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The Role of Interior Design in Achieving Healthy Workplaces According to Lighting Indicators of "WELL Standard"

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ABSTRACT

As the incidence of indoor health concerns escalates, the prioritization of healthy interior design techniques in workplaces emerges as a critical strategy to enhance worker productivity and efficiency. Extensive research has highlighted the profound impact of lighting on employee physical and mental health, designating it as a key determinant of wellbeing in the workplace. The WELL Building Standard (WELLv2) constitutes a comprehensive and rigorous framework addressing the multifaceted origins of these concerns. It engenders lighting conditions that bolster mental, visual, and psychological health, and in professional settings, these conditions are demonstrated to improve mood and productivity. The research problem identified herein is the pervasive lack of awareness of interior design elements, such as lighting, and their misapplication in alignment with international standards. This lapse engenders environments that are detrimental to health. In this investigation, the extent to which architectural designers integrate WELLv2 lighting indicators in working environments is scrutinized in relation to healthy interior design. A descriptive-analytical method is employed to probe the research topic. Three buildings are evaluated against WELL lighting indicators. Moreover, the Wellness Score metric is utilized to assess the indoor lighting of the selected buildings, determining their eligibility for WELL certification. The primary objective of this study is to identify the key design needs of architectural designers for promoting healthy indoor lighting. The fulfillment of this objective is pursued through the use of WELL lighting indicators and standards.

1. INTRODUCTION

A deficiency in architectural designers' knowledge of global standards and specifications pertaining to workplace interior lighting design has given rise to a multitude of designs that overlook the concept of healthy architecture. Consequently, these designs fail to cater to user needs, provide visual comfort, and enhance visual acuity. To transform buildings into healthier environments, the integration of specific elements into interior design that address these needs is imperative [1]. Interior design is recognized as an influential discipline that profoundly impacts the environment and human life. The significant influence exerted by the built environment on human health is underscored by the fact that individuals typically spend over 80% of their lifetimes in indoor settings [2]. Lighting, a vital component of interior spaces, significantly shapes our utilization and experience of these spaces. Both natural and artificial lighting can contribute to the creation of an environment that is comfortable, safe, and productive [3]. In recent years, awareness of the potential health impacts of interior design in workplaces has grown, a trend that has been further amplified by the COVID-19 pandemic [4].

Numerous studies have been conducted on the importance of the internal environment's impact on human health, and green building rating systems have gained popularity. This popularity has spurred the rapid proliferation of green buildings globally, leading to enhanced human health and comfort and the reinvention of buildings that are beneficial not only for the planet, but also for the people inhabiting them [5, 6]. The application of standards addressing related issues, such as the WELL standard - the first certification in the world that focuses on human health and well-being within a built environment - can offer ideal workplace interior design solutions. This is achieved through a set of identifiers and features grounded in evidence-based medical and scientific research, with a focus on health in interior design [7]. The distinguishing feature of WELL, in comparison to traditional standards, is its ability to indicate how a built environment supports health and personal needs for users [8].

The identified research problem lies in the underutilization of interior design elements, particularly lighting, in line with global specifications and standards. This underutilization can engender unhealthy environments, potentially exerting detrimental effects on the health and well-being of individuals. The research questions thus formulated are: What is the impact of lighting on the health of workers in office buildings? Can the application of the WELL building standard's lighting specifications facilitate the creation of a healthy work environment? What are the paramount design requirements for implementing healthy indoor lighting in workplaces?

This research endeavors to construct an integrated theoretical framework elucidating the significance of lighting in workplace interior design. Alongside the development of this framework, the research also aims to provide a comprehensive understanding of the WELL standard, its

editions, and the concept of WELL LIGHT. The primary objective of the research is to distill the most critical design requirements for achieving healthy lighting in workplaces. These requirements function as tools aiding architects in refining interior design. The research approach is grounded in the principles and specifications of the WELL standard. Fulfillment of these principles and specifications is anticipated to contribute to a suitable and comfortable indoor climate, thereby enhancing the efficiency and productivity of workers.

2. THE THEORETICAL FRAMEWORK

This framework will provide a comprehensive understanding of the role of lighting in promoting the health, well-being, and productivity of workers in office buildings. and a comprehensive understanding of the WELL standard, which is a leading international rating system for healthy buildings. Highlight the concept of WELL light, which is a set of specific requirements for lighting in WELL-certified buildings.

2.1 Health concept definition

Foreign dictionaries have dealt with the concept of health, while the (Oxford) Dictionary has defined health as "a state of being free from any disease or injury", where is this view that society holds. Mosby's dictionary of Complementary and Alternative Medicine defines health as "the good state that takes into account the physical, mental, and emotional desires and needs of individuals," that is, the health of both body and mind. The World Health Organization defines health as "the state of being healthy, physically, mentally, psychologically and socially and not just being free from disease or infirmity" [9]. It is a state of complete physical, mental and social well-being and not just the absence of disease.

