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Daylight Impact on Learning Environment in Classrooms of Secondary High School at Ishwardi, Pabna, Bangladesh

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Abstract - *Lighting is an essential architectural factor that influences users' perception and behavior. Using natural light has always been a desirable building feature and it is a symbol of a good design. Daylight creates an ambience of quiet contemplation and visual comfort in a classroom. Effective use of daylighting can reduce energy consumption as well as make the classroom feel more human and less institutional. The study observes classrooms of a secondary level high school of Bangladesh where the students spend most of their time. This paper focuses on the impact of daylighting in classrooms with different window placement. The objective of this study is to find out the effect of daylight condition on the student performance of a classroom.*

***Key Words*: Daylighting, Classroom, Students, Window, Learning environment.**

1. INTRODUCTION

In architectural practice, daylight is an important factor and it is essential to design all the buildings in such a way that ensures user comfort from daylight. User comfort has a greater link to the well-being, physical and psychological sensations of individuals in a given environment [1]. Comfortable luminous environment of school is a kind of incentives for students and even teachers to have better performance [2]. Proper daylighting in school buildings significantly affect students whereas poor daylighting causes discomfort and reduces learning capacity. It is also harmful to the physical and mental health of students [3].

Daylighting is not only good for health but also can reduce energy consumption [4]. Buildings occupants prefer to utilize the outside view and natural light instead of electrical light. In well-designed interior zones, daylight increases visual quality and mental health benefits, which are costly and hard to reproduce through artificial lighting [5]. Daylight is one of the most important natural forces to enhance the visual quality of interior space which is an abundant resource in the tropical city in Bangladesh [6]. For getting proper daylighting to satisfy human needs for visual comfort, well-being and health, large or small windows with or without shading system are used in different type of buildings.

Previously, in the classroom design development, a concept of 'open-air design' was popularized but now the concept shifted the focus of classroom design towards 'daylighting considerations' because the concept allows too much daylight amount in the classroom that causes visual discomfort [7]. Learning space that receives high daylight intensity with low glare, added with high quality artificial light source improves the visual comfort, which improves the learning space environment [8].

Various research has proven that sufficient daylight in a classroom is required due to its positive effect towards the students including improvements on learning performance, alertness, cognitive skills, behaviour, mood, circadian rhythm, vocal strength and productivity. Thus, various standards and guidelines are introduced all around the world which ensures the proper daylight that is needed for designing a proper learning space. In general, lighting quality integrates individual well-being, economics and architecture [2] (Figure 01) and for the students, daylights directly effect on performance, psychology of the students in classrooms and learning achievement [3] (Figure 02).

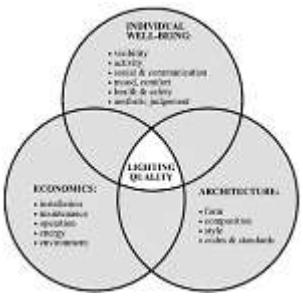


Figure 01: Lighting quality: the integration of individual well-being, architecture, and economics [2].

Figure 02: Effects of Daylight on Students [3].

In Bangladesh, from class 6 to 10 (secondary level), students spend almost six hours a day in a school. So, when they grow up, a huge amount of time is spent in their classroom. But most of the classrooms are not well designed and for this reason, students do not get desire natural light and their concentration fluctuated.

The primary goal of this study is to examine three different types of classroom in the educational buildings of Ishwardi Girls high school which is situated at Ishwardi, Pabna, Bangladesh to determine whether daylight can affect student performance. This school is consisted of three education buildings which are constructed in different phases on different times and the architectural design is not similar to

each other. Three types of class room with different window placement is found and collecting information about the daylight condition in those classrooms is the first step to test the impact on student performance. Also, other aspects of the internal environment of the classrooms are considered for determining the interaction of students with daylight.

