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Perception of the luminous environment in university classrooms in Algeria

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Light has a significant impact on humans and affects directly their biological function. In learning spaces, the visual ambience is successful when users can perform their work without discomfort. It is based on quantitative and qualitative parameters related to comfort. This research focuses mainly on a qualitative study of the luminous environment in classrooms of the University of Oum El Bouaghi (Algeria). Typical classrooms with a single side or bilateral windows were investigated. For that, the user's perception of visual comfort in classrooms is collected by a questionnaire survey to identify the benefits and disadvantages of both lighting systems. The findings of this study help to provide design recommendations for improving the luminous comfort in classrooms.

Key words: Luminous environment, university classroom, visual comfort, user's perception

INTRODUCTION

Light is a major element in the design of building's interior. The creation of well-daylighted spaces remains a challenge that is difficult to meet. The idea of using natural light to illuminate interior spaces is not new. The 1990s are witnessing a resurgence of interest in daylighted buildings, driven in part by a renewed interest in the welfare of occupants within buildings and by longer term, broader concerns encompassed within the "green buildings and sustainable design movements" (Gregg D, 1995).

Natural light does not only affect vision, but also our biological functions (Gronfier, 2013). It influences the architectural space from a functional, aesthetic and emotional point of view (Belakhal, 2007). The user's response to the lighting conditions is therefore very important. A more appropriate response must balance the needs of owners, occupants and society by integrating concerns or aesthetics, amenity, comfort, energy efficiency, and cost effectiveness (Gregg D, 1995).

These variables are of primary importance in learning buildings because they help to improve and reduce building energy consumption. They also impact on student's health, well-being, and performance (De Dear et al., 2015, Ackley et al, 2017, 2018).

Indeed, daylight affects the physiological and psychological state of teachers and students, improves cognitive performance and satisfaction and reduces eyestrain. Achieving a good level of visual comfort in classrooms is essential to create a satisfying and productive learning environment.

Several studies have demonstrated the relationship between daylighting and improved academic performance. Nicklas and Bailey (1997) reported that students in daylit schools performed 5-14% better than those in non daylit schools. Similarly, Heschong Mahone (1999) showed that students in classrooms with the most daylight had test scores 7-18% higher than those in classrooms with less light. Schneider (2002), Fisher (2001) and Lackney (1999) also confirm that good daylighting in a classroom has positive effects on user behavior as well.

In this regard, Juslen and Tenner (2005) cited by (Samani and Samani, 2012) explain that light improves productivity and increases performance via the following mechanisms:

1) Visual performance: when people can see the visual task clearly, they work better.

2) Visual comfort: according to experts, removing or reducing discomfort, it increases performance by improving concentration.

3) Interpersonal relationships: when occupants can see each other, they can establish better communication and cooperation.

On the other hand, when classrooms are adequately daylit, melatonin production becomes suppressed, leading to an increase in concentration that will improve learning performance (Bellia et al, 2015).

However, poor daylighting in classrooms may cause glare and visual discomfort (Rouag, 2001; Benharkat, 2006). It can also generate solar heat gain, increasing ventilation and cooling loads (Shannon, 2020).

In Algeria, more than 1.5 million students are studying at universities (APS, 2021). They spend an average of eight hours per day inside classrooms, hence the interest of a good quality of natural lighting. The current study aims to highlight the importance of daylighting in university designs in order to optimize its use. It is a qualitative assessment of the lighting environment in typical classrooms.

METHOD

A questionnaire was employed to assess participant responses to luminous environment within classrooms in the University of Oum El Bouaghi (Algeria). For that the subjective appreciation of daylight conditions in typical classrooms with a single side or bilateral windows (daylighting from two opposite sides) was collected.

Situation and Description of the Classrooms

Typical buildings were chosen for the current study in Oum El Bouaghi city located in the east of Algeria (latitude 35°52', longitude 7°06'). According to the daylight zoning of Algeria carried out by (Zemmouri, 2005), Oum El Bouaghi city belongs to the first luminous climatic zone characterized by an average horizontal illuminance of 35 kilolux and a dominant partially covered Sky conditions (Fig.1).

