Analysis of Lighting Performance in the Architecture Design Studio: The Case of Architecture Department, Salahaddin University-Erbil

Siham M. Kareem, Hardi K. Abdullah*, Snur A. A. Agha

Department of Architecture, College of Engineering, Salahaddin University-Erbil, Erbil, Iraq, 44001.

* Corresponding author: hardi.abdullah@su.edu.krd

https://doi.org/10.31972/iceit2024.055

Abstract

In the design studios, daylighting and artificial lighting have a primary influence on providing visual comfort and students' satisfaction with the environment. The design and drawing activities performed in these spaces require an acceptable lighting performance. The aim of this study is evaluating the lighting quality in the design studios and providing lighting design recommendations to improve the students' creativity and productivity. Observations were performed to obtain physical studio data and existing lighting system. A simulation software, namely DiaLux Evo 10, is used to simulate the lighting performance in the existing design studio at the Department of Architecture, College of Engineering, Salahaddin University-Erbil (SUE). The simulation results of daylight factor (DF), illumination levels (Lux), and glare value are analyzed in accordance to the British/ European Standard (BS EN 12464-1:2021). The results reveal that the lighting performance at the studied design studio is not sufficient, thus the study suggests possible modifications for the type and quantity of existing artificial lighting.

Keywords: Lighting performance, daylighting, artificial lighting, design studio, Dialux Evo 10.

1. Introduction

In architecture, lighting plays a dual role of functional fulfillment and creating psychological impact to the occupants. Therefore, lighting design optimization, both natural and artificial, is necessary to achieve a sufficient lighting performance (Miran and Abdullah, 2016). Since design is the architecture department's primary area of expertise, working and learning mostly takes place in the design studios. Thus, it requires an adequate environment that can promote these activities efficiently. When there is not enough natural light, supplementary artificial light is required, which uses electrical power. Proper utilization of light in learning facilities is important to guarantee that learning can be carried out in a well-lit environment.

According to the British/ European Standard (BS EN 12464-1:2021), for this activity and space usage, the lighting needed is at least 750 lux (BSI Standard, 2021). Students need to have this level of lighting to work on their design drawings as efficient as possible. To ensure that students are comfortable during the drawing and design activities, lighting arrangements should be

considered. An enthusiastic learning environment and a delighted mood can be enhanced by well-lit spaces (Febriyursandi et al., 2019)

The Department of Architecture Engineering at Salahaddin University-Erbil, SUE accommodates five similar architectural design studios as part of its Architecture Study Program. The design studios are distributed as following: studios 1 and 2 are located on the ground floor and studios 3, 4, and 5 are situated on the first floor. These locations correspond to the various studio-based subjects, including Basic Design, Architectural Design, Building Materials, Interior Design, and Landscape Design, etc. Among the studio-based activities that take place in these spaces are tutoring, leading workshops, mentoring, critique sessions, and project exhibitions. Creating project models, using various materials, and design drawing activities are part of the studio activities. All of these activities demand an adequate level of lighting, which has to be of excellent quality.

This study aims at identifying the lighting performance in the design studio of Architecture Department, College of Engineering, Salahaddin University-Erbil and assessing it by comparing to a relevant lighting standard recommendation. Accordingly, the research attempts to provide recommendations for appropriate lighting design for similar Architecture design studios.

1.1 The Importance of Lighting in Architecture Design Studio

Natural lighting comes from both direct and indirect sunlight, whereas artificial lighting is provided by light fixtures, such as lamps (Fahmi, M. K., 2013). When it comes to satisfying human visual needs to perceive colors, textures, and overall space impression, both lighting systems are crucial. In a psychological perspective, the color that light creates can affect a person's mood and emotions in different ways, including making an environment appear warm or cold provoking or sympathetic, exciting or relaxing **(**Marsya et al., 2016).

In architecture study, the design studio functions as a learning center for architecture education where the frequency of use and time spent in these spaces is higher than traditional classroom settings. Therefore, it is important to take into account the lighting quality to improve user comfort and create a certain ambiance in the space (Nurrohman et al., 2021). The lighting that confirms the spaciousness/confusedness, visual clarity/haziness, relaxation/activation, and private/public impression can validate the user's perception (Houser et al., 2002). This has to do with the amount of lighting, the choice of light color, and how the light source is positioned within the space.

