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ILLUMINANCE AND DAYLIGHT DISTRIBUTION ASSESSMENT FOR LEARNERS' COMFORT AND SAFETY IN ONE-SIDE-WINDOW ORIENTED CLASSROOM BUILDING

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Abstract
Natural light as source of illumination in different environmental settings has the highest degree of acceptability as it offers many qualitative strengths and quantitative advantages. The visual functions effects of light are expected since the illumination from a particular light conforms to relevant standard for glare-free and visual conveniences. The present research work measured classroom environment illuminance and light distributions in a one-side-window oriented classroom building for visual comfort and glare. The quantitative measurement of illumination of the inside and outside of the classrooms was done using lux digital meter of high precision wide measurement range of 1 - 1200,000 lux with an accuracy of ±4% ±10 digits (<10000 lux); ±5% ± 10 digits (> 10000 lux). The resolution was set to 1 lux and measuring ranges of 2000/20000/200000 Lux. The measurement was taken according to the school timetable, three times each day at six different points; five points in the classroom (at the front right (FR), back right (BR), front left (FL) and back left (BL) corners, and at the centre (C)), and one outside the classroom (taken along the passageway by the various classrooms' entrances). The time of data collection were during the assembly/breakfast period (7:50 – 8:30 am), the recess period (11:50 am – 12:20 pm) and short break before afternoon prep (2:20 – 2:30 pm) from March through December, 2016. These periods were chosen to avoid the distraction of the teaching-learning process in the school. Assessment of operational safety for illuminance and daylight distribution of various assessed classrooms were carried out on the basis of Useful Daylight Illuminances (UDI). The result obtained showed significant illumination variation on either side of the classrooms with much effects of under-lit on the un-windowed side and glare potentials on the side close to the windows. It, therefore, demands that for uniformly distributed illumination with glare-free and visual comfort classroom environment, the daylight entrance should be from two or more directions.

Keywords: Light, illumination, classroom, uniformly, glare, comfort.

1. Introduction

Human eyes perceive part of the electromagnetic spectrum that is radiated out from a source often referred to as light. The wavelength of light that is perceived by our eyes is between the range of 380 and 780 nm (Staff, 2004). The amount of light absorbed by an individual has a gross impact in such individual's performance, safety, and well-being. Light characteristically exhibit three main effects on the human body system. These include visual function, human circadian rhythm support, scenes and effects creation (Staff, 2004). Visual function effects of light are expected that illumination from a particular light source conforms to a relevant standard for glare-free and visual conveniences.

Lighting according to Philips (1997) is the most fundamental physical characteristics of the classroom environment. This consists of light which might not be detectable, student's desk illumination, screens, and windows light projections (Sanaz and Soodeh, 2012; Suleman and Hussain, 2014). Illumination accounts for direct natural light, indirect natural and artificial lights, reflected light, and all light sources control (McCreery and Hill, 2005). Daylight was described by Pulay (2010) as a natural light in space that enters the space through the windows and skylights but incidentally, it is totally different from artificial lights in a room. In general, Barrett and Zhang (2009) categorically described the fundamental requirements for effective daylighting in schools as, satisfactory distribution of adequate amount of light, window placement for optimization of daylight distribution, and pervade space lighting.

The effective lighting on students' learning environment is only benefited when the classroom lighting is efficiently planned (Pulay, 2010). Yacan (2014) opined that natural lighting should be adopted and used as the main source of light during daylight hours for reasons of light quality and sustainability in schools. The structural design of a classroom building describes its physical environment as it determines the amount of daylight that enters a classroom for appropriate and sufficient light quality (Yacan, 2014). The classroom structures consist of the room size, form, height, windows, doors, furnishings, and lighting (Yacan, 2014). Heschong *et al.* (2002) reported that window-to-wall ratio plays an important role in natural lighting in terms of well-being and performance improvement tendency. According to Tregenza (1998), effective illumination can be obtained into a room essentially from a significant distance of 5/2 times the window height above the workplane.

