

Evaluating Lighting Condition of Primary Schools in 2015 (Case Study: Nahavand City of Hamadan Province, Iran)

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ABSTRACT

The quality of vision is essential that universally understood about the human condition in a learning environment. In this regard, lighting exceeds than standard level increased visual fatigue as reflection decrease by eye blinks. Against exposure to lower maximum allowed to involve Nystagmus, headaches and impaired vision as the most significant symptoms for students. Therefore, this study aimed to evaluate the total lighting condition (a combination of natural and artificial lighting) in primary schools in Nahavand city and compared it with the international standards. This study investigated average lighting using illumination meter DX200 INS in Nahavand's primary schools. Results showed that mean lighting for whole classrooms was 415.7 ± 166 lux. Also, ratio of window area/floor area (WA/FA) was less than the standard ratio only in 8 classes from 121 totals with the coefficient of correlation 0.56 between illuminances average and ratio of WA/FA. These findings might have practical implications for the implementation of desirable and standard lighting in schools for better practice of students.

Key words: Lighting, Classroom, Illuminances Standard, Nahavand, Hamadan

INTRODUCTION

Iran National Standards Committee and relevant Commission On February 24, 2003, in the ninety-fourth meeting, approved building standard and construction materials. Based on this standard, maintenance and improvement of the students' performance depend on lighting condition in school building especially, classrooms. In fact, ambient lighting of educational facilities should be followed by national standard No. 3763 that has been approved in 1996[1]. Compliant with regulation; illumination in the classroom, amphitheater and hallway of school is 300, 500 and 100-150 lux, respectively. It is also to prevent glaring eye must be provided 300-500 lux for black board[1].

Our surroundings are consisted of a variety of elements such as building shape, viewing and its perfect with light and color, which people are directly affected by them. A well-designed of the environment can make people happy and in the mean time, the role of lighting in our lives to have an ideal environment for everyone is obvious[2]. Importance of this issue to the extent that Tanner *et al.* (2008) announced, after two key elements (food and water)

in human functioning, light is the most important thing[3]. Among a variety of illumination, natural lighting for accomplishing visual comfort, increased productivity and individual outcomes like improved test score and attaining the best achievement is important. Since that natural lighting offers a cheery sense and good color rendering is considered as the best source for brightness[4]. In return, artificial lighting is the other source to supply appropriate luminance with electricity consumption. Poor illumination environment can be the cause of several diseases such as Eyestrain, Nystagmus, Headaches, and impaired vision and accident are other effects of low light or brilliance (glare) [2-3, 5-8].

Artificial light is used to define the term electric light that makes children feel better and due to increase of motivation resembling natural light. The adequacy artificial lighting just like natural lighting lead to increasing memory and it is followed to prevent somnolence mood or children's numbness in the morning. Change in management is effective on the results process change. Given that the change process affects well as individual performance, it can be said that the change in illumination to provide sufficient light is a change in process[9].

Many studies have emphasized the need for adequate lighting to create interest in students for study and provide visual comfort as well as refer to increase productivity [10]. For example, Pulay (2010) is having narrated well design of lighting in the classroom has a significant role in glare control, protection of the human eye and higher reflectance ratings [6]. Several studies have been investigated negative or positive of illuminating quality on students' skills [11]. Cheatum (2000) cited different problems in the learning environment like visual impairments which they can cause lack of concentration and a state of confusion in learning process as a result of inadequate lighting. According to this study 20% of children who enter the school encountered with problems such as lazy eye, strabismus, eye tracking and etc. [12]. Based on literature review essay, the importance of illumines for good performance in adults is well established. However, somewhat evidence on the extent to which lighting affects the school performance of children is poorly reported. This study has been conducted to

investigate the combination of natural and artificial lighting condition in primary schools in Nahavand city and compared it with the international standards for necessary modification.

MATERIALS AND METHODS

The descriptive - analytical study involved an evaluation of combined natural and artificial lighting condition in Nahavand state primary schools. Nahavand city is located in western part of Iran (Lat. 48°24'E; Long. 23°22'N) in the south of Hamadan Province with 1460 km² area. It has a population of, 181711 people making it the biggest city in Hamadan (Fig. 1).

