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# Compliance of Classroom and Library Illuminance with Indonesian National Standard in An Elementary School

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## ABSTRACT

This study evaluates whether the illuminance of one elementary school classroom and one library satisfies SNI (Standar Nasional Indonesia) 6197:2020. Field data from a lux-meter workbook and layout drawings were analyzed using a descriptive-comparative approach. The classroom (9 m × 7 m) was measured at 48 points arranged on a 6 × 8 grid, while the library (6 m × 7 m) was measured at 30 points on a 6 × 5 grid, with measurements conducted in six 20-minute intervals from 11:00 to 13:00. The classroom achieved a mean illuminance of 510.12 lux and the library 377.91 lux, both exceeding the SNI standard of 350 lux. However, the median illuminance values remained below the standard at 283.85 lux and 287.60 lux, respectively. In addition, the uniformity ratios were low (0.05 in the classroom and 0.28 in the library), and only 41.67% of classroom points and 36.67% of library points met the required illuminance level after temporal averaging. The classroom showed a strong concentration of brightness in the rear zone with a maximum value of 4503 lux, while the library exhibited uneven lighting distribution, particularly weaker illumination near row F. These results indicate that compliance based solely on average illuminance is insufficient to represent spatial lighting quality. Therefore, lighting improvements should focus on distribution balance, daylight control, and optimization of lighting zones rather than merely increasing lamp output.

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## 1. INTRODUCTION

Lighting quality is a critical environmental factor in school buildings because reading, writing, observing the board, and browsing printed materials all depend on stable visual conditions. In Indonesia, the basic benchmark for indoor lighting performance is Standar Nasional Indonesia (SNI) 6197:2020. According to (Badan Standardisasi Nasional, 2020), the recommended minimum average illuminance is 350 lux for classrooms and library reading rooms. For elementary school facilities, this benchmark is important not only for energy efficiency but also for learning effectiveness, visual comfort, and fatigue reduction during routine activities. Previous studies consistently show that lighting performance in educational buildings should not be interpreted only from lamp quantity or installed power. Studies on teaching buildings and school lighting systems likewise indicate that performance depends on the interaction between daylight, electric lighting configuration, and operational strategy rather than nominal capacity alone (Awang et al., 2020; Miranda et al., 2024). Classroom studies have highlighted the roles of daylight penetration, façade design, surface reflectance, luminaire layout, and glare control in shaping usable illuminance and comfort (Aghajari & Chen, 2025; Costanzo et al., 2017; Hidayat, 2022; Lo Verso et al., 2023; Luo et al., 2024; Michael & Heracleous, 2017). Other reviews also emphasize that a healthy visual environment requires adequate brightness, low contrast stress, and spatial continuity instead of isolated bright patches (Soares et al., 2017; Šujanová et al., 2019; Tunahan et al., 2022).

Library rooms present a related but slightly different challenge because most activities involve prolonged visual tasks such as reading, selecting books, and focused seat-based study. Research on library lighting has shown that daylight can improve room quality, but excessive direct penetration can also create strong hotspots, non-uniformity, and localized glare, while edge zones may remain underlit (Akanmu et al., 2021; Adzanti & Nurwidyaningrum, 2025; Fanpu et al., 2024; Voronkova & Podlasek, 2024; Zhang, 2019). This means that a room may appear compliant when judged only by its mean lux value while still performing poorly from the perspective of visual distribution. Although research on lighting systems in educational buildings has increased in recent years, studies comparing illuminance conditions between elementary school classrooms and libraries are still limited, especially those using direct field measurements within the same observation timeframe. Previous research conducted by (Iqbal et al., 2025) and (Sugiharti et al., 2025) highlighted the importance of data-driven evaluation and practical recommendations in building engineering studies. Nevertheless, investigations focusing on illuminance distribution patterns and compliance with lighting standards across different educational spaces remain insufficiently explored.

