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Geospatial Assessment of Ambient Lighting Condition of Classroom Environment in Schools

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Abstract: Ambient lighting in classrooms is an integral component that enhances the optimal performance of all academic activities in schools. This study examined the existing ambient lighting condition of selected classrooms using day lighting and combination of day and artificial lighting; assesses the factors influencing the ambient lighting condition and explores the ways of enhancing the ambient lighting condition of selected classrooms environment in the study area with a view of improving the lighting conditions of the classroom environment in the study area. Data were obtained for the study using a quantitative approach. The study makes use of NTS-350 infrared light total stations to locate points and Extech LT300 light meter for the measurement ambient lighting condition of geospatial marked points in relation to seating arrangement for two purposively selected classrooms at intervals of 8-10 am, 10-12 pm, 12-2 pm, 2-4 pm, 4-6 pm, respectively for 3-days during the dry season period (October-December) under different external conditions. The subjective approach involved administering of seventy-one (71) questionnaires to randomly selected students and lecturers who have direct daily contact with the classroom environment. Data collected were analysed using frequency distribution, simple percentage, standard mean average and RII. The result of the 3-days average ambient conditions of the marked points at periodic intervals shows that the average ambient lighting values of the classroom were grossly insufficient, with Quantity Surveying hall having average illuminance values of (21, 32; 54, 75; 59, 86; 52, 85 and 33, 64 lux) and Akagun Hall (74, 106; 172, 222; 641, 686; 263, 295 and 140, 177 lux) respectively. Findings also show that the study ranked high non-adherence strictly to micro factors, poorly designed classrooms, bad artificial lighting conditions and controls. The study suggested that passive design principles to be strictly adhered to, building plans to accommodate micro factors, routine maintenance of installed lamps, Painting/coating of ceilings and wall finishes using reflective material, and increased number of lighting facilities in the classroom environment.

Keywords: Ambient Lighting, Assessment, Classroom, Conditions, Geospatial

1. Introduction

Lighting is an essential component in an academic environment that affects visibility and performance of visual tasks, which involves writing, reading and learning processes. Daylight mainly plays a critical role in human life. It influences productivity, comfort, mood, the occupant's health, and the overall performance of students in schools. On the other hand, the controlling body of human beings is directly stimulated and regulated by daylight [16, 11]. Sufficient illumination is vital in any classroom environment, and adequate daylighting is considered a primary resource needed in schools. Lighting conditions have long been an essential internal environmental quality (IEQ) criteria in the built environment, including electric and daylight sources. Each one of these sources of light has a unique role in assessing user satisfaction within the built environment. Most

significantly, exposure to various types of light can be associated with physiological responses in human performance. The daylight from windows can provide both visual lighting and an opportunity to view objects outside or within the internal environment, which has also been positively influencing human behaviour. In addition, daylighting provided through skylights also positively affects students' in classrooms. Inadequate lighting and the lack of attention to improving the lighting facilities in the classroom environment or using daylight are critical problems that many institutional buildings and learning environments face [12]. Studies conducted in elementary school setting shows a positive and significant correlation between daylight and student performances across three school districts [7].

Subsequent studies involving classrooms with more substantial daylighting than classrooms with the least amount of daylight showed a 21% increase in student performance [9, 7]. Similarly, electric lighting has long been found to improve test scores, reduce off-task behaviour, and plays a role in student performance particularly in classroom environments [8]. However, pilot studies conducted in academic institutions' classrooms revealed that a poor ambient lighting condition is characterized with majority of the academic classrooms in developing countries. This outcome is attributed to poorly designed classrooms, frequent failure of existing fluorescent lambs, low quality of fluorescent lamps imported into the countries, poor finance and budgetary allocation and inability of the institution to replace failed lamps regularly in academic institution classrooms [2]. Consequently, the users' low visibility and reduction in viewing capacity often have to bring task lamps to see and listen to lectures to enhance and make learning effective [2].

According to [13] the behavioural impact of measuring the ambient lighting conditions of position in a classroom on the economic, architectural and well-being of students in schools. Still, it only considers the direct results of the bright situations on the students. Subsequently, educational institution classrooms are recommended by [5] to have an illuminance level of 300-500lux in various locations and positions within the classroom. Still, the majority of them falls below the minimum illuminance standard. Having recognised the need for illumination improvement of institutional building classrooms, Geospatial in recent time is gaining recognition within the built environment. It involves associated technology that is used to describe the collective data with a geographical or locational component. Geospatial technologies are used to describe the range of modern tools contributing to the geographic mapping and analysis of the earth and human societies [6]. It is referred to all technologies used to acquire, manipulate, and store geographical information [6]. GIS is one form of geospatial technology. GPS, remote sensing and geo-fencing are other forms of geospatial technology. Literature revealed that these technologies have developed since ancient times.