The researchers Huber et al. [10] suggested that health is conceptualized as an adaptability and self-management. This may be a starting point for a brand new way for the 21th century to visualize human health with a group of features and dynamic dimensions which can be measured that are presented in the three health domains: Physical, mental and social. In the physical health field, a healthy organism is able to "allostasis" to maintain physiological homoeostasis through changing conditions. In the mental health field, Antonovsky describes a "sense of coherence" as a factor contributing to the successful ability to adapt and recover from psychological stress and to prevent post-traumatic stress disorder. Many dimensions of health can be identified in the social field, including the ability of people to recognize their potential and obligations.

There are many factors that affects human health and comfort, as many studies proved that light affects physical, psychological and physiological condition of people, while poor lighting affects the occupants' sleep patterns and daily hormonal secretion patterns, body temperature, etc. [11]. Light acts as a major engine affecting the human biological clock rhythms, it regulates the wake-sleep cycle, functions and behaviors of the body [12].

The light has a main effect on human biological clock rhythms and so his health. We will discuss in the next paragraph, the concept of healthy workplaces and what is the effect of lighting on workers' health.

2.2 Healthy workplaces

The world Health Organization defines a healthy workplace as "A place where workers and managers collaborate to use the continuous improvement process to protect and promote health, safety and well-being for all workers, and the sustainability of the workplace" [13]. Researchers defines a health office as a workplace that does not at least compromise the well-being of employees [14].

Workplaces play major role in promoting or reducing the individual's health. There are four basic elements that help achieve health in the workplace, including:

•Health and safety occupational: Reducing work-related injuries, illnesses, and disabilities by treating the physical environment and work procedures. It is including factors like the quality of air, lighting, physical, chemical and biological dangers and violence prevention.

•Health and Lifestyle practices: Creating a supportive environment that encourages personal lifestyle that promotes health, for example healthy eating, physical activity and smoking abstain.

•Organization culture: Strengthening a supportive environment where employees can actively involve and empower. Focusing on factors that affect the interaction between people, their work and organization.

•Organizational social responsibility: Participating in the community to improve the workers' health and their families and other community's members [15].

The researcher Bluyssen [16], in his book indicated that there are four basic environmental factors in the interior environment that affects directly in perception of that interior environment through senses, but it also effects the physical and mental state (comfortable and health) of users. This includes: thermal comfort, visual or lighting quality, indoor air quality, acoustical quality.

There are a set of elements that affects the work environment and help achieve the worker's health and comfort. In the next paragraph, we will discuss the impact of lighting in the workplace's interior design of workplaces on the health and worker's well-being.

2.3 Lighting in the interior design of workplaces

In the early 1920s, researchers were in an agreement that physical workplaces conditions such as lighting, temperature, noise, and humidity has a significant impact on productivity of the worker. And if the workers are provided with optimal environmental conditions, the work rate and performance will improve [17]. At the work place, the sense of sight is the most important compared to other senses and visual comfort is the most important thing to achieve the user satisfaction in terms of health and productivity of work and that good lighting leads to a better performance in terms of speed, less accidents and less absenteeism [18].

Studies have presented that exposure to natural light in the workplace can improve productivity up to 20% and access to natural and landscaping can help reduce physiological stress, the access to natural light and beautiful views can improve productivity, stress reducing and impact positively on person's sense of well-being [19]. The daily response of humans to light depends on the entering of light to the eye. Factors like spectral characteristics of the light, brightness levels, duration and timing of light exposure should be considered; also levels of light should be achieved on a vertical plane, and at user's eye

level to simulate the light at enters the eye [20]. Levels of light in space can promote the user's ability to perform tasks in that space with contributing the feeling of comfort. Also the age of the person is an important factor in determining the required amount of light for visual intensity [21].

The studies have also shown that glare of light can lead to a poor eyesight and discomfort, which can cause accidents in workplaces. Persons under the age of 50 will be more sensitive to glare since a large portion of workforce is within this age group, so it is important to address glare to avoid visual fatigue and headaches that caused by the glare [22].

It is clear that there are many considerations that should be taken in account by the architectural designer to provide appropriate lighting quality in designing healthy workplaces that achieve comfort and productivity of employees; these are linked to the presence of criteria and determinants in which it is based, including (WELL) standard which will be discussed in the next paragraph.

2.4 General idea about the standard (WELL)

Standard is a group of instructions used to evaluate product quality according to ISO where standards are "a document which is written by common consent and agreed by recognized body which states a common and repeated use as rules or instructions or features for activities of its results" [23].

The standard WELL is an environmental evaluating program to measure and observe the interior environment features which effect on well-being and health of human [7]. It is an integrated system re-invent environment which built on its users, and transfer places lived by people who work and learn to create systems which aim to reinforce and improve well-being and human health. The standard relies on a group of medical research which discovers the relation between buildings and affections of health on their users. This will help to establish built environments work on improve nutrition, fitness, mood, and sleeping pattern [24].