In response to this research gap, this study evaluates the illuminance performance of an elementary school classroom and library using the Indonesian National Standard (SNI) as the reference benchmark. The assessment emphasizes three main aspects: (1) compliance with the minimum illuminance standard of 350 lux based on average values, (2) the spatial distribution of lighting across measurement points, and (3) changes in illuminance during midday observation periods. The results of this study are expected to contribute practical insights for optimizing lighting quality and visual comfort in educational environments.

## 2. METHOD

This study used a quantitative descriptive-comparative approach based on field measurement data. Two rooms in the same elementary school setting were analyzed: one classroom and one library. The uploaded layout identifies the classroom as Ruang Kelas SD and the second room as Perpustakaan. According to the layout dimensions, the classroom measured 9 m × 7 m and the library measured 6 m × 7 m. Measurements were recorded in six 20-minute intervals from 11:00 to 13:00. In the reanalysis, each recorded point was treated as a horizontal work-plane illuminance reading consistent with the grid layout and the lux-meter workbook structure. The uploaded dataset did not include a separate laboratory recalibration certificate; therefore, the instrument is reported as a field-use lux meter whose readings were assumed to represent normal operating conditions during the observation session. The measurement period was kept within one continuous midday window so that both rooms were assessed under comparable daylight conditions. The measurement grid layout for both rooms is illustrated in **Figure 1**. The figure presents two floor plans: the classroom (Ruang Kelas SD) and the library (Perpustakaan), each divided into measurement points based on a one-meter interval grid. This grid system was used to record horizontal work-plane illuminance at six 20-minute intervals between 11:00 and 13:00.

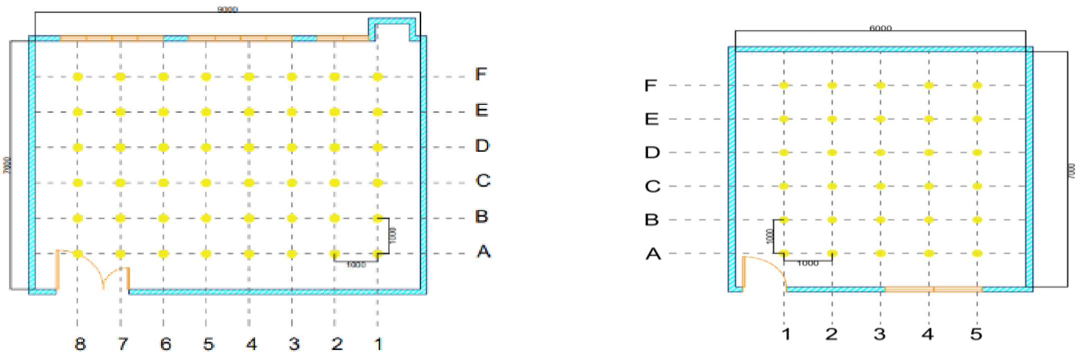


**Figure 1**. Measurement Grids of The Classroom (left) and Library (right).

Based on **Figure 1**, the classroom floor plan has grid dimensions of 7×8 meters, which is depicted using rows A–F and columns 1–8. In contrast, the library floor plan measures 5×6 meters, represented by rows A–F and columns 1–5. The figure also shows that the number of sample points was calculated based on a 1-meter measurement interval, resulting in 48 measurement points for the classroom and 30 measurement points for the library. These grid distributions illustrate the coverage of the work area in each room, allowing for a comparative analysis of illuminance levels under similar daylight conditions.

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The measurement configuration and room characteristics for both spaces are summarized in **Table 1**. The table presents key parameters, including room size, grid layout, number of valid measurement points, observation time, and the SNI illuminance target (350 lux) used as the compliance benchmark for both the classroom and the library.

