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INVESTIGATING USE OF DAYLIGHT IN A TYPICAL ALGERIAN PUBLIC CLASSROOM TYPOLOGY

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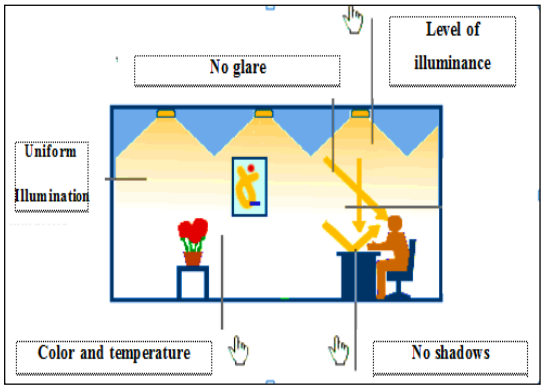
Graphical abstract



Abstract

The presence of daylight affects human beings both physiologically and psychologically. Admitting daylight into an indoor enclosure improves mood, enhances morale, lowers fatigue, and reduces eyestrain. To adequately capture the characteristics of current daylight design practice in typical Algerian classroom A field observations was carried out in the study area which comprises the school buildings and including performing a series of measurements for daylighting inside the classrooms. This was further confirmed by the use of simulation using IES <VE> software. As investigated the standard sky condition in Algeria is overcast and based on this; the conceptual models of Algerian public schools are divided into two types of school buildings. Schools inherited from the colonial period and those built during the period of French occupation which are characterized by variation on the arrangements of classrooms even for a single school and are streamlined into; linear assembly with simple distribution (traditional classroom) which is common and the second type which has a linear assembly with double distribution. Based on the existing guideline from the Ministry of National Education which was adopted from the colonial masters. The simulation result confirm that class room typologies in Algeria had less consideration for climatic and comfort conditions and the window openings allowed excessive daylight.

Keywords: Typology, classroom, Algeria, daylight model

1.0 INTRODUCTION

The presence of daylight affects human beings both physiologically and psychologically. Admitting daylight into an indoor enclosure improves mood, enhances morale, lowers fatigue, and reduces eyestrain. One additional and important psychological aspect from daylighting is meeting the need for contact with the outside living environment [1]. It has been discovered that man's short-term memory works in an efficient way from 10am to 6pm, which has an appropriate impact on concentration in schoolwork. The period from 6pm to midnight is preferred for studying, since human long-term memory works better during this period. Daylight variations have a big impact on children. Therefore, it is very significant to keep children's rhythm and natural biological clock of their body in the classroom [2]. As sunlight is scattered through the atmosphere, it turns the entire sky dome into a daylight source, which makes the sun and sky the main daylight sources [3]. A 63MW power flux is released by the sun. That is equal to six thousand million lumens for every meter squared of its surface area. Around 134kilo-lux of the power released reaches the outer atmosphere of the Earth.

Approximately 20% of this light is absorbed by the atmosphere, while 25% is reflected out to the space. The remaining 55% reaches the Earth surface as sunlight together with the rest of the light scattered by the atmosphere as skylight make up daylight. The variation of the amount of light that is received over the ground surface to be: location. Latitude, climate, and air quality affect the intensity and duration of daylight [4]. The main objective is to investigate the use of daylight in a typical Algerian public classroom typology.

1.1 Parameters of Visual Comfort in Classroom

To achieve successful design, [5] defines the parameters for visual comfort through the aspects of daylight level, daylight quality and ensuring the access of enough daylight for all the occupants of the room and allowing a connection with the outside. It is essential to take into account the use and especially the various activities that are sheltered, in order to achieve visual comfort in space. On schools where reading and writing are the two main visual tasks, the parameters of the most important visual comfort (Figure 1) that affect a solution of architectural design in the classroom are: Lighting uniformity; level of illuminance; No glare; correct colors.

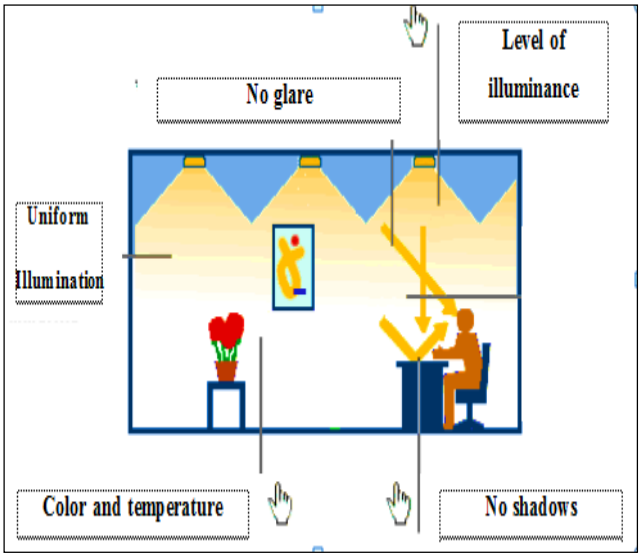


Figure 1 Visual comfort parameters [5]