It is possible to distinguish artificial light control that changes to variations in illumination levels by modifying light scenarios based on spatial requirements or by alternating and dimming lights. To reduce glare from light sources, it is recommended to use task lighting from both sides and general diffused lighting when drafting, drawing, or painting (Mandala and Ritva Santoso, 2018).

Even in places where there is no activity at night, artificial lighting is crucial for both indoor and outdoor areas. Examples of these include factories, offices, and retail establishments. The process of choosing artificial lighting is not simple and requires careful consideration of

several crucial factors. This covers the light source's location, the kind of fixture used, how light is supposed to be distributed, and, how the lights interact with the surrounding space and available surfaces.

When designing a lighting system, the average illumination serves as a reference point for determining the required lamp count and illumination level in a given space or area. Then, this benchmark is recalculated according to the area's color, dimensions, and layout (Wotton, 2000). Due to variations in color, room function, lighting source, and lighting arrangement, two spaces might be seen as distinct areas inside a single building. The aforementioned elements are all connected to the lighting's ability to produce consistent illuminations (Liberman,1991).

A lighting system is generally considered to be of high quality when it produces an environment that is comfortable for people to see, while engaging in daily tasks like eating, walking, and reading. It also aids in the development of positive interactions and communication, appropriate mood states (happiness, alertness, satisfaction, and preference), the promotion of a safe and healthy environment, the avoidance of negative effects, and the evaluation and appreciation of the space's aesthetic qualities (Knez and Kers, 2000).

2. Materials and Methods

2.1 Data Collection Method

Observation method is used to collect the required data concerning the studio design in terms of layout shape, size, furniture arrangement, and other elements. Daylighting data collection include window size, orientation, glazing material, and environmental conditions. While, artificial lighting data collection encompasses light type, light arrangement, number of lights, and other relevant specifications.

Computer simulation method is used to acquire data about lighting illumination level, light distribution, daylight factor, uniformity, and glare disturbance as a result of direct sunlight penetration. In this research, DiaLux Evo 10, a tool for simulating artificial lighting and daylight, is used to perform simulations. DiaLux is a program designed to simulate and visualize light conditions. Previous studies confirm the effectiveness and reliability of this software in studying various aspects of lighting performance (Febriyursandi et al., 2019; Mandala, 2019; Nurrohman et al., 2021; Poursafar et al., 2016; Satwiko, 2011).

2.2 Analysis Method

The color of light and illumination level have a significant impact on the visual quality and user perception in a space, thus they affect productivity and creativity of the students in the design studios. In this study, the British/ European Standard (BS EN 12464-1:2021), *Light and lighting - Lighting of work places - Part 1: Indoor work places* (BSI Standards, 2021), is used for the evaluation of simulation results in the studied design studio. It specifies lighting requirements for humans in indoor work places, which meet the needs for visual comfort and performance of

people having normal visual capacity. This standard offers the minimum recommendation levels of illumination for office spaces based on the activity performance. According to the BS EN 12464-1:2021 standard, a 750 Lux illumination is required for technical drawings and similar activities, and the minimum daylight factor for a classroom (and design studios) is 2 %. To perform the visual drawing tasks, 1500 Lux on the workplane is recommended (Mandala, 2019).

2.3 Case Study

In this study, the lighting performance of a design studio at the Architecture Department, SUE is evaluated. The department of architecture consists of two floors; ground floor and first floor. Studios 1 and 2 are located on the ground floor, while studios 3,4, and 5 are located on the first floor (see Figure 1). The floor area of each studio is 152.66 m^2. These studios are designed with an open plan layout using rectangular shape with length, width, and height dimensions of 14.2 m, 10.4 m, 2.8 m, respectively. In this study, studio 1 (ground floor) is selected, as a typical design studio at the Department of Architecture, SUE, for simulation and evaluation of lighting level (Lux), daylight factor (DF) and glare value. Studio 1 has three apertures (3.20 m length and 1.40 m height) on both the east and west orientations and three apertures (two 0.6 m length x 1.40 m height and one 3.20 m length and 1.40 m height) on the north side. The window sill height for all the apertures is 1.0 m, and these windows receive direct daylight. The finishing material used for the walls and ceiling is gypsum plaster with white color paint and light-colored ceramic tiles are used for the floor finishing. This studio contains 28 white color adjustable drawing tables arranged with a grid system (four rows and seven columns).