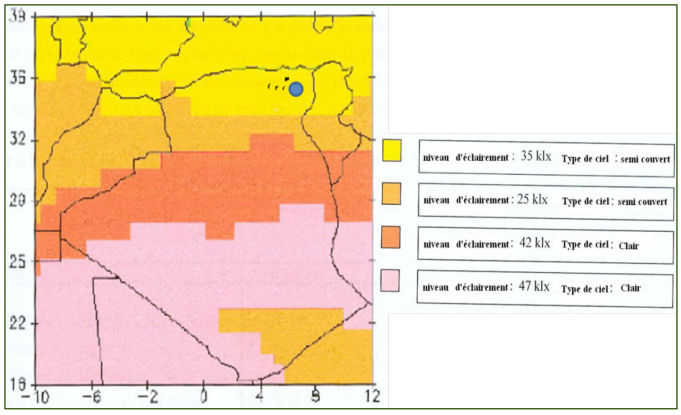

Figure 1. Zoning of daylight availability in Algeria. (Zemmouri, 2005)

Three different oriented classrooms in buildings (A) and (B) of the department of management of urban techniques were chosen for the study. The classrooms in building (A) are sidelit with vertical openings. The classroom (A1) has a northeast exposure and four windows. As for classroom (A2), it has six windows facing south-west. This conventional single side lighting system remains the usual method of fenestration in classrooms in Algeria.

The classroom in building (B), is equipped with a sidelighting bilateral Lighting. It has three windows facing north and four windows facing south overlooking a gallery on the ground floor (Figure 2).

The interior walls and ceilings are white (reflectance = 0.8) and the floors are covered with light beige granito tiles. Figure 3 shows the light ambiences inside the classrooms studied during January and May.

The windows have blue-tinted glazing with wood joinery (Figure 4). The calculated glazing indices for the studied classrooms are as follows:

Iv (A1) = 17.09%, Iv (A2)=17.63%, Iv (B)=31.22% (The glazing index (Iv) is the ratio of the sum of the glazed surfaces of a classroom to the floor area)

Figure 2. Views of building A (top) and Building B (bottom)

Figure 3. Luminous environment in the studied classrooms

Figure 4. Type of windows and glazing of the studied classrooms

Sample

In order to assess the visual comfort perception of the occupants in classrooms, we established a questionnaire with students and teachers trying to include as many participants as possible. This study was carried out during the winter (January) and mid-season (May) and was completed by on-site observations.

A sample size of n=156 (teachers and students) was determined. 95 and 61subjects for the building (A) and (B) respectively were selected. For the North-East facing classroom (A1), the sample collected was composed of 49 participants. For the southwest facing classroom (A2), it is 46 and 61 participants for the classroom (B).

Figure 5 shows the distribution of the respondents according to gender and user group. It shows that 71.15% of the users interviewed are female and 28.85% are male. The majority of participants were female (71.15%) almost all (85.26%) were students and 14.74% were teachers whose age range varies between 35 and 51 years and that of the students varies between 18 and 29 years (Bachelor's cycle of 18-23 years and Master's cycle of 22-29 years). It should be noted that students spend more time than teachers in the classroom. Most of the classrooms are usually occupied from 8:00 am to 3:30 pm.

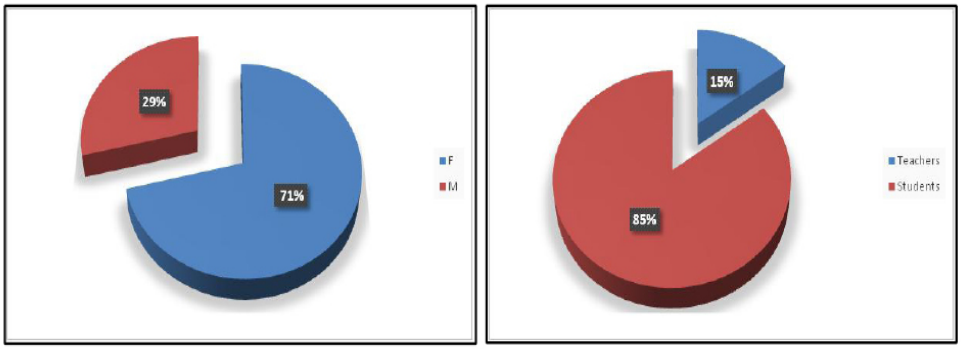

Figure 5. Distribution of respondents by gender and user group.

Description of the Questionnaire

The questionnaires consisted of 15 items divided into closed-ended and open-ended questions. Three items include intrinsic characteristics of the participants regarding age, gender and user group (student or teacher). The other items are related to lighting environment variables.

