# The impact of lighting on enhancing the productivity of high school students in the classroom at smart cities

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**Abstract**:

Good lighting can improve concentration, lessen fatigue, and provide the best possible learning environment. Even though classroom design is acknowledged to be important, many educational institutions fail to consider how lighting affects student performance. Academic progress may be hampered by a lack of care which could lead to less-than-ideal learning environments. The purpose of this study is to investigate the connection between student productivity and various forms of classroom lighting. It specifically aims to ascertain how changes in artificial and natural light impact students' general academic performance. For this investigation, a mixed-methods strategy was used. Standardized by research designs, participants then data collection and analysis. According to research, classrooms with natural light considerably increase student

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productivity when compared to those with only artificial illumination. Teachers observed better behavior and participation during lessons, while students reported higher levels of interaction and attentiveness in well-lit classrooms. By offering empirical data on how lighting affects student productivity, this study adds to the body of knowledge already in existence. To promote improved learning outcomes, it provides educators and leaders with useful suggestions for classroom design that give priority to efficient lighting options.

**Keywords:**

Classroom; Lighting; Highschool; Illumination.

**Question:**

How light affect students?

**2. Introduction:**

Smart cities are an innovative way of urban development that improves citizens' quality of life by combining data-driven solutions and technology. Smart cities' complex structures and connections allow better learning environments in the context of education. They encourage collaboration between local governments and educational institutions, supporting projects that use technology to enhance instruction. Students' focus, attitude, and general academic performance are all greatly impacted by lighting in classroom settings. Appropriate lighting can improve sight, lessen eye strain, and foster a learning environment. Given that it has been demonstrated to enhance student engagement and wellbeing, natural light is especially advantageous. Classrooms with smart lighting systems can adjust to different activities throughout the day, creating the best possible environment for instruction and learning. Therefore, incorporating smart city ideas into educational environments not only improves infrastructure but also encourages more efficient and healthy learning environment. It is important to investigate how illumination affects student productivity for several reasons. First, their attention, memory, and general academic achievement are all greatly impacted by their learning environment.


*(Fig.1) How light affect human (Fardin,2019)*
http://ledjournal.com/lighting-and-human-health/

**Research Objective:**

Examining the impact of classroom illumination on students' productivity is the aim of this project. In the end, this will result in improved educational outcomes.

• To Examine the Connection Between Lighting and Student Involvement: Examine how various lighting configurations (natural,

fluorescent, and LED)
• To evaluate how lighting affects academic performance.
• To Investigate Lighting's Psychological Impact on Learning Environments: Look into how classroom lighting decisions affect students' psychological well-being.
• To Examine the Connection Between Colors and Lighting: Examining the potential effects of color on light.
The purpose of this study is to evaluate the best color and lighting combinations that improve student learning environments and learning results.

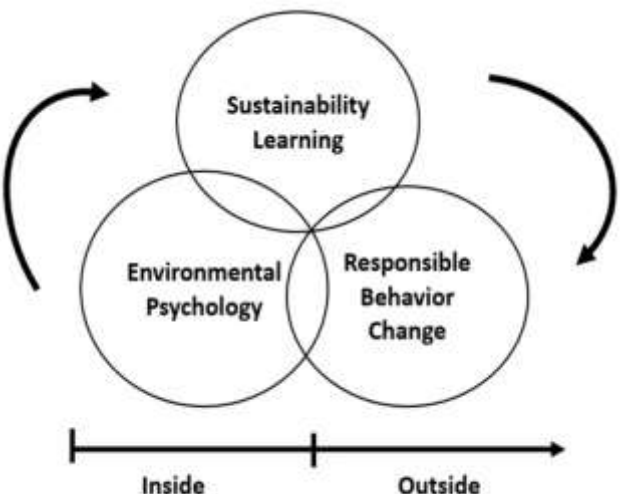
**3. Field of Research:**

With emphasis on how different lighting conditions in smart city classrooms can affect high school students' productivity, this research study will examine the relationship between environmental psychology and educational technology. The physiological and psychological impacts of artificial and natural lighting, the function of adaptable lighting systems in smart classrooms, and their consequences for student engagement, focus, and general academic achievement will all be covered.