1.2 Geographic and Demographic Characteristics of Algeria

Algeria is a country located in the Maghreb region of North Africa on the Mediterranean coast. Its capital and most populous city is Algiers. With a total area of 2,381,741 square kilometers (919,595 sq. mi), 90% of which is desert. The Sahara desert covers more than four-fifths of its territory, where the inhabitants are concentrated in oases surrounded by desert. More than 90 percent of Algerians are living along the Mediterranean coastlands on only 12 percent of the country's land. Thus, most educational buildings are concentrated in this zone [6]. Algeria is the tenth-largest country in the world and the largest in Africa and the Mediterranean. The country is bordered in the northeast by Tunisia, in the east by Libya, in the west by Morocco, in the southwest by Western Sahara, Mauritania, and Mali, in the southeast by Niger, and in the north by the Mediterranean Sea.

1.3 Sky Condition in Algeria

In Algeria, as in most European countries, the fully overcast sky has been selected as a standard design sky to which daylight factor is related in daylighting designs as it represents minimum daylighting conditions. However, the relevance of the overcast sky represents the least favorable lighting condition in many regions [6]. Weather stations provide indices of total cloudiness (octa), duration of sunshine (hours) and global solar radiation in (Wh/m2), but they do not measure illuminance. For this reason, the various existing light climates across the country have not been defined on the basis of actual measurements. [7] proposed a clean bright Algeria zoning (Fig 2.35) based on the calculation by computer simulation using the "Matlight" software, horizontal illuminance and on the basis of data from the NASA cloudiness. According to the results: the daylight climate in Algeria can be classified into four broad regions or design sky zones as shown in the Figure 3 [7]:

1. The first zone, located between latitude 34°-36°, is characterized by an average horizontal illuminance equal to 35kilolux and dominance overcast sky.
2. The second area, which includes a narrow band located between latitude 31°-34° and the Hoggar region is characterized by an average horizontal illuminance equal to 25kilolux and dominance overcast sky.
3. The third area, identify by the north of the Sahara between latitude 27°-31°, is characterized by an average horizontal illuminance equal to 42kilolux dominance and clear sky.
4. The fourth area, which covers half of the Algerian territory located on the south of the Sahara between latitude 18°-27°, is characterized by an average horizontal illuminance equal to 47 kilo lux and the dominance of clear sky.

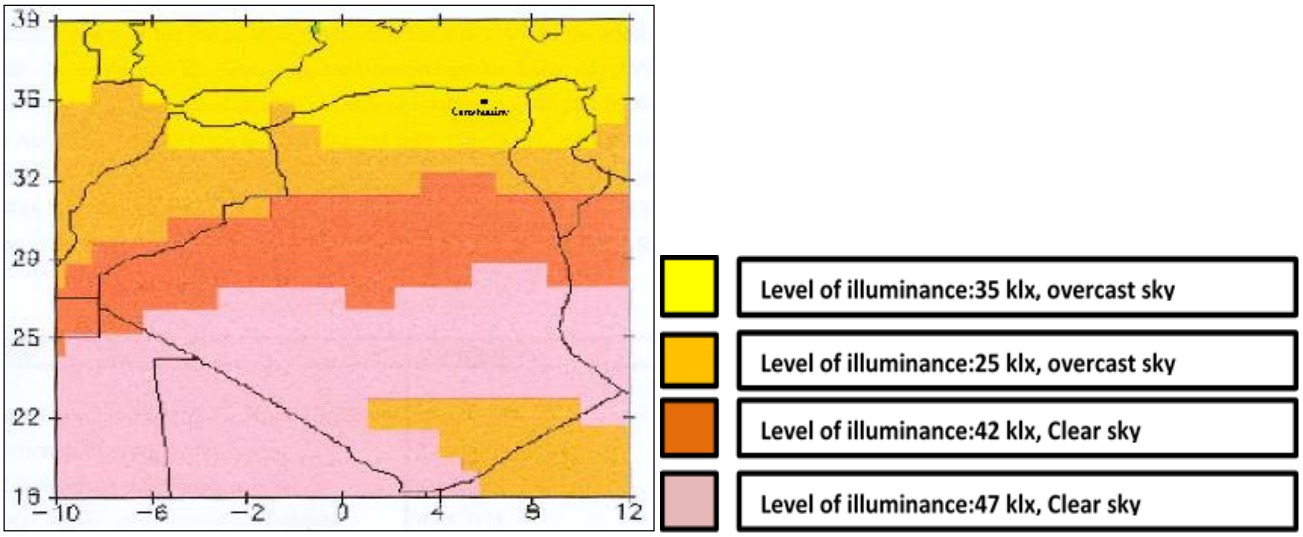


Figure 2 Resulting zoning of daylight availability over Algeria [7]

2.0 BACKGROUND

2.1 Situation

School site plays a significant role as for the residents and surrounding buildings. Thus, there are many guidance that should be considered during the design of schools. Their locations should be distant from the annoyances and the radius of influence of the school exceeds 1-2km for primary schools, 3km for intermediate school and 5km for high schools.