The artificial lighting with a grid pattern on the ceiling is positioned using Philips TMS022 2x36W 2xTL-D36W/840 HF Standard + GMS022 R. The color of these lights is white and there are twelve lights attached to the ceiling, with three lights per a row. Figure 2 shows the interior views of the typical design studios at the Architecture Department, SUE.

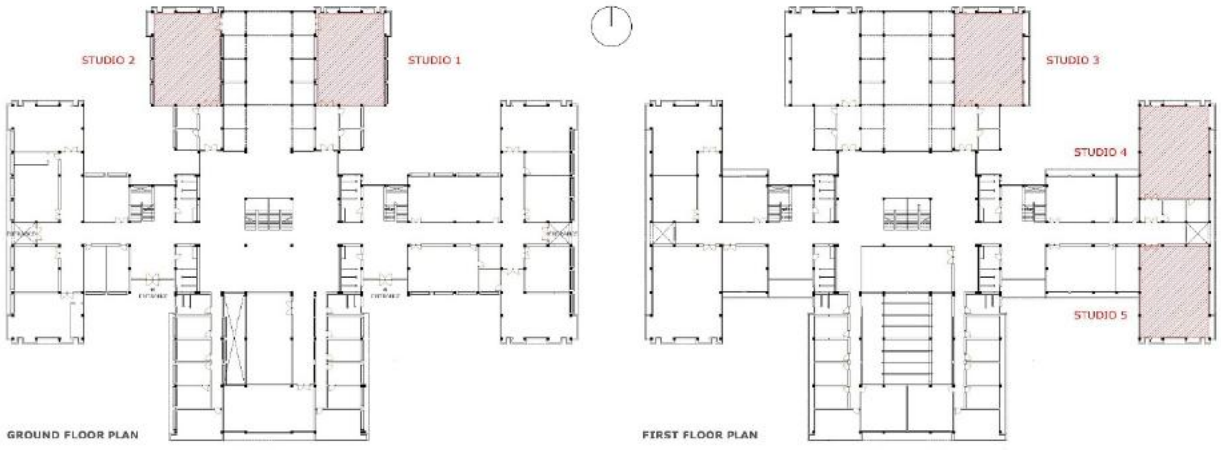

Figure 1. Floor plans of the architecture department, SUE and the locations of the design studios.

Figure 2. The interior views of the design studios.

3. Results and Discussion

The simulation results of daylight and artificial light in the studied design studio are presented in the Figures 3-5. Figure 3 shows daylighting distribution for the clear sky condition at 12:00 PM and Figure 4 illustrates the artificial light distribution for the existing 12 light sources. Considering the daylighting alone, the reflection factors for the ceiling, walls, and floor are 70.0 %, 53.4 %, and 75.5 %, respectively. While, for effect of the artificial light, the reflection factors for the ceiling, walls, and floor are 81.5 %, 73.5 %, and 75.5 %, respectively (see Figure 5).