**4. Research Methodology:**

Using surveys or questionnaires to collect quantitative information about how students view their learning environment and how it relates to their performance.

High school students from different smart city schools will be among the study's participants. To guarantee a thorough grasp of how various lighting conditions impact their classroom efficiency, these students will be chosen from a variety of backgrounds. Teachers also be involved in the study to obtain




*(fig. 2)Conceptual framework of sustainability learning, environmental psychology, and responsible behaviour*

information about the learning environment and how it affects student performance. Use surveys to gather information. These questionnaires will evaluate how students view lighting and how it relates to concentration, involvement, and general academic achievement. statistical methods including regression analysis to find correlations, ANOVA to compare group means, and descriptive statistics to highlight trends in the data. This method will clarify the connection between academic achievement and lighting conditions.

## 5. Previous studies:

### 5.1 Theories Related to Environmental Psychology and its Impact on Learning

The study of environmental psychology focuses on how people interact with their physical surroundings and how these interactions affect behavior, emotions, and thought processes. One important environmental element that can have a big impact on students' learning experiences in classrooms is illumination. Both natural light and thoughtfully planned artificial lighting can improve concentration and lessen cognitive tiredness, according to theories like the Attention Restoration Theory (ART). (Heather Ohly, Mathew P. White, Benedict W. Wheeler, Alison Bethel, Obioha C. Ukoumunne, Vasilis Nikolaou & Ruth Garside (2016) Attention Restoration Theory: A systematic review of the attention restoration potential of exposure to natural environments, Journal of Toxicology and Environmental Health) Environments that offer restorative experiences can increase attention spans, which is essential for successful learning. The Stimulus-Organism-Response (S-O-R) model is another pertinent theory that suggests external cues, like illumination, influence an organism's internal state, such motivation or mood, and cause reactions, like learning engagement. According to research, good lighting can improve students' motivation and attitude while also fostering a positive learning environment. (Aysu.e, Anuradha.m, Alexander.s, Jonathan.e, Nilufar.b , 2024, Consumer behavior in immersive virtual reality retail environments: A systematic literature review using the stimuli-organisms-responses (S-O-r) model )

### 5.2 Previous Studies Exploring Lighting Conditions in Classrooms

The effects of lighting on students' performance and wellbeing have been the subject of numerous research. According to Daylight specialists, students' academic performance was much enhanced in classrooms with

sufficient natural light as opposed to those with inadequate lighting. Likewise, a 1999 study by the Heschong Mahone Group showed that pupils in classrooms with lots of windows outperformed those without windows on standardized assessments.

Furthermore, science of the total environment showed that changes in classroom illumination could affect students' emotional states and general contentment with their learning environment. Higher levels of student involvement and reduced levels of fatigue were found to be positively connected with bright, evenly dispersed light.

**The Role of smart Technologies in Optimizing Classroom Environments**

Kong and Jakubiec found that lecture rooms with an average horizontal illuminance level of about 370 lux were considered too bright, with over 50% of the students demanding a drop in illumination, despite the fact that the lowest recommended illuminance level for a typical classroom is 350 lux. There are now more opportunities to optimize classroom environments, especially about lighting control, thanks to the incorporation of smart technologies into educational settings. Based on real-time information about occupancy, the time of day, and even personal preferences, smart lighting systems enable dynamic modifications. According to research, for example, employing smart sensors to modify lighting settings based on the amount of natural light available can improve student comfort and energy efficiency (Aris.b, Yun-Shang.c., 2024, Visual comfort and energy savings in classrooms using surveillance camera derived HDR images for lighting and daylighting control system).

Additionally, research by (Bernardo Tabuenca, Manuel Uche-Soria, Wolfgang Greller, Davinia Hernández-Leo, Paula Balcells-Falgueras, Peter Gloor, Juan Garbajosa, Greening smart learning environments with Artificial Intelligence of Things, Internet of Things, Volume 25, 2024) investigated how smart technology could support individualized learning experiences by providing lighting solutions that are flexible to each person's needs. These solutions help to create a more engaging learning environment in addition to improving the physical surroundings.

**Key Findings from Studies**

- Natural Light Benefits: Classrooms with ample natural light lead to improved academic performance.

- Emotional Impact: Properly designed lighting enhances mood and reduces fatigue among students.
- Smart Technologies: Adaptive smart lighting systems optimize both energy use and student comfort.

