:00). It has been observed that around 800-1400 lx is

acceptable for the students. Some individual differences were also observed for group B and D in B207. They mostly found the illumination level normal for the tasks and they are mostly satisfied with the lighting conditions. However, according to the measurement results, the illumination level is not enough for some of the tasks in group B and for all the tasks in group D. They also stated that illumination level does not prevent them while studying. Group B suggested that daylight, outside view and lighting are important for their motivation levels but even when the daylight illuminance is low in their area, they do not report any negative comments regarding daylight illuminance in their section. This might be the case because they are not too far from windows and they have outside view, they may perceive as if the daylight illuminance is not too low in their section. The illumination level is between 355-367 lx in their section which is acceptable for some of the tasks that are carried out in the studio.

33% of the participants in group D in B207, on the other hand, reported that lighting is not important for their motivation and 33% stated as neutral. While most of the participants indicated that it is very important to have windows to benefit from daylight, only 67% of group D, indicated as neutral. Although daylight illuminance is very low in their section, 67% of the participants in group D disagreed with the statement, “I feel less alert, energetic and active especially in the mornings because of the lack of daylight”. Therefore, it is clear that lighting and the existence or level of daylight illuminance do not affect them because of their personal perception.

Comparing all three studios, B208 is the most appreciated one in terms of lighting conditions. Studio B207 is a little bit more pleased than A206. Group A, C and E in B208 are more pleased than group A, C and E in B207 in terms of lighting conditions. On the other hand, group B and D in B207 are more satisfied than group B and D in B208. Personal perception of group B and D in B207 influences this situation. Group A and B in B208 are more pleased than group A and B in A206. The pleasantness of Group C in B208 and in A206 is similar. Group A in B207 is more pleased than group A in A206 and group B in B207 is much more pleased than group B in A206, however, group C in B207 is less pleased than group C in A206. In the table below, the groups are classified according to the range of illumination levels and their perception of illumination is specified.

Table 5.1. Separation of the groups according to the range of illumination level.

<300	300-400	400-500	500-800	800>
C in B207 x D in B207 √	C in A206 ~ C in B208 ~ D in B208 x B in B207 √	B in A206 x B in B208 ~	E in B208 o A in B207 o E in B207 ~	A in A206 x A in B208 √

x: Unacceptable (Section A) Q2; respondents < 50%, Section B) Q3; respondents < 50%, Section C) Q3-d; respondents > 50%)

~:Slightly unacceptable: (Section A) Q2, respondents<50%, Section B) Q3; respondents > 50% neutral; Section C) Q3; respondents > 50% neutral; Section A) Q2, respondents=50%, Section B) Q3; respondents > 50% neutral; Section C) Q3; respondents > 50%).

o: Slightly acceptable (Section A) Q2, respondents>50%, Section B) Q3; respondents > 50% neutral; Section C) Q3; respondents > 50% neutral; Section A) Q2, respondents = 50%, Section B) Q3; respondents > 50% neutral, Section C) Q3; respondents < 50%)

√: Acceptable (Section A) Q2; respondents > 50%, Section B) Q3; respondents > 50%, Section C) Q3-d; respondents < 50%)

The appraisal of students in terms of illumination levels in their study area according to the tasks they study on is evaluated to investigate acceptable and unacceptable levels of illumination considering three key questions: Q2 of Section A, Q3 of Section B and Q3-d of Section C. In Q2 of Section A, the students were asked to evaluate the illumination level in their study area according to various tasks with the options of "too dim", "dim", "normal", "bright", "too bright". In Q3 of Section B, the students were asked to rate their satisfaction levels according to those tasks with the options of "unsatisfied", "less satisfied", "neutral", "satisfied", "very satisfied". In Q3-d of Section C, the agreement of students with the statement of *"Insufficient lighting in my study area makes me feel uncomfortable and demotivated"* was investigated including the options of "strongly disagree", "disagree", "neutral", "agree", "strongly agree". While making the evaluation of these three questions, only technical drawing and model-making tasks were considered in Q2 of Section A and Q3 of Section B because for reading/writing tasks and computer-based studies, students in all three studios generally found the

illumination level normal. As parallel to their statements, the results of measurements demonstrate that almost all the sections in all three studios have at least 300 lux illumination level which is already a minimum value for these tasks. However, for technical drawing and model making tasks, which are the most common tasks in architecture design studios, the evaluation of the students varies. To make this evaluation process clear, a detailed explanation for the information in Table 5.1 is given below:

Unacceptable: Section A) Q2; *respondents < 50%* indicates that less than half of the students find illumination level "normal" for the evaluated tasks, which suggests that they generally find illumination level "dim" or "too dim" for those tasks. Section B) Q3; *respondents < 50%* means that less than half of the students are "satisfied" with the lighting for these tasks. Section C) Q3-d; *respondents > 50%* means that more than half of the students agree with the statement of *"Insufficient lighting in my study area makes me feel uncomfortable and demotivated".* When all these evaluations come together, it is concluded that the illumination level of the responders' study area is not acceptable for them. In addition, to evaluate the illumination level in the study area as unacceptable, there should be negative statements regarding at least two of these questions.

Slightly unacceptable: The explanation of the statement of "Section A) Q2, *respondents<50%* is given above. Section B) Q3; *respondents > 50% "neutral"* means that more than half of the students rated their satisfaction levels regarding the evaluated tasks as "neutral". Section C) Q3; *respondents > 50% "neutral*" has the same meaning. In this situation, there are two neutral and one unacceptable statement. There is one more option to gather this result of "slightly unacceptable." Section A) Q2, *respondents=50%* means that students evaluated the illumination level for one of the evaluated tasks as "normal"; however, they evaluated it as "dim" or "too dim" for the other task. This means that the illumination level is acceptable for half of the tasks, while for the remaining half it is unacceptable. This kind of evaluation is considered as "balanced" which is shown as *"=50%"*. The meaning of Section B) Q3; *respondents > 50% "neutral"* is explained above. Section C) Q3; *respondents > 50%* means that more than half of the students agreed with the statement of *"Insufficient lighting in my study area makes me feel uncomfortable and demotivated".* In this situation, there are two neutral and one unacceptable statement as well. There need to be two neutral and one unacceptable statement to evaluate the illumination level in the study area as slightly unacceptable.