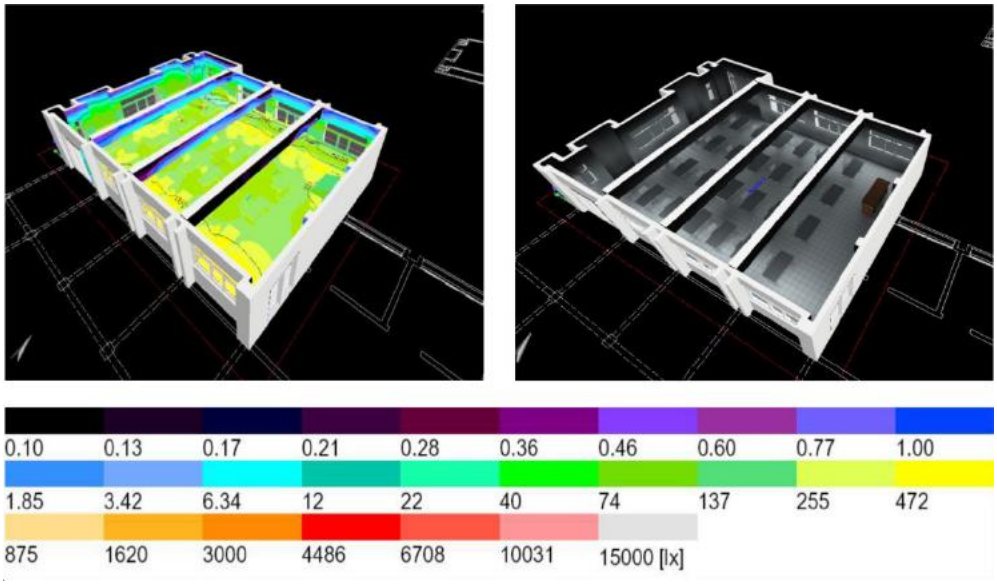

Figure 3. Daylight (clear sky) simulation results at 12:00 PM for studio 1.

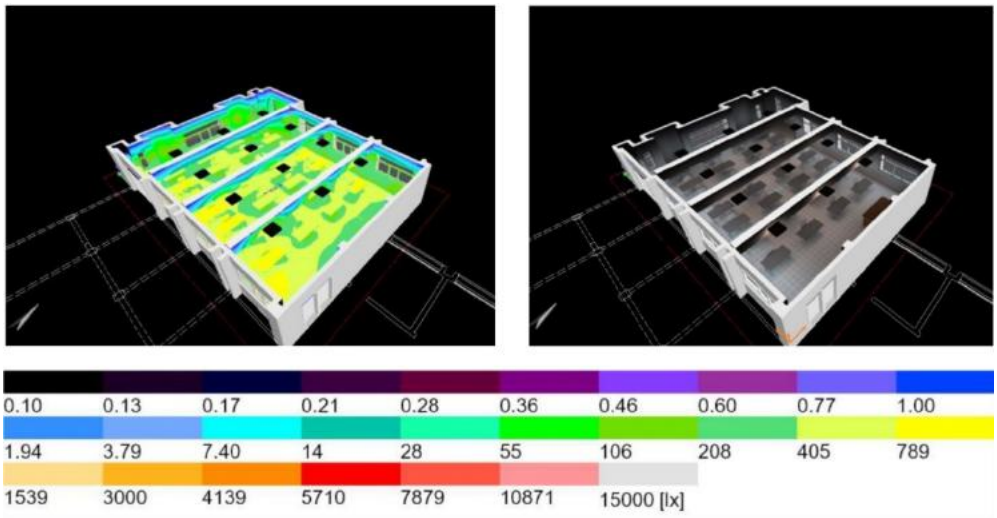

Figure 4. Artificial light simulation results with 12 light sources for studio 1.

