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Evaluation of Natural Daylight and Indoor Temperature Levels in Drawing Studios at Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt

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Abstract

This study evaluates the adequacy of the natural daylight and indoor thermal conditions in four Architectural drawing studios at Captain Elechi Amadi Polytechnic in Port Harcourt, Nigeria. Since visual and thermal comfort are crucial in educational spaces, especially for tasks that require high visual sharpness like manual Architectural drafting. This research aims to assess the current studio designs to determine if they actually meet the recommended standards. Over the period of ten consecutive working days, measurements of illuminance (lux) and temperature were taken at two spots in each studio: the center and 1.2 meters from the window, at 9:00 AM and 2:00 PM. The results showed that while the areas near the windows got close to the ideal 750 lux for detailed work, the central areas were lacking, with some readings dropping to just 42.04 lux. Additionally, temperature readings consistently went beyond the comfortable range of 20°C to 26°C for optimal thermal comfort, hitting an average high of 31.10°C. These issues can be attributed to factors such as limited window to floor area ratios, poor window orientations, and interior finishes with low reflectance. The study highlights the urgent need for Architectural improvements, such as enhanced natural lighting solutions and passive cooling strategies, to enhance the indoor environment in educational buildings located in tropical climates.

Keywords: daylight performance, architectural studios, LUX measurement, building design, thermal comfort, daylight, Nigeria

1. Introduction

1.1 Background

Natural daylight and thermal comfort play a crucial role in educational settings, significantly impacting students' health, productivity, and overall learning outcomes (Lamberti et al., 2021). In Architectural studios, where tasks require optimal visual focus, adequate lighting is vital to reduce eye strain and improve accuracy (Babalola et al., 2024; Ahmed et al, 2020). Daylight not only enhances visual comfort but also helps regulate circadian rhythms, which can influence students' sleep patterns and overall health in tropical regions like Port Harcourt, Nigeria, maintaining an ideal indoor environment can be quite challenging due to the high temperatures and humidity, which can worsen thermal discomfort and hinder effective learning (Munonye & Ji, 2020; Munonye 2020). When students experience thermal discomfort, it can lead to a drop in concentration, increased fatigue, and lower academic performance. To improve thermal comfort in these settings, it's crucial to implement passive design strategies, such as natural ventilation, proper building orientation, and using materials with suitable thermal properties. Despite the acknowledged significance of daylight and thermal comfort in educational settings, there's a noticeable lack of empirical data on these factors in Nigerian polytechnics. Most existing research has concentrated on primary and secondary schools, leaving a gap in our understanding of the environmental conditions in higher educational institutions, particularly in Architectural studios where the need for visual and thermal comfort is even greater. This study seeks to fill that gap by assessing the levels of natural daylight and indoor temperatures in the drawing studios at Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt, Nigeria.

1.2 Research Problem

Despite the acknowledgement of the importance of daylight and thermal comfort in educational spaces, there has been little empirical data or research assessing these factors in Nigerian higher institutions. Most existing studies have zeroed in on primary and secondary schools, which leaves a big gap in our understanding of the environment in higher education, especially in Drawing studios where the need for visual and thermal comfort is even more critical (Munonye & Ji, 2020; Munonye, 2020).

1.3 Research Objectives

This study will be carried out by;

- Evaluating how adequate natural daylight works in the drawing studios using LUX measurements.
- Assessing the indoor thermal conditions by recording temperature readings.
- Comparing the results with international standards like the CIBSE Lighting Guide 7 and ASHRAE Standard 55.

1.4 Scope & Limitations

The study examines four drawing studios located on the first floor of the Governing Council block at Captain Elechi Amadi Polytechnic. Each studio spans a floor area of 75 m², boasts a ceiling height of 3.3 meters, and features a total window area of 6.48 m². Measurements were taken at two different spots in each studio: first, right in the center, and second, at a distance of 1.2 meters from the window, during two time slots at 9:00 AM and 2:00 PM over a span of ten consecutive working days. Some limitations of the study include its focus on just one institution and the fact that it doesn't consider artificial lighting or ventilation systems in the analysis.