Slightly acceptable: The explanation for the legends is given above. When responders find illumination level "normal" for the considered tasks but remain with the option

"neutral" for Q3 in Section B and Q3-d in Section C, the illumination level in their study area is evaluated as slightly acceptable. There is one more option to get this result which is when students evaluated the illumination level "normal" for one of the evaluated tasks while they indicated as it as "dim" or "too dim" for the other task. In addition to this, they mostly remain with the option "neutral" for Q3 of Section B and less than 50% of them indicated as "agree" or "strongly agree" for Q3-d of Section C. In these situations, there are two neutral and one acceptable statement. There need to be two neutral and one acceptable statement to evaluate the illumination level in the study area as slightly acceptable.

Acceptable: When more than half of the students find illumination level "normal" for the considered tasks and more than half of them are "satisfied" regarding the lighting for these tasks and less than half of them indicated as "agree" or "strongly agree" with the statement in Q3-d of Section C, the illumination level in their study area is evaluated as acceptable. When the responses to at least two of these questions are positive, the illumination level in the study area is evaluated as acceptable.

The illumination levels which are under 300 lx and between 300-400 lx are generally not acceptable for the students in terms of appreciation regarding lighting in their area. The illumination levels which are between 400-500 lx are slightly unacceptable. Between 500-800 lx is better but still not meaningfully acceptable. Over 800 lx is a bit better illumination range for the students. Group A in A206 has over 800 lx for most of the day. However, as the day approaches the end, it decreases to 683 lx. Even though, group A in A206 has over 800 lux for most of the part of the day, they found lighting insufficient. The reason behind this could be their position to the windows. While group A in B208 takes daylight from their right side, group A in A206 takes it from their back. They turn their back to the windows; thus, their own body may become obstruction for daylight illuminance. The direction of daylight penetration may impact users. If the back of a person is facing the window, her/his own body might obstruct daylight illumination and cause shadow. On the contrary, if one is facing the window, although illumination level is not enough, s/he may perceive the illumination level as sufficient because of the luminosity (Cilasun, 2016). From the evaluation, it is inferred that the low illumination levels are not acceptable for the students for their common critical tasks; illumination over 800 lx is good enough.

Results from this study showed that daylight plays a significant role in the perceptions of individuals regarding the sufficiency of lighting conditions. The other

factors including illumination level, color of light, shadows and glare have also been found to be important. Glare and illumination level have a significant impact on the evaluation process of lighting conditions. Both factors are related to daylight and artificial lighting. If there is glare because of daylight, this means that daylight is not distributed to the space in a controlled manner. If the reason is the light sources, then these sources are not proper to use; they may not be properly arranged and distract the visual comfort of the students. As daylight illuminance is very important for the users but glare is one of the biggest problems to study, then daylight illuminance should be adjusted and provided in a more controlled way.

Different tasks require different illumination levels. Moreover, individual differences have been observed in results of some responders, but generally the responses are parallel to the measurements. There are some common key tasks for studios such as computer-based studies, technical drawings, and model making. The students in all three studios found the illumination "normal" only for computer studies. Especially for technical drawing task, they found illumination "insufficient" in general. It is also clear that in some sections, the standard illumination requirements for those tasks cannot be provided with the existing lighting conditions considering measurement results. There are some negative statements regarding model-making task especially in A206. These tasks are the most common ones in architectural design studios. Thus, proper illumination for those tasks should be provided.

5.2. Discussion of Key Findings Regarding the Effects of Lighting Conditions on Motivation Levels of the Students

Most of the students in all three studios indicated that lighting plays a significant role in their motivation levels. Almost all of them stated that it is very important to have windows and daylight as it has a positive impact on their motivation. Outside view is also very important for students' motivation in general. Examining the effects of lighting insufficiency on students' comfort and motivation, it has been observed that groups with less illumination or with unstable illumination like group E in B207 are more inclined to feel uncomfortable and demotivated.

The effects of glare on students' motivation also examined as it is another important factor regarding lighting conditions. Most of the students in all three studios indicated that glare in their surrounding area has a negative impact on their motivation levels. Some of the participants reported as being neutral and some disagreed with minor percentages. The responses to the statement of "I believe glare in the surrounding area has a negative impact on my motivation level" and "I do not prefer to sit at the desks that are close to the windows because of the glare" are much parallel to each other. This suggests that students cannot benefit from daylight efficiently because they avoid daylight glare. Only groups of A's in all studios mostly indicated as neutral or disagreed. It has been found out that those groups endure glare to benefit from daylight.

Lack of daylight could have a negative impact on students' alertness and energy. Especially the morning daylight is very important as it affects circadian rhythm. It helps the body awaken and energize itself. If it is low, people can have trouble in keeping themselves awake, energetic, and alert (Shisregar, 2016). Since studio B207 has the least daylight illumination level, it is observed that most of the students in studio B207 face those negative impacts more than the students in A206 and B208. In studio A206, for example, 50% of the participants indicated that they feel less alert, active, and energetic especially in the mornings, 20% as neutral and 30% stated that they do not. In B208, 41% of the participants reported that they do, 22% as neutral and 41% as they do not. In B207, 62% of the students stated that they do, 23% as neutral and 15% as they do not. In total, most of the students in all studios mentioned that they feel less alert, active, and energetic, especially in the mornings. However, in B208 the situation is a bit more neutral compared to the other studios. In direct proportion to these results, most of the students in all three studios suggested that they feel sleepy, especially in the mornings. This could be the case due to the lack of daylight as well. In B207, the percentage of the students who feel sleepy is higher compared to other studios. The students reported that the lighting conditions make them feel sleepy, uncomfortable, and demotivated from more to less. While there are just a few students stated that they feel stressful, some students did not choose any of these options.

5.3. Implications and Suggestions to Improve Lighting Conditions in Architecture Design Studios

According to the results of this study, it is inferred that since there is a flexible and dynamic environment with various actions in architecture design studios, the lighting of these environments cannot be stable; on the contrary, it should be flexible adapting to the structure of the environment. The important point is how to achieve this flexibility in lighting design. Architecture students can carry out various tasks during the day and some of these tasks could need less illumination while the others need higher illumination levels. Defining a standard illumination level does not seem possible for architecture design studios. That is why a control system might be suggested for these educational environments to achieve different light levels for each task and user needs. There could be many options for choosing a control system as these systems also vary. However, for architecture studios following options could be suggested: 1) manual control system + automatic control system, 2) lighting automations system, and 3) task lighting with an adequate general lighting design.