2.2 Orientation

Generally, classrooms are oriented to the north – south side. This provision reduces the effects of the radiance in the hot season. The orientations from south east to south can be accepted, but it requires mobile sun blinds and effective ventilation (Techicums Nomenclature des locaux et Normes fonctionnelles).

2.3 Daylighting

As well as for natural lighting there are numerous significant points pointed out by the Algerian guideline. The guideline recommends the use of mode of lighting (Unilateral lighting) which is sufficient for classrooms that do not exceed 7.8m depth. Hence, the daylight should be from the left side of students. Another important point concerning dimensions of the apertures is that the glazing surface of the window must represent at least 10-15% of the floor area (WFR) is equivalent to 30% Windows Wall Ratio (WWR) [8]. Concerning the dimension of ordinary classrooms in Algerian schools design, the typical surface of classroom ranging from 57 to 62m^2 with rectangular shape dimension (6.00m x 9.60m), (7.20m x 8.40m) (7.80m x 7.80m) and Ceiling height does not exceed (2.70 – 3.00m).

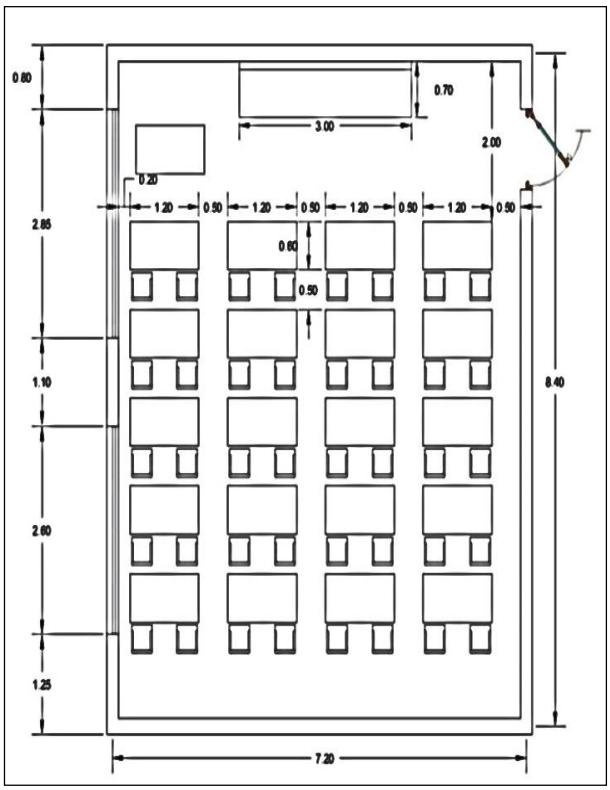


Figure 3 Typical classroom dimensions [9].

2.4 Technical Requirement (Guideline) of Public Schools Building in Algeria

Through a comprehensive study of quantitative data, various construction guidelines and specifications and graphic documents collected from the Ministry of National Education of Algeria, it was discovered that schools are designed primarily according to the guidelines presented in these documents and that the quality of the school environment was largely determined by a normalization of dimensional characteristics. They follow recommendations from (Techicums Nomenclature des locaux et Normes Fonctionnelles). In general, the relationship between lighting levels and visual comfort is strong. Nevertheless, lighting level develops to achieve high visual performance [10]. The activities carried out by students in the classroom are different. Therefore, the light should be available in the classroom and must suit with the activities practiced by the students [11]. In Figure 2.18) levels of illumination begin from 20lux to 20,000lux. Depending on the type of task, sometimes it needs low levels of illumination and sometimes requires normal levels such as classrooms that require around 300-500 lux. Others reach 20000lux as special task for instance surgery. The European Committee for Standardization (CEN/TC 169) suggests the illuminance values for the different visual tasks that can be seen in Figure 2.

Table 1 International standards for classroom lighting [12].

Areas	Chile	DS 548 Argentina	Brazil	United Kingdom	Australia	Finland	European EN 12464-1	IESNA
General	500 lux classroom	500 lux		300 lux classroom 500 lux complex tasks	240 lux	150-300 lux	> 300 lux	Max 1500-2000 lux (150-200 fc) Min 300 lux (30fc)
PC	---	750 lux	---	---	160 lux	150 -300 lux	50 lux	160 lux (15 fc)
Reading	---	---	200 - 500 lux	---	320 lux	500 -1000 lux	> 500 lux	500 lux (45 fc)
Drawing	---	1000 lux	3000 lux	---	600 lux	1000 -2000 lux	>500 lux	500 lux (45 fc)

3.0 METHOD

The research was conducted using two methods; field measurement and was validated through the use of simulation using IES <VE> software.