1.5 Significance

Theoretically, this study contributes to the body of knowledge on how indoor environmental quality affects educational buildings within the tropical climates. On a practical level, the results can guide Architects and policymakers in creating designs that boost natural light and thermal comfort in schools, ultimately leading to better student well-being and improved academic performance.

2. Literature Review

2.1 Daylight in Educational Spaces

Adequate natural light is very critical for both visual comfort and energy savings in educational buildings. The Chartered Institution of Building Services Engineers (CIBSE) recommends at least 750 lux of light for tasks that require detail, such as Architectural drafting (CIBSE, 2015). Several factors can affect daylight availability, such as the size and direction of windows, the type of glazing used, and how reflective the interior surfaces are (Babalola et al., 2024). Research indicates that using light-coloured finishes inside can help spread daylight more effectively by reflecting more light around the room (Salihu et al., 2024). Architects, engineers, and builders can achieve energy efficiency, cost savings, visual attractiveness, and solar radiation control in their building designs by integrating daylighting strategies. Daylighting systems offer a variety of advantages to building occupants, including enhanced indoor comfort and well-being (Arkar et al., 2023).

2.2 Thermal Comfort in Tropical Climates

Thermal comfort is defined as the state of mind that expresses satisfaction with the surrounding environment (ASHRAE, 2021). In tropical areas, maintaining that thermal comfort can be quite a challenge because of the high ambient temperatures and humidity levels. Studies show that occupants of naturally ventilated buildings in warm and humid climates can actually tolerate higher indoor temperatures, with comfort levels reaching up to 32.3°C (Munonye & Ji, 2020; Munonye, 2020). However, exposure to temperature above 30°C can lead to discomfort and cognitive performance (Lamberti et al., 2021).

2.3 Standards & Benchmarks

International standards lay out the guidelines for what constitutes acceptable indoor environmental conditions. For instance, ASHRAE Standard 55 outlines a comfortable temperature range of 20°C to 26°C for activities where people are mostly sitting (ASHRAE, 2021). While CIBSE Lighting Guide 7 suggests that a minimum brightness of 750 lux is necessary for tasks that require sharp visual focus (CIBSE, 2015). Additionally, EN 17037 highlights the significance of having access to natural daylight in buildings, promoting design approaches that enhance natural light while reducing glare and the risk of overheating (EN 17037, 2018).

3. Methodology

3.1 Study Area & Studio Description

The research was conducted at Captain Elechi Amadi Polytechnic, which is located in Port Harcourt, Rivers State, Nigeria. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria in the Tropical region of West Africa with the coordinates of 4.8472^{o}N and 6.9746^{o}E. and annual mean temperature of approximately 27^{0}c (Uko, 2013).

The four drawing studios that were evaluated are located on the first floor of the Governing Council block, each covering a floor area of 75 m^2, with a ceiling height of 3.3 meters and a total window area of 6.48 m^2. Studios 1, 3, and 4 feature cream coloured walls, while Studio 2 has beige walls. Each studio is equipped with three windows with two facing northeast and one facing southwest. The orientation of the building is approximately Nort East / South West.

Plate 1. Perspective view of the Governing council Block at Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt

Source: Researchers field work, 2025.

3.2 Data Collection

Measurement of illuminance in lux and temperature were taken using a split type LUX meter and a digital thermometer. The data collection took place at two spots in each studio; the center and 1.2 meters from the window, at 9:00 AM and 2:00 PM over a period of ten consecutive working days, from February 24th to March 7th, 2025. All readings were recorded during active studio sessions with students present.

Plate 2. Picture showing the split type lux meter used to take readings in the studios

3.3 Data Analysis

The data collected were analyzed using descriptive statistical tools to establish the average levels of illuminance and temperature. The figures were compared with the international standards to evaluate compliance. In addition, the differences between studios and measurement positions were determined to identify factors affecting daylight and thermal performance.