The users of the studios in this study evaluated light levels differently according to the different tasks. In addition, daylight illuminance has a vital importance for them. Thus, a control system with daylight integration which serves to users' different needs could be considered. From the side of users' satisfaction, to control light levels manually by their own preferences in accordance with the tasks they study on could be useful. A constant light level during the day or an automatic-only control system in which users have no control over light amount should be avoided. With manual lighting control which includes dimming system, however, users could control the light levels as they need. However, a manual-only system may not be enough because of the lack of daylight illuminance integration. Daylight illuminance changes during the day and if the lighting system could adapt to these changes, users benefit from daylight more rather than exposing unnecessary artificial light illumination. Veitch et. al. (2008) found that given an option to users, they tend to dim electric lighting when there is sufficient daylight without glare. Previous studies also suggest that daylight illuminance is more likely to be preferred by users over artificial lighting as mentioned in Chapter 2. This study also emphasizes the importance of daylight through users' own perspectives. Since daylight is a priority for users, artificial lighting should be used when daylight illuminance falls short.

If a manual system is used without daylight illuminance consideration in the space, users may forget to adjust light levels if they focus on their study; thus, they may be exposed to less illumination or over illumination. Likewise, adjusting light levels according to the changes of daylight illuminance during a day could tire and interrupt the users while studying in such a busy environment like architecture studios. For example, if a user needs 500 lux in their study area for computer-drawing in the morning, and there is 100 lux daylight illuminance in their study area, they may want to increase the light level to 500 lux with the help of artificial lighting. However, in the afternoon, if daylight illuminance reaches to 500 lux, artificial lighting would be unnecessary. Controlling light levels manually depending on the daylight illuminance may disturb the users and reduce their satisfaction regarding lighting conditions from another angle. In order not to tire and interrupt the users during their study, it would be better if the system automatically detects these changes in daylight illuminance and adjusts light levels in accordance with the command that the user has given before. Thus, a daylight-linked control system with manual control option which allows users to adjust light levels with dimming system could be useful for this purpose. In addition to the combination of manual and automatic control systems, lighting automation systems could also offer the same option. With the help of lighting automation systems, the system could adjust light levels in accordance with daylight illuminance and users' commands. Also, various lighting scenarios could be given by users to the system. Besides offering a dimmable system, these control and automation systems could also offer changes in light color. As mentioned before, there is a strong relationship between light color and illumination level. Thus, it might be beneficial for users if they are arranged together in harmony with each other.

Task lighting with dimming control could also be useful for architecture design studios as it provides individual control over light amount. Several studies have indicated the importance of user control over lighting. Collins et. al (1990), for example, found that satisfaction regarding lighting quality is improved when users are given the opportunity to control lighting. Users with task lighting generally demonstrated higher satisfaction than the ones who did not have task lighting. Boyce et. al (2003) indicated that users with dimming control perceive higher lighting quality, demonstrate environmental satisfaction, and better productivity. Similarly, according to the study of Sharmin (2011), students indicated the absence of task lighting as a problem, because they sometimes need more amount of light and sometimes need less. All of these studies indicate the

importance of task lighting as it provides individual control over lighting; however, task lighting should be considered carefully for architecture students. The desks of the workers in an office environment are generally fixed, as every office worker has her/his own desk. However, in studios, the positions of the desks change continuously because of the flexible environment of the studios. Thus, task lighting system in architecture design studios had better to be in the form of desk lamps. However, it should be considered that sometimes students use their desks in an angular form while making drawings, so the desk lamps are better to be independent from some part of the desks or fixed on the desks but flexible which means they can move with the movement of the desks. Lamps can be attached to desks horizontally with a movable head and body so that they can move together, and users may adjust the position of the lamps. In addition, the desks of the students might be over-crowded, so it is better to consider a finely designed lamp which will not occupy much place over desks. According to research results of Nieveen van Dijkum (2013), some students indicated that their study area is still dark even there is task lighting. Task lighting could help students adjust light levels themselves; however, the illumination level in the surrounding area of the students is also very important. Appropriate general lighting combination is needed to avoid high level of luminance contrasts in study areas of the students, especially the ones with less daylight illumination.

The importance of users' control over lighting has been emphasized in various studies. Research has revealed that when users have the option to adjust illumination level on their desks, their environmental satisfaction increases and perceptions regarding lighting quality and quantity, mood, motivation, and vigilance are affected positively (Veitch et al., 2003, 2008; Moore et al., 2004; Boyce et al., 2006). Boyce et al. (2006), for instance, found that participants who have dimming control were more motivated to continue to work on difficult tasks and demonstrated enhanced performance regarding attention. Personal control over lighting conditions led to better lighting quality perceptions and among the other tested lighting installations, the one which included personal control had highest rates of user satisfaction (Boyce et al., 2006).

To summarize, as daylight illumination has crucial importance for students, first, daylight illumination should be maximized in accordance with the required illumination levels. The distribution of daylight illumination and glare have vital importance for students. Thus, with the help of daylight control systems, the sections which are far from windows and remain dark like corners and wall-side should be well-illuminated. Glare

problems should be solved with control systems as much as it could be. According to the findings of this study, it is observed that students had to make a choice between daylight illuminance and avoiding glare because the existence of daylight and the absence of glare are both important as they affect their visual comfort, satisfaction, and motivation levels significantly. In addition, the seating preference of the students changes according to these factors. With a uniformly distributed daylight, not only adequate daylight illuminance is provided for almost all users, but also huge luminance contrasts, shadows and glare problem could be resolved.

Although previous studies have shown that daylight illumination is of vital importance for users' visual comfort, mood, satisfaction, well-being, and motivation in work and learning environments, there is another important factor for architecture design students. Providing efficient daylight illumination may not be enough for architecture students as they not only study in daily hours in their studios, but also generally stay for a whole night till the next morning unlike the students in regular classrooms. Thus, for them, artificial lighting design is important as much as daylighting. Even though the integration of daylight could be improved with an appropriate lighting design during the day, the students will fully depend on artificial lighting at nights. Likewise, the students in the present study also indicated that they use artificial lighting at nights, in their responses to the question of *"if you use artificial lighting frequently, what is the reason behind it?"* Thus, careful consideration should be given to artificial lighting design in architecture design studios as it has a vital importance for the students. Light sources should be chosen carefully so that they do not become a source of glare themselves. The maintenance of lamps should be done regularly, the ones who do not work or seize up need to be changed with the new ones. Instead of placing the lamps in the same regular order or illuminating every part of the space with the same light level, daylight illuminance distribution should be considered before applying artificial lighting. In the current study, likewise, position to windows and distance from windows affected the way students evaluated illumination levels as well as their overall satisfaction, visual comfort, and motivation. To be more specific, the sections which take less daylight illuminance will probably need more artificial lighting; on the other hand, the windowed sections may not need as much artificial lighting because there is more daylight illuminance in their area. Thus, if a lighting control or automation system will be applied, the switching should be separate according to each section. Section A, B, C, D and E had better have separate