Part of a survey asks about that may influence the user's appreciation of the luminous environment, the users' perception of the quality and level of natural light, the daylight distribution, the use of artificial lighting, and even the visual annoyance within the studied classrooms through closed and/or open-ended questions.

Respondents completed the questionnaire in real time based on how they actually perceived the luminous environment and what kind of disturbances they may feel during lecture sessions. Technical terms such as glare were explained to the participants. This section concerns also user preference offering them the opportunity to express themselves more freely and to formulate their needs and preferences.

Part of the questionnaire was constructed as a 5-point Likert scale. It is ranging from -2 to 2 in which respondents specify their level of satisfaction to light conditions within classrooms. The values given correspond to the following statements:

-2 very dissatisfied, -1 dissatisfied, 0 neither satisfied nor dissatisfied, 1 satisfied, 2 very satisfied (for the level of user's satisfaction of luminous environment within classrooms)

-2 very insufficient, -1 insufficient, 0 neither sufficient nor insufficient, 1 sufficient 2 very sufficient (for the perception of the amount of natural lighting)

-2 Very dark, -1 dark, 0 neutral, 1 bright, 2 very bright (for the daylight distribution)

-2 Unpleasant, -1 uncomfortable, 0 neutral, 1 comfortable, 2 pleasant (for the perception of the light environment within classrooms)

RESULTS AND DISCUSSION

After administering the questionnaires to students and teachers during the winter and mid-season period, data results have been classified and analyzed. By comparing the results from the different classrooms, we found significant differences between the two seasons and between the two lighting systems.

User's Satisfaction of Luminous Environment Within Classrooms

Regarding the luminous satisfaction of participants towards their luminous environments, figure 6 indicate that all the respondents of the classrooms with one-sided lighting had a negative impression about daylight in winter time. 22.43% of the users were dissatisfied of their visual environment and 77.57% were very dissatisfied.

As for the classroom with bilateral sidelighting, 16.39% of the respondents show that they are satisfied towards their lighting environment, 45.9% are neutral, 32.79% are dissatisfied and 4.92% are very dissatisfied.

In mid-season, we noted a considerable satisfaction from the user's classroom (B) (67.21%) in front of 27.87% of neutral persons and 4.92% of very satisfied persons. On the other hand, for the two classrooms (A), the users showed an average satisfaction with their lighting environment. We noted 32.56% of satisfied people, 49.62% neutral and 17.82% of dissatisfied people.

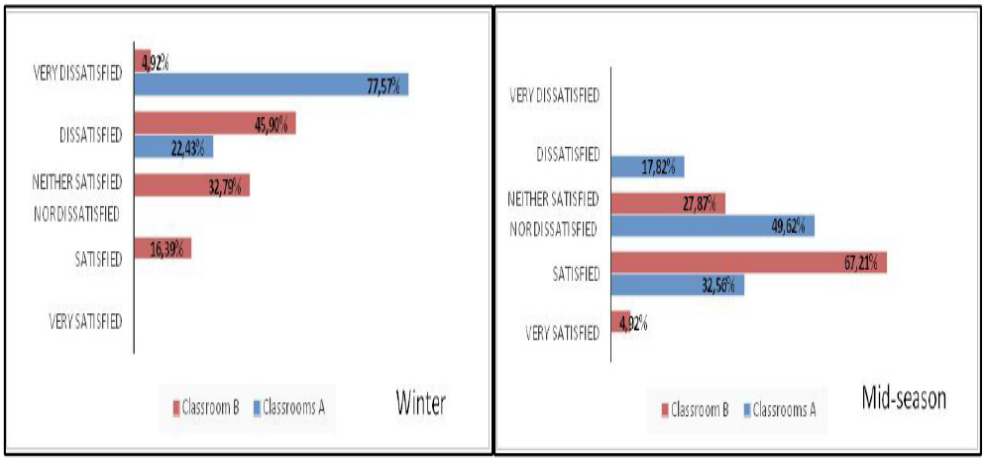

Figure 6. User's satisfaction degree of luminous environment in winter and mid-season.

The Daylight Level in the Classrooms

As can be seen in figure 7, results indicate that 95.92% of the respondents in classroom (A1) find the natural lighting very insufficient in winter, in front of 4.08% who consider it insufficient and only 0.17% are neutral. Northern light is relatively diffuse (a homogeneous light but insufficient especially on overcast days).