Geospatial technology is used to indicate data with a geographic component. This practice means that the records in a dataset have locational information such as geographical data in coordinates, addresses, cities, or ZIP codes [6]. GIS data is a form of geospatial data that can originate from GPS data, satellite imagery and geo-tagging. With this technology, the various sitting arrangements in classrooms are connected to these geographical data components in the form of coordinates, indicating that the ambient lighting conditions of these classroom environments vary in lux using either natural or a combination of both natural and artificial lighting. On the other hand, an ambient lighting condition varies within various points in the classrooms environment due to several factors influencing it. Thus, this study examined the existing ambient lighting condition of two purposively selected classrooms environment in Federal Polytechnic Ede, using a light meter to measure the natural daylight condition and combination of daylight and artificial lighting condition in classrooms selected in the study area, examines the factors influencing the ambient lighting conditions of the classrooms and suggests ways of enhancing the ambient lighting of the classroom environment in the study area.

2. Literature Review

2.1. Need for Illumination in Classroom Environment

The overall objective for lighting in a classroom environment is to achieve the desired lighting performance by creating a pleasing visual appearance and facilitating the functional performance within the space with the minimum use of energy. The primary requirement is to seek a suitably daylight level to satisfy the lighting requirement for the optimum portion of time. This requirement is essential for every classroom to have physical environmental features such as a device of control for sunlight to minimised glare and integrate in designs the need for natural lighting and ambience. Suitable illumination is vital in students' education. Hence, the strict regulations governing the natural and artificial lighting for students in educational facilities. Also, most students spend most of the day in enclosed spaces where the sun penetration is limited. Most problematic is during dry season period when lack of natural light is critical, although several buildings struggle with the proper daylight throughout the year. The main struggle of educational establishments nowadays is inappropriate thermal insulation, inadequate micro-climatic conditions affecting the ambient lighting in classrooms, the absence of a mechanical ventilation system, or insufficient natural daylight [10]. Besides lifestyle, genetic dispositions, and healthcare quality, environmental conditions are among the fundamental parameters affecting human health.

2.2. Factor Influencing Ambient Lighting Condition of Classroom Environment

In a research carried out by [4, 20] ascertained that environmental conditions can influence students' health,

well-being and students' performance in a classroom environment. Several studies dealing with environmental conditions affecting the learning process in the classroom environment include the following. Well-chosen building orientation and window sizes are crucial for reducing the electricity used on the lighting system.

1) Window to Wall Size: The effect of window geometries and building orientation on daylight availability in a classroom environment with one window investigated [14]. The geographical location was in the tropics; thus, it cannot be generalised to the case of temperate region. Research shows that the best window to wall ratio in the European climate is between 0.30 and 0.45. However, room users should bear in mind that the size of the windows affects the insolation of the room. In the excellent season, this phenomenon is beneficial; however, it may cause the rooms to overheat in the dry season.
2) Location Control: In adjusting artificial lighting illuminance, a sensor measures the illuminance level at the installed place. Therefore, the control algorithm must determine and implement the correlation between this level and the required illuminance level on the working surface. In addition, as mentioned earlier, daylight illuminance changes in the room's depth and this distribution depend on many factors. However, electricity savings with lighting controls considering the daylight is still a constraint, and the estimation of energy-saving potentials in actual buildings shows significant discrepancies.
3) Day Lighting Performance: The daylighting performance is evaluated using the Useful Daylight Illuminance (UDI) metric, which permits the prediction of the occurrence of illuminance levels throughout the year in a specific range from 300-3,000lux.
4) Time of the Day: A preliminary framework for evaluating non-visual effects of daylight is proposed, described more extensively. This was based on vertical illuminance received at the eye level, three periods of the day are distinguished for their differentiated effects on the ambient lighting alertness of 06:00-10:00 (morning period), 10:00-18:00 (afternoon period) and 18:00-06:00 (night period).
5) Glare: Glare, on the other hand, is excessive contrast, bad adaptation conditions to the point of visual discomfort or disability. In buildings, it principally occurs where windows or light fittings appear too bright compared with the average brightness of the interior [8] It is essential to ensure that the avoidance of glare in class/learning rooms is made absolute.
6) Viewing Point: It is well-known that building occupants, almost without exception, will prefer a workstation with a view of the outdoor environment to a windowless office. A view to the outside indicates, of course, the presence of daylight, although the relationship between thought and daylight provision is not straightforward, being dependent on many factors. In addition to subjective preferences for daylight spaces, it is now firmly established that light has measurable biochemical effects on the human body, particularly maintaining a healthy sleep-wake cycle.
7) Illumination: illuminance is the concentration of lighting while Illumination is the general process of lighting [18]. Illuminance is the resulting illumination level, luminous flux density, achieved on the working plane. An excellent working level inside is about 300lux [18]. The crucial function of lighting in the classroom cannot be overemphasised as 80% of all external stimuli come through the eyes [19]. [3] stated that reading and writing, which are the daily predisposed jobs in the classrooms at all educational levels, are visual tasks. This task demands the level of illumination of the classroom work planes be well balanced for safety, clarity and pleasantness in sighting things, without eyestrain tendency. The quality of light of any work plane is supposed to, at least, meet or exceed the minimum specification for adequate illumination level. This light quality makes it crucial that those visual classroom conditions are within the appropriate quantity and quality limit for an effective teaching-learning process in schools [1]. [15] illumination comprises reflected light, artificial light, daylight, and all sources of light control. However, in Nigeria, daylight and artificial lighting are the aspects of a classroom environment lighting systems' physical characteristics that affect the visual task in the classrooms. Daylight is the utilisation of sunlight illumination, which naturally enters into space through the structural design openings; windows, doors and skylight [17]. This daylight, according to [21] is mostly preferred during the day time hours due to the quality of life and sustainability it offers in schools. Even though the optimal lighting may vary based on the visual task, it requires a balance of both daylight and artificial light source to be utilised. This requirement implies that good lighting design for a school building needs to balance with natural and artificial lighting sufficient for the tasks space illuminance [4].