Once a building is erected, the sunlight illumination of the building or the amount of light that enters the space and the distribution within the space is mainly determined by overall glazing design factors, such as the numbers of windows, the width of the window, floor-to-floor height, heads close, the size of glazed areas, their disposition and shape as well as sloped ceiling for good light reflectance (Barrett and Zhang, 2009; Sanaz and Soodeh, 2012; Hans and Stanfield, 2014). High windows tend to admit more useful daylight than low ones of the same size, as they offer the chance for the back of the room to be exposed to more sky (Barrett and Zhang, 2009).

The factors that affect the amount and distribution of daylight in a classroom, includes daily and seasonal movement of the sun in relation to the orientation of the window, shading elements, and reflections off of adjacent buildings (Heschong Mahone Group, 2003; McCreery and Hill, 2005). For a school building, good lighting design, natural and artificial needs balanced, diffuse and glare-free daylight from two or more directions, sufficient light levels for the tasks in the space (Barrett and Zhang, 2009). Against Barrett and Zhang (2009)'s assertion that with more windows in a room, the daylight will be more uniformly distributed in the space compared to a room that has just one single window. The building under consideration is one-side-window oriented classrooms with high glazing area and ratio to compensate for illumination and light distribution into the space.

Illuminance is the total luminous flux incident on an area divided by the area (Taylor, 2000; Long, 1992; Mardaljevic, 2012).

Mathematically

The flux F falls on area A, the illuminance E is defined by

$$E = \frac{F}{A} \quad (\mathrm{Im/m^2}) \tag{1}$$

Where:

F = flux measured in lumen (Im);

A = area measured in meter square (m^2)

Natural daylight is predominantly engaged in Nigerian schools because most schools in the nation operate exclusively during daylight hours with the sunlight being the main and in most cases the only lighting source for the amount of light received within the classroom spaces. This is not different with the school considered as a case study in this research work. This phenomenon has been capitalized on for the classrooms lighting through making the most fundamental design choice in the building's orientation for the daylight control. Understanding good environmental designing in school and the relationship between light and the environment can help designers, engineers or architects to devise, improve and advance designs for better performances (Oneworkplace, 1999). The fundamental features of classroom building environment and its structure, be it new construction or modernization of existing structural building, should be carefully considered and addressed on daylight illumination basis and achievement of safety and comfort for all building users through good lighting (Sanaz and Soodeh, 2012).

Reading and writing which are the third and fourth fundamental skills of learning that are carried through to other educational levels are predisposed to visual actions. Daylight provides the richest spectral, usable light, and eases some of the visual stress to the eye. It also offers physiological and psychological benefits for teachers and students. Research literature showed that reading is the most visually stressful task for students essentially demanding appropriate lighting system (Liberman 1991; Sanaz and Soodeh, 2012). Therefore, it is essential that comfortable visual conditions should be created in school buildings which will unequivocally contribute to the teaching-learning process in schools (Abdelatia *et al*., 2010). Consequently, students spend the majority of their time in the schools or learning places (Sanaz and Soodeh, 2012). A recent study noted that schools and colleges delineate an essential quality of student's life as they spend at least one-quarter of the day (6 hours) in the schools and colleges (Kekare, 2015). To support and enhance students' safe learning environment for qualitative and quantitative impacts, the level of light sufficiency in the environment has to be assessed for alteration if need be. This formed the main focus of this study as it quantified the classroom daylight illuminance and verify daylight distribution in the classroom environment for useful daylight illuminance (UDI) for visual comfort and glare determination.

2. Materials and Methods

Five classrooms operating under the considered structural design (one-side-window oriented classrooms) were assessed. The determination of the glazing ratio was carried out to determine daylight admittance into the classrooms. Additional factors to the openings (doors and windows) that affect the light distribution in a building space were described by Barrett and Zhang (2009) as building orientation (sun path), and location. Building orientation (sun path), windows, and location are three practical design options according to the study (Barrett and Zhang, 2009) that determine the visual comfort and glare-free in the building environment. Physical observation made in this study showed that the orientation of the classroom building is one side-windowed with the openings (doors and windows) facing west. Perhaps the window orientations towards the west were with regards to sunrise to sunset pathway. The dimensions of these classrooms were taken which include the windows, doors and the walls. This was carried out through the use of 1,500 meters measurement tape. Table 1 showed the dimensions of the sizes of the windows according to their numbers, the doors, the classrooms' heights, lengths, and breadths. These dimensions were taken as the structural design of a classroom building describes its physical environment such as heat, sound, air-light distribution, illuminance etc (Ward, 2004; Barrett and Zhang, 2009). The window and door openings dictate to a great extent the effective depth of illumination with daylight.