**Table 1.** Room Characteristics and Measurement Configuration

| Space | Room size | Grid | Valid points | Measurement time | SNI target |
|---|---|---|---|---|---|
| Classroom | 9 m × 7 m | A-F × 1-8 | 48 | 11:00-13:00 (20-min interval) | 350 lux |
| Library | 6 m × 7 m | A-F × 1-5 | 30 | 11:00-13:00 (20-min interval) | 350 lux |

Based on **Table 1,** the classroom has a larger floor area (9 m × 7 m) than the library (6 m × 7 m), resulting in a higher number of valid measurement points (48 points in the classroom and 30 points in the library). Both rooms were observed within the same measurement period (11:00–13:00 with six 20-minute intervals) and evaluated using the same SNI illuminance benchmark of 350 lux. This configuration enables a direct comparative analysis of illuminance performance under identical temporal conditions despite differences in room size and grid density. The illuminance measurement data were analyzed based on room type, measurement point, and observation time. Six indicators were used in the analysis. The first is average illuminance (Eavg), representing the arithmetic mean of all measured points within a room. The second is median illuminance, which was used to identify skewness caused by excessively bright points. The third and fourth indicators are the minimum and maximum illuminance values, which describe the spread of the data distribution. The fifth indicator is uniformity ($U_0$), calculated using the ratio between minimum illuminance and average illuminance. The sixth indicator is compliance level, evaluated based on both the room average and the percentage of averaged grid points that achieved at least 350 lux. The average illuminance and uniformity values were calculated using the following equations.

$$Eavg = \Sigma Ei / n$$

$$U0 = Emin / Eavg$$

Time-based averages were also calculated for each 20-minute interval to identify dominant brightness patterns during the observation period. For spatial analysis, the six observations at each measurement point were first averaged and then visualized as heatmaps. This approach allows the heatmaps to represent the dominant lighting characteristics of each room rather than conditions at a single observation time. To support interpretation, the study presents room configuration data, overall performance comparisons, time-based analysis, and spatial heatmap visualizations.

## 3. RESULT AND DISCUSSION

This section presents the overall illuminance results, spatial distribution, temporal variation, and a discussion of practical implications based on the measurement data.

### 3.1 Evaluation of Illuminance Distribution Against SNI Standards

The initial evaluation of lighting performance was conducted by comparing the measured illuminance values in each room with the minimum requirement specified in SNI 6197:2020, namely 350 lux (Badan Standardisasi Nasional, 2020). Based on the average illuminance values, both rooms fulfilled the recommended standard. The classroom recorded an average illuminance of 510.12 lux, while the library achieved 377.91 lux, indicating that both spaces exceeded the minimum requirement. Although these results suggest acceptable lighting conditions at the room scale, further statistical evaluation is necessary to examine whether the illuminance was distributed evenly across the measured area. **Table 2** presents a statistical comparison of illuminance performance in the classroom and library. Several indicators were analyzed, including average illuminance (Eavg), minimum illuminance (Emin), maximum illuminance (Emax), uniformity ratio ($U_0$), compliance status, and deviation from the 350 lux benchmark. These indicators were used to evaluate not only the adequacy of lighting levels but also the consistency of illuminance distribution within each room.

**Table 2**. Overall Illuminance Performance Compared with The 350 Lux Benchmark.

| Space | Eavg (lux) | Emin (lux) | Emax (lux) | U0 = Emin/Eavg | Compliance status | Difference from SNI |
|---|---|---|---|---|---|---|
| Classroom | 510.12 | 26.60 | 4503.00 | 0.05 | Compliant on average | +160.12 lux |
| Library | 377.91 | 105.80 | 1210.50 | 0.28 | Compliant on average | +27.91 lux |

The results in Table 2 indicate that compliance with the SNI standard based solely on average illuminance does not necessarily reflect good lighting quality throughout the entire room. Although the classroom achieved the highest average illuminance, its uniformity ratio was extremely low (0.05), accompanied by a minimum illuminance of only 26.60 lux. This finding indicates the presence of highly uneven lighting distribution, where certain areas were excessively bright while other areas remained inadequately illuminated. A similar pattern was observed in the library, which demonstrated a better uniformity ratio than the classroom but still showed median illuminance values below the recommended standard.

