Analyzing the Luminous Environment in a University Campus in Biskra, Algeria: A Pilot Study

S Boucherit¹, D Berkouk², TAK Bouzir³ and S Khelil²

¹ Department of Architecture and Industrial Design, Università degli Studi della Campania “Luigi Vanvitelli”, 81031 Aversa (CE), Italy
² Department of Architecture, Biskra University, Biskra 07000, Algeria
³ Institute of Architecture and Urban Planning, Blida University, Blida 09000, Algeria
E-mail: samiha.boucherit@unicampania.it

Abstract. This paper aims to assess and analyze the indoor, semi-outdoor, and outdoor luminous environments of a Biskra university campus, to determine the relationship between these three luminous environments in terms of contrast and brightness, and to evaluate the perception and the occupant's luminous comfort. This preliminary study is essentially based on a subjective assessment using in situ survey. In order to make a quantitative and qualitative evaluation, this research is based on the analysis of digital images of selected spaces. Findings show that the risk of discomfort due to glare is higher in outdoor spaces, whereas the risk of contrast discomfort is higher in the semi-outdoor spaces, while the risks of discomfort from the low quantity of daylight are higher in indoor spaces. The findings of this research also invite to study the physical dimensions of the environment to make a multisensory evaluation of the university campus occupants in regions with hot and arid climates.

1. Introduction
The Saharan regions of northern Africa, particularly in Algeria, are characterized by a hot and arid climate with clear and sunny skies most of the year. This allowed the sufficient presence of daylight in these regions throughout the days of the year, because daylight is considered as the totality of visible radiation originating from the sky and the sun during the daytime hours [1]. Daylight is perceived according to the common parlance and building physics as an outdoors brightness that includes all variants, from twilight to the brightest moment of the day when the sun is highest; ranging from diffuse light in the shaded areas or with the cloudy sky to the direct sunlight [2]. The availability of daylight in urban sites is influenced by the buildings and streets orientation and by the surrounding buildings [3], knowing that these urban factors determine the daylight quantity of indoor spaces and the views from the windows [4]. Where daylight can have positive effects on view, luminous comfort, psychological comfort and even the health and productivity of the occupants [5]. However, in the absence of daylight, humans have diverse and sometimes contradictory physiological and psychological needs [6]. And in the event that the daylight is uncontrolled, the building environment may be affected by negative effects [7].

Regarding university campuses, several studies have shown that the environmental quality of learning spaces influences the health, productivity, and psychological level of users [8], and that a conducive and comfortable learning environment can promote active learning, which can possibly improve a conceptual understanding of the learners [9]. In this perspective, few works have studied the university campus, in terms of outdoor thermal comfort [10], pedestrians' wind comfort and wind safety [11],
thermal comfort of indoor and semi-outdoor spaces [12], and even in terms of energy and indoor comfort [13]. However, there is only a little researches that have investigated the importance of daylight for the luminous comfort of indoor, semi-outdoor, and outdoor spaces of the university campuses, especially those universities in North Africa.

The main objective of this preliminary research is to assess and analyze the indoor, semi-outdoor, and outdoor luminous environment of Biskra university campus, to determine the relationship between its three luminous environments in terms of contrast and brightness, and to assess the perception and the level of luminous comfort of the occupants in these spaces.

2. Methodological approach

In order to assess and analyze the indoor, semi-outdoor, and outdoor luminous environment of Chetma university campus of Biskra, which contains the Faculty of Human and Social Sciences (see Figure 1), a series of in situ digital images was realized at the three types of spaces studied the outdoor, semi-outdoor, and indoor luminous environments in this university campus. Biskra city was considered as a context for this study because it is characterized by a desert climate with a clear and sunny sky almost throughout the year [14]. The photography was done with a digital camera by the use of the digital images’ technique. Additionally, a subjective approach was carried out by using an in-situ questionnaire to evaluate the luminous sensation and the comfort level of the participating students.

Figure 1. Localization of Chetma university campus (Google Earth).

Indeed, this research is based primarily on the realization of a subjective evaluation. On this subject, an investigation was conducted during the month of June 2019 on the satisfaction level, comfort, sensation, and the level of participating students acceptance of each luminous environment and even the effect of glare (high brightness) and contrast. The in-situ questionnaire of this study based principally on the questions as presented in Table 1.