In the classroom (A2), 65.22% of users find the lighting very insufficient and 34.78% find it insufficient. The south-western classrooms are exposed to low direct sunlight in winter in the early afternoon: a more intense light but which can cause significant contrasts.

For the classroom with a bilateral lighting system, 39.34% of the participants consider that in winter, natural light is insufficient, especially when the sky is overcast, while 18.04% find it sufficient and 42.62% are neutral.

With a North-South bi-orientation, the classrooms face the sunlight during the whole day but this is attenuated by the use of tinted glazing.

On the other hand, the data analysis shows that 73.77% of the users of the classroom (B) receive adequate amount of daylight and considered it as sufficient in mid-season while 6.56% found it very sufficient and 19.67% of them are neutral.

34.69% of the occupants of classroom A1 felt that the natural light in this classroom is insufficient, 42.86% are neutral and 22.45% found it sufficient. For classroom A2, 28.26% of the respondents considered it sufficient, 41.3% were neutral while 30.44% found it insufficient.

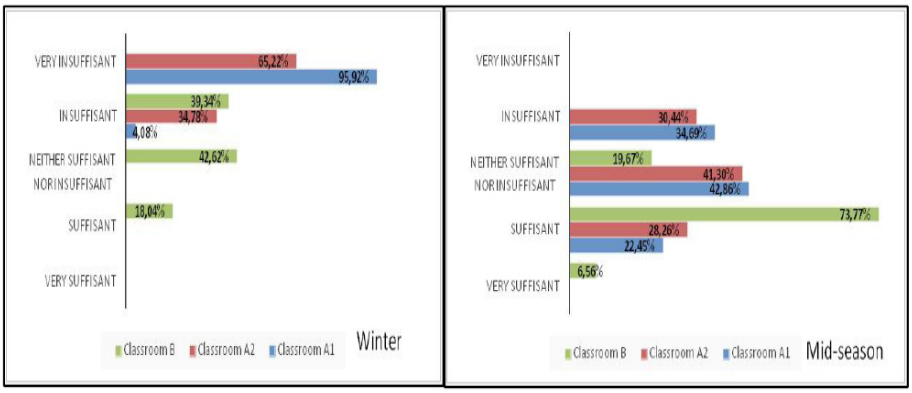

Figure 7. Distribution of user's perception of the natural light level in classrooms in winter and mid-season.

Daylight Distribution in Classrooms

According to Figure 8, the light in classroom (A1) is perceived as very dark by all users (83.67%) and 16.33% find it dark during winter. For classroom (A2), 26.09% of the users rated the classroom lighting as very dark, 52.17% found it dark, and 21.74% of them were neutral.

This lighting environment is closely linked to the quality of the glass used and its color. It has a crucial role on the visual comfort of the occupants. According to the respondents, the blue and dirty glazing considerably reduces the amount of light penetrating inside the classrooms and even causes them tiring visual adaptations in winter.

For the classroom (B), the results indicate that 31.15% of the users described the light environment as dark, over than the half (59,02%) were neutral and only 9.83% found it bright.

About the users' opinions regarding the quality of natural light in mid-season, the comparison of the results of the different classrooms indicates that 40.82% of the users of the classroom (A1) qualified it as dark, 57.14% were neutral and only 2.04% found it bright. For the classroom (A2), 39.13% of the respondents described it as dark, 47.83% were neutral and 13.04% considered it light.

In contrast, the classroom with bilateral windows, 50.82% of the users rated it as light and 49.18% were neutral. (Mesloub, 2019) suggests that a bilateral typology for school should be used to achieve an adequate daylight uniformity 0.5 and optimal distribution.