3.1 Survey

The measures illuminance levels are performed by using a light meter (the instrument of measurement). Measurements of horizontal illuminance outside on the ground level (courtyard) of high school prototype (one is North facing and the other is facing South, West; measurements of horizontal illuminance inside the classroom. It is important to point out that with only three light meters, the measurements could not be carried out simultaneously as previously recommended in past research. These measurements were performed in summer day (22 July 2014) and winter day (22 December 2014). Referring to the type of glass used in this school, the predominantly used in most schools is single clear glass 3mm with U-value of 5.25 W/m2K, and visible transmittance 92%. There was presence of coating on the bottom half of the windows in both sides of classrooms.

3.2 Simulation

After the survey simulation with IES VE on the result obtained from the survey to ascertain the degree of daylight availability in the schools measured based on the prototype.

4.0 RESULT AND DISCUSSION

4.1 Conceptual Models of Public Schools in Algeria

Based on consultations with professors and officials in the Directorate of Education Algeria, the conceptual models of Algerian public schools are divided into two types of school buildings. Schools inherited from the colonial period; those built during the period of French occupation are characterized by variation on the arrangements of classrooms even for a single school. Usually, unilateral lighting is the common design of daylighting in these schools. Their architectural designs do not provide too much visual comfort due to insufficient daylight due to the restriction in the area of windows, which obstruct the admission of natural light. Finally, it is necessary to note that schools classified under this type are disappearing.

Schools which have been established according to the proposed model (prototype design of school) for schools in Algeria started from the eighties until now. During this period, Algeria has used the almost universal standardization (precisely French standard) of school facilities projects to adapt to different sites, neglecting bioclimatic characteristics of different regions and socio-cultural practices of the local population.

Depending on types of conceptual models of public schools in Algeria as seen in Figures 4, 5 and 6) the classrooms are organized in blocks on the ground floor with one or two floors. Spatial configuration of instructional units is obtained by assembling a number of classrooms arranged in several geometric compositions including:

a) Linear assembly, L-shaped and U-shaped, with simple distribution corridors (circulation as galleries, courtyards)
b) Linear assembly with double distribution (central circulation with release)
c) Assembly radiant with multiple distributions (central circulation hall with distribution) and are surrounded by a boundary wall about four meters high.

In general, two types of organizations are presented, linear assembly with simple distribution (traditional classroom) which is common and the second type which has a linear assembly with double distribution.

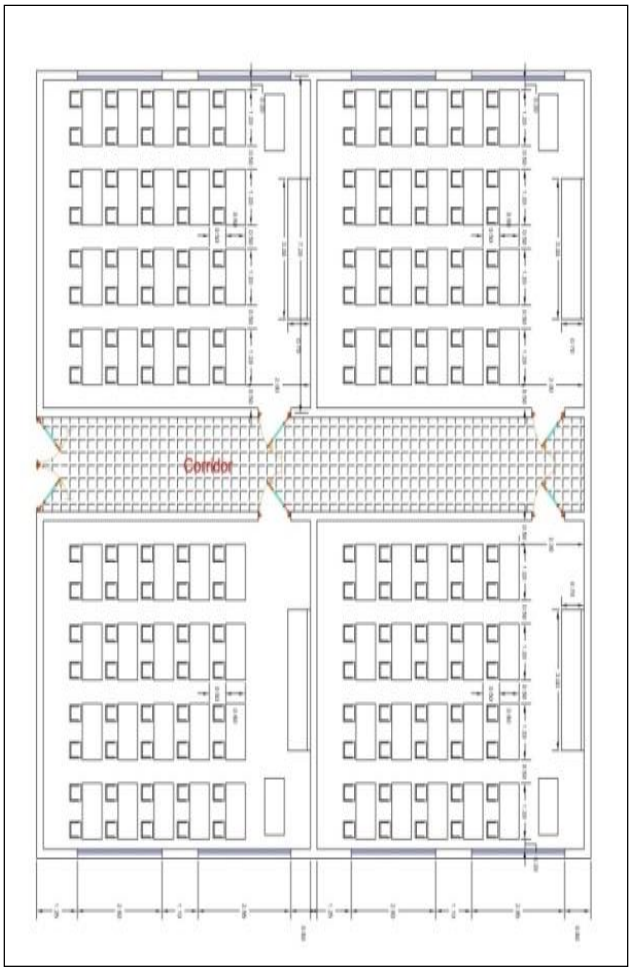


Figure 4 Design of classrooms at colonial period (unilateral mode)