4. Results

4.1 Daylight Levels (LUX Measurements)

Table 1. Average Illuminance Levels (Lux)

Position/time	**Center at 9am**	**Near window at 9am**	**Center at 2pm**	**Near window at 2pm**
STUDIOS	**Lux 1**	**Lux 2**	**Lux 3**	**Lux 4**
DRAWING STUDIO 1	52.24	671.38	55.40	708.43
DRAWING STUDIO 2	42.04	539.79	46.97	691.43
DRAWING STUDIO 3	55.20	790.00	60.90	851.28
DRAWING STUDIO 4	54.21	811.71	61.04	846.33

Source: Researchers field work, 2025.

Table 1 presents the average illuminance levels recorded in each studio for ten consecutive working days between 24th February and 7th March, 2025.

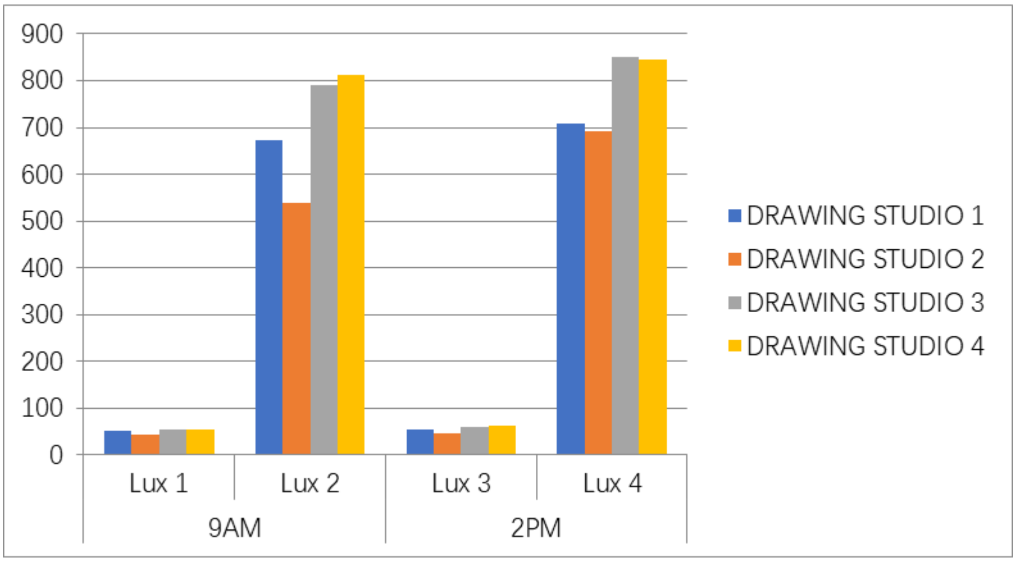

Figure 1. Descriptive chart illustrating the average daylight levels in each studio

Figure 1 illustrates the average daylight pattern in the four studios indicating the average illuminance levels at the center of the studio by 9am and 2pm below 100lux far below the recommended 750lux for drawing studios and the values near the windows at same times ranging between 500lux and 850lux.

4.2 Thermal Comfort (Temperature Readings)

Table 2. Average Temperature Readings (°C)

Position/time	**Center at 9am**	**Near window at 9am**	**Center at 2pm**	**Near window at 2pm**
STUDIOS	**T1 (°C)**	**T2 (°C)**	**T3 (°C)**	**T4(°C)**
DRAWING STUDIO 1	30.14	30.20	30.69	31.00
DRAWING STUDIO 2	29.48	30.15	30.72	31.09
DRAWING STUDIO 3	30.41	30.54	31.02	31.10
DRAWING STUDIO 4	29.96	30.31	31.00	31.05

Source: Researchers field work, 2025.

Table 2 presents the average temperature readings in each studio.