**light measure**

It is crucial to comprehend both the measurement methods and the suggested light levels to measure light in classrooms and choose the ideal lighting conditions for learning environments. A lux meter, which measures illumination in lux (lx), is the most often used instrument for determining light intensity. One lumen per square meter is equal to one lux. Using a lux meter:


**(fig.3) Lux level** https://www.elesi.com/blog/what-is-lux-level/

- Place the sensor at desk height in different parts of the classroom.
- Take readings in several locations, paying particular attention to those that are furthest distant from the windows.
- Measure in a variety of settings, such as with the blinds open or closed and the lights on or off.

Documenting whether artificial lights are on and whether blinds are drawn is crucial because these two elements have a big impact on light levels. Determine the mean lux levels in the various classroom sections after data collection. This will make it easier to spot potentially over- or under-lit regions.

**Recommended light level for classrooms**

Guidelines provided by lighting authority serve as the basis for the suggested illumination levels (Ehling, 1949) for different areas in educational settings:

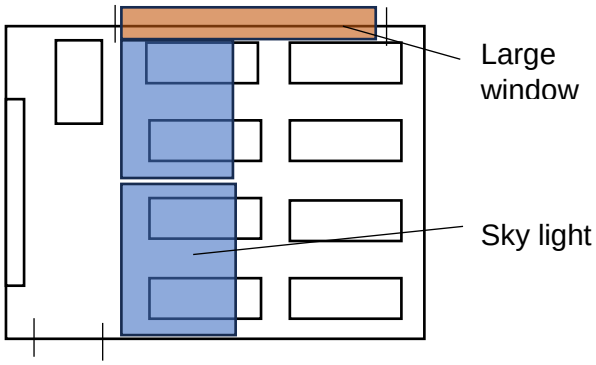
- Classroom lighting: 300 lux

- Kitchens and Laboratories: 500 lux
- 750 lux in technical drawing rooms

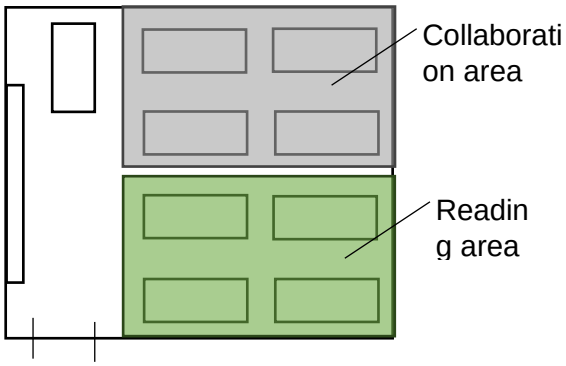
By preventing eye strain, these levels guarantee that students can see well, improving focus and academic performance.

**Best light practices for classrooms**

Promote the utilization of natural daylight by keeping windows free of obstructions and using curtains to somewhat disperse rather than totally block sunlight. Make use of energy-efficient LED lights to reduce glare and give sufficient illumination. In addition, LEDs produce less heat and last longer than conventional lamps. By modifying light levels according to actual usage, occupancy sensors and dimming controllers can assist save energy consumption. To maintain ideal light levels over time, set up a maintenance program that includes cleaning windows, inspecting fixtures, and changing out outdated lightbulbs. Students can still benefit from natural light while reducing glare by positioning their desks, so they face away from the sun.




(fig.4)Uses of natural light




*( fig.5)Different area with different light intensity*

**Sustainable Practices in Educational places**

Schools are increasingly adopting green construction standards that emphasize the use of natural light in addition to energy-efficient artificial lighting systems (US Green construction Council). These strategies not only support environmental sustainability but also enhance academic performance by creating better learning environments. Creating spaces that promote health and well-being while simultaneously being environmentally mindful is the aim of sustainable interior design. One crucial concept is to optimize natural light by utilizing architectural features like windows, skylights, and reflective surfaces (Brandon Gullotti, 2019).

By employing daylighting techniques, Designers can reduce their reliance on artificial illumination and conserve energy. Furthermore, implementing artificial lighting technologies that use less energy, such LED lights, might enhance sustainability in educational settings. In addition to using less energy, LED lights provide a spectrum of light that may be altered to support various learning activities, according to a study by Illuminated Integration (2023).