2. LITERATURE REVIEW

2.1 SCHOOL ARCHITECTURE

Many researchers discuss school design for finding out the possibilities of designing a responsive school and shows that the school building is an important factor for successful schools. There is some relationship between the architecture of the school and classrooms and the learning that takes place within these schools and classrooms [9]. Color scheme, form design, lighting, heating, cooling and ventilation, acoustics and noise, furniture and equipment are the main elements for designing a school [10].

Many studies on building quality and academic outcomes focuses on indoor quality, lighting, noise and acoustics, occupant density and thermal comfort [11]. Some basic functions of school architecture and classrooms have been found, five of them have become important for subsequent educational research. Those are security and shelter, pleasure, symbolic identification, task instrumentality, and social contact [12]. However, these empirical studies have only considered the surroundings as important factors for well-being in schools, and do not provide any detailed evidence of their importance for teaching and learning [10]. But daylighting in a classroom is also important for overall environment and performance of students and it should also consider while designing a school building.

2.2 DAYLIGHT AND PRODUCTIVITY

The actual scientific results concerning the impact of daylight on human performance are still unsure [13]. However, compared the effects of several schools in the same country for more than 4 years and the result showed that daylighting positively affects student performance [14] (Fig 03). Some research illustrate that Good daylighting can improve classroom conditions, promote students learning, and reduce the rate of absenteeism in classrooms [3] (Figure 04).

Also, classrooms with effectively incorporated daylight yield lighter electric loads and reduce heating and cooling loads and are more popular with students and teachers.

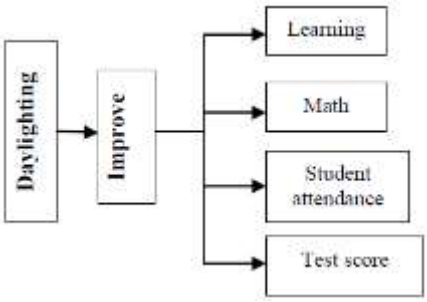


Figure 03: Positive effects of daylighting on students [14]

Improved			Reduced	
Health	Psychological	Learning achievement	Health	Psychological
Vitamin D	Mood	Learning	Headache	Depression
Student's vision	Cheerful	Math	Cancer	Fatigue
Calcium absorption	Student attendance	Student attendance	Stomach ulcers	Seasonal affective disorder
Bone formation	Sleep	Test score	High blood pressure	Violent behaviour
Biological clock			Stress	Stress
			Microbes	Security

Figure 04: Benefit of daylighting on students [3].

2.3 VISUAL COMFORT

The visual comfort is often defined in literature as the absence of discomfort, i.e. glare. Inappropriate size of windows may give rise to glare [15]. But visual comfort is more than the absence of discomfort; other parameters such as illuminance level, colour rendering, modelling, luminance distribution in the visual felt are also important for the impression of comfortable visual conditions.

2.4 STANDARD FOR DAYLIGHT IN CLASSROOM

The importance of daylight in classrooms is highlighted in various standards and guidelines. Illuminating Engineering Society of North America (IESNA) recommended 300 lux to 500 lux of illuminance level for learning tasks [7]. Others recommended the same illuminance level of 300 lux to 500 lux for common reading task in general teaching spaces (Table 01).

Table 01: Illuminance level Recommendations [7].

Learning Space	Standards and Guidelines		
	Illuminating Engineering Society of North America (IESNA)	Malaysian Standard 1525 (MS1525)	Public Works Department (JKR)
General Teaching Space	300-500	300-500	300-500
Science Laboratories	500	300	300
Library	300	300-500	300

3. METHODOLOGY

The study is conducted through the following steps:

Step 1: Case Study Selection and Analysis: A secondary high school is selected and the classrooms are categorized according their design difference. Then information is collected from direct observation and questionnaire survey from the students. Photographic registration and schematic drawings were done from direct observation. By this, several problems have been identified which are mainly created by the window placement. By using Digital Light Lux Meter, daylighting condition in each bench is measured. And from the questionnaire survey, it has been found that the daylight is highly demanded by students.