In this study, a total of 14 schools, 121 classrooms were randomly selected assuming a standard deviation of 120 for illumination and measurement error of 95% toward confidence interval $d=48$ using Cochran's formula is obtained as follows (Equation 1):

$$N = \frac{Z_{1-\alpha/2}^2 \times N \times d^2}{(N-1)d^2 + Z_{1-\alpha/2}^2 \times \sigma^2} \quad (1)$$

$$N = \frac{1.96_{1-\alpha/2}^2 \times 21 \times 160^2}{(21-1)48^2 + 1.96_{1-\alpha/2}^2 \times 160^2} = 14$$

Parts of school like classrooms and hallway for lighting measurement were targeted that this is because students spend most of their time in these places. Supplementary information regarding conditions ceiling and walls classes, window surface area and floor area were collected with general evaluation form for schools lighting. The ratio of window to floor area was determined by dividing the area of windows to floor area. After the random selection of classes, was attempted to mapping for location and lights layout. The working plane is shown at a height of 0.76 m above floor level in both the season autumn and winter and in accordance to Fig. 2. For measuring the brightness, photocell is located horizontally, so that the shadow does not fall on the photocell. Then lighting was assessed using a lux meter (ILLUMINTAION METER DX200 INS ENTERPRISE, TAIWAN). Device calibration has been carried out by zero point calibration method. Network method was used to measure the luminance and in this method first class floor was measured, a simple map was traced in a regular checkerboard network and cell division of 1*1m. After calibration

of luxury meter, it was placed on the desired station. After that, the measured values in the station entered to the checkerboard network cells and luminance of classrooms and corridors were calculated. To avoid any interference with the climate at the time of measurement, sunny days from 10 A.m to 12 P.m for the study in network method were considered [13] that is expressed in the following equation (2):

$$RI = \frac{L \cdot W}{h_m + (L + W)} \quad (2)$$

Where RI is Room Index, L is the length; W is width of the room measured and h_m is height of the luminaries from the work surface. By this method, in each range minimum points of the measure were obtained based on Room Index. The value of $RI < 1$ indicates, number of points should not be less than nine points. RI between 1-2, 2-3 and 3-4, number of points is 18, 25 and 36, respectively. Finally, to $RI > 4$ should not be less than 50 points. Furthermore, data were analyzed by descriptive and non-parametric statistics using SPSS-20 and MiniTab-16 software.