Table 1: Dimensions of the structural design of a classroom building

	Classrooms			Windows 1		Windows 2		Doors	
	H (cm)	B (cm)	L (cm)	H (cm)	B (cm)	H (cm)	B (cm)	H (cm)	B (cm)
1st	270	602	536	178	292	180	200	215	96
2nd	270	605	536	182	300	178	195	220	95
3rd	270	605	536	180	304	180	200	218	95
4th	270	610	533	170	290	170	200	215	95
5th	270	610	541	170	290	170	200	220	100

Key: H= height; L= length; B = breadth

These two variables (doors and windows) were used to determine the glazing ratio of all the assessed classrooms. In this study, the values obtained for glazing area, wall area and glazing ratio showed high values which imply high daylight admittance into the classrooms. Glazing ratio of the classrooms structures noted was determined using the room size, height, windows and doors (Table 2). The glazing ratio was determined using the equation reported by Barrett and Zhang (2009) as follows

$$\text{glazing ratio} = \frac{\text{glazing area}}{\text{wall area}} \tag{2}$$

Where,
Glazing areas = the windows and the doors openings in each of the classrooms;
Wall areas = the solid wall area (nontransparent areas).

Table 2: Glazing ratio for daylight admittance into the classrooms

Classrooms	Glazing area (cm^2)	Wall area (cm^2)	Glazing ratio
1st	108616	57178	1.8996
2nd	110210	57680	1.9107
3rd	111430	57630	1.9335
4th	103725	58195	1.7824
5th	105300	57630	1.8272

Also, the distance between the top of the desk and the window sitting for each of the classrooms showed approximate values of 20 cm. Tregenza (1998) interpreted the distance between the top of the desk and the window sitting thus; if the top of the window is 2 meters above the height of the desk, the area that could be adequately illuminated by the daylight is up to 5 meters deep from the walls of the window. The distance between the widow sitting and top of the desk obtained in this study implies adequate daylight potentials. The window to wall ratio for each of the classrooms is shown in table 2 with 1.7824 as the lowest value obtained which is an enlarged ration that will guarantee high illumination. High levels of natural light via large windows to the classroom are optimum, moderated by a need to avoid glare from direct sunlight.

The quantitative measurement of illumination of inside and outside the classrooms was obtained using Lux digital meter of high precision wide measurement range of 1 - 1200,000 Lux with an accuracy of ±4% ±10 digits (<10000 Lux); ±5% ± 10 digits (> 10000 Lux). The resolution was set to 1 Lux and measuring ranges of 2000/20000/200000 Lux. The measurement was taken three times each day, during the assembly/breakfast period (7:50 – 8:30 am), the recess (long break) period (11:50 am - 12:20 pm) and short break before afternoon prep (2:20 pm- 2:30 pm). These periods were chosen following the school's timetable so as to avoid distraction of teaching and learning processes in the school. For each of the five classrooms, illuminance measurements were taken at six different points; five of which were in the classrooms, at the front right (FR), back right (BR), front left (FL) and back left (BL) corners, and at the center (C). The outside measurement was taken along the passageway by the various classrooms' entrances. For each of the six points, the minimum and the maximum illuminance values were recorded. To ensure uniformity of obtained values, measurements were taken on the top of students' desk of approximately the same heights (70 cm) placed at each of the 6 points of where the readings were taken for the five classrooms. Useful Daylight Illuminance (UDI) analysis was carried out using three standard metric bins hourly time values stipulated by Nabil and Mardaljevic (2006) (Table 3).

Table 3: Useful Daylight Illuminance three standard metric bins hourly time values

Useful Daylight Illuminance	Lux ranges
Under-lit	<100 Lux
Useful daylight	100 and 2000 Lux
Potential glare	>2000 Lux

Adopted from Nabil and Mardaljevic (2006)

Data was collected from the months of March through to December 2016 besides weekends and vacation periods. The obtained data were entered into Statistical Package for Social Science (SPSS 16.0) and Microsoft Excel Entry for statistical analysis.