Step 2: Literature Review: Reviewing of some research works on the similar ground that took place around the world was conducted to understanding about the subject matter.

Step 3: Data analysis: After analysing the survey data, the data are also analysed with computer-based simulation application- Ecotect to understanding the scenario of the situation that help to take the decision comparing with survey data.

Step 4: Result, discussion and conclusion: Considering the design options, better daylight configuration is suggested to improve the learning environment in the classrooms of the selected school.

4. CASE STUDY

The school selected for the study was founded in 1929. It is situated in Ishwadi, Pabna (Figure 05). It is the one and only girl's high school in Ishwardi Upazila.

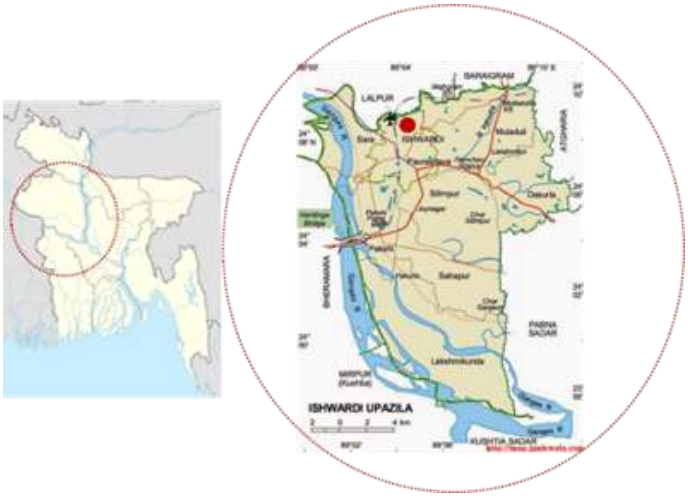


Figure 05: Location map of Ishwardi Upazila [internet].

The school has one administrative building with library and three academic building with classroom and laboratory. Those academic buildings are constructed in three different phases and around 750 student study in this school and the school is consisted of 19 classrooms (Figure 06).

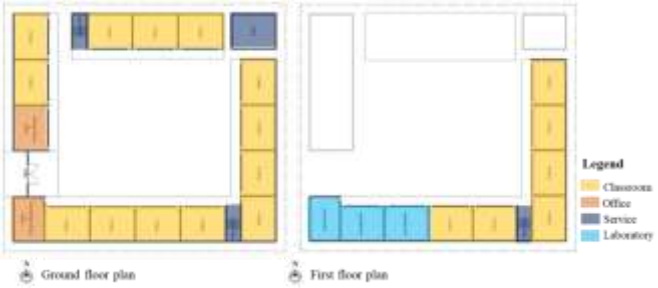


Figure 06: Ground floor plan and first floor plan [Author].

Three types of classroom are categorized based on window placement (Figure 07).

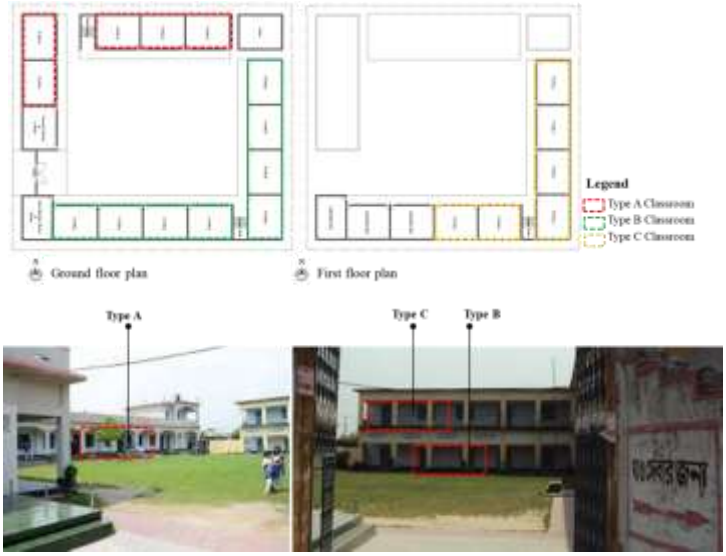


Figure 07: Classroom category [Author].