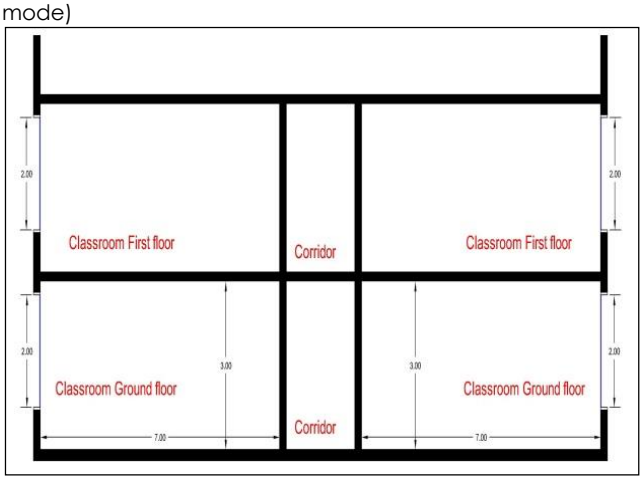


Figure 5 Sections on colonial school design (Classroom)

Traditional classrooms are most widely used in Algeria and recommended by the authorities. Formal schemes with rows for students, where teachers have to remain in one spot, essentially teaching from the front of the classroom and furniture cannot be moved. The interesting point here is the whiteboard and the teacher's area. It is easy to implement on a project, since it allows several floors above it. It is a simple bilateral strategy of illumination. On the main facade,

direct light penetrates the opposite side of the classroom. Since the objective of this research is to use (typical classroom) the traditional context, we chose this type of arrangement for our study.

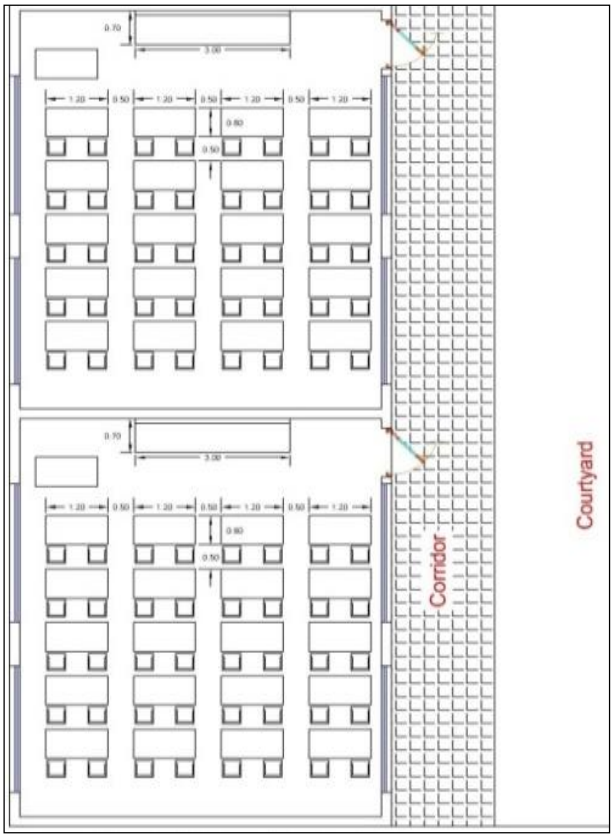


Figure 6 Section on pedagogic bloc (classroom)

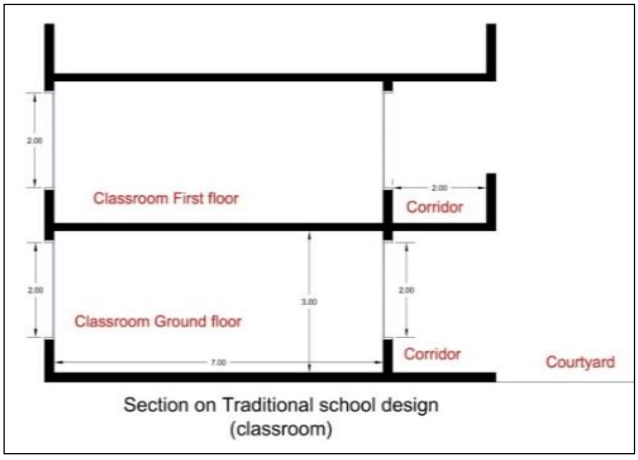


Figure 7 Plan of traditional school (classrooms)

4.2 Simulation Result

On the one hand the simulation result to verify the typology use in Algerian classroom as shown in Figures 8-11 are carried out with spatial illuminance distribution on the West-East axis the result shows peak values of illuminance in all classrooms was close to windows that overlook the main façade, the points received WPI more than 500 lux, the value reach to a maximum of1870llux, as shown in figures 8 – 11. The average illuminance was unstable in the morning and evening in both seasons. The East oriented classroom benefits from the morning sun but the solar radiation is then difficult to control because the sun is low on the horizon. In cases where there is no overcast sky during the winter months, the sunlight is not as strong but penetrates farther into the classroom than in summer when the sun is high in the sky. But in summer, the eastern orientation presents a higher solar exposure than the southern orientation, therefore, there is a real risk of glare, and the sun can induce a significant overheating.