The standard WELL has been developed by (Delos Living LLC [25]). The main difference between WELL and other traditional standards is it detects first before everything how a built environment supports health and personal needs for users, i.e., it goes deeper in social sustainability where the interior environment is the main point for this standard [8].

•The main indicators (preconditions): Some of WELL features are classified as preconditions i.e., they are necessary for all levels to get WELL certificate. Also, it is possible to consider preconditions as it is essential for well-being for built environment. It is important to notice that it is necessary to fulfilling all previous conditions to grant a certificate.

•The supporting indicator (Optimization): Enhancements are not required to get silver level certificate, but creating a flexible path to get a golden or platinum level certificate. These features have techniques, strategies, and optional designs. The IWBI recommends that all project to pursue in order to achieve as much number as of Optimization [6].

The second version of standard WELL (WELL v2), has been written in 2018 depending on the 1st version, which includes many strategies supported by newest scientific research which aim to raise the health of human throughout the efforts of design and operation performance which encourages culture, health, and well-being. Each feature of (WELL v2) meets four rules: evidence - based, checkable, implementable, and an introduction for external entries [26]. This standard has ten concepts: air, water, nutrition, light, movement, thermal comfort, sound, materials, mind, and society. As shown in Table 1.

Table 1. The ten concepts of WELL virsion2 with their contents

Concepts	Implications
Air	The concept WELL Air aims at insuring high levels of interior air quality from the age of the building through various strategies which excludes the source of the air or reduce it, active and passive building designing, and strategies for operation and human behavior interference.
Water	The concept of WELL Water covers quality, distribution, and controlling water inside the building. This concept consists of treatment features for drinking water availability and boundaries of pollutions. It consists, in addition, features about water management to avoid damaging building materials and environment conditions.
Nourishment	The concept of well nourishment requires availability in fruit and vegetable and nourishment transparency which encourages building nourishment environment to much healthier and easier.
Light	The concept of WELL Light enhances the exposure to the light and it aims to build ideal lighting environment for visual, mind, and biological health.
Movement	The concept of WELL movement enhances movement, physical activity, and active life. This concept deactivates steady behaviours through strategies, programs, and polices of environment design.
Thermal Comfort	The concept of WELL Thermal Comfort aims to enhance human production and insure the optimal level of thermal comfort among all building users by improving the design of HVAC system and control it by accept individual thermal preferences.
Sound	The concept of WELL Sound aims to enhance the health and luxury of people through defines and lightens the comfort standard of sound which composes users' experiences in the built environment.
Materials	The concept of WELL Materials aims to decrease human exposure to dangerous materials through bind or remove poisons components or products and exchange them by more safe materials, also the dangerous components on workers' health and/or the components which are biologically accumulated in bound environment which are in some cases not allowed.
Mind	This concept enhances the psychological health through polices, programs, and strategies of design which pursues to treat various factors which affect on knowledge and emotion luxury.
Community	The concept of WELL Community aims to support reaching the basic health care and enhances health at work places and accommodations for new parents with establishing integrated and entire community through social justice, civil participation, and design which is easy to reach.

Source: Organization of the two researchers based on [27]

Studies have shown that implementing WELL Building Standard indicators in office workplaces can lead to improved health and well-being for workers by focusing on putting humans at the heart of design decisions. A study by Park and Rider [28] found that the built environment can play a significant role in wellness programs. The study proposed integrating the WELL Building Standard into wellness programs to improve users' health and well-being. A study by Licina and Yildirim [29] suggests that implementing WELL Building Standard indicators in WELL-certified office buildings leads to increased occupant satisfaction with indoor air quality, reduced symptoms of sick building syndrome, and increased self-reported productivity. The study found that building and workspace satisfaction increased significantly after moving to WELL buildings, from an average of 7.2 to 7.7 on a scale of 1 to 10. Sick building syndrome symptoms also decreased significantly, from an average of 2.2 to 1.8 on a scale of 1 to 5. However, satisfaction ratings did not change during the first year of working in WELL buildings. This suggests that the health and well-being benefits of implementing WELL Building Standard indicators will continue to emerge over time. A study published in the Journal of Building and Environment found that WELL certification improves user satisfaction, health, well-being, and productivity. The research team analyzed the impact of WELL certification using more than 1300 pre- and post-occupancy survey responses from six companies in North America. And the study's main findings were:

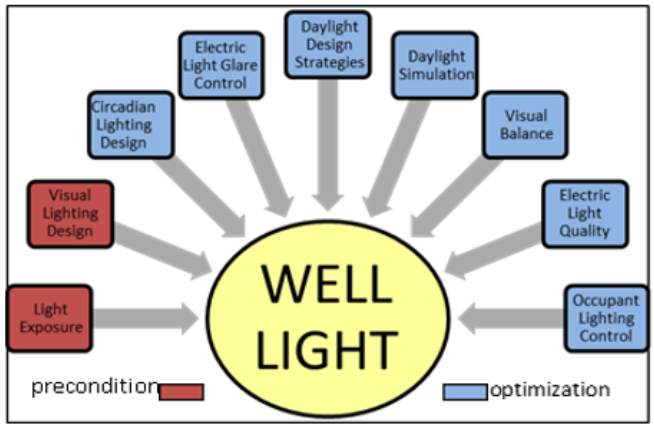
- User satisfaction: The study found that WELL certification led to a significant increase in user satisfaction with their workplace. The average workplace satisfaction score increased from 42% to 70% after obtaining WELL certification.
- Well-being: The study also found that WELL certification led to increased well-being among users. The average self-reported well-being score increased from 74% to 90% after obtaining WELL certification.
- Health: The study found that WELL certification led to improvements in users' mental and physical health. The average mental health score increased from 72% to 82%, and the average physical health score increased from 68% to 70% after obtaining WELL certification.
- Productivity: The study found that WELL certification led to increased productivity among users. The average productivity score increased from 80% to 90% after obtaining WELL certification [30].

The concept WELL Light will be studied widely by knowing its identifiers, its primary and secondary parts, and the role of these parts in achieving interior healthy light in work places.

2.4.1 WELL light

The concept of WELL Light enhances exposure to a light. It aims to establish light environments to boost visual, mind, and biological health. This aims to provide light environment to reduce the disorder of daily stage, improve sleeping, and affect positively on mood and production of workers [31]. Visually stimulating lighting is able to affect positively on mood and feelings while reaching the sunlight supports the circadian rhythm. Moreover, sufficient bright can stimulate waking up and increase productivity. On the other hand, excessive bright is a distraction which causes headache and eye strain. The deficient of sunlight may cause circadian rhythm disorder. While unsuitable shadowing for windows and high density light may cause a glare of computer screen. This concept aims to create interior environment where building users' benefit of positive affects for day and electric light. At the same time, the comfort of work and production do not negatively influence by extra or insufficient lighting [8].

This concept has two main factors (Precondition) in a condition of achieve them in a building to get WELL certificate, and seven supporting parts by achieving them more points will be collected to the building to get a higher rank certificate within WELL standard. These factors are showed in Figure 1 and Table 2.



Source: Organized by the researchers based on [31]

Figure 1. The concept of lighting for well standard and its nine parts

Table 2. The basic and supporting indicators of the concept of lighting Source: Organized by the researchers based on the previous source

	Indicator	Meaning
Main indicator	Light exposure	Provide indoor light exposure through daylight and electrical lighting strategies.
	Visual lighting design	Providing visual comfort and enhancing visual acuity for all users through electric lighting.
Supporting indicators	Circadian lighting design	Support daily and psychological health through exposure to indoor daylight and outdoor views.
	Electric light glare control	Reduce glare caused by electric light.
	Daylight design strategies	Provide daylight exposure indoors through design strategies.
	Daylight simulation	Ensure exposure to indoor daylight with daylight simulation strategies.
	Visual balance	Creating lighting environments that enhance visual comfort.
	Electric light quality	Enhance visual comfort and reduce electric light flicker.
	Occupant lighting control	Providing people with access to customizable lighting environments.

After knowing the concept WELL Light and its indicators and its main and supporting features which plays a vital role in achieving healthy, comfort and quit interior environment which will be applied on chosen study cases as in the following.

3. THE PRACTICAL FRAMEWORK OF THE STYDY

The study's practical component involved the selection of three case studies that were concerned with achieving indoor lighting, as represented by:

1. Sustainable Landscape Center in Pennsylvania (WELL- certified for the first edition);
2. Louvre Abu Dhabi Museum (LEED-certified);
3. Institut du Monde Arabe (LEED-certified).

In this section, the study will investigate the extent to which the interior design of the case study models meets the lighting indicators of the second edition of WELL standard, which are extracted in Table 2. This will be done by analyzing the design considerations that the architectural designers used in interior design to provide adequate indoor lighting and exploring the extent of their relationship and suitability with the indicators of WELL standard.

Finally, the equation (wellness score) for the lighting determinant for each of the selected cases will be used to measure the extent to which it could obtain or not obtain WELL certification for the second edition.

3.1 Study cases description

3.1.1 Center for sustainable landscape (CSL)

The sustainable landscape center of Phipps Institute for botanic gardens in (Pittsburgh, Pennsylvania) represents a model for office and educational buildings by focusing the designs on the links between the built environment and human health with meeting the highest comfort and health standards for all building occupants and visitors, as this is shown in Table 3 and Figure 2.

Source: [32]

Figure 2. The center for sustainable landscapes in Pennsylvania

3.1.2 Louvre Museum in Abu Dhabi

It is an art museum on the Saadiyat Island in Abu Dhabi, the capital of the United Arab Emirates, opened at 2017. An architecture and construction masterpiece and considered as one of the most innovative museum projects that built in recent times. The lighting in this museum plays a massive and important role in creating comfortable and healthy interior environments and spaces, also creates a welcoming world that combines light, shade, thought and quiet. As shown in Figure 3 and Table 4.