switching. Even when daylight illuminance is uniformly distributed to the space with success, changes in its spectrum and orientation of the studios still matter; thus, it is better to zone the studios by taking into consideration particularly the distribution of daylight illumination, which can help guarantee sufficient levels of illumination. Therefore, having well-lit and less-lit spaces at the same time in the studio could be avoided, and an equal lighting opportunity for each student can be provided. In addition, with the option to change color temperature in these systems, different atmospheres could be created. Higher temperatures are preferred with higher illumination levels for alertness while studying; on the other hand, lower temperatures with warmer colors could give relaxing effect to the space (Şahin, 2012). Changes in color temperature of light could be useful at nights for architecture students. More specifically, as students sometimes stay in studios to study whole night, they may change the light color for a warmer atmosphere to relax while resting. If task lighting will be applied with general illumination, then, for general lighting design, the light sources which remain in windowless sides should give more illumination than the ones in windowed areas. In other words, as the findings from this study also indicate, applying same light sources with a symmetrical order with the same amount of illumination is not helpful for all users.

5.4. Conclusion

The aim of this study was to investigate how the lighting conditions affect the visual comfort, satisfaction, and motivation levels of architecture students. In this regard, three architecture design studios in Izmir Institute of Technology were selected. Field measurements and survey methods were conducted for the purpose of the study. A survey was administered to investigate the users' own perceptions regarding lighting conditions in their studio environments, their overall satisfaction, visual comfort, and motivation. The questions were directed to evaluate lighting conditions both in studios generally and in students' study areas specifically. Since architecture studies are practice-oriented, the illumination levels in students' study areas are highly important. In this regard, the findings from this study suggested that lighting and daylight are of crucial importance for students. Illumination level, glare and daylight were found to be the key factors that affect students' visual comfort, satisfaction, and motivation levels. Outside view was also found to be important for students' motivation. Student responses revealed that lighting

conditions also affect their comfort, alertness, concentration, and sleepiness. It was also found out that distance from windows significantly impacts the perceptions of students regarding lighting conditions and that daylight and glare affect seating preference of the students. According to the results, the lighting conditions in all three studios are inadequate. Even if some of the studios meet the standards, for students, it was found that lighting is insufficient in all studios. Meeting the standard levels of illumination is not enough when there is lack of daylight in the studio especially in the sections which have less daylight illuminance because of the distance from window. Insufficient illumination levels, glare, shadow, light color, and improperly designed artificial lighting contributed to inadequate lighting as well. Only one of the studios was found to be better than the others regarding lighting conditions when compared section by section. For improving the lighting conditions in architecture design studios, it is essential to provide a uniformly distributed, glare-free daylight illumination. After providing sufficient daylight illumination without glare, the selection and arrangement of artificial light sources are very important. Not only daily hours but also night-time should be considered while designing artificial lighting. Since the tasks carried out in a studio vary, a flexible design of artificial lighting such as lighting control and automation systems can be considered. For future research, this study could be replicated with a larger sample or with the integration of other design disciplines. In addition, the effects of lighting conditions on architecture students could be investigated at night-time as they are also used to studying at nights. Survey and measurements could be conducted at night in order to investigate the efficiency of artificial light sources and night-time lighting effects on students. Future studies could also investigate lighting control systems in architecture design studios.

REFERENCES

Altuncu, Damla, and Burak Tansel. 2016. “Aydınlatma Kontrol Sistemlerinin Hastanelerde Kullanımı.” *Tasarım+Kuram* 5, no.8: 116-127.

Apikoğlu, Sezen. 2014. “Ofislerdeki Aydınlatma Koşullarının Görsel Konfor, Memnuniyet ve Ruh Durumu Üzerindeki Etkileri: TWBA Binası Örneği.” Master’s Thesis, Bahçeşehir University, Istanbul. ULAKBIM.

Borisuit, Apiparn, F. Linhart, Jean-Louis Scartezzini, and M. Munch. 2014. “Effects of Realistic Office Daylighting and Electric Lighting Conditions on Visual Comfort, Alertness and Mood.” *Lighting Research & Technology* 47, no.2: 197-209.doi: 10.1177/1477153514531518

Boyce, Peter, Claudia Hunter, and Owen Howlett. *The Benefits of Daylight through Windows*. New York: Lighting Research Center, Rensselaer Polytechnic Institute, 2003.

Boyce, Peter, Jennifer Veitch, Guy Newsham, M. Myer, C. Hunter. 2006. “Lighting Quality and Office Work: Two field Simulation Experiments.” *Lighting Research and Technology* 38, no.3: 191-223.

Carter, D. J., A. I. Slater, M. J. Perry, K. P. Mansfield, D. L. Loe, and J. Sandoval. 1994. "The Influence of Luminance Distribution on Subjective Impressions and Performance within a Non-uniformly lit Office." In Proc. of the CIBSE National Lighting Conference. 61 74.

Castilla, Nuria, Carmen Llinares, Jose Maria Bravo, and Vicente Blanca. 2017. “Subjective Assessment of University Classroom Environment.” *Building and Environment* 122, 72-81.

Celik, Kasım, and Rengin Unver. 2017. “An Investigation on Lighting Matter in Design Guides of Educational Buildings.” Paper Presented at Lux Europa, Ljublajana, Slovenia.

Cetin, Banu. 2009. “Alışveriş Merkezlerinde Mağaza Aydınlatması Ve Uygulama Örnekleri.” Master’s Thesis, Istanbul Technical University, Istanbul. https://polen.itu.edu.tr/handle/11527/8212

“CIBSE Recommended Lux Levels.” *Kellwood Lighting*. January 26, 2017. https://www.kellwoodlighting.co.uk/technical/cibse-recommended-lux-levels

Cilasun, Arzu. 2016. “Categorization of Manual Lighting Control Behavior Patterns Based onInterior Layout in Offices.” PhD diss., Izmir Institute of Technology, Izmir.

Collins, B.L. 1990. “Evaluation of the Role of Luminance Distributions in Occupant Response to Lighting.” Paper Presented at CIBSE National Lighting Conference, Cambridge, April 8-11, 1990.