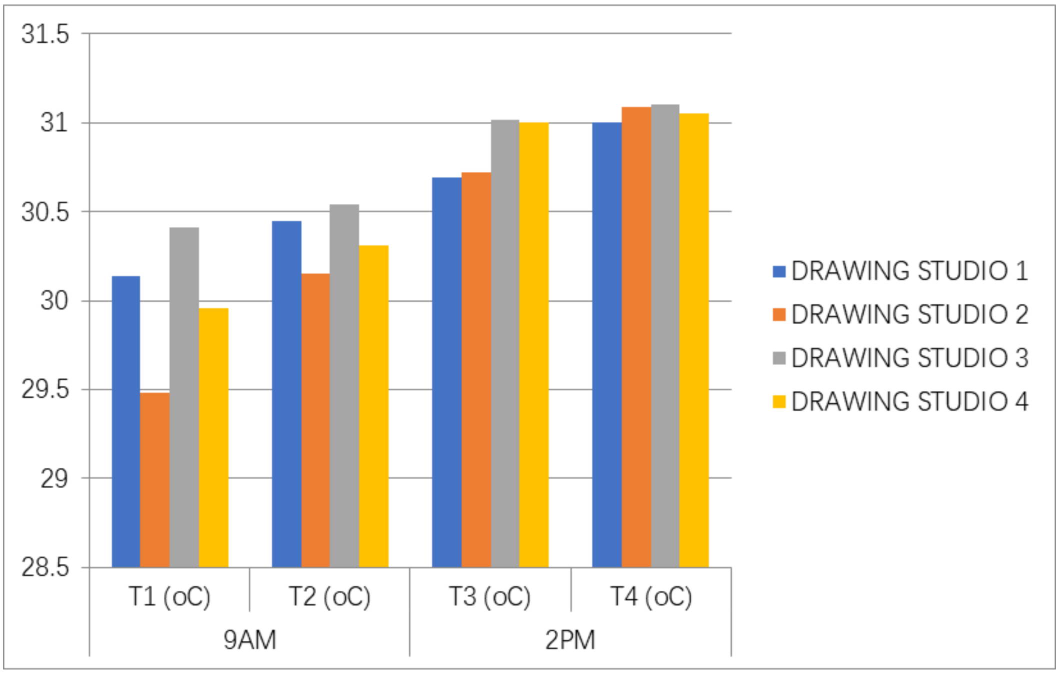

Figure 2. Descriptive chart illustrating the average Temperature levels in each studio

The data shows that all studios consistently recorded temperatures that exceeded the optimal thermal comfort range of 20°C to 26°C, as recommended by ASHRAE Standard 55 (ASHRAE, 2021). The maximum temperatures were recorded at 2 PM near the windows, with Studio 3 recording up to 31.10°C. These elevated temperature readings suggest that the passive cooling strategies in place are inadequate and underscore the challenges of achieving thermal comfort in naturally ventilated buildings, especially in tropical climates.

4.3 Comparative Analysis

A comparative analysis of the studios shows that Studios 3 and 4, with their cream coloured walls, had brighter daylighting near the windows, suggesting better daylight penetration. On the other hand, Studio 2, which features beige walls, consistently had the dimmest lighting, indicating that wall colour plays a crucial role on daylight distribution in a room. The temperature differences between the studios were minimal, suggesting that features such as window orientation and size have a greater impact on the thermal condition of an environment than the colour of the walls.

5. Discussion

5.1 Daylight Adequacy

The findings of the study highlight a significant deficiency in daylight at the center of all studios, with daylight levels measuring significantly falling below the recommended 750 lux for tasks that require sharp visual clarity (CIBSE, 2015). This shortfall can be linked to the limited window to floor area ratio of about 8.6%, inappropriate window orientations, and the room depths that restrict effective daylight penetration. Interestingly, the brighter light levels near the windows in Studios 3 and 4 indicate that using lighter wall colours can improve daylight distribution. This aligns with earlier research that suggests interior finishes play a crucial role in daylight performance (Salihu et al., 2024).

5.2 Thermal Performance

The consistently high indoor temperatures in all studios, which go beyond the optimal comfort range, emphasize the challenges of keeping thermal conditions pleasant in naturally ventilated buildings located in tropical climates. Several factors can be responsible for this increased temperature values; such as insufficient cross ventilation, lack of adequate shading devices, and the use of materials with low thermal mass. These observations are in line with research that highlights the importance of passive cooling strategies for educational buildings in warm and humid areas (Munonye & Ji, 2021).