2.3. Categories of Classroom Environment in Schools

A classroom is a learning space in which both children and adults learn. A typical classroom provides a space where outside distraction can take place uninterrupted. The classroom is found in educational institutions ranging from pre-school to university. A classroom can be located in other areas where education or training is provided, such as corporations, religious and humanitarian organisations. A category of classroom environment includes the following:

1) Small Classroom: classrooms with level floor and capacity of 17-150.
2) Medium Classroom: classroom with sloped floor or stadium seating with a capacity of 67-240 capacity.
3) Large Classroom: The maximum capacities of students are usually above 240 capacities [3].

3. Methodology

3.1. Method of Data Collection

The study adopts a purposive sampling technique of classrooms. The classrooms are categorised under medium and large classrooms in Federal Polytechnic Ede. The sample size was selected from the fraction of classrooms to be studied with the assumption that a representative of a school can be generalised as findings from categories of chosen classrooms. This study was carried out using both quantitative and subjective approaches. The quantitative approach involved using NTS-350 infrared light total stations and Extech LT300 light meter (Figures 1 & 2) to collect existing ambient lighting conditions of classrooms at intervals. While the subjective process involved the administration of (71) open-ended structured questionnaires to randomly selected lecturers and students having daily contact with the classroom environment to tick and rank the questions appropriately. Five Linkert scales were utilised to express the view of individual respondents, which includes very important (VI), important (I), neutral (N), rarely important (RI) and not important (NI), respectively. The study measured the view through the relative important index (RII) of 5, 4, 3, 2, 1, respectively, to rank various factors influencing the ways of improving the ambient lighting conditions of the classroom environment in the study area.

3.2. Experimental Procedure

Selection of classrooms in the study area to examine the ambient lighting condition under the categorisation of a medium and large classroom.

Geospatial assessment of points in a selected classroom (Figure 1) was based on the sitting arrangement of students in a classroom environment.

The use of light meter (Figure 2) to collect ambient lighting data at different points and intervals of the day (8-10 am, 10-12 pm, 12-2 pm, 2-4 pm, 4-6 pm) in the classroom. The study considered this practice for both natural and artificial lighting in the classroom environment.

Repeat the same process for three (3) days within the three months of (October-December) and evaluate the average ambient lighting in various classroom environments for both natural and combination of natural and artificial lighting in the classroom.

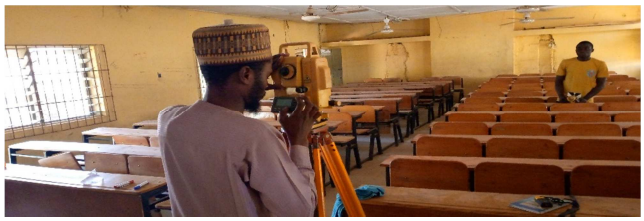

Figure 1. *Location of Point in a Classroom Environment (Q/S Classroom) using NTS-350 infrared light total stations.*

Figure 2. *Extech LT300 Light Meter.*

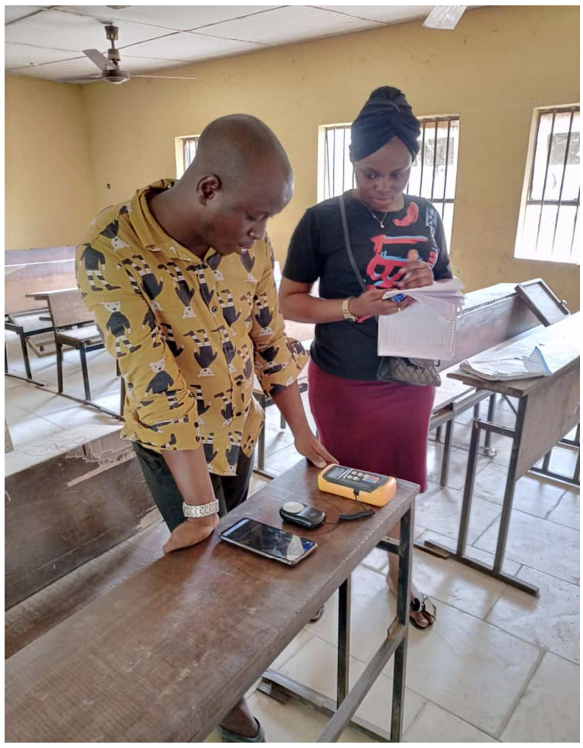

Figure 3. *Taking Ambient Lighting reading of classroom Environment with a Light Meter.*