Corbett, Richard, B Middleton, and Jo Arendt. 2012. “An Hour of Bright White Light in the Early Morning Improves Performance and Advances Sleep and Circadian Phase during the Antarctic Winter.” *Neuroscience Letters* 525, no.2: 146-151.

Despenic, Marija, Sanae Chraibi, Tatiana Lashina, and Alexander Rosemann. 2017. “Lighting Preference Profiles of Users in an Open Office Environment.” *Building and Environment* 116: 89–107. https://doi.org/10.1016/j.buildenv.2017.01.033.

Dilouie, Craig. “Introduction to Lighting Controls.” Last modified June 21, 2017. https://lightingcontrolsassociation.org/2017/07/21/introduction-to-lighting-controls/

Fielding, Randall. 2006. “Learning, Lighting and Color: Lighting Design for Schools and Universities in the 21st Century.” *European Lighting Designers’ Association*. https://files.eric.ed.gov/fulltext/ED497664.pdf

Fotios, Steve. 2011. “Lighting in Offices: Lamp Spectrum and Brightness.” *Coloration Technology* 127, no. 2: 114–120.https://doi.org/10.1111/j.1478-4408.2011.00285.x.

Frontczak, Monika, and Pawel Wargocki. 2011. “Literature Survey on How Different Factors Influence Human Comfort in Indoor Environments.” *Building and Environment* 46, no. 4: 922–37. https://doi.org/10.1016/j.buildenv.2010.10.021.

Gelfand, Lisa, Eric Corey Freed. 2010. *Sustainable School Architecture: Design for Elementary and Secondary School*. New York, NY: John Wiley and Sons Inc.

“Good Lighting for a Better Learning Environment.” *Licht Wissen*, March 5, 2012. https://issuu.com/licht.de/docs/lichtwissen02_better-learning-environment

"Guideline and Recommended Lighting Levels." *CIBSE*. 2017. https://irpcdn.multiscreensite.com/8c467baa/files/uploaded/CIBSE%20Guideline%20Documntation%20V1.3.pdf

Haq, Mohammad Asif, Mohammad Yusri Hassan, Hayati Abdullah, Hasimah Abdul Rahman, Md Pauzi Abdullah, Faridah Hussin, and Dalila Mat Said. 2014. "A Review on Lighting Control Technologies in Commercial Buildings, Their Performance and Affecting Factors." *Renewable and Sustainable Energy Reviews* 33: 268–79. https://doi.org/10.1016/j.rser.2014.01.090.

Heerwagen, Judith. 2000. "Green Buildings, Organizational Success, and Occupant Productivity." *Building Research and Information* 28, no.5: 353-367.

Heschong, Lisa. *Windows and Classrooms: A Study of Student Performance and The Indoor Environment*. Sacramento, CA: California Energy Commission, 2003.

Hoffmann, Georg, Veronika Gufler, Andrea Griesmacher, Christian Bartenbach, Markus Canazei, Siegmund Staggl, and Wolfgang Schobersberger. 2008. "Effects of Variable Lighting Intensities and Color Temperatures on Sulphatoxymelatonin and Subjective Mood in an Experimental Office Workplace." *Applied Ergonomics* 9: 719–728. doi:10.1016/j.apergo.2007.11.005.

International Commission on Illumination. *Lighting for Workplaces, Part 1 Indoor (ISO: 8995-1: 2002 E).* Vienna: International Commission on Illumination, 2002.

Jamrozik, Anja, Christian Ramos, Jie Zhao, Joleen Bernau, Nicholas Clements, Trace Wolf, and Brent Bauer. 2018. "A Novel Methodology to Realistically Monitor Office Occupant Reactions and Environmental Conditions Using a Living Lab." *Building and Environment* 130: 190–199.

Jusl´en, Henry and Ariadne Tenner. 2005. "Mechanisms Involved in Enhancing Human Performance by Changing the Lighting in the Industrial Workplace*." International Journal of Industrial Ergonomics* 35, no. 9: 843–855.

Katabaro, Justine, and Yonghong Yan. 2019. "Effects of Lighting Quality on Working Efficiency of Workers in Office Building in Tanzania." *Journal of Environmental and Public Health* 2019, no.12: 1-12.

Kazanasmaz, Tuğçe. 2015. "Okullarda İç Çevre Konfor Bileşeni Olarak Aydınlatma." Paper Presented at 12. Ulusal Tesisat Mühendisliği Kongresi, 8-11 April 2015, Izmir: https://www.tesisat.org/okullarda-ic-cevre-konfor-bileseni-olarak- aydinlatma.html

Korkmaz, Seyhan. 2008. “Hastanelerde Doktor, Hemşire ve Ebelerin Motivasyonunu Etkileyen Faktörler: Bir Uygulama.” Master’s Thesis, University of Cag, Mersin. ULAKBIM.

Kralikova, Ruzena, Miriama Pinosova and Beate Hricova. 2016. “Lighting Quality and Its Effects on Productivity and Human Healths.” *International Journal of Interdisciplinarity in Theory and Practice* 10*: 8-12.*

Kruithof Curve. (2021, March 5). In *Wikipedia.* https://en.wikipedia.org/wiki/Kruithof_curve#cite_note-1

Kuller, Rikard and Carin Lindsten. 1992. “Health and Behavior of Children in Classrooms with and without Windows.” *Journal of Environmental Psychology* 12: 305-317.

Kuller, Rikard and Lennart Wetterberg. 1993. “Melatonin, Cortisol, EEG, ECG and Subjective Comfort in Healthy Humans: Impact of Two Fluorescent Lamp Types at Two light Intensities.” *Lighting Research and Technology* 25, no. 2: 71–80.

Lamb, S., and K.C.S. Kwok. 2016. “A Longitudinal Investigation of Work Environment Stressors on the Performance and Wellbeing of Office Workers.” *Applied Ergonomics* 52: 104–11. https://doi.org/10.1016/j.apergo.2015.07.010.

Lee, Ji-Hyun, Jin-Woo Moon and Sooyoung Kim. 2014. “Analysis of Occupants’ Visual Perception to Refine Indoor Lighting Environment for Office Tasks.” *Energies* 7, no. 7: 4116–4139.

Leichtfried, Veronika, Maria Mair-Raggautz, Viktoria Schaeffer, Angelika Hammerer, Gerald Mair, Christian Bartenbach, Markus Canazei, and Wolfang Schobersberger. 2015. “Intense Illumination in the Morning Hours Improved Mood and Alertness but not Mental Performance.” *Applied Ergonomics* 46: 54-59.