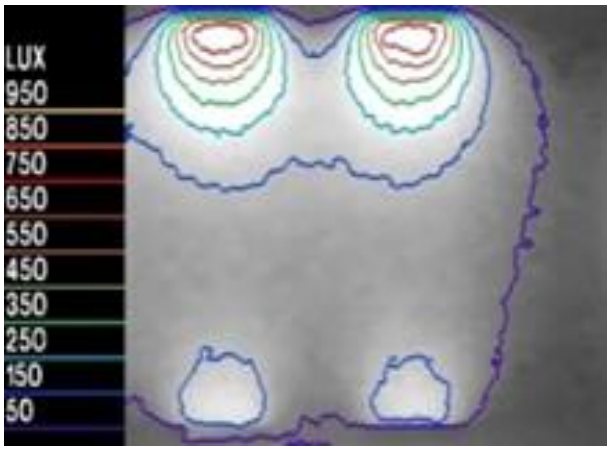


Figure 8 Spatial Illuminance distribution (West-East) orientation 9.00am summer

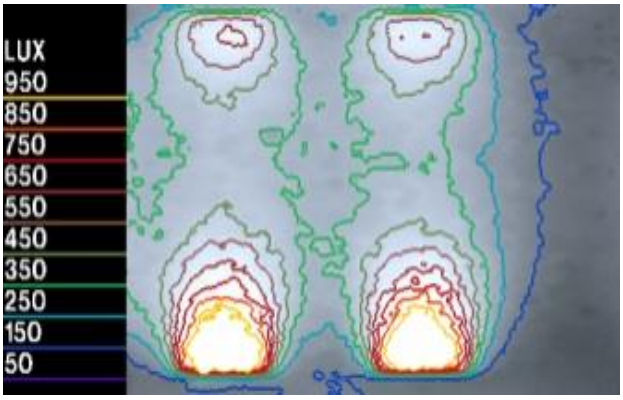


Figure 9 Spatial Illuminance distributions (West-East) orientation 9.00am winter

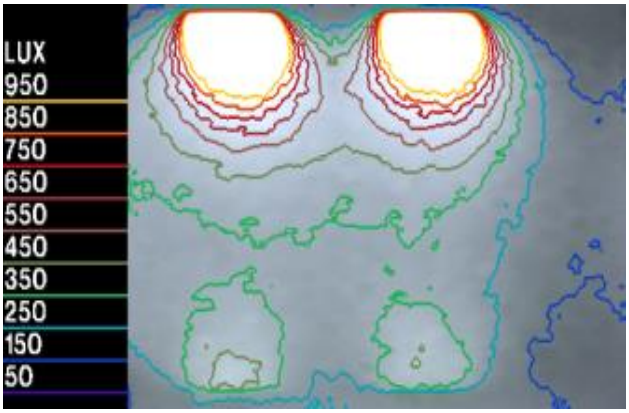


Figure 10 Spatial Illuminance distribution (West-East) orientation 14.00pm

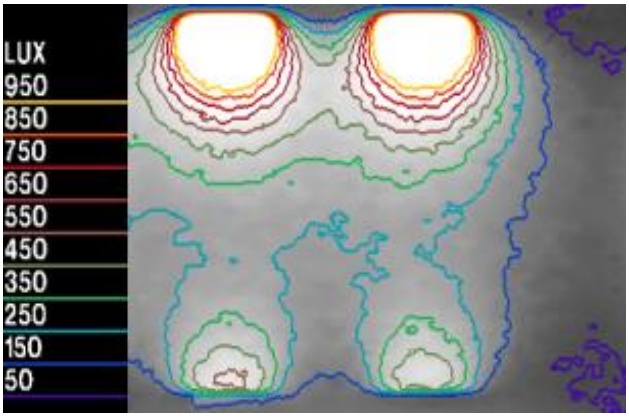


Figure 11 Spatial Illuminance distributions (West-East) orientation 14.00pm winter

On the other hand figures 12 -15 are simulations carried out with spatial illuminance distribution on the north-south axis, the result shows that there is presence of an excessive illuminance reaching towards 6689lux in that often leads to visual discomfort due to the saturation of light and even glare where closed to the opening in all classrooms direction. Also used in Algeria is easy to implement on a project, since it allows several floors above it. It is a simple unilateral strategy of illumination with direct light penetrating through the main facade and the opposite side of the classroom receives indirect light by way of clerestory beside corridor. The window of the classroom that looks into the corridor is considered at a height of 1meter and along the entire wall there is no structural beam that may obstruct the light.