The distribution analysis further revealed that only a limited number of measurement points satisfied the 350 lux requirement. In the classroom, only 20 out of 48 points reached the target value, while the library achieved compliance at 11 out of 30 points. These findings suggest that high average illuminance values were strongly influenced by localized bright zones rather than by consistently adequate lighting conditions across the entire work plane. Consequently, the use of arithmetic mean alone may lead to an overestimation of actual lighting performance, particularly in spaces with strong illuminance contrasts. To maintain analytical consistency, all statistical calculations in this study were recalculated directly from the raw measurement dataset rather than adopting automated spreadsheet summaries (Awang et al., 2020).

### 3.2 Analysis of Spatial Lighting Patterns

Lighting quality in educational spaces is influenced not only by average illuminance values but also by the consistency of light distribution throughout the room. Uneven lighting conditions may create excessive brightness contrasts between areas, potentially reducing visual comfort and increasing visual fatigue during learning activities (Voronkova & Podlasek, 2024). Therefore, spatial illuminance analysis is necessary to evaluate whether lighting conditions are distributed adequately across the entire observation area rather than concentrated at specific points only. This subsection examines the spatial distribution of illuminance in the classroom and library using measurement-point data arranged on the observation grid described in **Table 1**. The analysis was supported by heatmap visualization to identify dominant bright zones, underlit areas, and general lighting distribution patterns within each room.

**Figure 2** illustrates the spatial illuminance distribution in the classroom based on the average lux value recorded at each measurement point. The visualization reveals substantial variation in lighting intensity across the classroom area, indicating poor illuminance uniformity. High illuminance concentrations were primarily observed in rows E and F, particularly at points F4, F5, F7, and F8. Point F4 recorded the highest average illuminance value at 2165.83 lux, followed by F7 (2010.08 lux) and F8 (1632.82 lux). In contrast, several points located in rows A and B remained below 250 lux, with values ranging approximately between 118 and 225 lux.