3. Results and Discussion

The results obtained for Daylight Illuminance in the assessed classrooms were presented in tables 4-6. The measurement taken in the morning sessions for the five classes showed similar results that at the front right (FR) and back right (BR) corner high there was useful daylight, followed by potential glare then under-lit records (Table 4). The proportion for front and back left (FL and BL) corners showed high under-lit proportion followed by less useful daylight but no records for potential glare. This showed that FR and BR records were inverse the values obtained for FL and BL measurements (Table 4).

Table 4: Results obtained for morning session useful daylight illuminance analysis

Classroom	UDL	Maximum						Minimum					
		FR	FL	C	BR	BL	O	FR	FL	C	BR	BL	O
1st	UL	1(1.0%)	92(88.5%)	31(29.8%)	0(0.0%)	94(90.4%)	0(0.0%)	1(1.0%)	95(91.3%)	31(29.8%)	1(1.0%)	94(90.4%)	0(0.0%)
	UD	72(69.2%)	12(11.5%)	72(69.2%)	66(63.5%)	10(9.6%)	53(51.0%)	76(73.1%)	9(8.7%)	73(70.2%)	65(62.5%)	10(9.6%)	55(52.9%)
	PG	31(29.8%)	0(0.0%)	1(1.0%)	38(36.5%)	0(0.0%)	51(49.0%)	27(26.0%)	0(0.0%)	0(0.0%)	38(36.5%)	0(0.0%)	49(47.1%)
2nd	UL	0(0.0%)	80(82.5%)	39(40.2%)	1(1.0%)	83(85.6%)	0(0.0%)	0(0.0%)	82(84.5%)	40(41.2%)	2(2.1%)	86(88.7%)	0(0.0%)
	UD	61(62.9%)	16(16.5%)	50(51.5%)	59(60.8%)	12(12.4%)	51(52.6%)	35(36.1%)	15(15.5%)	50(51.5%)	60(61.9%)	9(9.3%)	51(52.6%)
	PG	36(37.1%)	1(1.0%)	8(8.2%)	37(38.1%)	2(2.1%)	46(47.4%)	62(63.9%)	0(0.0%)	7(7.2%)	35(36.1%)	2(2.1%)	46(47.4%)
3rd	UL	0(0.0%)	73(72.3%)	39(38.6%)	1(1.0%)	77(76.2%)	1(1.0%)	1(1.0%)	73(72.3%)	40(39.6%)	1(1.0)	81(80.2%)	1(1.0%)
	UD	72(71.3%)	28(27.7%)	62(61.4%)	66(65.3%)	24(23.8%)	39(38.6%)	71(70.3%)	28(27.7%)	61(60.4%)	67(66.3%)	20(19.8%)	40(39.6%)
	PG	29(28.7%)	0(0.0%)	0(0.0%)	34(33.7%)	0(0.0%)	61(60.4%)	29(28.7%)	0(0.0%)	0(0.0%)	33(32.7%)	0(0.0%)	60(59.4%)
4th	UL	0(0.0%)	72(72.0%)	14(14.0%)	3(3.0%)	68(68.0%)	1(1.0%)	0(0.0%)	74(74.0%)	14(14.0%)	3(3.0%)	73(73.0%)	1(1.0%
	UD	62(62.0%)	28(28.0%)	83(83.0%)	58(58.0%)	31(31.0%)	25(25.0%)	64(64.0%)	26(26.0%)	83(83.0%)	60(60.0%)	26(26.0%)	26(26.0%)
	PG	38(38.0%)	0(0.0%)	3(3.0%)	39(39.0%)	1(1.0%)	74(74.0%)	36(36.0%)	0(0.0%)	3(3.0%)	37(37.0%)	1(1.0%)	73(73.0%)
5th	UL	0(0.0%)	35(38.5%)	6(6.6%)	1(1.1%)	44(48.4%)	1(1.1%)	1(1.1%)	37(40.7%)	6(6.6%)	1(1.1%)	46(50.5%)	1(1.1%)
	UD	55(60.4%)	56(61.5%)	75(82.4%)	53(58.2%)	47(51.6%)	19(20.9%)	57(62.6%)	54(59.3%)	77(84.6%)	55(60.4%)	45(49.5%)	20(22.0%)
	PG	36(39.6%)	0(0.0%)	10(11.0%)	37(40.7%)	0(0.0%)	71(78.0%)	33(36.3%)	0(0.0%)	8(8.8%)	35(38.5%)	0(0.0%)	70(76.9%)