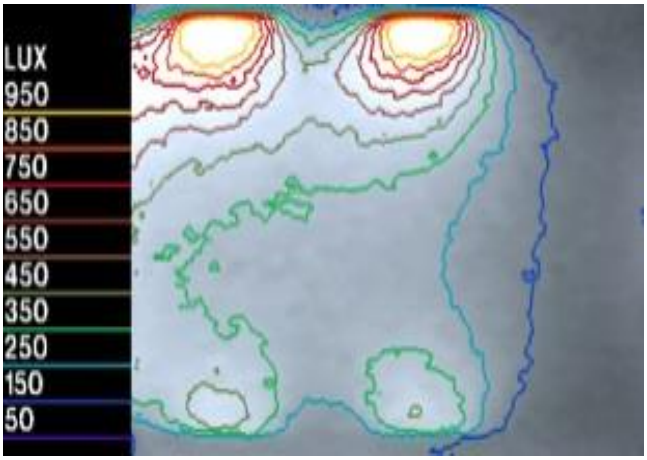


Figure 12 Spatial Illuminance distribution (North-south) orientation 9.00am Summer

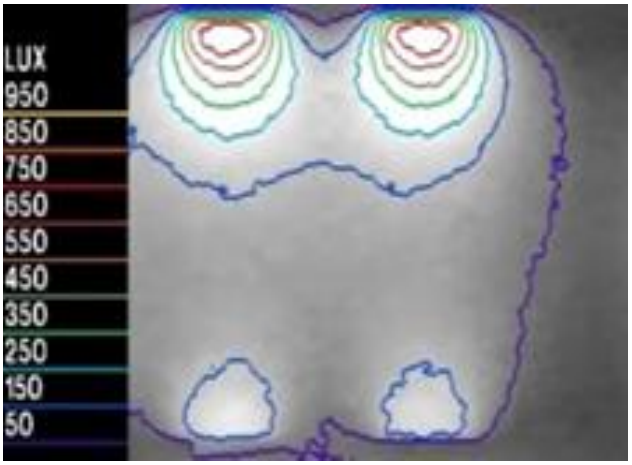


Figure 13 Spatial Illuminance distribution (North-south) orientation 9.00am winter

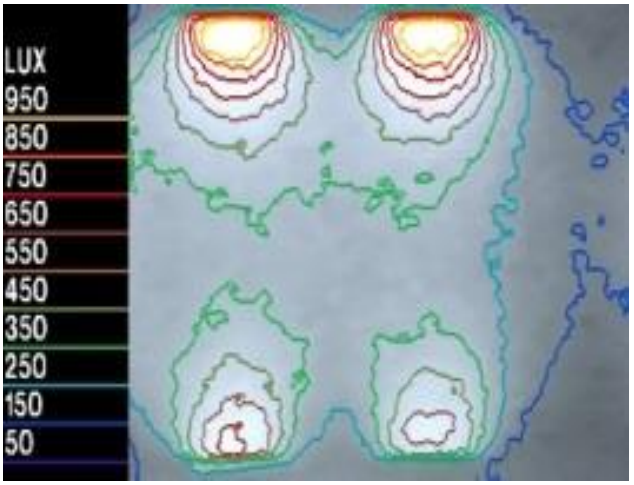


Figure 14 Spatial Illuminance distributions (North-south) orientation 14.00pm summer

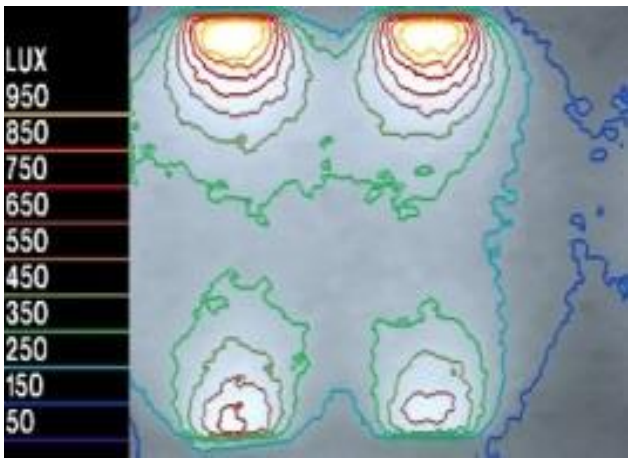


Figure 15 Spatial Illuminance distributions (North-south) orientation 14.00pm winter