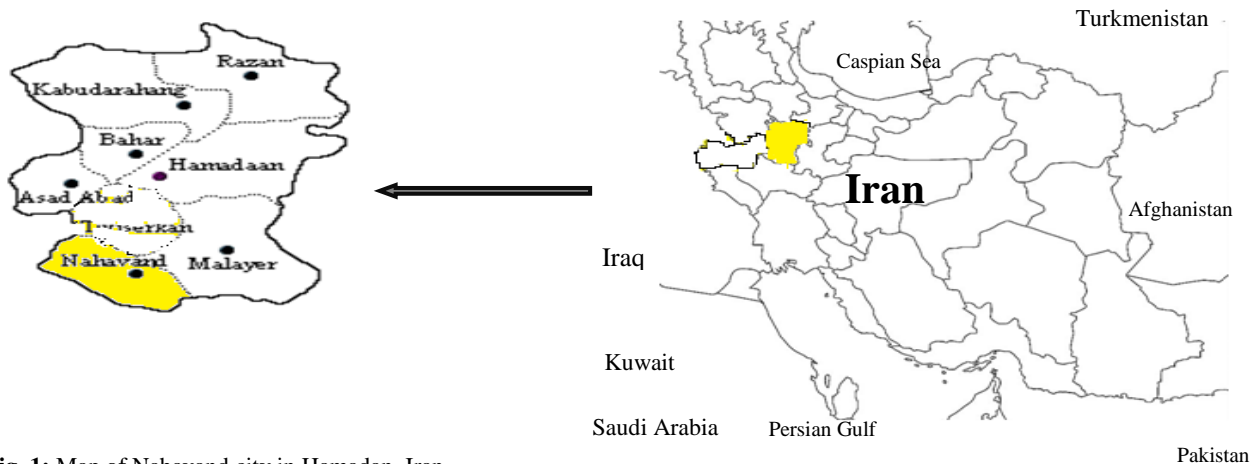


Fig. 1: Map of Nahavand city in Hamadan, Iran

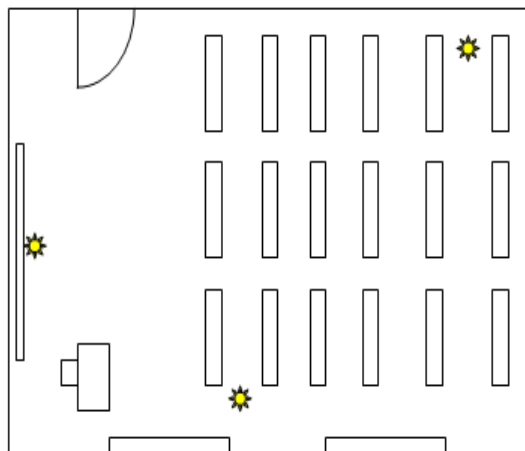


Fig. 2: Plan of the lighting measurement location (1,2 and 3) of a classroom

RESULTS AND DISCUSSIONS

The type and number of lamp in classrooms were recorded in Fig. 3 and followed the percentage of classrooms and amount of illumination is shown in Table1. According to Iran’s school standard, the mean of illumination in classrooms is 300-500 lux that it is obligatory[1].

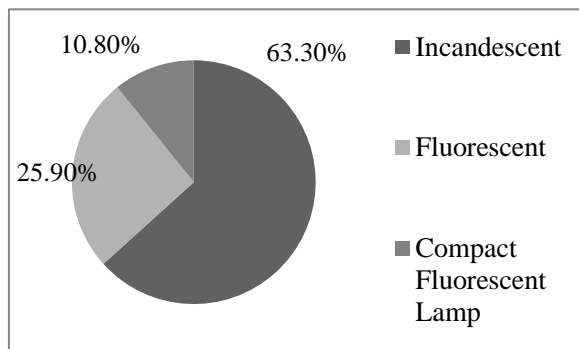


Fig 3: Type of different lamp in classrooms (%)

Many research studies such as Slater (1993), Rea (1982) and Smith (2005) emphasized that, increasing or decreasing lighting permissible limit (300-500 lux)

can lead to decreasing visual comfort and subsequently reduced task performance[14-16]. Johnson (2011) reported bloodshot eyes, skipping lines and words or fidgeting during reading or writing and etc. because of poor lighting on people particularly students in schools[17]. According to many studies has been shown that the natural light has positive effects on human responses (like physical and psychological responses)[18-19]. The mean lighting (both natural and artificial) to whole classrooms was 415.7 ± 166 lux (Fig. 4). Although half of classrooms lighting is accordance with recommendation rate but also some of them aren't enjoy desirable lighting. This is because that the incorrect placement of windows in the school as well as the poor distribution of lamps in class1. Other classes had poor luminance because of improper ratio of windows to floor level and dirty ceiling.

The findings of Michael S. Mott study (2012), entitled “Illuminating the Effects of Dynamic Lighting on Student Learning” indicated that the light is as essential element for human; as a result, the authors have presented that rate of oral reading fluency (ORF) and words read correctly per minute (WCPM) of each students was according to authority standards. The results between the performance of the experimental group and control group providing evidence which those desirable and sufficient illuminances in the classroom as an instructional technology improved by ORF and WCPM at a rate greater than the improvement experienced[5]. Indeed, this study reported desirable light in classroom environments can lead to student’s achievement, motivation, concentration and cognition. Also these results have been confirmed by Schulte-Markwort (2011) by ORF index measurement, when students had been tested[20]. Carol M. Werner (2012) suggested “students did not turn off the lights because they did not think of it and were not sure they were allowed to”[21].

Numerous studies reveal the benefits of lighting, which can help decline absenteeism and raise productivity in buildings, increasing test scores in learning environment and even remission of patients in hospital [2, 22-24]. In terms of desirable lighting classrooms, Hourani *et al.* (2012) found impacts on different aspect of students' health like attendance, immediacy, behavior and performance [23]. Two published studies were conducted in schools

demonstrated lighting important for attendance and performances among of students by boosting test score because of progress faster in reading and resolving of mathematics[25-26]. Overall, based on Veitch categories (2001) human requirement namely: "visibility, task performance, communication and social behavior, health and safety, mood and comfort, aesthetic, and judgments" marked by lighting[27].