Table 1. Main questions for the luminous environments’ evaluation.

| Variables                  | Questions                                                                 |
|----------------------------|---------------------------------------------------------------------------|
| Luminous satisfaction      | (A) Do you consider that the luminous environment of this space is satisfactory? |
|                            | Strongly disagree (-2) Disagreement (-1) Neutral (0) Agreement (+1) Strongly agree (+2) |
| Luminous comfort level     | (B) In this space, are you generally in a state:                               |
|                            | Very uncomfortable (1) Uncomfortable (2) Little uncomfortable (3) Comfortable (5) Very comfortable (6) |
| Luminous sensation         | (C) How do you find the luminous environment of this space?                 |
|                            | Acceptable Unacceptable                                                     |
| Luminous discomfort        | (D) Show how often you think daylight brings you such problems in this environment.: (one answer to each line) |
|                            | (a) Luminous discomfort due to glare (high brightness)                        |
|                            | Always (1) Often (2) Sometimes (3) Rarely (4) Never (5)                      |
|                            | (b) Luminous discomfort due to the contrast                                  |
|                            | Always (1) Often (2) Sometimes (3) Rarely (4) Never (5)                      |
In parallel to the subjective evaluation, this research also bases on the analysis of digital images of the chosen spaces "outdoor, semi-outdoor and indoor" to make a quantitative and qualitative evaluation of these different luminous environments and to compare the environments of these three types of spaces by studying brightness and contrast, based on the captured digital images. The work process is presented in Figure 2.

Figure 2. Work process for the objective evaluation.

In the first step of the objective evaluation, the digital images were captured in the summer period by the use of a digital camera during a weekend in the same month for each space. The research setting was based on 63 digital images for outdoor spaces, 132 for semi-outdoor spaces, and 168 images for indoor spaces, Figure 3. The transformation of colors into black and white was considered as a second step, knowing that this step was achieved by the use of image treatment software, Adobe Photoshop. After this step, two treatment methods were completed on black-and-white images (image treatment with 256 brightness levels and the treatment of 5 brightness levels). The method of the 5 grey levels (the 5-greyscale method) is based on the use of Adobe Photoshop software by reducing the brightness levels of images from 256 grey levels only to 5 brightness levels [15], which can be described as a brightness map, as shown in Figure 4. In the following, the export of these images to the ArchiCad software is considered as another step, in order to calculate the percentages of each grey level (the brightness percentage) of every image. The aim of this treatment is to show the impact of the point of view on the luminous environment evaluation. Therefore, we based this part of the study only on two digital images obtained in the same space.

In the second method, we imported the black and white images in the Iris software to export the histograms of these images in (.txt) format. Then we imported the Iris software outputs to the Excel software for the transfer and processed the results to be compatible with the SPSS Statistical Package for the Social Sciences. As a result, the Excel software acts as an intermediary between the Iris software and the SPSS software.

In a final step, the statistical analysis was carried out using the SPSS software; the results were then exported as histograms, graphs and tables.

Figure 3. Examples of captured views: (a) indoor; (b) semi-outdoor; (c) and outdoor spaces.
3. Results and discussion

3.1. Subjective assessment of the luminous environment perception

In order to make a subjective assessment of the luminous comfort of the participating students, Figure 5 presents the luminous satisfaction of participants towards their luminous environments. This study shows that there are present slight variations in the representative percentages of luminous satisfaction level of students participating in the outdoor, semi-outdoor, and indoor spaces of the university campus. Where we found that 54.8% of outdoor space occupants were between "agree" and "strongly agree" with the question (that they are satisfied with the luminous environment). While 59.4% and 77.7% of the participating students in the semi-outdoor and indoor spaces respectively show that, they are "satisfied" to "strongly satisfied".

The luminous comfort level of the participants in the three types of space is presented in Figure 6. It shows that 55.5%, 59.5%, and 57.2% of the participating occupants of outdoor, semi-outdoor, and indoor spaces, respectively, have a comfort level that varies between "uncomfortable" and "comfortable". This slight variation between these low results shows that occupants do not have an optimal level in these three spaces.