5.3 Design Implications

To boost daylight and thermal performance in the studios, here are a few Architectural Design interventions to consider:

- Increase Window to Floor Area Ratio: enlarging window sizes or adding more openings, can enhance natural light penetration and natural ventilation.
- Optimize Window Orientation: Adjusting the direction of your windows to capture the best daylight while keeping heat gain in check can significantly improve the indoor environment.
- Utilize Light-Coloured Interior Finishes: Using lighter colours for walls and ceilings can help improve daylight distribution evenly throughout the space.
- Incorporate Shading Devices: Installing external shading features like louvers or overhangs can assist to cut down on solar heat gain and reduce glare.
- Enhance Natural Ventilation: Designing for effective cross ventilation with strategically placed openings can support passive cooling efforts.

6. Conclusion & Recommendations

6.1 Summary of Findings

The comprehensive assessment of natural light and indoor temperature in the four Architectural drawing studios at Captain Elechi Amadi Polytechnic shows some remarkable shortcomings in both aspects. The central areas in each studio did not meet the recommended brightness levels needed for detailed work, and the indoor temperatures were consistently higher than optimal thermal comfort ranges.

Daylight Performance

The study reveals that all the studios fall short of the recommended standards for tasks that require high visual sharpness. Particularly, the central areas of the studios showed average illuminance levels between 42.04 lux and 61.04 lux, which is significantly lower than the 750 lux benchmark set by the Chartered Institution of Building Services Engineers (CIBSE) for detailed tasks like Architectural drafting (CIBSE, 2015). Notably, the spots near the windows had higher illuminance levels, ranging from 539.79 lux to 851.28 lux, but they still fall below the outdoor average of 41,000 lux. This variation highlights the inadequate natural light penetration in the inner parts of the studios, likely due to the limited window-to-floor area ratio of about 8.6% and less than ideal window orientations. These results are consistent with earlier research that points out the challenges in achieving adequate daylighting in educational spaces located in tropical climates, where high external brightness doesn’t always necessarily translate to adequate indoor lighting due to Architectural limitations (Salihu et al., 2024).

Thermal Comfort

Temperature readings in all the studios consistently went beyond the optimal comfort range of 20°C to 26°C, as outlined by ASHRAE Standard 55 (ASHRAE, 2021). At 2 PM, measurements taken near the windows hit an average high of 31.10°C, which clearly shows that there’s significant thermal discomfort during the busiest and most productive hours. The minimal difference in temperatures between the center of the studios and the areas close to the windows points to a real lack of effective cross-ventilation and proper thermal insulation. These challenges are made worse by the building’s design, which lacks shading devices and uses materials with low thermal mass, leading to heat retention. Similar research in Nigerian educational settings has highlighted these same challenges, emphasizing the urgent need for design improvements to enhance thermal comfort in naturally ventilated buildings (Munonye & Ji, 2021).

Influence of Interior Finishes

The study also noted that the studios with cream coloured walls (Studios 1, 3, and 4) had slightly higher levels of illuminance compared to Studio 2, which features beige walls. This indicates that lighter interior finishes might improve the way natural light spreads throughout a space, a conclusion that aligns with previous research on how surface reflectance affects indoor lighting conditions (Salihu et al., 2024).

Comparative Analysis

Among the studios, Studio 3 stood out with relatively better performance in terms of daylighting and thermal conditions, likely due to the choice of interior finishes. However, all studios failed to meet the required standards for both illuminance and thermal comfort, revealing some fundamental design flaws. These challenges not only hinder the studios’ functionality for detailed architectural work but also affect the well being and productivity of the occupants. In summary, the findings highlight an urgent need for Architectural interventions to enhance natural lighting and thermal comfort in educational environments, especially in tropical climates. To effectively tackle these challenges, strategies such as increasing the window-to-floor area ratios, optimizing window placements, adding shading devices, and using materials with better thermal mass should definitely be considered.