Manav, Banu. 2005. “ Ofislerde Aydınlık Düzeyi, Parıltı Farkı ve Renk Sıcaklığının Görsel Konfor Koşullarına Etkisi: Bir Model Çalışması.” PhD diss., Istanbul Technical University, Istanbul. ULAKBIM.

Mandala, A. 2019. “Lighting Quality In The Architectural Design Studio (Case Study: Architecture Design Studio at Universitas Katolik Parahyangan, Bandung, Indonesia).” *IOP Conference Series: Earth and Environmental Science* 238: 12-32. https://doi.org/10.1088/1755-1315/238/1/012032.

Mapio. Accessed June 5, 2021. https://mapio.net/pic/p-25123602/.

Moore, T, Daven Carter, and Al Slater. 2004. “A Study of Opinion in Offices with and without User Controlled Lighting.” *Lighting Research & Technology* 36, no.2: 131-146.

Mork, Randi, Helle K. Falkenberg, Knut Inge Fostervold, and Hanne-Mari Schiøtz Thorud. 2019. “Discomfort Glare and Psychological Stress during Computer Work: Subjective Responses and Associations between Neck Pain and Trapezius Muscle Blood Flow.” *International Archives of Occupational and Environmental Health* 93, no. 1: 29–42. https://doi.org/10.1007/s00420-019-01457-w.

Obeidat, Asem, and Raed Al-Share. 2012. “Quality Learning Environments: Design-Studio Classroom.” *Asian Culture and History* 4, no. 2: 165-174. https://doi.org/10.5539/ach.v4n2p165.

“Office Lighting: Motivating and Efficient.” *Licht Wissen*, August 16, 2012. https://issuu.com/licht.de/docs/lichtwissen04_office_lighting_motivating_and_effic

Oldham GR, and Nancy Rotchford. 1983. “Relationships between Office Characteristics and Employee Reactions: A Study of the Physical Environment.” *Administrative Science Quarterly* 28, no.4: 542-556.

Ozkum, Esra. 2011. “Doğal ve Yapay Aydınlatmanın İnsan Psikolojisi Üzerindeki Etkileri.” Master’s thesis, Marmara University, İstanbul. ULAKBIM.

Pauley, Stephen. 2004. “Lighting for the Human Circadian Clock: Recent Research Indicates That Lighting Has Become a Public Health Issue.” *Medical Hypotheses*, 63, no. 4: 588–596.

“Parıltı (cd/m2) ve Aydınlık (lx) Arasındaki Fark Nedir?” *Aydınlatma Portalı*. March 20, 2020. https://www.aydinlatma.org/parilti-cd-m2-ve-aydinlik-lx-arasindaki-fark nedir.html.

Phipps, Jo-Phipps, Jennifer Redman, Derk-Jan Dijk, and Shantha Rajaratnam. 2003. "Daytime Exposure to Bright Light, as Compared to Dim Light, Decreases Sleepiness and Improves Psychomotor Vigilance Performance." *Sleep* 26, no.6: 695-700.

Pulay, Alana. *Awareness of Daylighting on Student Learning in an Educational Facility*. Nebraska, NE: University of Nebraska-Lincoln, 2010.

Rea, Mark Stanley. *The IESNA Lighting Handbook: Reference and Application*. New York, NY: Illuminating Engineering Society of North America, 2000.

Research Highlights. 2012. IZTECH. https://iyte.edu.tr/wp- content/uploads/2019/03/15.pdf

Robbins, Claude. 1986. *Daylighting: Design and Analysis*. New York: Van Nostrand Reinhold.

Ryan, Richard, and Edward Deci. (2000). "Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-being." *American Psychologist* 55, no.1: 68–78.

Sahin, Dilek. 2012. "Aydınlatma Tasarımının Kullanıcı Üzerindeki Fizyolojik ve Psikolojik Etkileri Açısından İncelenmesi." Master's Thesis, Istanbul Technical University, Istanbul. ULAKBIM.

Samani, Sanaz. 2012. "The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A knowledge internalization perspective." *International Journal of Business and Social Science* 3, no. 24: 127-136.

Sharmin, Tanzia, 2011. "A Study of the Luminous Environment in Architecture Design Studios of Bangladesh." Master's Thesis. Bangladesh University of Engineering and Technology.

Shishegar, Nastaran and Mohamed Boubekri. 2016. "Natural Light and Productivity: Analyzing the Impacts of Daylighting on Students' and Workers' Health and Alertness." *International Journal of Advances in Chemical Engineering & Biological Sciences (IJACEBS)* 3, no.1: 72-77.

Sirel, Hülya. 1992. "İç ve Dış Aydınlatma Konularının Karşılaştırılması." Paper presented at Şehir Aydınlatması Kollokyumu, TMMOB Elektrik Mühendisleri Odası.

Sözen, Şerefhanoğlu, M. 2002. "Aydınlığın Niceliği ve Niteliği Yönünden Işık Renginin Önemi," *Kaynak Elektrik Dergisi,* no. 5: 132-136.

Surveey. "Online Survey System." www.surveey.com (March 2, 2020).

Teri. 2018. *Glare Management Guidelines for Artificial Lighting*. New Delhi: The Energy and Resources Institute.

Van Bommel, Wout and Gj Van Den Beld, 2004. "Lighting for Work: A Review of Visual and Biological Effects." *Lighting Research and Technology* 36, no. 4: 255–266.

Van den Berg, Thomas J.T.P., L.J. (René) van Rijn, R. Kaper-Bongers, D.J. Vonhoff, H.J. Völker-Dieben, G. Grabner, C. Nischler, M. Emesz, H. Wilhelm, and D. Gamer. 2009."Disability Glare in the Aging Eye. Assessment and Impact on Driving." *Journal of Optometry* 2, no. 3: 112–18. https://doi.org/10.3921/joptom.2009.112.

Van Dijkum, Charlotte. 2013. "An ethnographic study of architecture students and their workspaces." Master's Thesis, Delft University of Technology, The Netherlands. https://repository.tudelft.nl/islandora/object/uuid%3A251b0d39-4435-4076-a0f9-0c46cc9abdde

Veitch, Jennifer, and G.R Newsham. 1998. "Lighting Quality and Energy Efficiency Effects on Task Performance, Mood, Health, Satisfaction, and Comfort." *Journal of the Illuminating Engineering Society* 27, no. 1: 107–129.

Veitch, Jennifer. *Creating High-quality Workplaces Using Lighting*. Canada: NRC Publications, 2000.