Figure 7 illustrates that the luminous environments of these three spaces are acceptable that's because only 62.2% of the participating occupants in outdoor spaces, as only 75.7% and 77.8% of the participating students in the semi-outdoor and indoor spaces judged respectively, their luminous environments as acceptable. From this, we can consider the luminous environment of these three spaces is not acceptable, because the majority of the results indicate levels lower than 80%. On the other hand, the indoor spaces are more comfortable than the semi-outdoor and the outdoor spaces, as the interior spaces are closer to this 80%, this confirms the results of Figure 5. In this regard, Hirning, Isoardi, and Cowling (2014) [16] and Yun, Yoon, and Kim (2014) [17] stated that daylighting is an important factor in determining indoor visual comfort, and affects occupant satisfaction and productivity.
Indeed, the discomfort glare causes discomfits due to high luminance contrasts or inappropriate luminance distributions within the visual field, without unavoidably reducing visual performance or visibility [18]. However, Figure 8 shows that the majority of participating students may not be aware of these two phenomena (contrast, and glare).

3.2. Assessment of the luminous environment

In order to understand the impact of view (viewpoints) on the luminous environment evaluation, this part of the study is based on two digital images that were recorded from two completely different viewpoints in the same environment and at the same time, Figure 9 (a). The first viewpoint is towards the front door of the university campus, while the second is towards the courtyard of this building, as shown in Figure 9 (b). Using Photoshop software, the digital images were processed in black and white, then the grayscales were reduced from 256 to 5-grayscales, Figure 9 (c).

Figure 9 (d) shows that the number of dominant pixels in image 1 (view 1, towards the courtyard) corresponds to the level (0%) i.e. pure black, with an average percentage of 57.42%. While the gray of
the level (50%) takes the maximum pixel percentage of 48.8% for image 2 (view 2, towards the door). This shows that the view has a considerable impact on the luminous environment. Where the digital image (1) is considered dark, so the luminous environment is dark. In contrast, the average clarity of the image (2), refers that the same environment is characterized by average clarity. This contradiction confirms that a single digital image from a single viewpoint cannot give accurate information of the luminous environment, hence it is imperative to study the data of several images from different directions, to assess the luminous environment by using digital images.

Figure 9. (a) Point of view; (b) Black and white image; (c) 5 levels of grey; (d) Proportion of zone per image brightness level.

To the assessment of the luminous environment of the university campus, the classical reading of the 370 histograms presented by the Adobe Photoshop software for each digital image, based on the three tones, from (dark tones) to (light tones), was considered as a method of the luminous environment evaluation. Figure 10 shows the luminosity level of each image according to each architectural space (outdoor spaces, semi-outdoor, and indoor spaces). The midtones are the most dominant for digital images in each luminous environment, where the number of 30 out of 63 images (47.62% of images) of outdoor spaces has average tonal values higher values of dark tones and light tones. While 59 out of 139 images (42.45% of images) of semi-outdoor spaces are characterized by the dominance of medium luminosity values. Furthermore, 53.57% of the images of the indoor spaces are images with a medium clarity because they are characterized by the dominance of the medium tones compared to the other tones. From all the above, we deduce that the luminous environments of this case of study are characterized by a medium level of clarity.

Figure 11 shows a comparative presentation of the average histogram of the recorded images in the function of each digital image, where the horizontal axis shows the average brightness values (average tonal values), and the vertical axis shows the number of pixels. For outdoor spaces, 45.36% of the average pixels’ number of each luminous environment image characterizes the medium brightness values (the medium tonal values), whereas only 19.42% of the pixel’s number of the dark tonal values, and 35.22% of the average number of pixels in each frame in this environment show clear brightness values. Figure 11 also shows that 53.06% and 50.02% of the average pixels’ number of each image recorded respectively in the semi-outdoor and the indoor spaces are characterized by a medium level of clarity. While 26.42% and 36.11% respectively of the image’s pixels of these two spaces are dark pixels. Whereas, only 20.52% of the images’ pixels of the semi-outdoor spaces and 13.88% of the images’ pixels of the indoor spaces are clear pixels. From this, we deduce also that the spaces of the university campus are spaces with medium clarity.
As visual clarity (brightness) is related to the feeling of contrast [19], this pilot study was based on the distribution of the images that were collected in the university campus for luminous environments classification according to a theoretical relationship between brightness and contrast of the image, this data acquisition method was developed by Demers in 1997 [20]. Figure 12 (a) shows that there are slight variations between the results of the different outdoor, semi-outdoor, and indoor spaces. Where the values obtained for these spaces are located in the left part of the graph, that is to say towards the darkest light typologies with a brightness average of 45.72% and a standard deviation of 13.28% between the different results in different spaces studied. Furthermore, these spaces are characterized by low contrast, since most of the results of different luminous environments are located in the lower part of the graph with a contrast average percentage that reaches 37.18% and with a standard deviation of 7.23% between different luminous environments.