6.2 Recommendations

To tackle these challenges, the following strategies are recommended:

- Architectural interventions: Adopt design modifications to improve natural light penetration and natural ventilation such as enlarging window sizes, optimizing their placement, and adding shading devices.
- Policy Recommendations: Create and enforce building regulations and standards that focus on improving indoor environmental quality in educational facilities, especially in tropical regions.

This comprehensive assessment emphasizes the urgent need for design changes that improve natural light and thermal comfort in schools located in tropical climates. By putting the suggested strategies into action, we can greatly enhance the learning atmosphere, which in turn will promote improved academic performance and overall student well-being.

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Appendix

Appendix A: Detailed Measurement Data

Table A1. STUDIO 1 Daily Average Illuminance Levels (Lux) and Temperature Readings (°C)

DRAWING STUDIO 1									
L1 and L3 = Lux level at the center of studio **L2 and L4 = Lux level at 1.2meter away from window**									
T1 and T3 = temperature at the center of studio **T2 and T4 = Temperature at 1.2 meter away from the window**									
DAY	**DATES**	**Daylight level in lux**				**Temperature in degree Celsius**			
		9AM		**2PM**		**9AM**		**2PM**	
		Lux 1	**Lux 2**	**Lux 3**	**Lux 4**	**T1**	**T2**	**T3**	**T4**
1	24/2/2025	56.0	731.6	63.7	724.5	30.7	30.3	31.3	31.8
2	25/2/2025	59.5	613.7	56.4	701.6	30.5	30.5	30.3	30.5
3	26/2/2025	50.4	601.6	50.0	677.7	30.6	30.1	29.1	30.1
4	27/2/2025	55.0	638.8	71.0	830.4	30.0	30.0	29.5	29.7
5	28/2/2025	52.3	619.2	46.1	609.1	29.3	29.4	29.5	29.7
6	3/3/2025	50.4	748.6	44.3	669.3	28.6	28.9	31.3	32.0
7	4/3/2025	58.0	855.3	58.1	695.7	29.9	30.1	31.2	31.7
8	5/3/2025	41.9	590.8	56.0	698.0	31.2	31.1	31.7	30.9
9	6/3/2025	46.6	686.5	58.9	787,0	30.2	31.1	31.5	31.7
10	7/3/2025	52.3	627.7	49.5	691.1	30.4	30.5	31.5	31.9
TOTAL		522.4	6713.8	554	7084.3	301.4	302	306.9	310
AVERAGE		52.24	671.38	55.4	708.43	30.14	30.2	30.69	31

(Researchers field work, 2025)

Table A2. STUDIO 2 Daily Average Illuminance Levels (Lux) and Temperature Readings (°C)

DRAWING STUDIO 2									
L1 and L3 = Lux level at the center of studio. **L2 and L4 = Lux level at 1.2meter away from window**									
T1 and T3 = temperature at the center of studio **T2 and T4 = Temperature at 1.2 meter away from the window**									
DAY	**DATES**	**Daylight level in lux**				**Temperature in degree Celsius**			
		9AM		**2PM**		**9AM**		**2PM**	
		Lux 1	**Lux 2**	**Lux 3**	**Lux 4**	**T1**	**T2**	**T3**	**T4**
1	24/2/2025	40.8	569.1	56.1	733.5	30.2	30.2	31.3	31.9
2	25/2/2025	44.7	649.8	46.0	691.7	30.4	30.5	30.6	30.7
3	26/2/2025	46.1	698.1	49.7	801.3	29.5	30.3	30.2	30.2
4	27/2/2025	30.0	470.3	33.2	548.7	28.2	28.5	28.3	28.4
5	28/2/2025	59.0	527.4	64.7	538.2	29.1	30.1	28.6	29.1
6	3/3/2025	43.3	537.8	51.1	773.4	28.4	29.9	31.8	32.1
7	4/3/2025	36.5	443.4	38.6	575.5	27.8	29.0	31.6	32.2
8	5/3/2025	34.8	431.7	43.6	745.8	31.1	31.6	32.1	32.7