Key: FR = Front right corners, BR = Back right corners, FL = Front left corners, BL = Back left corners, C = Centre, UL = Under-lit, UD = Useful light,
PG = Potential glare

It therefore implies that as more useful daylights and less potential glares were experienced at right sides, more under-lits and less useful daylights were experienced on the left sides. Consequently, values obtained from the center points' measurements were different from that of the right (FR and BR) and the left (FL and BL) sides as high useful daylights followed by under-lits but with minimal potential glares were recorded. The variations that were observed in this study showed that at the five points from which the illuminance was obtained basically grouped as right (FR and BR) side, left (FL and BL) side and center, the illuminations were not uniformly distributed. Under-lit was predominantly observed at the left side (morning sessions) whereas the right side observed more glare potential than any other part. However, the record obtained for the center points were comparatively high and fell within the useful daylight range.

The under-lit range of illuminance in the morning sessions is evidence of poor lighting. Poor spectral light can be strenuous on students' eyes, which is liable to a declined in learning and information processing ability in learners and prompts higher stress levels (Liberman 1991). Other lighting challenge includes insufficient lighting controls. Insufficient lighting controls according to McCreery and Hill (2005) is associated with a number of health, psychological and physiological problems like eyestrain, decreased attention span, serious musculoskeletal injuries, increased body temperature and, accordingly poor students and teachers performances. Likewise, Jago and Tanner (1999) maintained that inappropriate lighting or illumination levels not only abuse the human eye but also presents unfortunate physiological consequences. Each cell in the human body is such that it can separately sense and respond correctly to the positive and negative influences in environments (Rice, 2010). As a result, activation, arousal, and stress are the three mental reactions that considered to be affected by lighting (Rice, 2010). During the break period sessions, the values recorded for the right sides (FR and BR) revealed high useful daylight but relatively less than the values obtained during the morning sessions. As well slightly high glare was observed during the break period sessions when compared to the morning sessions (Table 5). This is due to the high

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window-to-wall ratio which according to Simons et al. (2014), associated building space effects commonly experienced by occupants using a high window-to-wall ratio (WWR) includes thermal and visual discomfort. The left (FL and BL) sides observed higher useful daylight during the break period sessions. Potential glare and under-lit values obtained reduced and the useful daylight increased in this session (Table 5).

Table 5: Result obtained for break period session useful daylight illuminance analysis