**Flexible Lighting Solutions**

A flexible artificial lighting solution must consider a number of factors, including color temperature, light intensity, and the ability to adjust settings based on activities or the time of day. The following ideas can assist in establishing a healthy lighting environment in the classroom:

- Dynamic Led lighting system
- Task illumination
- Zoned lighting
- Smart lighting control
- Use of natural light

**Color Temperature and Its Effects**

The color temperature of a certain light source is measured in Kelvin (K). It is significant in several contexts, including classrooms, where it can significantly affect children's mood, general health, and ability to study. The concept of color temperature is based on the laws of light and how they affect human perception.

(Iván Meana 2023) explains color temperature as follows: There are three main ranges of color temperature:

- Warm light (below 3000K): This includes hues like yellow and red. Warm light tends to create a pleasant ambiance, but it can also induce drowsiness or relaxation.

- Neutral light (3000K to 5000K): This spectrum includes white light that resembles daylight. It is sometimes said to be ideal for workstations since it increases alertness and focus.
- Cold light (beyond 5000K): Associated with daylight, cool light appears bluish-white. While excessive exposure might increase focus and productivity, it can also lead to eye discomfort and weariness.

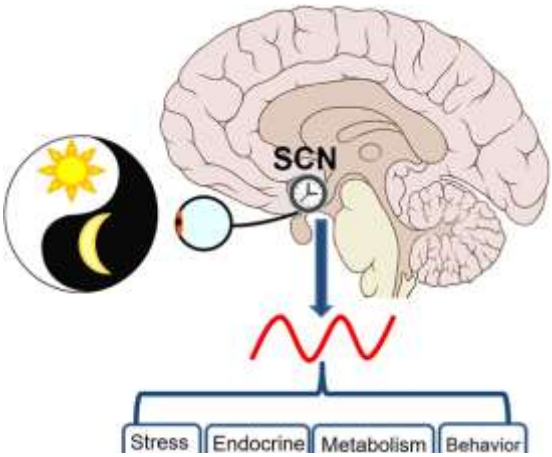
**How color affect light**

Understanding how color affects light requires looking at the relationship between light wavelengths, human perception, and psychological responses. Each color corresponds to a specific light wavelength that may have an impact on an individual's physical and emotional well-being.


*(fig.6) Show Different light same color (tekled,2023)*

**Circadian Rhythms and Well-Being**

Lighting affects students' circadian rhythms, which are biological processes that regulate sleep-wake cycles, in addition to their immediate cognitive effects. Exposure to natural light during school hours aids in the regulation of these cycles, hence improving the quality of sleep at night (Marie Dumont, Catherine Beaulieu, 2006).




*(Fig.7) Biology and physiology of circadian (Lostfalco,2023)*

*(table 1) IES light logic table*
https://chillinmcmillin.com/2019/11/14/bride-tip-lighting-design-shapes-your-atmosphere/

| PSYCHOLOGICAL IMPACT | LIGHTING EFFECT | LIGHT DISTRIBUTION |
|---|---|---|
| Tense | Intense direct light from above. | Non-uniform |
| Relaxed | Lower overhead lighting with some lighting at room perimeter, warm color tones. | Non-uniform |
| Work/Visual Clarity | Bright light on workplane with less light at the perimeter, wall lighting, cooler color tones. | Uniform |
| Spaciousness | Bright light with lighting on walls and possibly ceiling. | Uniform |
| Privacy/Intimacy | Low light level at activity space with a little perimeter lighting and dark areas in rest of space. | Non-uniform |

Getting more sleep improves students' overall health, emotional regulation, and cognitive function. Beyond only facilitating vision, light—more especially, optical radiation—has other physiological benefits. This article describes the regulation of the circadian rhythm, the effects of direct skin contact, and other indirect effects on functioning and well-being that are also linked to lifestyle choices and interactions with cities and environment. The effect of light treatment on mental health can influence any of these traits, which encourages a useful application of this understanding to treat mental diseases such as depression or anxiety, somatic symptom disorder, and others. This narrative review's goal is to give an overview of current research and knowledge of how light affects human biology, with an emphasis on

- **Psychological Effects of Lighting**

- Cognitive Performance: Research indicates that lighting significantly affects pupils' capacity to concentrate and retain information. Bright lighting has been associated with increased awareness and better focus. However, inadequate lighting can impair cognitive function by resulting in fatigue and a decrease in drive. (Morrow BL, Kanakri SM, 2018).