3.1.3 The Arab World Institute in France

The Institute Arab World in Paris is one of the most important global projects in the use of lighting as a design basis, it is considered as a bridge between Eastern and Western culture. It is a French institution dedicated to Arab culture, located in the heart of historic Paris. This magnificent building was opened in Paris in November 1987 as part of the Urban Development Program (Grand Projects) which aims to create modern landmarks of Paris. As shown in Figure 4 and Table 5.

Table 3. The general description of the sustainable landscape building

Center for Sustainable Landscapes					
Area	Location	Client	Activities	Architect	Floor height
24,350 m^2	Pittsburgh, Pennsylvania, USA	The Phipps company	Educational, research and office	The design alliance	Two floors occupied with a third floor green roof
Design idea	The designer used clear glass to enhance the visual connection between interior and exterior and biophilic design principles to create unique interior environments that affect human health and comfort while creating a highly distinctive sense of place and location.				
Sustainability	This facility is the first globally to acquire the International Well Building Institute's (IWBI) highest certification, the "WELL Platinum Pilot" award, and three green criteria. Living Building Challenge (LBC), LEED Platinum, and SITESTM certifications set rigorous criteria for promoting healthier, wealthier, and nature-reconnected communities.				

Table 4. The general description of the building

Louvre Museum in Abu Dhabi				
Area	Year	Location	Architect	Interior Design
97000 m^2	2017	Abu Dhabi, United Arab Emirates	Ateliers Jean Nouvel	JND, Eric Nespoulous
Design idea	One of the most influential architects of the last 50 years, Jean Nouvel, designed the museum. The designer combined traditional UAE designs with contemporary construction methods to create a peaceful space that allows guests to experience the ever-changing connection between the sun, dome, sea, buildings, and land. Nouvel proposed a 7500-ton floating dome of shade and light, similar to the Eiffel Tower. The geometric dome, a hallmark of Arab architecture, is composed of 7850 repeating stars of various sizes and angles in eight levels, allowing sunlight to pass through the dome's openings to produce the "beam of light". The Abu Dhabi palms' folds enable sunlight to flow on the ground and lessen its intensity, inspiring the design.			
Sustainability	The museum was constructed for LEED Silver environmental excellence. The Three Pearls Estidama-winning museum uses negative cooling influenced by local culture and regional architecture to create a peaceful microclimate. Water and energy-efficient HVAC, lighting, and sanitary technologies are also used in the Louvre Abu Dhabi. The ornamented ceiling lets sunshine in without heating or wind, while the stone floor and wall cladding keep the building cooler throughout the day.			

Source: [33]

Figure 3. The Louvre Museum in Abu Dhabi

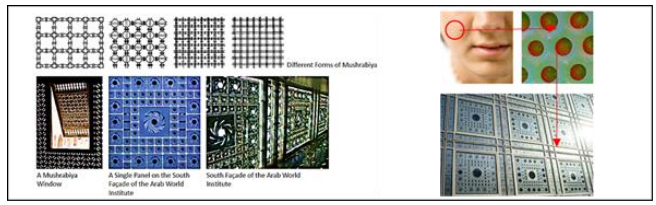


Figure 4. The borrowing of the Mashrabiya from Arab cultures and its use in a contemporary manner in a manner similar to the function of pores in the human body

Table 5. General description of the Arab World Institute

The Arab World Institute in France					
Area	Year	Location	Architect	Structural System	Major Materials
25,000 m^2	1987	Paris	Jean Nouvel	Metal structure; Curtain walls	Aluminum, glass
Project description	The southern section stands parallel to the university building and has nine stories, while the northern part curves with the Seine River and has seven levels. The two blocks are split by a slit on the same axis as the Notrdame Church, the institution entrance that finishes in an interior courtyard. A restaurant, museum, library, offices, and a celebration hall are within. A multi-level glass lobby with steel upstairs and lifts visible from within Like a minaret, the library has three stories [34].				
Design idea	The institute's design concept was inspired by architect Jean Nofal's belief that light can be used as a material in buildings. By manipulating light as an essential element, the institute creates a deeper sense of place and enhances the overall experience. The design combines traditional Arab architectural elements with modern elements, evoking memories of architecture. The northern interface reflects Parisian blocks across the Seine River, while the southern interface is covered with automatic hexagonal lenses whose pattern and optical properties resemble the mashrabiya, a reticulate work idea in Arab architecture that provides comfortable shaded indoor lighting. The institute's most stunning metaphor, the thousands of integuments on the southern interface, mimics the structure and function of human skin pores. As the main cooling strategy, pores control body temperature. Interface layers are part of the building's cooling system. They electrically manage the building temperature using an optical sensor. When these integuments open or shut, the skin seems to breathe [35].				