Table 1: Classroom luminance (lux) (Mean±SD, Minimum and Maximum)

Schools	Number of Classroom	Mean	±SD	Min	Max	Standard Lux	Average	Description
1	7	318.029	150.004	52	526	300-500	50%	permissible limit
2	11	619.364	180.723	166	756			
3	9	399.856	107.545	197	540			
4	5	242.66	104.102	150	398.3			
5	6	239.167	43.4070	160	275	<300	21.4%	Lower than permissible limit
6	6	245.667	26.2043	214	280			
7	12	320.292	84.4911	210	460			
8	12	463.25	135.296	310	714.5			
9	12	477.017	72.6015	350	592	>500	28.6%	Higher than permissible limit
10	8	301.275	159.490	110	510			
11	9	516.189	144.190	215	650			
12	6	305.917	126.728	210	485.5			
13	6	554.167	43.5220	515	600			
14	12	516.333	138.217	340	720			

In every classroom, window should be installed. Installation of the window is better on the side or rear wall. Classroom's specifications namely window area/floor area is shown in Table 2. Based on results,

only 8 classes have inappropriate window area/floor ratio, which redesign of classrooms for achieving standard is suggested.

Table 2: Classroom's specifications (Mean, Min and Max of window area/floor area)

Schools	Number of Classroom	Mean	±SD	Minimum	Maximum
1	7	0.255	0.063	0.16	0.30
2	11	0.223	0.045	0.19	0.28
3	9	0.182	0.025	0.13	0.20
4	5	0.208	0.043	0.17	0.26
5	6	0.195	0.012	0.17	0.20
6	6	0.20	0.000	0.20	0.20
7	12	0.295	0.014	0.25	0.30
8	12	0.283	0.246	0.25	0.30
9	12	0.303	0.049	0.30	0.31
10	8	0.217	0.048	0.14	0.25
11	9	0.270	0.415	0.18	0.30
12	6	0.208	0.020	0.20	0.25
13	6	0.263	0.051	0.26	0.27
14	12	0.250	0.000	0.25	0.25

Fig. 5 had shown that regression between illuminances average with window area to floor area (WA/FA). The coefficient of correlation between illuminances average and window area to floor area was obtained 0.56. Correlation test indicates tolerable correlation between variables. This tolerable correlation not excellent correlation, despite

sufficient (WA/FA) in some classrooms, because of the dirty ceiling and the class that are cause of poor illuminances (Fig. 6). For this reason, periodic cleaning windows in schools, replacement of lamps burned and considering the lamp's lifetime must take in consideration.