Type-A classroom has four windows in the outer façade and two windows in the corridor side, Type-B classroom has only two windows in outer façade and Type-C has two windows in the outer façade and one window in the corridor side (Figure 08). Approximately 40 students are accommodated in each classroom and total area of each class room is 825sft. Typical window section for every classroom is given below (Figure 09).

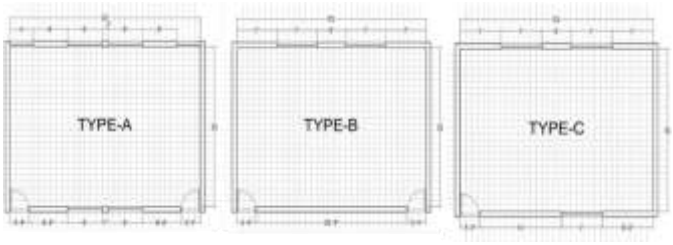


Figure 08: Category of classroom according to placement of window (Type- A, B and C) [Author].

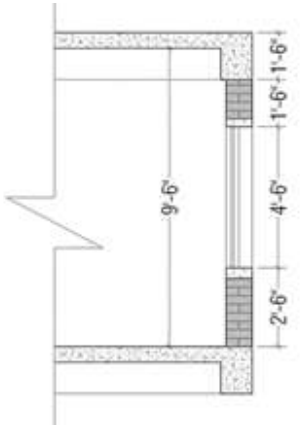


Figure 09: Typical window section [Author].

5. PROBLEM IDENTIFICATION

In order to identify the problems three steps are implemented: Direct survey, Feedback from teachers and Feedback from students. After identifying the problems, computer simulation is also used for justifying the observations.

5.1 DIRECT SURVEY

For identifying the luminous level, every reading table of each classroom are physically measured with Digital Light Lux Meter between 10am to 12pm on the month of June, 2019. It has been found that there are no table with luminous value below 100 lux and highest amount of table (24 nos) with luminous value more than 300 lux in Type-A class room which is the highest value among the three types of classroom (Figure 10).

Classroom Type	Luminous level (below 100 lux)	Luminous level (100 to 150 lux)	Luminous level (150 to 200 lux)	Luminous level (300 to more) lux)
Type A (Reading Table)	0	6	10	24
Type B (Reading Table)	0	16	8	16
Type C (Reading Table)	0	8	16	16

Figure 10: Luminous level in classrooms (Type- A, B and C) [Author].

5.2 TEACHERS OBSERVATION

Students of these three different types of classroom are observed based on the class performance, attentiveness and behavior pattern by the teachers of that school for one week. Then, they made a chart where Type- A classroom obtained highest value for performance which is 66% and Type-B classroom obtained 49% which is the lowest (Figure 11).

Classroom Type	Response in class (%)		
	Low	Moderate	High
Type A	12%	24%	66%
Type B	16%	35%	49%
Type C	6%	37%	57%

Figure 11: Response in classrooms (Type- A, B and C). [Author].

5.3 STUDENTS FEEDBACK

A questionnaire survey was conducted individually among the students of three types of classroom and the results are as follows: maximum students of Type-A told that they get the maximum daylight light on the other hand, Type-B gets minimum daylight and Type-C gets moderate daylight (Figure 12). Then students are reshuffled among the classrooms for a week and another survey was conducted on which classroom they prefer most. Most of the students prefer Type-A classroom, some prefer to remain in the same class and some of the student did not gave any comments (Figure 13).