Classroom	UDL	Maximum						Minimum					
		FR	FL	C	BR	BL	O	FR	FL	C	BR	BL	O
1st	UL	1(1.0%)	49(47.1%)	7(6.7%)	1(1.0%)	49(47.1%)	0(0.0%)	1(1.0%)	58(55.8%)	6(5.8%)	0(0.0%)	56(53.8%)	1(1.0%)
	UD	64(61.5%)	55(52.9%)	93(89.4%)	62(59.6%)	53(51.0%)	53(51.0%)	67(64.4%)	46(44.2%)	94(90.4%)	62(59.6%)	47(45.2%)	55(52.9%)
	PG	39(37.5%)	0(0.0%)	4(3.8%)	41(39.4%)	2(1.9%)	51(49.0%)	36(34.6%)	0(0.0%)	4(3.8%)	42(40.4%)	1(1.0%)	48(46.2%)
2nd	UL	2(2.1%)	56(57.7%)	10(10.3%)	1(1.0%)	42(43.3%)	0(0.0%)	5(5.2%)	65(67.0%)	10(10.3)	1(1.0%)	45(46.4%)	0(0.0%)
	UD	53(54.6%)	41(42.3%)	72(74.2%)	53(54.6%)	55(56.7%)	48(49.5%)	51(52.6%)	32(33.0%)	74(76.3%)	56(57.7%)	52(53.6%)	49(50.5%)
	PG	42(43.3%)	0(0.0%)	15(15.5%)	43(44.3%)	0(0.0%)	49(50.5%)	41(42.3%)	0(0.0%)	13(13.4%)	40(41.2%)	0(0.0%)	48(49.5%)
3rd	UL	1(1.0%)	22(21.8%)	8(7.9%)	1(1.0%)	28(27.7%)	0(0.0%)	2(2.0%)	25(24.8%)	10(9.9%)	1(1.0%)	29(28.7%)	0(0.0%)
	UD	31(30.7%)	73(72.3%)	88(87.1%)	30(29.7%)	70(69.3%)	15(14.9%)	33(32.7%)	70(69.3%)	86(85.1%)	30(29.7%)	69(68.3%)	15(14.9%)
	PG	69(68.3%)	6(5.9%)	5(5.0%)	70(69.3%)	3(3.0%)	86(85.1%)	66(65.3%)	6(5.9%)	5(5.0%)	70(69.3%)	3(3.0%)	86(85.1%)
4th	UL	3(3.0%)	28(28.0%)	4(4.0%)	1(1.0%)	32(32.0%)	0(0.0%)	4(4.0%)	4(4.0%)	4(4.0%)	1(1.0%)	32(32.0%)	1(1.0%)
	UD	28(28.0%)	68(68.0%)	84(84.0%)	30(30.0%)	65(65.0%)	17(17.0%)	28(28.0%)	28(28.0%)	28(28.0%)	32(32.0%)	65(65.0%)	16(16.0%)
	PG	69(69.0%)	4(4.0%)	12(12.0%)	69(69.0%)	3(3.0%)	83(83.0%)	68(68.0%)	68(68.0%)	68(68.0%)	67(67.0%)	3(3.0%)	83(83.0%)
5th	UL	2(2.2%)	20(22.0%)	1(1.1%)	2(2.2%)	22(24.2%)	1(1.1%)	2(2.2%)	22(24.2%)	1(1.1%)	2(2.2%)	23(25.3%)	1(1.1%)
	UD	24(26.4%)	70(76.9%)	58(63.7%)	26(28.6%)	68(74.7%)	8(8.8%)	24(26.4%)	68(74.7%)	62(68.1%)	28(30.8%)	67(73.6%)	8(8.8%)
	PG	65(71.4%)	1(1.1%)	32(35.2%)	63(69.2%)	1(1.1%)	82(90.1%)	65(71.4%)	1(1.1%)	28(30.8%)	61(67.0%)	1(1.1%)	82(90.1%)

Key: FR = front right corners, BR = back right corners, FL = front left corners,
BL = back left corners, C = centre, UL = Under-lit, UD = Useful light,
PG = Potential glare

The center points recorded very high useful daylight with very minimal glare potential and under-lit during the break periods. The afternoon records showed high glare potentials for the right (FR and BR) sides across the five classes, the proportions of the results for left (FL and BL) sides maintained useful daylight and under-lit. Useful daylight was still high in the center points across the classes during afternoon sessions but relatively lower than the values obtained during the break periods (Table 6).

Control of space-illumination to prevent discomfort and glare the occurrences in all different types of lighting is essentially requisite in the learning environment (Sanaz and Soodeh, 2012). Human eyesight is elastic and has the capability to rebound readily from the adverse visual condition, in essence, making the problems caused by poor lighting incognizant. Nevertheless, conscious effect accrued from inadequate space illumination includes slower reading, poor posture, diminished concentration and long-term weakened vision. Lighting in schools is required not only for general safety but also for visual tasks.

Table 6: Result obtained for afternoon session useful daylight illuminance analysis