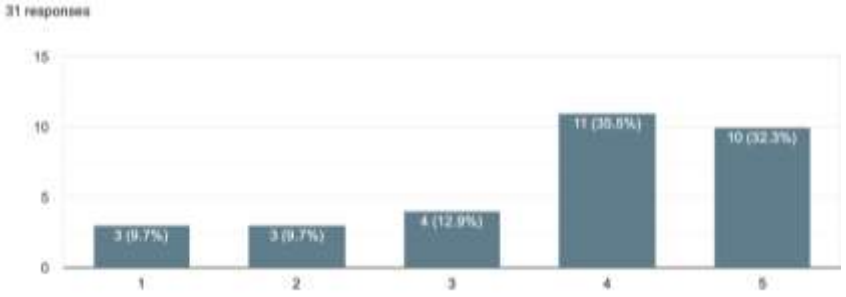
- Mood and Emotional Health: Classroom lighting may have an impact on students' moods. It has been demonstrated that pupils who receive adequate natural light experience happier moods and less signs of worry and despair. Conversely, artificial illumination, especially fluorescent lighting, can cause discomfort or anxiety. This emotional response may have a direct effect on a student's ability to engage with the material being taught. (Christian Even, Carmen M. Schröder, Serge Friedman, Frédéric Rouillon,2007).
- Visual Comfort: Appropriate lighting has an impact on how comfortably students can read materials or watch presentations without experiencing eye strain. Poor lighting conditions have been linked to headaches, eye strain, and general discomfort, all of which have an adverse effect on learning. ( Hanui Yu, Takeshi Akita, 2020)
- Behavioral Outcomes: For the 3766 students in the study, physical classroom features account for 16% of the variation in learning gain over the course of a year. To put it more concretely, it is anticipated that a "average" child would advance 1.3 sub-levels if they were moved from the least effective to the most effective space. This is significant considering that students normally advance two sub-levels annually. Studies indicate that classroom illumination can reduce aggressive conduct. When students feel at ease in their environment, which is partially made possible by suitable lighting, they are more likely to engage in constructive interactions with their professors and peers. (Barrett et al., 2013).

- **high school students**

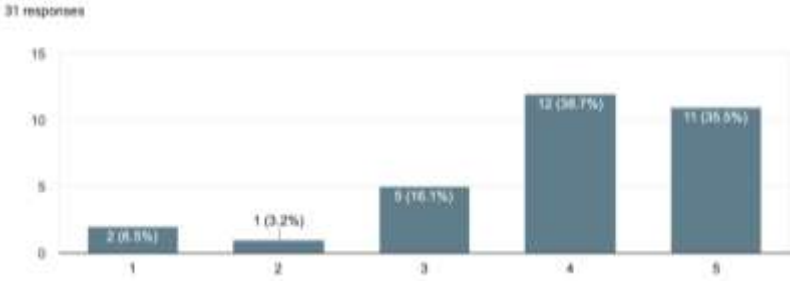
Students in high school who spend more time outside or in brightly lit areas report feeling happier and less stressed. On the other hand, poor illumination, especially in classrooms, can make people feel drained and agitated. According to research, cognitive functions including attention, memory retention, and general academic performance are all directly impacted by illumination quality. Compared to poorly illuminated settings, brightly lighted classrooms boost concentration and information processing, which results in higher grades. For high school students, who frequently study difficult courses that call for prolonged focus, this is especially crucial. (Giuseppe Curcio, Michele Ferrara, Luigi De Gennaro,2006)

By following these guidelines, schools can create an environment conducive to learning while also being mindful of energy consumption.