4. Data Presentation and Discussion of Results

4.1. Data Presentation

Table 1 shows the various geospatial locations of points regarding the sitting arrangement of students in the classroom environment. Thirty-six (36) points were located in Quantity Surveying Classrooms and fifty-four (54) points in the Akogun classroom environment, respectively. The different point marked was carried out using south NTS-350 infrared light stations. Through the geospatial observations made in the classes, the coordinates of the marked points and the classroom areas were obtained as shown in QS1PI-QS1P4 and AKP1-AKP4, respectively. The details of the geospatial point locations are presented in the Tables 1 and 2 respectively.

Table 1. *Geospatial Position of Marked Points in Quantity Surveying Classroom Environment.*

ID	N (m)	E (m)	H (m)	LOCATION
QS101	854723.3	657061.7	88.778	QS 1
QS102	854723.1	657060.7	88.775	QS 1
QS103	854722.9	657059.7	88.761	QS 1
QS104	854722.5	657058.4	88.778	QS 1
QS105	854722.2	657057.4	88.782	QS 1
QS106	854722	657056.4	88.781	QS 1
QS107	854721.9	657061.9	88.781	QS 1
QS108	854721.7	657061.1	88.771	QS 1
QS109	854721.5	657060	88.787	QS 1
QS110	854721	657058.7	88.800	QS 1
QS111	854720.8	657057.8	88.785	QS 1
QS112	854720.5	657056.8	88.784	QS 1
QS113	854720.3	657062.3	88.761	QS 1
QS114	854720.2	657061.3	88.791	QS 1
QS115	854720	657060.3	88.787	QS 1
QS116	854719.6	657059.1	88.799	QS 1
QS117	854719.3	657058.2	88.802	QS 1
QS118	854719.1	657057.2	88.806	QS 1
QS119	854719.0	657062.6	88.786	QS 1
QS120	854718.7	657061.7	88.790	QS 1
QS121	854718.4	657060.7	88.819	QS 1
QS122	854718.1	657059.5	88.798	QS 1
QS123	854717.9	657058.5	88.799	QS 1
QS124	854717.6	657057.6	88.821	QS 1
QS125	854717.4	657063	88.790	QS 1
QS126	854717.2	657061.9	88.785	QS 1
QS127	854717.0	657061	88.806	QS 1
QS128	854716.6	657059.8	88.808	QS 1
QS129	854716.4	657058.9	88.896	QS 1
QS130	854716.2	657057.9	88.796	QS 1
QS131	854715.9	657063.2	88.786	QS 1
QS132	854715.7	657062.2	88.792	QS 1
QS133	854715.6	657061.3	88.794	QS 1
QS134	854715.2	657060.2	88.775	QS 1
QS135	854714.9	657059.3	88.786	QS 1
QS136	854714.6	657058.3	88.794	QS 1
QS1P1	854724.7	657054.7	89.243	QS 1
QS1P2	854726.5	657061.7	89.219	QS 1
QS1P3	854714.3	657064.9	89.210	QS 1
QS1P4	854712.5	657057.9	89.200	QS 1

Table 2. *Geospatial Position of Marked Points in Akogun Classroom Environment.*

ID	N (m)	E (m)	H (m)	LOCATION
AK1	855026.8	657040.5	88.321	Akogun
AK2	855027.5	657040	88.331	Akogun
AK3	855028.3	657039.4	88.327	Akogun
AK4	855029.5	657038.4	88.485	Akogun
AK5	855030.3	657037.8	88.492	Akogun
AK6	855031.1	657037.3	88.496	Akogun
AK7	855032.0	657036	88.365	Akogun
AK8	855032.7	657035.5	88.355	Akogun
AK9	855033.6	657034.8	88.367	Akogun
AK10	855027.7	657042	88.482	Akogun
AK11	855028.4	657041.3	88.503	Akogun
AK12	855029.3	657040.7	88.498	Akogun
AK13	855030.5	657039.7	88.476	Akogun
AK14	855031.3	657039.1	88.481	Akogun
AK15	855032.1	657038.5	88.486	Akogun
AK16	855033.0	657037.2	88.488	Akogun
AK17	855033.9	657036.6	88.515	Akogun
AK18	855034.6	657036.1	88.519	Akogun
AK19	855028.5	657043.3	88.638	Akogun
AK20	855029.3	657042.7	88.621	Akogun
AK21	855030.1	657042.1	88.625	Akogun