3.2 Analysis of the interior design of case studies according to the lighting indicators of the WELL V2 standard according to Table 6

After carrying out the analysis study the quality of the building interior lighting will be measured according to WELL v2 standard by using Wellness Score equation by counting the total number of indicators to a number of achieved indicators in the building where (0-4) refers to failing in achieving the main indicators which led to failing to get a WELL certificate. While, marks between (5-6) means that all the main indicators have been applied lead to get a silver certificate. Marks from (7-8) means all main indicators and some of the secondary indicators have been applied to get a golden certificate. Finally, marks from (9-10) means getting a platinum certificate [6] as following:

Total Preconditions=TP
Preconditions Achieved=PA
Total Optimizations=TO
Optimizations Achieved=OA
Wellness Score=WS
FAIL: If (PA/TP)<1 then WS=(PA/TP)×5 (rounded down to nearest whole number)
PASS: If (PA/TP)=1 then WS=5+(OA/TO)×5 (rounded down to nearest whole number).
The previous equation will be applied to the selected building models to measure the lighting quality in them, according to the following and Table 7, Figure 12:

1. (WS) for Lighting of the Louvre Museum

(PA/TP) =1 then WS == 5 +(7/7) × 5= 10

2. (WS) for Lighting of the Arab World Institute in France

(PA/TP) =1 then WS == 5 +(5/7)×5=7.78=8.6=9

3. (WS) for Lighting of the Center for Sustainable Landscapes

(PA/TP) =1 then WS == 5 +(7/7)×5=10

(a) Window spaces in the main meeting room of the building near the workplaces (https://www.phipps.conservatory.org/assets/documents/Phipps_Green_Building_Toolkit_1_WELL.pdf)

(b) Entry of natural lighting into the museum through the geometric dome openings

(c) Interior daylight through Mashrabiya openings (https://www.pinterest.com/pin/977351556607946334/)

Figure 5. Light exposure index achieved for study cases

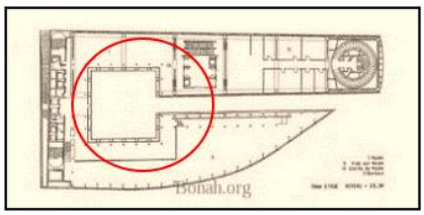
(a) Control the areas of the windows to obtain healthy amounts of lighting

(b) Lighting levels obtained by photovoltaics in the Institut's library area (https://cutt.us/Letm5)

Figure 6. Visual Lighting Design index achieved for study cases

(a) Staff rest periods to encourage the natural daylight experience (https://www.aiatopten.org/node/507)

(b) Ceiling skylights provide suitable natural lighting (https://2u.pw/JA7nU)



(c) The central courtyard, which is the meeting point of parts of the building (https://cutt.us/VjbtN)

Figure 7. Circadian Lighting Design index achieved for study cases

(a) Use solar breakers to prevent glare (https://cutt.us/KrJqR)

(b) Reduce glare by using filters in skylights (https://shade.ms/ar/300-484544/)

(c) Using panels to cover the mashrabiya to reduce the intensity of lighting entering the museum

Figure 8. Electric Light Glare Control index achieved for study cases

(a) Provide exposure to daylight through skylights above the main lobby (https://www.aiatopten.org/node/507)

(b) The engineering dome is used as a main source of daylight and at the same time it acts as a giant canopy for the blocks under it (https://al-ain.com/article/louvre-abu-dhabi-children-museum-opens-june-18)

Figure 9. Daylight design strategies index achieved for study cases

(a) Glass partitions in the interior design of the center

(b) Different sizes of openings designed to determine the quantities of healthy and appropriate lighting (https://www.pascalls.co.uk/work/leisure-and-hospitality/louvre-abu-dhabi/)

Figure 10. Daylight simulation index achieved for study cases

(a) The colors of the interior walls used in the building (https://cutt.us/mSgPt)

(b) The effect of water on creating visual balance (https://2u.pw/15DF55)

(c) Unity and repetition in the formation of decorative units balance the entry of natural light

Figure 11. Visual balance index achieved for study cases

Table 6. Interior design analysis of the study cases according to the lighting indicators of the standard (WELL V2)