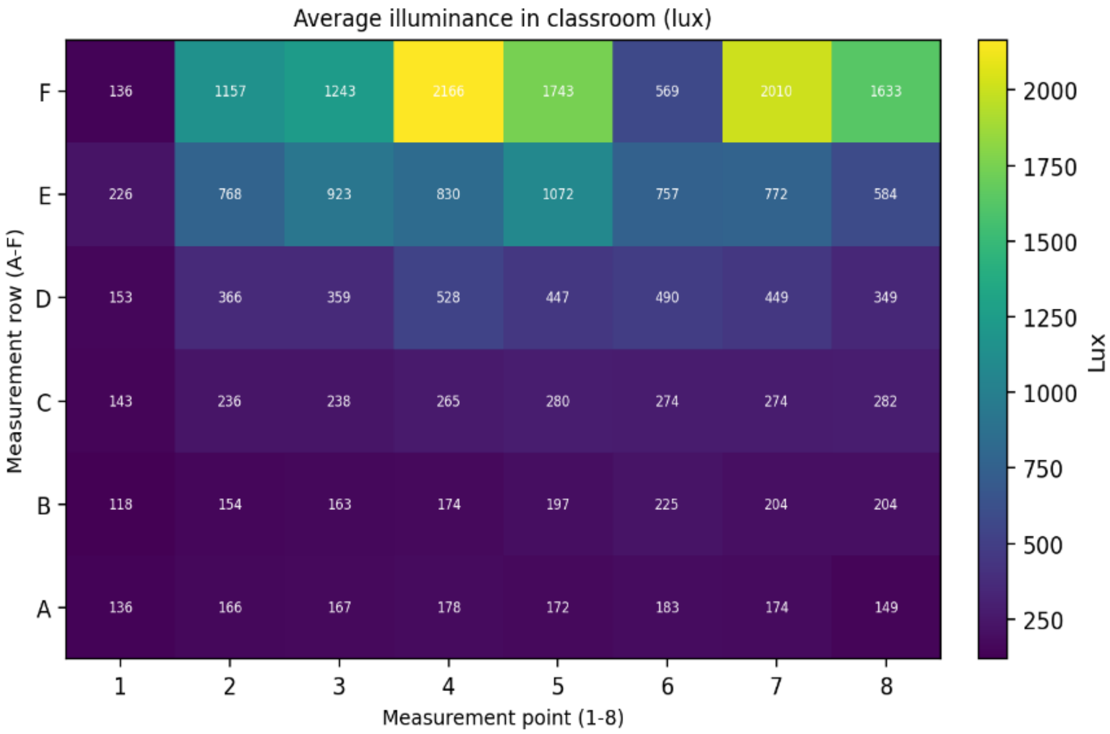


**Figure 2.** Average Illuminance Heatmap of The Classroom

The spatial pattern shown in Figure 2 demonstrates that classroom lighting was highly concentrated in several localized zones rather than distributed evenly across the learning area. Although the overall room average exceeded the SNI standard, the excessive brightness at a limited number of points disproportionately increased the mean illuminance value. Consequently, substantial portions of the classroom remained underlit and potentially less comfortable for visual activities. A similar spatial evaluation was conducted for the library environment, as presented in Figure 3. The heatmap visualizes the average illuminance value at each measurement point across the 30-point observation grid. Compared with the classroom, the library exhibited a more moderate lighting gradient; however, illuminance distribution remained uneven across several areas.