ID	N (m)	E (m)	H (m)	LOCATION
AK22	855031.5	657041	88.619	Akogun
AK23	855032.3	657040.5	88.627	Akogun
AK24	855033.1	657039.8	88.612	Akogun
AK25	855033.9	657038.6	88.634	Akogun
AK26	855034.7	657037.9	88.636	Akogun
AK27	855035.6	657037.3	88.615	Akogun
AK28	855029.4	657044.5	88.624	Akogun
AK29	855030.2	657044	88.642	Akogun
AK30	855031.0	657043.4	88.611	Akogun
AK31	855032.2	657042.4	88.792	Akogun
AK32	855033.1	657041.8	88.793	Akogun
AK33	855033.8	657041.3	88.791	Akogun
AK34	855035.0	657039.9	88.615	Akogun
AK35	855035.7	657039.3	88.638	Akogun
AK36	855036.6	657038.7	88.623	Akogun
AK37	855030.3	657046	88.952	Akogun
AK38	855031.0	657045.4	88.951	Akogun
AK39	855031.8	657044.8	88.927	Akogun
AK40	855033.1	657043.8	88.819	Akogun
AK41	855033.9	657043.2	88.793	Akogun
AK42	855034.7	657042.7	88.791	Akogun

ID	N (m)	E (m)	H (m)	LOCATION
AK43	855036	657041.1	88.794	Akogun
AK44	855036.8	657040.5	88.807	Akogun
AK45	855037.6	657039.9	88.8	Akogun
AK46	855031.3	657047.3	88.934	Akogun
AK47	855032	657046.7	88.978	Akogun
AK48	855032.9	657046.1	88.953	Akogun
AK49	855034	657045.1	88.832	Akogun
AK50	855034.9	657044.5	88.832	Akogun
AK51	855035.6	657044.1	88.832	Akogun
AK52	855036.9	657042.5	88.822	Akogun
AK53	855037.7	657041.9	88.819	Akogun
AK54	855038.6	657041.2	88.815	Akogun
AKP1	855040.8	657043.4	89.279	Akogun
AKP2	855031.5	657050.3	89.245	Akogun
AKP3	855022.3	657037.7	88.656	Akogun
AKP4	855031.6	657030.7	88.650	Akogun

Tables 1 and 2 shows the spatial plotting and distribution of ambient lighting in large (Akogun classroom) and medium (Quantity Surveying) classrooms, respectively. The results show that between 8 and 10 am, none of the spatial positions marked in these classrooms meets up with the standard ambient lighting of 300-500lux. The ambient lighting decreases away from windows and doors towards the center of the classroom. This loss in ambient lighting signifies that the Akogun classroom and QS are dark in the early hours of the morning. Again, between 10 and 12 pm, none of the spatial positions marked in Akogun and QS classrooms also measured up with the standard ambient lighting of 300-500lux with the ambient lighting decreases from windows or doors locations. Data also shows that ambient lighting increased compared with one obtained between 8 and 10 am. This result signifies that the Akogun and QS classrooms are brighter than it was in the early hour of the morning. Between 12 and 2 pm, fouty-one (41) points of the geospatial positions marked in Akogun met the required ambient lighting conditions and none was in the QS classroom. It is observed that the ambient lighting increased in numbers of spatial points significantly between 2 and 4 pm in the Akogun classroom. Between 4 and 6 pm, the ambient lighting conditions decreased further considerably in the Akogun classroom. This improvement was attributed to the change in the climate factors in the study area. Significantly when comparing, the Akogun classroom became brighter than the QS classroom during the three months periods.

Similarly, the average illuminance of the ambient lighting of Quantity Surveying Classrooms and Akogun Classrooms for the three days between October and December between the hours of 8 &10, 10 &12, 12 & 2, 2 & 4 and 4 & 6 pm were (21, 32; 54, 75; 59, 86; 52, 85 and 33, 64) and (74, 106; 172, 222; 641, 686; 263, 295 and 140, 177) respectively for Quantity Surveying and Akogun hall. The results, as shown in Tables 3 and 4, also show that the average illuminance of the Quantity Surveying Classroom was grossly inadequate throughout the three selected days in three months under the categories of hours within the day for both natural and combination of natural and artificial lighting conditions. While, the result of the average illuminance level for the Akogun Classroom shows that between the hours of 12 & 2 pm (641, 686) of the three days observed for both conditions had sufficient ambient lighting conditions for a few points

located in the classroom. This good ambient lighting condition was because the point locations are attracted by the sunny state of the sky component and the unobstructed openings of the classroom. In contrast, the other point location does not meet the ambient lighting condition of the classroom environment. This lapse was also because these points are either far from the openings or are not attracted to the sunny conditions, giving the classrooms better sky components. The study thus, revealed that the average illuminance of the classroom environment is not adequate. Hence, the illumination conditions must be improved upon for both conditions in the classroom environment to meet the required standard. Relatively, the result obtained was similar to the outcome of research carried out by (20) which revealed that the average mean illuminance at pupils desk was inadequate (55, 60 lux) with blinds open and lights on and was lower with blinds open and lights off with and (51 lux) with blind closed and light on. Subsequently, the present research considers the geospatial point locations in relation with sitting arrangement and lighting fittings in classrooms environment which is relatively different from the outcome of (20) under natural day light condition and combination of daylight and artificial lighting conditions in class environment in schools.