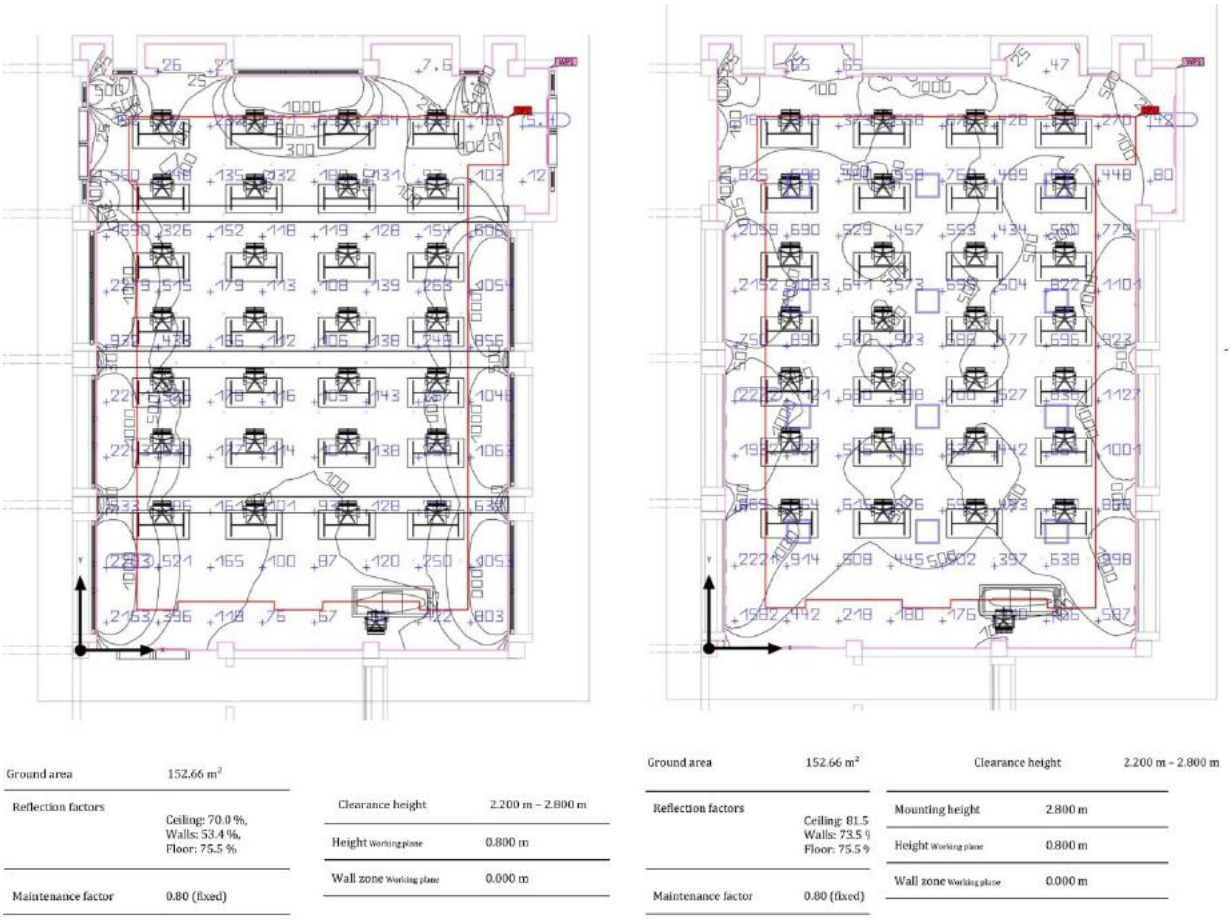

Figure 5. Daylight (**left**) and artificial light + Daylight (**right**) simulation results for studio 1.

By looking at the summary of results presented in Figures 6 and 7, the calculated average daylight factor ($DF_{av.}$) is 1.136 %, which does not meet the target of 2.0 %. The average

illumination level in the case of daylight alone is 408 Lux and for the artificial light is 663 Lux. These lighting levels are below the BS EN 12464-1:2021 standard recommendations and the 1500 Lux target on the workplane cannot be met by the combined effects of both light systems. One reason is that the design studios at the Department of Architecture, SUE have a general lighting system and there are no direct or local lightings for the drawing tables, thus it does not satisfy the requirement for these particular drawing activities.

The lighting uniformity has significant impact on visual performance in design studios. Uniformity (U_o) value is calculated by dividing the minimum brightness (E_{min}) resulting from calculations according to the current lighting order, to the average brightness value (E_{avg}). Uniformity value determined according to the type of fixture, number, light angle and mounting position. Uniformity value greater than 0.60 is recommended in the design studios due to the fact that the change in light levels cannot be sensed by students and that facilitates comfortable environment. The uniformity target was not achieved in the studied case. Finally, glare is found is the places close to the windows; however, the average glare value is 18, which does not exceed the acceptable threshold of ≤ 19.

Results

	Symbol	Calculated	Target	Check	Index
Daylight	D	1.136 %	–		DF1
Working plane	$\bar{E}_{perpendicular}$	408 lx	≥ 750 lx	✗	WP1
	U_o (g_1)	0.00	≥ 0.60	✗	WP1
Energy estimation(2)	Consumption	0.00 kWh/a	max. 50 kWh/a	✓	
Room	Lighting power density	0.00 W/m²	–		
		0.00 W/m²/100 lx	–		

Figure 6. Evaluation of daylight results based on the recommendations of the BS EN 12464-1:2021 standard.

Results

	Symbol	Calculated	Target	Check	Index
Daylight	D	1.136 %	–		DF1
Working plane	$\bar{E}_{perpendicular}$	663 lx	≥ 750 lx	✗	WP1
	U_o (g_1)	0.00	≥ 0.60	✗	WP1
Glare valuation(1)	$R_{UG,max}$	18	≤ 19	✓	
Energy estimation(2)	Consumption	[512.40 - 820.80] kWh/a	max. 5350 kWh/a	✓	
Room	Lighting power density	3.77 W/m²	–		
		0.57 W/m²/100 lx	–		

Figure 7. Evaluation of Artificial light results based on the recommendations of the BS EN 12464-1:2021 standard.