Veitch, Jennifer, and Kelly Farley. *A Room with a View: A Review of the Effects of Windows on Work and Well-Being*. Ottawa: National Research Council, 2001.

Veitch, Jennifer, Kelley Farley, and Guy Newsham. 2002. "Environmental Satisfaction in Open-plan Environments: 1. Scale Validation and Method." NRC/IRC Research Report IR-844, National Research Council Canada, Institute for Research in Construction, Ottawa, Ontario, Canada.

Veitch, Jennifer, Kate Charles, Guy Newsham, and C. Marquardt, Jan Geerts, 2003. "Environmental Satisfaction in Open-plan Environments: 5. Workstation and Physical Condition Effects." NRC/IRC Research Report RR-154, National Research Council Canada, Institute for Research in Construction, Ottawa, Ontario, Canada.

Veitch, Jennifer, Guy Newsham, and Chantal Arsenault. 2004. "Effect of dimming control on office worker satisfaction and performance," in Proceedings of the IESNA annual conference, Tampa FL, New York.

Veitch, Jennifer, J. Geerts, Kate Charles, Guy Newsham and C. J.G. Marquardt. "Satisfaction with Lighting in Open-plan Offices: COPE Field Findings." Paper Presented at *10th European Lighting Conference, Berlin, Germany, 2005.* Canada: NRC Publications https://nrcpublications.canada.ca/eng/view/accepted/?id=77c8f550-909b-467b-9ae2cd29857dd795

Veitch, Jennifer, Guy Newsham, Peter Robert Boyce, and CC Jones. 2008. "Lighting Appraisal, Well-being, and Performance in Open-plan Offices: A linked Mechanisms Approach." *Lighting Research and Technology* 40, no.2: 133-151.

Wessolowski, Nino, Heiko Koenig, Michael Schulte-Markwort, and ClausBarkmann. 2014. "The Effect of Variable Light on the Fidgetiness and Social Behavior of Pupils in School." *Journal of Environmental Psychology* 39: 101–108.

Winterbottom, Mark & Arnold Wilkins. 2009. "Lighting and discomfort in the classroom." *Journal of Environmental Psychology* 29, no.1: 63-75.

Zhounghua Gou, Stephen Siu-Yu Lau, and Feng Qian. 2013. "Comparison of Mood and Task Performance in Naturally lit and Artificial lit Environments." *Indoor and Built Environment* 24, no.1: 27-36.

APPENDICES

APPENDIX A. SURVEY QUESTIONS

Survey

***Please indicate which section you generally sit by considering the drawing above.**

A (window side)

B (center of the studio)

C (wall side)

D (back of the studio [wall side])

E (back of the studio [window side])

SECTION A

LIGHTING CONDITIONS

1) Do you think the general lighting in the studio is sufficient?

a) Yes

b) No

If not, what do you think is the reason behind it? (You may choose more than one option.)

a) The amount of light sources

b) The type of light sources

c) Insufficient daylight

d) Other: …… (Please indicate it.)

2) Please put a check to the options that fit you.

	Too Bright	Bright	Normal	Dim	Too dim
Illumination level of artificial lighting					
Illumination level on the desk while making model					
Illumination level on the desk while making technical drawing					
Illumination level on the desk while reading and writing					
Illumination level on your computer screen					
Illumination level on the projection screen during presentations					

3) How important is it to have windows in the studio to benefit from daylight?

a) Very important

b) Important

c) Neutral

d) Less important

e) Unimportant

4) How often do you use artificial lighting inside the studio?

a) Always

b) Often

c) Sometimes

d) Rarely

e) Never

If you use artificial lighting frequently, what is the reason behind it? (You may choose more than one option.)

Insufficient daylight

Glare resulting from daylight

Other: …… (Please indicate it.)

5) When you raise your head from your desk, how does the surrounding seem to you?

a) Too bright

b) Bright

c) Neutral

d) Dark

e) Too dark

SECTION B

VISUAL COMFORT AND SATISFACTION

1) Do the following elements prevent you while you are studying?

	Yes	No
Illumination level		
Color of Light		
Shadows in your study area		
Glare		

If there is glare, what do you think is the reason behind it? (You may choose more than one option.)

a) Artificial light sources

b) Daylight

c) Material reflectance

d) Other: ..... (Please indicate it.)

2) Did you notice any glare on the .....?

	Yes	No
Board		
Computer screen		
Desk		
Projection screen		

3) Can you rate your satisfaction level with the lighting conditions between 1 to 5 according to each following task? (5-Very Satisfied, 4-Satisfied, 3-Neutral, 2-Less Satisfied, 1-Unsatisfied)

*Technical Drawing (.....)
*Computer Drawing (.....)
*Model Making (.....)
*Reading and writing (.....)
*Its effect on your concentration level while listening to the lecturer (.....)
*Watching a presentation (.....)

4) Please put a check to the options that fit you.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I do not like to study in this studio because of the lighting conditions					
I do not like to study in this studio because of the lack of daylight					
I do not like to study in this studio because of the artificial lighting conditions					

SECTION C

MOTIVATION LEVEL

1) How important is lighting for your motivation level?

a) Very important
b) Important
c) Neutral
d) Less important
e) Unimportant

2) How important for you to study in a studio with windows and daylight, from the side of your motivation level?

a) Very important
b) Important
c) Neutral
d) Less important
e) Unimportant

3) Please put a check to the options that fit you.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I believe daylight has a positive effect on my motivation level					
I feel less alert, energetic, and active especially in the mornings because of the lack of daylight					
Seeing outside while studying has a positive impact on my motivation level					
Insufficient lighting in my study area makes me feel uncomfortable and demotivated					
I believe glare in the surrounding area has a negative impact on my motivation level					
I do not prefer to sit at the desks that are close to the window because of the glare					

4) Especially in the mornings, the lighting conditions make me feel.....(You may choose more than one option.)

Stressful
Demotivated
Uncomfortable
Sleepy

Other: ..... (Please indicate it.)

None of them

SECTION D

PERSONAL INFORMATION

Gender: ☐Female ☐Male Age:

I spend ..... hours per week in this studio.