4.2 Windows Design

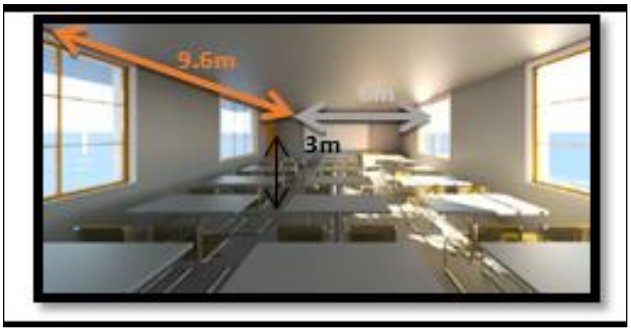
Windows can have both positive and negative impacts on student comfort and performance. Access to natural light and pleasant views are positive factors, but student performance can be negatively impacted by factors such as glare, uncomfortable temperature extremes, stuffy air, and noise pollution. Proper window design and operation can help mitigate these issues, creating more comfortable and productive learning environments [13].

To achieve the desired daylight and view in any building design, prompt attention is given to the building orientation, positioning of windows, the dimension of windows and material finishing of the window. Modern window design transcends beyond provision of simple windows with visible transmittance into more complex division [14]. The first division handles daylight glazing by deflecting direct light beams incident into the building through light shelves, reflective blinds or other reflective surfaces. These glazing are placed high in the wall or ceiling. The second division glazing are lowered down the wall level. Occupants of the space can enjoy the outdoor view. These divisions can be improved by addition of glazing to mitigate against glare and solar heat gain.

4.3 Basic Geometric Model

The geometric of the classrooms is determined by the Algerian Guideline of schools buildings (Classification Techicums of Local and Functional Standards). The classroom area for 36 students was defined for this study as 57.6m^2, measuring 9.6m long, and 6m wide in addition to a covered corridor for students up to 2m which is considered an overhang. For both of the classrooms, daylight illuminance diminished slightly with increasing distance from windows which overlook to the exterior, until the middle of classrooms and then rise up again until it reaches to the corresponding window. However the illuminance value on this side less than other side because of the existence of the overhang (shading device), except the classrooms facing the west-east orientation due to position of sun in the morning which allow to access more illuminance to the classrooms.

For both of the classrooms, seating position near window did not respond to the international standard (A.F.E) and considered poorly comfortable for visual performance due to the direct penetration to sunlight on work plans inside classrooms. The most significant characteristic of bilateral lighting concept that provides a more uniform daylight into the classrooms, therefore, when reviewing the daylight uniformity with clear sky it could be seen that all the classrooms achieved the uniformity greater than 0.5 which is clearly observed on graph (figure 13). Only the classroom oriented to the (North-south) at 14.00pm, which generated a low uniformity 0.42 as can be seen in the graphs of because of the greatest contrast which corresponds to 14.00pm between both sides of windows. Eventually, the main reason behind these large amounts of sunlight illuminance ratio because of direct sunlight.



(a) Perspective within the classroom

(b) Pictures showing the arrangement of tables and windows state within classroom

(c) Common Window Shapes in Algeria Schools

(d) Pictures showing the interior and exterior design of school

Figure 16 Geometric displays of various room forms used for the research

5.0 CONCLUSION

The past decade has proved to be a turning point in the quest for educational attainment in Algeria. The study of the architecture of comfort, building conditions, and environmental needs of the society has become paramount. This provides the opportunity for proper environmental monitoring of in-depth analysis of thermal, acoustic and luminal science that influences societal wellbeing as a whole most especially that of schools which house the future generations. The importance of daylighting in our educational buildings has dominated research in recent years. There has been a positive correlation between the positive effects, considerable capacity to the performance by the students, and the promotion of better health by proper lighting of schools [15]. It has been proved that daylighting affords the best quality of light available to mankind, classroom, and corridors. It has also been proved that daylighting eliminates noise pollution and flickering from electric light sources [16]. All this can be achieved through the typology used in constructing our schools.

The standard sky condition in Algeria is overcast and based on this; the conceptual models of Algerian public schools are divided into two types of school buildings. Schools inherited from the colonial period; those built during the period of French occupation are characterised by variation on the arrangements of classrooms even for a single school and are streamlined into; linear assembly with simple distribution (traditional classroom) which is common and the second type which has a linear assembly with double distribution. Based on the existing guideline from the Ministry of National Education; this was adopted from the colonial masters. The results of the investigation from the site measurements show that WWR was more than 40%; the WPI was found to be within the range of 300lux to 500lux. Result from simulation using IES <VE> by comparing the window used by colonial masters under (overcast sky condition) and summer season (under intermediate sky condition) support the preliminary investigation that class room typologies in Algeria had less consideration for climatic and comfort conditions and the window openings allowed excessive daylight. For the West-East facing windows result was supported by [17], the North-South Facing windows was supported by research work of [18]

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