Table 3. *Average Illuminance of Natural Lighting and Combination of Natural and Artificial Lighting (QS Classroom),*

Three Days Average Illuminance of QS Classroom for Natural Lighting (NL) and Combination of Natural Lighting & Artificial Lighting (NL) + (AL)										
Condition of Day	**Cloudy**		**Sunny**		**Sunny**		**Lightly Sunny**		**Lightly Sunny**	
Time Range	**8-10am**		**10-12 am**		**12-2 pm**		**2-4 pm**		**4-6 pm**	
	NL	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**
	72	78	194	225	166	205	148	205	108	138
	49	58	109	126	116	180	104	175	74	101
	33	39	83	123	86	101	78	90	54	75
	20	28	57	77	60	87	62	91	47	76
	18	29	49	68	55	79	44	67	31	54
	29	35	64	80	69	89	53	88	42	70
	36	49	89	85	106	152	87	120	44	82
	27	35	75	99	72	89	69	88	38	87
	21	28	62	86	62	89	57	89	34	79
	17	25	50	69	51	78	46	79	30	67
	19	27	49	78	52	88	43	88	31	67
	30	39	89	101	89	112	88	102	75	89
	12	23	34	55	38	64	31	62	21	49
	13	23	37	56	42	77	35	67	21	52
	14	23	37	57	42	79	36	67	23	52
	13	23	38	67	42	80	36	77	23	52
	14	23	42	78	46	82	41	88	27	49
	17	27	47	87	50	80	41	76	31	61
	31	39	62	89	65	85	59	78	42	67
	20	28	43	66	48	85	43	66	27	69
	16	25	37	57	41	78	38	88	23	67
	15	26	37	61	43	76	38	78	22	68
	16	26	40	66	46	76	38	79	22	65
	29	36	68	77	79	89	74	101	35	34
	11	19	27	45	31	60	27	60	16	50
	11	21	28	45	35	59	29	63	17	52
	13	23	31	45	38	67	33	67	22	52
	14	23	36	43	42	88	35	67	20	51

Table 3. *Continued,*

Three Days Average Illuminance of QS Classroom for Natural Lighting (NL) and Combination of Natural Lighting & Artificial Lighting (NL) + (AL)										
Condition of Day	**Cloudy**		**Sunny**		**Sunny**		**Lightly Sunny**		**Lightly Sunny**	
Time Range	**8-10am**		**10-12 am**		**12-2 pm**		**2-4 pm**		**4-6 pm**	
	NL	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**
	15	23	41	63	46	89	40	80	21	53
	15	24	50	60	59	89	57	78	27	60
	9	23	20	55	23	65	20	56	14	35
	9	23	22	54	27	65	22	55	14	35
	11	27	27	45	32	66	28	57	17	38
	13	27	32	55	38	67	34	66	21	55
	22	57	39	60	53	87	41	70	27	56
	28	60	87	86	102	87	90	132	43	56
Mean/Average %	21	32	54	75	59	86	52	85	33	64

Table 4. *Average (%) Illuminance of Natural Lighting and Combination of Natural and Artificial Lighting (Akogun Classroom).*

Three Days Average Illuminance of Akogun Classroom for Natural Lighting (NL) and Combination of Natural Lighting & Artificial Lighting (NL) + (AL)										
Condition of Day	**Cloudy**		**Sunny**		**Sunny**		**Lightly Sunny**		**Lightly Sunny**	
Time Range	**8-10am**		**10-12 am**		**12-2 pm**		**2-4 pm**		**4-6 pm**	
	NL	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**
	77	105	177	201	451	500	220	245	134	167
	76	109	142	198	452	498	196	232	136	177
	67	103	136	189	474	507	192	231	120	156
	46	96	111	167	456	507	170	203	105	153
	72	94	163	203	880	903	252	273	189	212
	56	99	158	203	175	203	180	201	156	211
	62	101	129	170	195	205	197	212	165	211
	60	102	129	171	259	295	266	301	163	207
	106	143	205	256	346	401	336	398	183	234
	82	120	182	210	593	605	249	289	162	199
	87	120	178	222	618	645	251	278	159	172
	83	123	177	223	588	632	620	672	160	197
	67	95	141	205	535	632	226	251	159	199
	77	103	148	207	518	618	189	221	130	187
	71	120	115	147	504	555	174	201	123	189
	53	88	117	160	723	810	200	234	148	179
	51	89	117	170	523	592	168	205	122	178