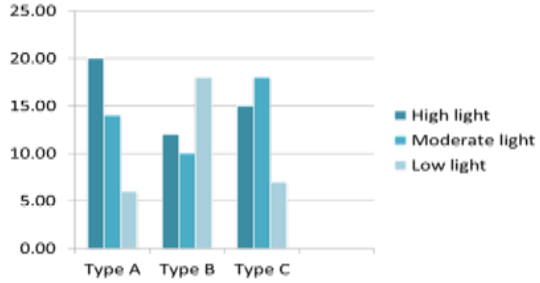


Figure 12: Daylight rating in classroom [Author].

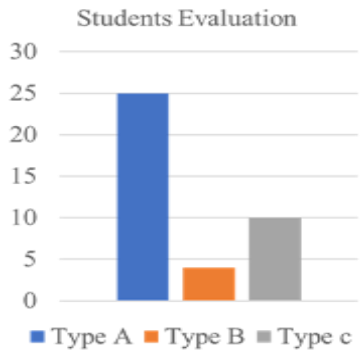


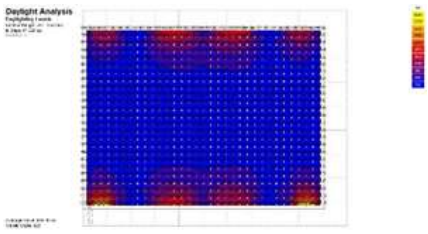
Figure 13: Classroom preference [Author].

5.4 SIMULATION STUDY

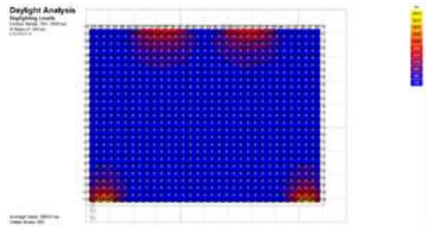
For the purpose of simulation study, the entire three classrooms were divided into 1feetX1feet grid and 825 visible nodes are found. Then the area was selected for generating of daylight levels at 2 feet above from floor level which is the top of the reading table. Daylight simulation was conducted by Autodesk Ecotect Analysis.

Room Dimesions: 33ft x 25 ft
Total Area: 825 sft
Clear Height: 9ft 6inch
Window Size: 5ft x 4ft 6 inch
Sill Level: 2ft 6inch
Work Plane Height: 2ft

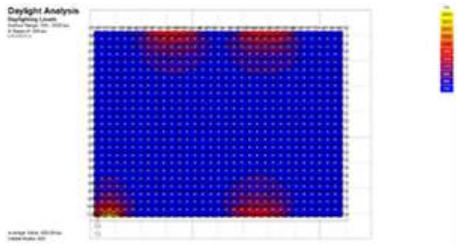
In type A, average illumination is 686.40 lux and 680 no. of points is high then 300 lux. In type B, average illumination is 399.61 lux and only 340 no. of points. In type C, average illumination is 429.29 lux and 550 no. points are higher than 300 lux (Figure 14).



Type-A



Type-B



Type-C

Figure 14: Simulation of three types classroom [Author].

6. RESULT DISCUSSION

From the survey among the students and teachers, it has been observed that type-A classroom is more desirable for maintaining better teaching environment and student behaviour pattern. Computer simulation also indicates the same statement.

To improve the responsiveness, attentiveness and overall behaviour of student's daylight is an essential factor. And for implementation of proper daylight, window configuration and placement are the key element. In the actual scenario from this school, Type-A classroom should be considered and Type-B, Type-C class room need to redesign for improving the performance of the students.

7. CONCLUSION

Daylight in classrooms has an essential effect on the learning environment. The careful introduction of daylight into educational buildings reduces operating costs, improves students' vision and perception, and contributes to students' health, comfort, and productivity. In general, classrooms should get as much daylight as possible and the study ensure that window must give in the corridor for penetrate daylight. This daylight not only improves student's physical and mental health but also reduce electricity use. Moreover, proper design solution should be followed while constructing the school buildings in different phase. So, Bangladesh government should take necessary steps to design a module for secondary school and ensure that everybody must follow the appropriate design module.

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