WELL Standard Lighting Indicators		Analytical Description of Evaluation Criteria		
		Center for Sustainable Landscapes	**Louvre Museum in Abu Dhabi**	**The Arab World Institute in France**
Main Indicator	**Light Exposure**	•The building layout maximizes natural illumination with wide-opening windows in meeting rooms and office areas. • Consider placing workstations near windows to maximize daylight exposure and enhance connection with nature and vistas. • Designating open locations for people to enjoy UV rays Figure 5(a) shows how a skylight above the main lobby lets natural light into the structure, eliminating the requirement for artificial lighting.	• The building's large geometric dome, inspired by Arab architecture, offers enough natural light throughout the day. A five-meter steel frame in the dome separates four layers of stainless steel and four layers of aluminum. Every light beam goes through eight levels before arriving or disappearing. The sun's movement creates a dramatic "Rain of Light" effect. The geometric dome openings permitted natural light into the museum and afforded workers and visitors security and comfort (Figure 5(b)).	Make use of the appropriate windows. Design each floor to have glass windows on the institute's southern façade with geometric patterns like the Mashrabiya for natural light. Figure 5(c) shows how hundreds of light-sensitive layers control light entering buildings for optimum exposure in restaurants, libraries, and museums. Thus providing healthy natural light inside.
	Visual Lighting Design	The center's interior was designed to provide visual comfort for all occupants by integrating daytime and electric lighting to meet user needs and standards. Workspaces have different ambient lighting than dining areas. All these lights are remote-controlled. When natural light is sufficient, inside lights are muted.	• Nofal collaborates with interior designers to provide user-friendly visual lighting that enhances productivity. • Correct lighting for all ages and museum visitors ensures visual comfort. • Place artificial lights carefully. window studies for displays looking outside to manage sunlight (Figure 6(a)).	Study of interior room lighting design Open and shut solar cells on the southern façade controlled by a central computer supply 10–30% of the nice light people require. Figure 6(b): Offer specialized lighting settings in the institute's museum, offices, and eating rooms to improve optical acuity for all users.
Supporting indicators	**Circadian Lighting Design**	•The facility promotes every day and psychological wellness via nature and outdoor environs, including planting local flora on the third level and offering outdoor gardens. •Promoting staff breaks in gardens to enjoy nature and natural light. What connects individuals to their natural daily illumination cycles? As in Figure 7(a).	• The structure is intended to maximize natural light in internal areas for optimal health and circadian rhythm alignment. The architectural designer carefully analyzed the geometric dome pattern, varying sizes and angles in eight levels to offer enough everyday illumination for visitors and employees. Gallery skylights give ample natural illumination, as seen in Figure 7(b).	• The building's design used the courtyard as a connection between the south and north and as a starting point for other rooms. Figure 7(c) shows that this patio increased interior sunshine, supported users' daily and psychological health, and enhanced their connection to the outdoors.
	Electric Light Glare	•The design team strategically placed sun diffusers on the building's facades to allow winter sun in while reducing summer solar gain. The awnings provide ample day lighting and reduce glare with internal solar racks that reduce direct light penetration by 90% or more.	• Interior skylights in showrooms filter natural light from side windows while viewing the surroundings. Glass mirrors may absorb sunlight and spread it into gallery areas to reduce glare. Museum galleries have 17 glass ceilings. Each has 18 kinds of glass panels. There are around 25,000 glass pieces. Figure 8(a) shows how these glass ceilings use natural and artificial illumination to highlight the artwork.	• Although the architect used modern natural lighting techniques in the facades of repeated metal geometric patterns to provide indoor daylight, the reflected glow of over 2000-foot candles caused discomfort for many office employees, as shown in Figure 8(b). **(Not achieved)**
	Daylight Design Strategies	The building was designed to maximize daylight exposure, with a skylight above the main hall allowing natural light to pass through (see Figure 9).	The museum was designed to maximize daylight entry, including the random arrangement of white blocks in galleries	The institute's interior design features glass instead of walls for transparency, flexibility, and communication, as well as to provide

			and the use of a giant dome as a canopy over the galleries.	indoor daylight exposure via photovoltaic cell closures.
	Daylight Simulation	Directed blocks for optimal daylight flow, designed facade windows with appropriate spaces, and utilized glass partitions for flexibility, transparency, and employee communication (see Figure 10(a)).	Lighting simulation on a miniature 3D model measured light levels in inner courtyards, assessing potential dome protection for the museum throughout the day and year-round (summer and winter) by manipulating opening sizes. Figure 10(b) shows how rotating the dome's eight layers at various angles reduces and filters sunlight.	**Not achieved**
	Visual Balance	• Colors significantly impact interior lighting, with white being prominent in most settings to increase light radiation and improve visual comfort. To create an active indoor environment, as depicted in Figure 11(a).	• The building's natural and artificial lighting combined with careful fixture selection promotes visual balance, considering color temperature and incorporating calm colors in exhibition design. • Figure 11(b) illustrates how the water element in the structure reflects light through the glass ceiling, creating colorful patterns on interior surfaces and walls.	The architectural designer used the principle of unity and repetition in the formation of the decorative units represented by the Mashrabiya in the southern facade, by relying on combinations of different sizes sensitive to light that work to balance the entry of natural light, as shown in Figure 11(c).
	Electric Light Quality	High-quality lighting units with a high color rendering index (CRI 80+) were used for the building to enhance color clarity for employees and visitors.	The choice of units used for electric lighting with a high-scale color rendering index was taken into account, which helped in the clarity of the interior colors and the exhibits in the eyes of visitors in a way that parallels sunlight and enhances visual comfort in addition to containing low frequencies of flicker.	Many of the artworks on display are sensitive to light, so appropriate lighting levels have been selected to ensure that the artworks remain undamaged for future generations. The electrical lighting used in the building contains low frequencies of flicker that are not present in daylight.
	Occupant Lighting Control	•Interior illumination is zoned, and levels may be controlled by altering color or temperature. They are individually regulated for versatility since occupancy sensors turn off after eight minutes of inactivity. •Internal sun shades on building windows minimize direct sunlight penetration by 90% or more, allowing for better management of sunlight.	To ensure that the ideal lighting conditions prevail in the building. The design team determined the required lighting for each room through the control unit containing electronic monitoring devices; that allocate the appropriate lighting for each room and ensure comfort and luxury for users in addition to preserving the artwork displayed properly.	Computer technologies and devices have been used to control the amount of light entering the building. The optical sensors on the facades are connected to a light-sensitive computer that opens the engineering units to enter the necessary sunlight and closes them when the lighting is intense.