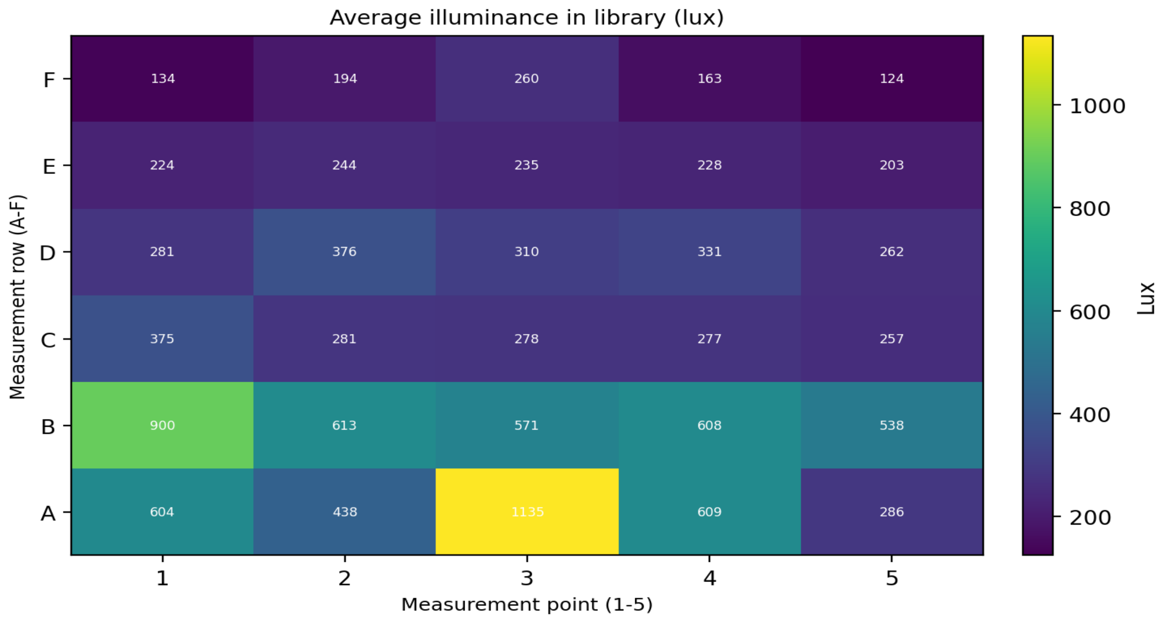


**Figure 3**. Average Illuminance Heatmap of The Library

The brightest zone in the library was observed at point A3 with an average illuminance of 1135.13 lux, followed by several adjacent points located in row A and row B. Conversely, the lowest illuminance value was identified at point F5 with only 123.85 lux, while multiple points in rows E and F also remained below 250 lux. These findings indicate that the upper and central areas of the library received substantially greater lighting exposure compared with the lower sections of the room. As a result, although the average illuminance value slightly exceeded the SNI benchmark, the lighting distribution throughout the library was still spatially inconsistent. Overall, the spatial analysis confirms that average illuminance alone is insufficient to represent lighting quality comprehensively. Both rooms demonstrated noticeable disparities between brightly illuminated zones and darker areas, emphasizing the importance of spatial uniformity in evaluating visual comfort within educational facilities.

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### 3.3 Temporal Variation

To examine how illuminance levels varied throughout the observation period, **Table 3** presents the time-based average illuminance for both rooms across six 20-minute intervals from 11:00 to 13:00. The table includes the average lux value for the classroom and library in each interval, the difference between the two rooms, and the compliance status of each room relative to the SNI 350 lux benchmark. This temporal breakdown allows for a direct comparison of how each room performed at different times of the day.

**Table 3**. Time-based Average Illuminance in Both Rooms

| Time interval | Classroom Eavg (lux) | Library Eavg (lux) | Difference (Classroom-Library) | Classroom status | Library status |
|---|---|---|---|---|---|
| 11:00-11:20 | 213.88 | 359.76 | -145.89 | Below standard | Above standard |
| 11:21-11:40 | 333.99 | 382.91 | -48.92 | Below standard | Above standard |
| 11:41-12:00 | 553.43 | 411.93 | +141.49 | Above standard | Above standard |
| 12:01-12:20 | 666.00 | 396.29 | +269.72 | Above standard | Above standard |
| 12:21-12:40 | 657.44 | 370.69 | +286.75 | Above standard | Above standard |
| 12:41-13:00 | 636.01 | 345.90 | +290.11 | Above standard | Below standard |

Based on **Table 3**, the two rooms exhibited distinctly different temporal patterns. The classroom started below the SNI standard during the first two intervals (213.88 lux and 333.99 lux, respectively), then rose sharply above 350 lux from 11:41 onward, peaking at 666.00 lux during 12:01-12:20. In contrast, the library showed a more stable pattern, remaining above the standard during the first five intervals and reaching its highest average of 411.93 lux between 11:41-12:00. However, the library dropped slightly below the benchmark (345.90 lux) during the final interval of 12:41-13:00. **Table 3** also reveals that the difference between the two rooms widened over time, from -145.89 lux (library brighter) in the first interval to +290.11 lux (classroom brighter) in the last interval. This indicates that the classroom was more sensitive to changing daylight conditions, while the library maintained relatively consistent illuminance levels throughout the midday period.

The temporal trends summarized in **Table 3** are visualized graphically in **Figure 4.** The figure presents a line chart comparing the average illuminance of the classroom and library across the six 20-minute intervals from 11:00 to 13:00. The horizontal axis represents the time intervals, while the vertical axis shows illuminance in lux. A horizontal reference line at 350 lux indicates the SNI minimum standard, allowing for quick visual assessment of when each room met or fell below the benchmark.