Table 4. *Continued.*

Three Days Average Illuminance of Akogun Classroom for Natural Lighting (NL) and Combination of Natural Lighting & Artificial Lighting (NL) + (AL)										
Condition of Day	**Cloudy**		**Sunny**		**Sunny**		**Lightly Sunny**		**Lightly Sunny**	
Time Range	**8-10am**		**10-12 am**		**12-2 pm**		**2-4 pm**		**4-6 pm**	
	NL	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**	**NL**	**NL+AL**
	57	101	101	170	461	521	97	123	72	122
	100	134	171	221	565	601	172	204	135	165
	98	135	168	223	554	602	177	204	147	187
	85	102	146	221	535	599	154	176	122	169
	75	101	123	231	471	505	140	167	98	132
	72	103	128	189	495	535	211	245	104	169
	50	89	142	201	762	800	220	261	140	179
	48	89	157	207	893	905	234	271	180	191
	78	121	148	207	692	705	188	213	135	179
	97	132	143	207	409	455	168	213	137	187
	94	132	253	300	567	599	286	301	180	213
	105	132	359	400	858	601	632	687	180	215
	76	103	435	432	1014	1150	682	704	178	211
	61	99	585	670	1131	1150	917	997	141	178
	74	103	110	140	400	450	179	213	109	142
	54	103	115	156	522	588	216	234	110	152
	51	121	122	169	827	888	186	213	150	184
	70	123	150	187	513	634	226	243	194	213
	59	88	160	121	502	542	190	213	140	182
	104	104	417	497	1109	1150	658	698	228	260
	88	123	376	401	1070	1135	687	687	233	264
	73	103	178	198	713	801	270	293	166	201
	61	99	111	167	665	790	172	213	126	176
	52	89	81	123	148	178	88	132	65	112
	55	89	80	125	150	187	85	133	68	113
	60	97	86	131	152	189	91	134	73	115
	60	99	125	156	1082	1102	170	186	97	134
	59	87	123	157	1767	1800	165	201	79	121
	139	180	227	271	1362	1399	707	777	189	203
	111	145	224	270	1292	1300	351	387	199	223
	87	112	194	245	1204	1251	319	345	157	172
	84	115	153	205	993	1021	254	289	184	203
	58	78	138	170	993	1021	223	267	129	161
	61	99	127	176	984	1022	191	205	113	145
	66	88	113	145	125	150	114	136	65	112
	63	89	135	178	161	180	142	145	89	112
	73	101	141	178	167	189	145	167	117	145
Mean/Average%	74	106	172	222	641	682	263	295	140	177

4.2. Characteristics of the Respondents and Classroom Environment

Table 5 Shows the percentage representation of students having direct contact with the classroom environment. Out of the 71 administered and retrieved questionnaires, 24 numbers of respondents are ND1 students representing 33.8%, 18 numbers of respondents are NDII students representing 25.35%, 7 numbers of the respondents are HND1 representing 9.86%, and 10 numbers of the respondents are HNDII students representing 14.71%. Similarly, the other 11 number of respondents were lecturers, instructors and higher technologists representing 9.80%, 4.23%, 2.81%, respectively. This figure implies that, the study sampled all categories of stakeholders in the study area who are capable of providing relevant information regarding the classroom environment. The table further shows that out of 71 respondents, 13 (22.5%) spent 2-4 hours daily in the classroom, 23 (32.5%) spent 4-6hours in the classroom, 21 (29.5%) spent 6-8hours daily in the classroom, 11 (15.5%) spent 8-10 hours daily in the classroom since most of their activities are carried out in the classroom. The table also shows the response of the lecturers and students on the daylight condition of the classroom environment having 13 (18.3%) excellent condition, 7 (9.8%) good condition, 15 (21.1%) undecided, 35 (49.3%) fairly condition and 1 (1.4%) terrible condition respectively. The data above implies that the state of lighting in the classroom needed to be upgraded since only 13% percent agreed that the ambient lighting condition of the classrooms is excellent. The table also shows that Artificial lighting condition of the classroom environment has 17 (23.94%) excellent condition, 25 (35.21%) good condition, 06 (8.45%) undecided, 9 (12.68%) bad condition. The above result implies that the state of lighting in the classroom needed to be upgraded since the more significant percentage agreed that the lighting condition is reasonable and fair in terrible shape, respectively. This is also in accordance with the result obtained by (20) that a mean of 5% of fluorescent lamps per classroom had not been replaced after malfunction.