Classroom	UDL	Maximum						Minimum					
		FR	FL	C	BR	BL	O	FR	FL	C	BR	BL	O
1st	UL	3(2.9%)	58(55.8%)	12(11.5%)	2(1.9%)	53(51.0%)	0(0.0%)	3(2.9%)	63(60.6%)	12(11.5%)	2(1.9%)	55(52.9%)	1(1.0%)
	UD	44(42.3%)	46(44.2%)	88(84.6%)	40(38.5%)	51(49.0%)	24(23.1%)	47(45.2%)	41(39.4%)	89(85.6%)	42(40.4%)	49(47.1%)	24(23.1%)
	PG	57(54.8%)	0(0.0%)	4(3.8%)	62(59.6%)	0(0.0%)	80(76.9%)	47(45.2%)	0(0.0%)	3(2.9%)	60(57.7%)	0(0.0%)	79(76.0%)
2nd	UL	4(4.1%)	43(44.3%)	9(9.3%)	2(2.1%)	42(43.3%)	0(0.0%)	4(4.1%)	49(50.5%)	9(9.3%)	2(2.1%)	45(46.4%)	0(0.0%)
	UD	29(29.9%)	51(52.6%)	65(67.0%)	32(33.0%)	54(55.7%)	20(20.6%)	30(30.9%)	46(47.4%)	69(71.1%)	33(34.0%)	51(52.6%)	20(20.6%)
	PG	64(66.0%)	3(3.1%)	23(23.7%)	63(64.9%)	1(1.0%)	77(79.4%)	63(64.9%)	2(2.1%)	19(19.6%)	62(63.9%)	1(1.0%)	77(79.4%)
3rd	UL	0(0.0%)	22(21.8%)	5(5.0%)	1(1.0%)	25(24.8%)	0(0.0%)	0(0.0%)	28(27.7%)	6(5.9%)	1(1.0%)	28(27.7%)	0(0.0%)
	UD	24(23.8%)	75(74.3%)	77(76.2%)	23(22.8%)	74(73.3%)	11(10.9%)	25(24.8%)	70(69.3%)	76(75.2%)	25(24.8%)	71(70.3%)	11(10.9%)
	PG	77(76.2%)	4(4.0%)	19(18.8%)	77(76.2%)	2(2.0%)	90(89.1%)	76(75.2%)	3(3.0%)	19(18.8%)	75(74.3%)	2(2.0%)	90(89.1%)
4th	UL	1(1.0%)	28(28.0%)	3(3.0%)	1(1.0%)	31(31.0%)	1(1.0%)	1(1.0%)	32(32.0%)	3(3.0%)	1(1.0%)	34(34.0%)	1(1.0%)
	UD	39(39.0%)	71(71.0%)	75(75.0%)	28(28.0%)	68(68.0%)	16(16.0%)	39(39.0%)	67(67.0%)	76(76.0%)	32(32.0%)	65(65.0%)	17(17.0%)
	PG	60(60.0%)	1(1.0%)	22(22.0%)	71(71.0%)	1(1.0%)	83(83.0%)	60(60.0%)	1(1.0%)	21(21.0%)	67(67.0%)	1(1.0%)	82(82.0%)
5th	UL	0(0.0%)	22(24.2%)	1(1.1%)	0(0.0%)	22(24.2%)	1(1.1%)	2(2.2%)	24(26.4%)	1(1.1%)	1(1.1%)	24(26.4%)	2(2.2%)
	UD	28(30.8%)	69(75.8%)	65(71.4%)	30(33.0%)	66(72.5%)	14(15.4%)	27(29.7%)	67(73.6%)	66(72.5%)	31(34.1%)	64(70.3%)	14(15.4%)
	PG	63(69.2%)	0(0.0%)	25(27.5%)	61(67.0%)	3(3.3%)	76(83.5%)	62(68.1%)	0(0.0%)	24(26.4%)	59(64.8%)	3(3.3%)	75(82.4%)

Key: FR = front right corners, BR = back right corners, FL = front left corners, BL = back left corners, C = centre, UL = Under-lit, UD = Useful light, PG = Potential glare

4. Conclusion

This study which measured classroom environment illuminance and light distributions showed that in all the sessions in the five classrooms assessed the morning sessions were besotted with high under-lit condition at the left side of the classrooms which has high eye strain tendency on the students which can result to serious musculoskeletal injuries, decreased attention span due to impaired information processing and learning ability, increased body temperature and eventually cause overall poor students and teachers input and output performances. On the other hand, the right (FR and BR) sides of all the classrooms during the afternoon session's experiences glare potentials. Glaring light can be a hindrance to lip reading; therefore, the teaching and learning environment should not be in a poorly lighted. Glare not only cause distorted vision, it can also cause pain, lead to headache, eyestrain, and fatigue. Besides the facts listed above, glare may not necessarily result in visual effects but it can lead to visual discomfort feelings. This study has shown that one-side-window oriented building does provide adequate lighting and uniform distribution of light in the learning environment. This, therefore, demands that modification of buildings operating under this structural design should be carried out forthwith for learners' visual comfort and safety.

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