Table 7. The number of indicators achieved in the selected buildings

The Building's Name	PRECONDITIONS		OPTIMIZATIONS		Wellness Score
	Applicable	Achieved (Main Indicator)	Applicable	Achieved (Supporting Indicator)	
	Center for Sustainable Landscapes				
	2	2	7	7	10
	Louvre Museum in Abu Dhabi				
	2	2	7	7	10
	The Arab World Institute in France				
	2	2	7	5	8.6

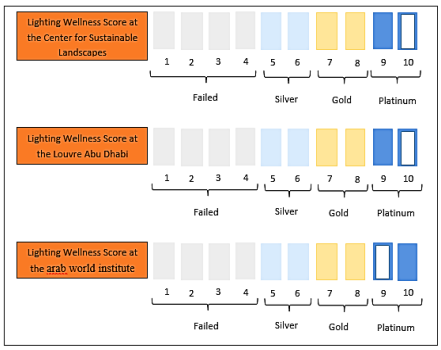


Figure 12. The measurement of (Wellness Score) for the selected buildings

4. RESULTS ANALYSIS

After conducting analytical studies in the center of sustainable perspective in the USA, Louver museum in Abu Dhabi, and the Arab World Institute in Paris and studying to what extent these buildings can apply standards of healthy architecture for lighting which are represented by the standard (WELL). Then, measuring the quality of interior lighting, the results are:

1. The center of sustainable perspective applies all main indicators of WELL standard in addition to all supporting indicators. It gained 10 marks when the (WS) equation has applied. This mark enables it to get platinum certificate.

2. Louver museum in Abu Dhabi applies all main indicators of WELL standard in addition to all supporting indicators. It

gained 10 marks when the (WS) equation has applied. This mark enables it to get platinum certificate.

3. Arabic World center in France applies for all main indicators of WELL Light in addition to five out of seven supporting indicators and getting nine marks after applying (WS) equation which enables it to get platinum certificate as well.

The results of the study support the hypothesis that achieving healthy interior design is related to the extent to which the architectural designer takes into account the application of lighting indicators of the WELL standard. The study found that the case studies met many of the WELL lighting indicators, indicating that they are well-lit and healthy indoor environments.

5. CONCLUSION

Several design elements were identified that can be used to achieve healthy indoor lighting according to the WELL standard for workplaces. These elements include:

- Adequate window space: Window space should account for at least 7% of the occupied floor area per floor. This helps to ensure that occupants are exposed to natural daylight, which is important for circadian rhythm regulation and overall health.
- Proper artificial lighting: Artificial lighting should be designed to meet the needs of occupants in each indoor space. This includes providing enough light for visual tasks, reducing glare, and creating a comfortable and inviting environment.
- Connection to nature: Providing access to natural light and views of nature can help improve well-being and productivity. This can be done by distributing workstations near windows, providing skylights or ceiling openings, or using natural materials in the interior design.
- Quality light fixtures: Lighting fixtures should emit high-quality light that is free of flicker and glare. This helps to protect occupant health and well-being.
- Daylight design strategies: Daylight design strategies can help to maximize the use of natural light in a building. This includes using solar shading to control glare and heat gain and designing spaces to take advantage of natural light.
- Visual balance: Visual balance is important for creating a comfortable and inviting environment. Using lighting fixtures that emit light with comparable color temperatures and brightness levels will help you achieve this.
- User controls: Users should have control over the levels of lighting in their workspaces. This allows them to adjust the lighting to meet their individual needs and preferences.

6. RECOMMENDATIONS

Paying attention to the health aspect as a central concept in interior workplaces designs, which in turn increases the worker's production.

We recommend interior designers to consider the health standards in interior design as well as the aesthetic standards by resorting well building standards and study all the basic and subsidiary concepts to produce healthy and comfortable architectural designs for humans.

We address educational institutions to provide an optional or mandatory curriculum that study the standards and their modernity in order contact the architectural student with science.

We suggest conducting further studies and research on all indicators of the WELL standard and applying them to school buildings as a case study.

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