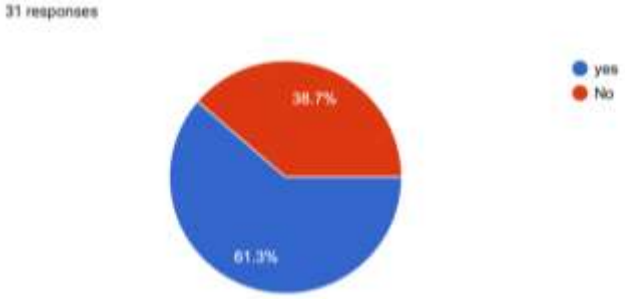
## Results




**(Fig.8) Rate the importance of natural light during study**




**(Fig.9) Rating how does the light affects concentration**




**(Fig.10) Does low light cause discomfort or eye strain**

The results of the poll indicate that natural light is highly preferred by both teachers and students in their classrooms, underscoring the significance of this component in improving productivity and well-being. Most respondents claimed to have made use of natural light, which has been shown to improve mood and cognitive function and foster a more conducive learning environment. Furthermore, while many participants favored brilliant white light for its clarity and capacity to enhance focus, a sizable portion of individuals preferred warm yellow light for its warmth and calming properties. Furthermore, both groups discovered that control over light intensity was essential since it allowed them to alter their environment to improve attention and lessen eye strain. This highlights the important role that lighting plays in health; poor lighting can lead to fatigue and hinder learning. All things considered, our findings demonstrate how important thoughtful lighting design is in educational settings to support both physical and academic well-being.

## Conclusion

In conclusion, the substantial influence of classroom illumination on student productivity has been emphasized in this study article. Important research shows that while inadequate artificial lighting might result in lower motivation and more eye strain, natural light improves focus and lessens weariness. These findings are important because they can influence classroom design and educational policy, which will ultimately create a more favorable learning environment.

According to the research's practical implications, schools should make it a priority to incorporate natural light into classroom designs, use artificial lighting systems that can be adjusted to simulate daylight, and make sure that there is enough lighting for different activities. Students' general well-being and academic performance may improve because of putting these techniques into practice.

The long-term impacts of various lighting conditions on a range of student demographics, including those with learning requirements, should be investigated in future studies. Additionally, research might investigate how classroom lighting interacts with other environmental elements including color schemes and furniture placement.

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# تأثير الإضاءة على تحسين إنتاجية طلاب المدارس الثانوية داخل الفصول الدراسية في المدن الذكية

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**المستخلص**

يمكن للإضاءة الجيدة أن تحسن التركيز وتقلل من التعب وتوفر أفضل بيئة تعليمية ممكنة. على الرغم من الاعتراف بأهمية تصميم الفصول الدراسية، إلا أن العديد من المؤسسات التعليمية تفشل في مراعاة كيفية تأثير الإضاءة على أداء الطلاب. قد يتم إعاقة التقدم الأكاديمي بسبب نقص الرعاية مما قد يؤدي إلى بيئات تعليمية أقل من مثالية. الغرض من هذه الدراسة هو دراسة العلاقة بين إنتاجية الطلاب والأشكال المختلفة لإضاءة الفصول الدراسية. ويهدف على وجه التحديد إلى التأكد من كيفية تأثير التغيرات في الضوء الاصطناعي والطبيعي على الأداء

الأكاديمي العام للطلاب. في هذا التحقيق، تم استخدام استراتيجية الأساليب المختلطة. موحدة من خلال تصاميم البحوث والمشاركين ثم جمع البيانات وتحليلها. وفقا للأبحاث، فإن الفصول الدراسية ذات الإضاءة الطبيعية تزيد من إنتاجية الطلاب بشكل كبير بالمقارنة مع تلك التي تحتوي على إضاءة صناعية فقط. لاحظ المعلمون سلوكًا ومشاركة أفضل أثناء الدروس، بينما أبلغ الطلاب عن مستويات أعلى من التفاعل والانتباه في الفصول الدراسية المضاءة جيدًا. ومن خلال تقديم بيانات تجريبية حول كيفية تأثير الإضاءة على إنتاجية الطلاب، تضيف هذه الدراسة إلى مجموعة المعرفة الموجودة بالفعل. لتعزيز نتائج التعلم المحسنة، فإنه يوفر للمعلمين والقادة اقتراحات مفيدة لتصميم الفصول الدراسية التي تعطي الأولوية لخيارات الإضاءة الفعالة.

**الكلمات المفتاحية:**

الفصول الدراسية؛ الإضاءة؛ المدرسة الثانوية؛ الإضاءة.