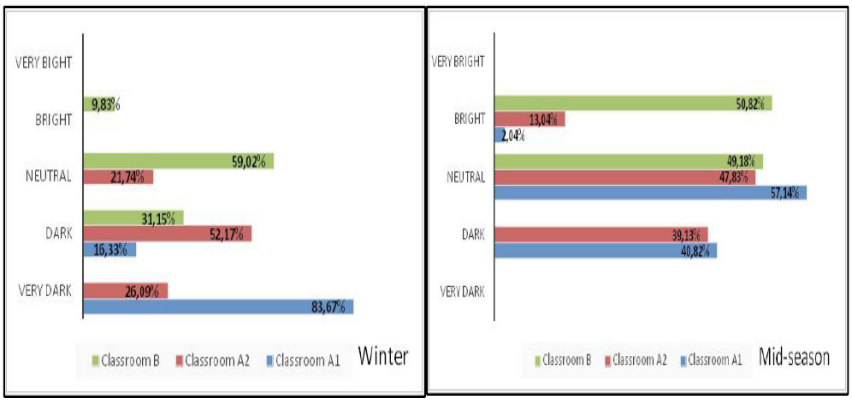

Figure 8. Distribution of users according to the daylight distribution in classrooms in winter and mid-season.

Visual Comfort Perception

The figure 9 shows that 20.41% of the respondents find the lighting environment in the northeast classroom unpleasant and 79.59% rated it as uncomfortable during the winter period. Some users even expressing eye fatigue and lack of concentration due to poor lighting. For the southwest classroom, only 6.52% of users found it unpleasant, 69.57% found it uncomfortable and 23.91% expressed their lighting environment as "neither comfortable nor uncomfortable" in winter.

Concerning the classroom (B), among the users questioned, 29.51% of them consider that the lighting environment in this classroom is uncomfortable, 44.26% are neutral and 26.23% believe that bilateral facing classroom is visually comfortable.

In mid-season, 57.14% of the users qualified the lighting environment of classroom A1 as uncomfortable, 36.74% were neutral and 6.12% of them found it comfortable. Similarly for classroom A2, 41.3% rated it as uncomfortable, 47.83% were neutral and 10.87% found it comfortable. For classroom B, the majority of respondents rated it as comfortable (59.02%) and 40.98% were neutral.

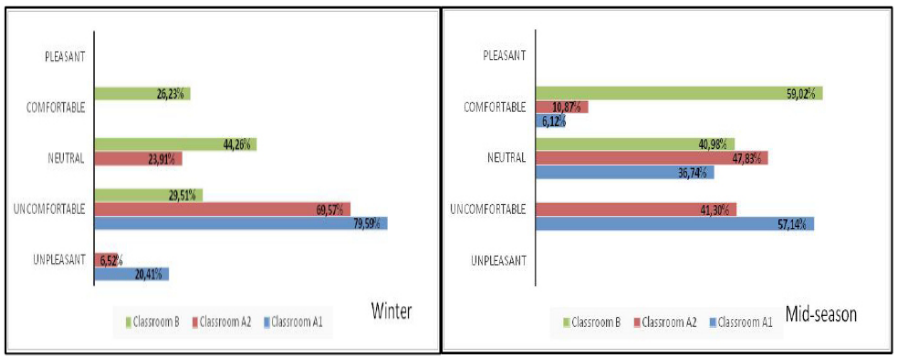

Figure 9. User's daylight perception within classrooms in winter and mid-season.

Use of Artificial Lighting

According to figure 10, 96.81% of the users of the single side lighting classrooms voted for "much" use of artificial lighting in winter so that they could perform their visual tasks properly and 3.19% used it moderately.

For the users of the bilateral lighting classrooms, 50.82% used it moderately and 29.51% voted for "little".

According to the majority of users, the lighting environment of the unilaterally lit classrooms in mid season requires the use of artificial lighting all day long (87.76% for classroom (A1) and 82.61% for classroom (A2)). While 80.33% of the users of classroom (B) declared that they rarely used it.

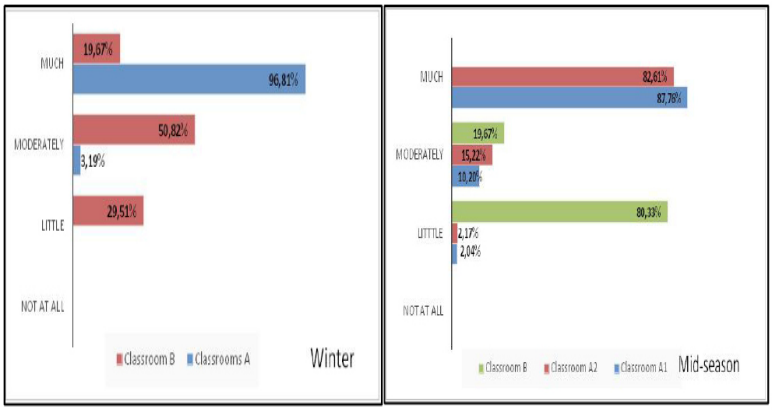

Figure 10. User's perception of the use of artificial lighting in classrooms in winter and mid-season.