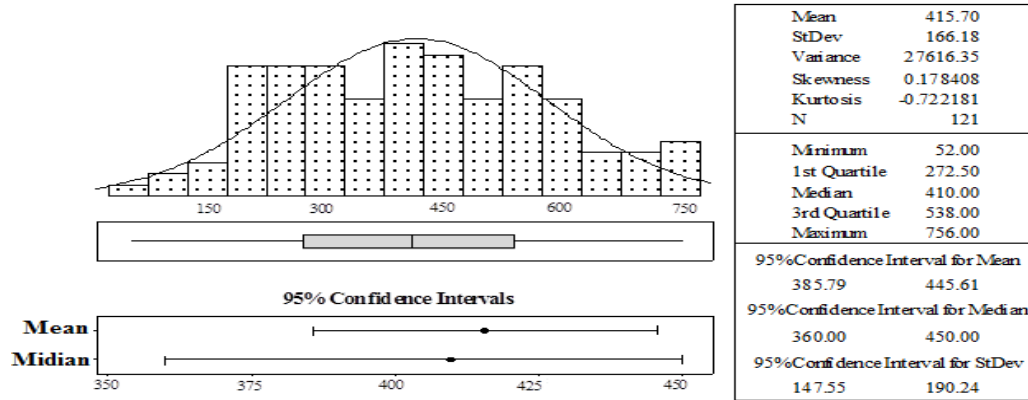


Fig. 4: The mean lighting in all classrooms

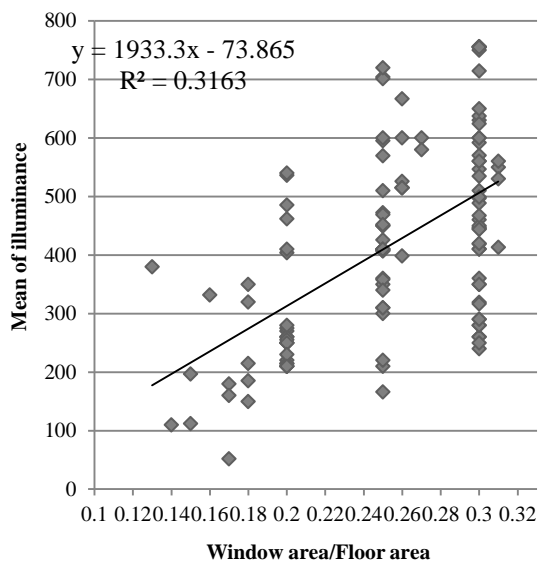


Fig. 5: Correlation between illuminances average versus Window area/Floor area

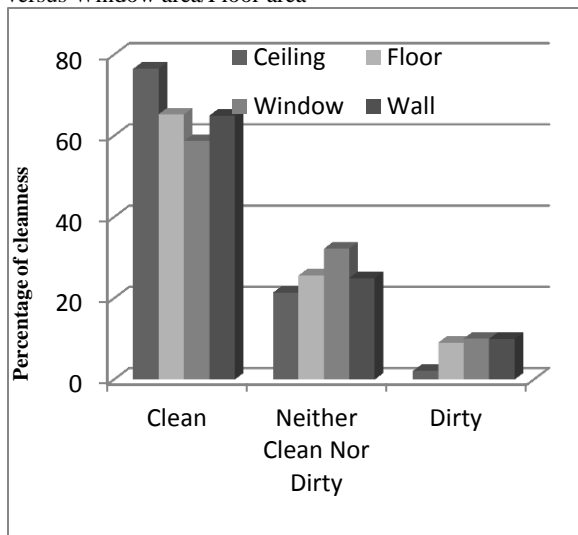


Fig. 6: Percentage of ceilings, floors, walls and windows of cleanliness

Heschong, (2003) studied the type of classroom quality and view out of windows in California's Central Valley. In this study reported that area suitable of window in the classroom was had just as traditional features such as teacher characteristics, attendance rates and educational facilities[28]. The large window allows for natural light. Although the importance of the well-design of the window is understand able but never the less reverse effects resulting from improper design like window layout and excessive surface area reported. Indeed, negative impacts of window improper design are caused sun penetration, glare and lack of visual control[29].

Based standard, illuminance recommendation for hallway must be provided 100 lux, via natural or artificial lighting [30]. Considering to Fig. 7, only 5-a and 5-b school hallways have non-standard lighting conditions, that the main reason for these problems is the low number of lamps and the lack of proper lighting windows and inadequate window area to floor area.

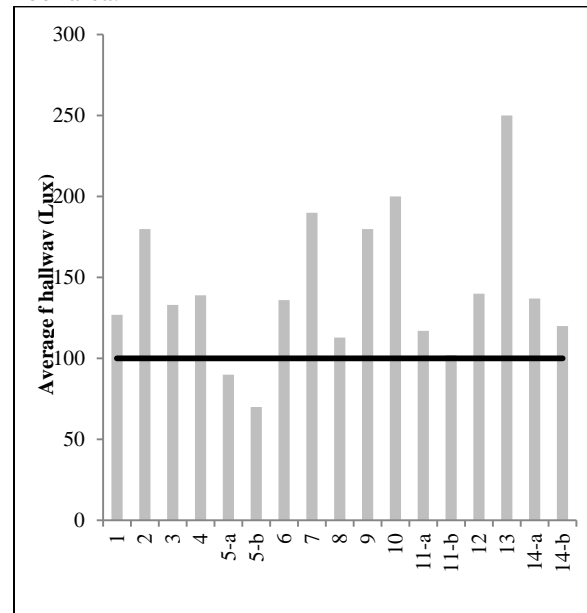


Fig. 7: Illuminance average of hallway (Lux)

CONCLUSION

In conclusion, the implications of our findings indicative the importance of lighting in schools why so the quality of vision is essentially universally understood to the human condition in a learning environment. Comprehensive assessment of luminance schools indicated, lighting conditions in class is eligible. Although there are cases of inappropriate lighting systems in schools, however, this does not necessarily mean that facilities do not exist. Indeed, the need for optimum distribution and uniform lighting in classrooms in a way that does not cause eye injuries, as well as regular and continuous program for cleaning of different parts of the class, such as windows, wall and floor is suggested.

ETHICAL ISSUES

The ethical issues were considered during the conduct of this study. Proper permission was obtained from office of education of Nahavand city before the field work.

CONFLICT OF INTEREST

We affirm that this article is the original work of the authors and have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

All authors were participated in all stages of the research.

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