4. Conclusion

The lighting performance in the design studio at the Department of Architecture, SUE is studied through observations and computer simulations using DiaLux Evo 10 software. Considering the British/ European Standard (BS EN 12464-1:2021) recommendations, the illumination level of the studied design studio did not meet the minimum value of 750 Lux. Differences in illumination levels in a space are mainly affected by the type of lights and the contribution of daylighting through the apertures. The calculated average daylight factor was less than the acceptability limit of 2.0 %. The uniformity target of greater than 0.60 was not met due to inappropriate lighting type, number, or arrangement positions. Besides observing glare issues around the apertures, the acceptable threshold of ≤ 19 was not exceeded.

The recommendation for enhancing the lighting performance in the existing design studios is to install task lighting on the working tables. Task lighting may facilitate concentration by promoting illumination and contrast levels. According to the type of activity they perform, each student can have an independent control over the task lighting. Furthermore, when architects design windows, consideration of daylighting is crucial to boost design studio lighting performance, thus less dependence will be on artificial light. Consequently, it results in reducing a considerable amount of energy consumption and carbon dioxide emission, which are the emerging goals of sustainability.

Conflicts of Interest: The authors declare no conflict of interest.

References

BSI Standard, 2021. BS EN 12464-1:2021 standard. Light and lighting. Lighting of work places Indoor work places. Available at: https://www.en-standard.eu/bs-en-12464-1-2021-light-and-lighting-lighting-of-work-places-indoor-work-places/

Fahmi, M. K., 2013. Disparities in Alami Pencahayaan and Computer Lab Equipment Regarding Siswa Kenyamanan in the Teaching Process (Doctoral dissertation, Universitas Pendidikan Indonesia).

Febriyursandi, R., Azryenni, A. Z., & Hamzah, A., 2019. Design lighting quality based on DiaLux evo 8.1. *Journal of Science and Applied Engineering*, *2*(2), 42.

Houser, K. W., Tiller, D. K., Bernecker, C. A. and Mistrick, R. G., 2002. Responses to lighting systems that use direct or indirect linear fluorescent lighting are subjective. *Lighting Research & Technology, 34*(3), pp. 243–260.

Knez, I. and Kers, C., 2000. Effects on mood and cognitive function of age, gender, and indoor illumination. *Behaviour and Environment, 32*(6), pp. 817-831.

Liberman, J., 1991. *Future Lighting Medicine*. Bear and Company Publications.

Mandala, A., 2019. The case study looks at the lighting of the Universitas Catholic Parahyangan's architectural design studio in Bandung, Indonesia. *IOP Conference Series: Earth and Environmental Science*, Vol. 238, No. 1, p. 012032). IOP Publications.

Mandala, A. and Ritva Santoso, A., 2018. Comparative Study of Daylighting Calculation Methods. *SHS Web of Conferences 41*, 06001, pp. 1-8.

Marsya, I. H. and Anggraita, A. W., 2016. Research on the effects of warning signs on users' psychological well-being, with a focus on the unit transfuse Darah Kota x. *Interior Journal, 1*(1), pp. 41–50.

Miran, F. D. and Abdullah, H. K., 2016. Evaluation of the Optimal Solar Shading Devices for Enhancing Daylight Performance of School Building (A case study of semi-arid climate–Erbil city). *ZANCO Journal of Pure and Applied Sciences*, *28*(2).

Nurrohman, M. L., Feros, P., Madina, R. F. and Pratiwi, N., 2021. A multipurpose architectural studio classroom's efficient lighting design makes use of the Dialux Evo 9. *IOP Conference Series: Earth and Environmental Science*, Vol. 738, No. 1, p. 012034), IOP.

Poursafar, Z., Devi, N. R. and Rodrigues, L. R., 2016. Determining the preferred colours and lighting schemes in architects' workplaces to enhance output. *Journal of Contemporary Scholarly Writing, International, 8*(3), p. 1.

Satwiko, P., 2011. The Use of Dialux Software as a Learning Aid for Lighting Design. *Journal of Architectural Design, 9*(2), pp. 142–154.

Wotton, E., 2000. *The IESNA Lighting Handbook and office lighting*. Lighting, 14.