12	12-16	More than 16

Anket

***Lütfen yukarıdaki plan çizimini dikkate alarak genel olarak sınıfta oturduğunuz bölgeyi işaretleyiniz.**

A (pencere tarafı)
B (orta sıra)
C (duvar tarafı)
D (Arka sıra duvar tarafı)
E (Arka sıra pencere tarafı)

BÖLÜM A

AYDINLATMA KOŞULLARI

1) Stüdyodaki genel aydınlatmanın yeterli olduğunu düşünüyor musunuz?
a) Evet
b) Hayır

Eğer yeterli değilse sizce sebebi nedir? (Birden fazla seçeneği işaretleyebilirsiniz.)
a) Işık kaynaklarının sayısı
b) Işık kaynaklarının türü
c) Günışığının yetersiz olması
d) Diğer: …… (Lütfen belirtiniz.)

2) Lütfen aşağıdaki her bir madde için size uygun olan seçeneği işaretleyiniz.

	Çok yüksek	Yüksek	Normal	Düşük	Çok düşük
Stüdyodaki yapay aydınlık seviyesi					
Maket yaparken sıranın üzerindeki aydınlık seviyesi					
Teknik çizim yaparken sıranın üzerindeki aydınlık seviyesi					
Okurken veya yazarken sıranın üzerindeki aydınlık seviyesi					
Bilgisayarla çalışırken bilgisayar ekranı üzerindeki aydınlık seviyesi					
Bir sunumu izlerken projeksiyon ekranı üzerindeki aydınlık seviyesi					

3) Ders yaptığınız stüdyoda, gün ışığından faydalanmak açısından, pencerelerin bulunması sizin için ne kadar önemlidir?

a) Çok önemli

b) Önemli

c) Nötr

d) Biraz önemli

e) Önemli değil

4) Sınıfta yapay aydınlatmayı ne sıklıkla kullanıyorsunuz?

a) Her zaman

b) Çoğu zaman

c) Bazen

d) Nadiren

e) Hiç kullanmıyoruz

Eğer sık kullanıyorsanız sebebi nedir? (Birden fazla seçeneği işaretleyebilirsiniz.)

Günışığının yetersiz olması

Günışığının kamaşmaya sebep olması

Diğer: ..... (Lütfen belirtiniz.)

5) Masanızda çalışırken başınızı kaldırdığınızda etrafınız size nasıl görünüyor?

a) Çok aydınlık

b) Aydınlık

c) Nötr

d) Karanlık

e) Çok karanlık

BÖLÜM B

GÖRSEL KONFOR VE MEMNUNİYET

1)Aşağıdaki öğeler çalışırken sizi engelliyor mu?

	Evet	Hayır
Aydınlık seviyesi		
Işığın rengi		
Çalışma alanınızdaki gölgeler		
Kamaşma		

Eğer kamaşma var ise, sizce kamaşmanın kaynağı nedir? (Birden fazla seçeneği işaretleyebilirsiniz)

a) Yapay ışık kaynakları

b) Gün ışığı

c) Malzemelerin yansıtıcı özelliği

d) Diğer: ..... (Lütfen belirtiniz.)

2) Aşağıdaki yüzeylerinde kamaşma fark ettiniz mi?

	Evet	Hayır
Tahta		
Bilgisayar ekranınız		
Sıranız		
Sunumlar sırasında projeksiyon ekranında		

3) Aşağıdaki her bir eyleme göre, stüdyonun aydınlatma koşullarına yönelik memnuniyet düzeyinizi 1 ile 5 arasında derecelendiriniz. (5-Çok memnun, 4-Memnun, 3-Nötr, 2-Pek memnun değil, 1-Hiç memnun değil)

*Teknik çizim yapma (.....)
* Bilgisayarla çizim yapma (.....)
* Maket yapımı (.....)
* Okuma ve yazma (.....)
* Öğretmen ders anlatırken konsantrasyon seviyenize etkisi (.....)
* Sunum izleme (.....)

4) Lütfen aşağıdaki her bir madde için size uygun olan seçeneği işaretleyiniz.

	Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
Genel aydınlatma koşulları nedeniyle bu stüdyoda çalışmaktan hoşlanmıyorum.					
Gün ışığı yetersiz olduğu için bu stüdyoda çalışmaktan hoşlanmıyorum.					
Yapay aydınlatma koşullarından dolayı bu stüdyoda çalışmaktan hoşlanmıyorum.					

BÖLÜM C

MOTİVASYON SEVİYESİ

1) Aydınlatma, motivasyon seviyeniz açısından, sizin için ne kadar önemlidir?

a) Çok önemli

b) Önemli

c) Nötr

d) Biraz önemli

e) Önemli değil

2) Pencerelerden gelen gün ışığının olduğu bir stüdyo ortamında ders yapmak, motivasyon seviyeniz açısından, sizin için ne kadar önemlidir?

a) Çok önemli

b) Önemli

c) Nötr

d) Biraz önemli

e) Önemli değil

3) Lütfen aşağıdaki her bir madde için size uygun olan seçeneği işaretleyiniz.

	Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
Gün ışığının motivasyon seviyem üzerinde olumlu bir etkisi olduğunu düşünüyorum.					
Özellikle sabahları, gün ışığı eksikliğinden dolayı kendimi yeterince zinde, enerjik ve aktif hissetmiyorum.					

	Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
Çalışırken dışarıyı görmek motivasyonumu olumlu yönde etkiliyor.					
Aydınlatmanın çalışma alanımda yetersiz olmasından dolayı konforsuz ve demotive hissediyorum.					
Çevremdeki kamaşmanın motivasyonum üzerinde olumsuz bir etkisi olduğunu düşünüyorum.					
Gün ışığından kaynaklanan kamaşma sebebiyle pencere yakınındaki sıralara oturmayı tercih etmiyorum.					

4) Özellikle de sabahları, aydınlatma koşulları kendimi ..... hissettiriyor. (Birden fazla seçeneği işaretleyebilirsiniz.)

Stresli
Demotive
Konforsuz
Uykulu
Diğer: .....(Lütfen belirtiniz.)
Hiçbiri

BÖLÜM D

KİŞİSEL BİLGİLER

Cinsiyet ☐ Kadın ☐ Erkek **Yaş:**

Haftada ..... saatimi bu stüdyoda geçiriyorum.

12	12-16	16 dan fazla

APPENDIX B

PLAN DRAWINGS AND SECTIONS OF STUDIOS

The plans of studios which were used in the beginning of the survey are indicated below. The sections of the studios were demonstrated with colors and it was asked students to indicate which section they generally sit in the studio and requested to answer the remaining questions according to their sections.

Figure B.1. The sections of the studio A206, B208 and B207; section A (window side), section B (center of the studio), section C (wall side), section D (back of the studio[wall side]), section E (back of the studio[window side]).