Table 5. *Characteristics of the Respondents and Classroom Environment.*

Characteristics of the Respondents and Classroom Environment		Frequency	Percentage
Class of the Respondent	ND 1	24	33.80
	ND 2	18	25.35
	HND 1	7	9.86
	HND 2	10	14.71
Nature of Staff	Lecturer	7	9.80
	Instructor	3	4.23
	Technologist	2	2.81
Hours Spent in Classroom Environment	2 - 4hours	16	22.5
	4 - 6hours	23	32.5
	6 - 8hours	21	29.5
	8 - 10hours	11	15.5
Natural Condition Lighting in Classroom	Very Good	13	18.3
	Good Condition	7	9.8
	Undecided	15	21.1
	Bad Condition	35	49.3
	Terrible Condition	1	1.4
Artificial Lighting Conditions of the Classroom	Excellent Condition	17	23.94
	Good Condition	25	35.21
	Undecided	6	8.45
	Bad Condition	9	12.68
	Terrible Condition	14	19.71

Table 6 shows the respondents' opinion on the factors observed that influence the ambient lighting condition of the classroom environment in the study area. The study revealed that non-adherence strictly to micro factors such as building orientation, the position of sunrise/sunset, internal glare condition, daylight performance of the atmosphere, and viewing points were ranked high as 1st, 2nd, 3rd, 4th and 5th with RII factors of 0.88, 0.76, 0.42, 0.4, 0.38 respectively for the classroom environment. While, issues related to poor designs of classrooms such as windows to wall ratio, non-functional windows, poor lighting design position/controls and seating position in the classrooms/school regarding the window were ranked as 6th, 7th, 8th, 9th and 10th with RII factors 0.37, 0.36, 0.35 and 0.32 respectively. These two factors identified are crucial factors influencing the ambient lighting conditions in the study area. The study also deduced that most micro factors are uncontrollable but could still be improved by integrating passive design architectural principles to increase the sky components.

Table 6. *Factors Influencing the Ambient Lighting Condition of Classroom Environment in Federal Polytechnic Ede.*

S/N	Factors Influencing the Ambient Lighting Condition of the Classroom	5	4	3	2	1	Total	RII	Ranking
1.	Orientation of the Classroom	26	25	1	2	1	55	0.76	2nd
2.	Sunrise and Sunset of the Classroom	30	25	6	3	1	65	0.88	1st
3.	Functional Windows of the Classroom	31	22	8	2	2	65	0.36	9th
4.	Time of the Day	29	22	10	3	1	65	0.37	8th
5.	Daylight Performance of the Atmosphere in the Classroom	36	21	6	2	_	65	0.32	11th
6.	Lighting Location Control of the Classroom	32	21	7	5	_	65	0.35	10th
7.	Windows to Wall Ratio of Classroom	26	22	9	7	1	65	0.4	4th
8.	Glare Condition of the Internal Classroom Environment	16	31	10	5	2	64	0.42	3rd
9.	Viewing Point in the Classroom Environment	25	22	11	7	_	65	0.4	4th
10.	Seating Position in the Classroom Environment in Respect of Installed Lamps	28	21	10	5	1	65	0.38	7th
11.	Seating Position in the Classroom Concerning the Windows	30	20	5	9	1	65	0.39	6th

Table 7 shows the respondents' opinions on ways to improving the ambient lighting conditions of classrooms in the study area. The study revealed that improvement of ambient lighting conditions of the classrooms is attributed to certain climatic factors. The factors include cutting down trees with bigger girth, increased number of windows, increased window to wall size ratio, and routine maintenance of installed lamps. Others include treating the internal surfaces with reflective paint and expanded classroom lighting facilities. The study ranked these factors as 1st, 2nd, 3rd, 4th, 5th and 6th with RII factors of 0.44, 0.41, 0.37, 0.34, 0.32, 0.31, 0.27, respectively. Increasing the ambient lighting conditions must involve the integration of passive designs and carrying out maintenance of the classroom environment. This maintenance includes constant routine maintenance of installed lamps, painting/coating of ceilings, and wall finishes using reflective painting materials are critical in meeting standard ambient lighting conditions of the classroom environment in the study area.

Table 7. *Factors contributing to better Ambient Lighting Condition of Classroom.*

S/N	Factors Contributing to A Better Classroom Environment in The Study Area	5	4	3	2	1	Total	RII	Ranking
1.	Increased number of lighting facilities in the classroom	47	15	2	1	_	65	0.27	6th
2.	Increased windows to wall ratio in the classroom to meet the required ambient lighting condition.	20	35	5	4	_	64	0.37	3rd
3.	Increased number of windows in the classroom.	23	35	5	4	_	67	0.41	2nd
4.	Painting/coating of ceilings and wall finishes using reflected materials	29	33	3	_	_	65	0.32	5th
5.	Cutting down trees around the classroom to increase daylight factors.	21	26	5	9	4	65	0.44	1st
6.	Routing maintenance of installed lamps in the selected classroom environment.	35	20	6	2	2	65	0.34	4th

5. Conclusion and Recommendation

The study concluded that the observed classrooms geospatial marked positions of ambient lighting were significantly low when compared with the required standard of 300-500lux expected in classroom internal environment. The study recommends strict consideration of micro factors, passively designed classrooms, improved artificial lighting conditions and controls for ensuring optimal performance of ambient lighting conditions of classrooms. The study also suggest other factors that could enhance the performance of the ambient lighting include routine maintenance of installed lamps, reflective material treatment of ceilings/wall finishes and increased number of lighting facilities in the classroom environment to meet the required lumen standards of (300-500lux) recommend for classrooms.

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