Visual Annoyance

In winter, All of the respondents in classroom (A1) (97.96%) did not feel any annoying glare, direct or unpleasant sunlight and 2.04% indicated that they were bothered by the reflection of solar rays (figure 11). The same is true for the classroom (A2), where 95.65% of the respondents declared that they were not bothered by sunlight patches or glare.

As for the users of the classroom (B), 33.07% of them suffer from the reflection of direct sunlight on their tables while 63.93% expressed no particular visual annoyance. These answers are directly related to the position of the respondent in daylit or sunlit areas. For that, users prefer to move their tables to a shaded area in the classroom.

In mid season, most of occupants of the classroom (A1) did not feel any direct sunlight and glare and 14.29% declare to have been bothered. This indicates that the classroom is rarely affected by direct radiation. For classroom (A2), 21.74% of

the respondents are often bothered by the reflection of the rays, and 78.26% did not suffer from any visual annoyance.

As for classroom (B), 59.02% of the users declared to have been bothered by direct sulight, especially for the respondents sitting near the windows, and 40.98% did not show any discomfort. Problems resulted from harsh shades and contrasts are also produced. This perception differs according to the lighting conditions and the position of the respondent in relation to the window. It also differs according to the orientation of the classrooms and the type of glazing.

For this, (Benharkat, 2017) recommends the use of low emissivity glazing and limiting the Iv glazing index to 12% for north-facing classrooms and 10% for the other orientations.

To improve visual comfort of the unilateral lit classrooms, 97.96% of users prefer the use of artificial lighting during both seasons and 2.04% prefer the opening of windows.

For the bilateral lighting classroom, users bothered by sunspots opted to move the tables. They also prefer to replace the blue glazing with clear and high-performance glazing with solar control system like curtains or Venetian blinds for more light and less heat.

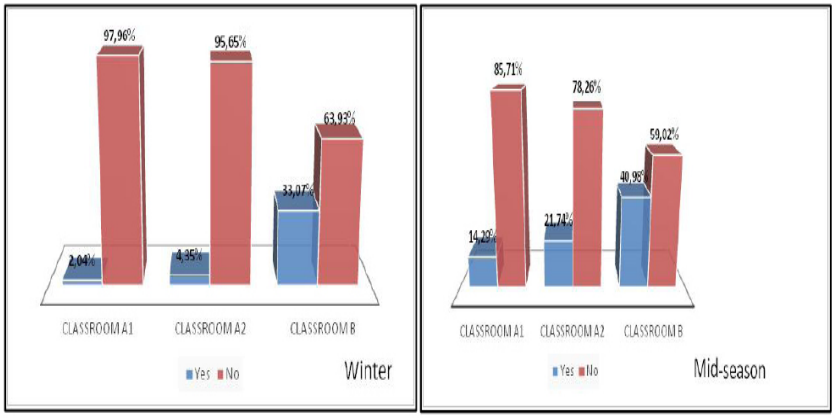

Figure 11. Distribution of users about visual annoyance in classrooms in winter and mid-season.

CONCLUSION

Daylighting is an essential element of sustainable building design. It may create a visually pleasing, healthier and more productive environment for learning spaces occupants and often results in lower energy bills.

This research aims at testing users' perception of visual environment through questionnaires in typical university classrooms to identify the negative and positive aspects of visual comfort in these spaces.

The results of this survey showed that the unilateral lighting system cannot provide sufficient lighting for the occupants. Moreover, the perception of the quality of light in these classrooms is negative during the winter period, especially for the northeast-facing classrooms, which increase the need for artificial lighting. Users described these classrooms as dark and uncomfortable because of the low transmissivity of the blue-tinted glazing, which greatly reduces the amount of natural light that's filtering through the windows. The average room reflectance and the glazing index also influencing this lighting mode. Moreover, it is recommended to use low-emissivity glazing and to limit the glazing index to 12% for north-facing classrooms and 10% for other orientations.

On the other hand, in mid-season, users find the lighting conditions in bilateral lighting classrooms quite satisfactory and comfortable. This lighting mode is more efficient and closely related to the lighting conditions, the orientation of the classrooms and the position of the respondent in relation to the window.

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