Figure 12 (b) presents an enlargement of Figure 12 (a) which gives a more tangible representation of the types of luminous ambiance found in the spaces studied by the results obtained from the 370 digital image treatments. For the brightness level, the three types of luminous environments have the same ambiance that there is a certain hierarchy between the brightness levels recorded between the results of different spaces. Where, the darkest results are recorded for digital images of indoor spaces with a brightness average percentage that affects 40.80% with a very low standard deviation of 13.83%, knowing that all values recorded for this space are recorded between 5.10% and 65.88%. We find that the semi-outdoor spaces are less dark than the indoor spaces, where the percentages of brightness recorded for the digital images of the semi-outdoor spaces are between 15.69% and 70.20% with an average percentage of 46.82% and a standard deviation of 10.95%. In addition, the statistical analysis shows that outdoor spaces are the least dark spaces compared to semi-outdoor and indoor spaces, where the average percentages of the brightness of outdoor spaces reach 56.54% with a very low standard deviation that reaches 8.54%. All the values obtained for these outdoor spaces are between 34.12% and 69.41%.
Figure 12. Images distribution that was collected in the university campus for a luminous environments classification according to a theoretical relationship between brightness and contrast of the image.

On the other hand, Figure 12 (b) shows that although the results are located in the same part of the graph. The most contrasting environments between the different types of spaces are semi-outdoor environments, where the percentages recorded for these environments are between 22.47% and 54.98% with an average percentage of 38.12%. While the average percentages of the contrast of the outdoor and the indoor spaces touch 39.84% and 35.45%, respectively. From all the above, we deduce that the discomfort risk due to glare (high brightness) is higher in outdoor spaces of the campus, while the risk of discomfort due to contrast is higher in semi-outdoor spaces. Additionally, we also deduce that the discomfort risks due to the low amount of daylight are higher in indoor spaces. From this, it is imperative for architects and designers to study this phenomenon well, as it can increase energy consumption to make indoor luminous comfort.

4. Conclusion
This pilot study shows that the occupants of outdoor, semi-outdoor, and indoor spaces of Chetma university campus in Biskra have an uncomfortable luminous environment. In addition, this research demonstrates that indoor spaces are more comfortable than semi-outdoor and outdoor spaces. Furthermore, the subjective results of the survey illustrate that the majority of participating students do not know the phenomenon of contrast and glare. In this respect, the objective and qualitative evaluation of digital image distribution according to the theoretical relationship between the brightness and the contrast of the image show that the risk of discomfort due to glare is higher in outdoor spaces. While the risk of contrast discomfort is higher in semi-outdoor spaces, though the risk of discomfort due to the low amount of daylight is higher in indoor spaces. This paper allows us to deduce that the viewpoint has a considerable impact on the reading of the luminous environment and that a single digital image from a single viewpoint cannot give correct or precise information on the luminous environment. Therefore, to evaluate a luminous environment by using digital images, it is imperative for the researcher to study the average results of several digital images in various directions of a single luminous environment.

Although this preliminary study is limited to the evaluation of the sensation and the luminous comfort by the use of a questionnaire and on the processing of the images captured in situ to evaluate the luminous environment, findings from this study open a lot of perspectives for future research, in particular, the use of simulation and in situ measurements to evaluate the different glare indices and the understanding of a multisensory evaluation [21] at the level of the university campus of regions with hot and arid climates.
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