9	6/3/2025	48.5	645.6	38.8	829.6	29.9	31.1	31.4	31.8
10	7/3/2025	36.7	424.8	48.1	676.6	30.2	30.3	31.3	31.8
TOTAL		420.4	5397.9	469.7	6914.3	294.8	301.5	307.2	310.9
AVERAGE		42.04	539.79	46.97	691.43	29.48	30.15	30.72	31.09

(Researchers field work, 2025)

Table A3. STUDIO 3 Daily Average Illuminance Levels (Lux) and Temperature Readings (°C)

DRAWING STUDIO 3									
L1 and L3 = Lux level at the center of studio **L2 and L4 = Lux level at 1.2meter away from window**									
T1 and T3 = temperature at the center of studio **T2 and T4 = Temperature at 1.2 meter away from the window**									
DAY	**DATES**	**Daylight level in lux**				**Temperature in degree Celsius**			
		9AM		**2PM**		**9AM**		**2PM**	
		Lux 1	**Lux 2**	**Lux 3**	**Lux 4**	**T1**	**T2**	**T3**	**T4**
1	24/2/2025	55.2	723.2	59.3	881.3	31.1	31.2	31.3	31.2
2	25/2/2025	57.5	723.1	57.3	778.6	30.8	30.5	30.1	31.1
3	26/2/2025	58.5	772.1	59.4	779.3	30.6	30.9	30.7	31.1
4	27/2/2025	59.0	864.1	70.1	785.8	31.7	30.1	29.5	29.4
5	28/2/2025	49.3	758.7	50.4	876.9	29.3	29.4	29.1	29.2
6	3/3/2025	50.4	781.6	59.6	878.9	29.6	29.9	32.2	32.0
7	4/3/2025	58.1	878.3	69.3	897.6	30.0	30.8	32.2	32.7
8	5/3/2025	56.7	867.9	69.8	885.1	30.2	31.2	33.3	32.9
9	6/3/2025	56.1	778.1	58.5	877.3	30.2	31.1	30.4	30.1
10	7/3/2025	51.2	752.9	55.3	872.1	30.6	30.3	31.4	31.3
TOTAL		552	7900	609	8512.8	304.1	305.4	310.2	311
AVERAGE		55.2	790	60.9	851.28	30.41	30.54	31.02	31.1

(Researchers field work, 2025)

Table A4. STUDIO 4 Daily Average Illuminance Levels (Lux) and Temperature Readings (°C)

DRAWING STUDIO 4									
L1 and L3 = Lux level at the center of studio **L2 and L4 = Lux level at 1.2meter away from window**									
T1 and T3 = temperature at the center of studio **T2 and T4 = Temperature at 1.2 meter away from the window**									
DAY	**DATES**	**Daylight level in lux**				**Temperature in degree Celsius**			
		9AM		**2PM**		**9AM**		**2PM**	
		Lux 1	**Lux 2**	**Lux 3**	**Lux 4**	**T1**	**T2**	**T3**	**T4**
1	24/2/2025	55.0	861.9	60.1	881.1	30.1	30.2	32.0	31.9
2	25/2/2025	55.5	857.3	60.9	878.0	30.1	30.9	30.7	30.9
3	26/2/2025	52.8	759.8	60.1	848.1	30.0	30.1	30.0	31.2
4	27/2/2025	59.8	857.9	69.2	881.3	31.0	30.8	29.1	29.7

5	28/2/2025	52.7	753.1	59.2	794.1	28.1	30.1	29.0	29.8
6	3/3/2025	49.9	744.1	59.3	770.3	29.6	29.9	31.3	28.0
7	4/3/2025	48.7	731.3	55.1	788.5	28.9	29.1	34.5	34.9
8	5/3/2025	56.9	873.3	59.2	890.2	30.2	30.2	30.1	29.2
9	6/3/2025	54.6	827.3	65.2	842.1	31.2	31.2	31.3	32.3
10	7/3/2025	56.2	851.1	62.1	889.7	30.4	30.6	32.0	32.6
TOTAL		542.1	8117.1	610.4	8463.3	299.6	303.1	310	310.5
AVERAGE		54.21	811.71	61.04	846.33	29.96	30.31	31	31.05

(Researchers field work, 2025)