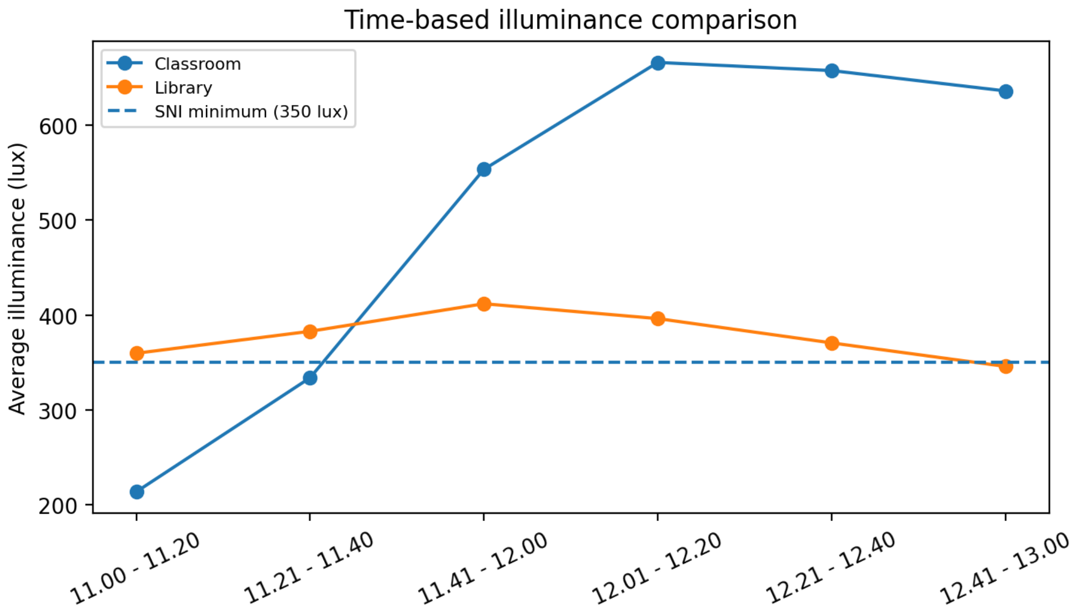


**Figure 4**. Temporal comparison of average illuminance from 11:00 to 13:00.

Based on Figure 4, the contrasting temporal behaviors of the two rooms are immediately apparent. The classroom's trajectory shows a sharp upward curve: starting below 250 lux, crossing the 350 lux threshold between 11:21-11:40, and peaking above 650 lux before plateauing slightly downward but remaining well above the standard. The library's trajectory, by contrast, is relatively flat, fluctuating between approximately 345 lux and 412 lux throughout the observation period. The library fell just below the SNI line only during the final interval (12:41-13:00 at 345.90 lux), whereas the classroom was below standard for the first 40 minutes (213.88 lux and 333.99 lux). This visual comparison reinforces that the classroom's average compliance was achieved through a late-stage surge in illuminance, peaking at 666.00 lux, while the library performed closer to the threshold throughout the measurement window. These trends suggest that the classroom was more strongly affected by changing daylight concentration, whereas the library remained more stable.

### 3.4 Interpretation of Findings and Improvement Strategies

The results indicate that compliance with the SNI illuminance standard should not be interpreted solely based on average lux values. Although the classroom exceeded the minimum requirement of 350 lux, the spatial distribution analysis revealed highly uneven lighting conditions characterized by localized hotspots and underlit areas. The extremely high illuminance value recorded at several points, particularly in rows E and F, suggests excessive direct daylight penetration that created strong brightness contrasts within the learning space. Such conditions may reduce visual comfort, increase eye fatigue, and disrupt students' visual adaptation when shifting attention between bright and dark zones (Idrus et al., 2020). Previous studies similarly emphasize that lighting quality in educational facilities depends not only on illuminance intensity but also on distribution uniformity, glare control, and balanced integration between daylight and artificial lighting systems (Aghajari & Chen, 2025; Hidayat, 2022; Kong et al., 2022; Miranda et al., 2024). Therefore, improving classroom lighting conditions requires strategies focused on redistributing light more evenly rather than simply increasing lamp quantity.

The classroom findings demonstrate that excessive brightness concentration in several measurement points disproportionately influenced the overall room average. While hotspot areas exceeded 2000 lux, several points in the front rows remained substantially below the recommended standard. This imbalance indicates that direct daylight entering from dominant openings was not adequately diffused throughout the room. Consequently, corrective measures such as installing shading or diffusing devices, rearranging desk orientation, and redistributing artificial lighting toward low-intensity zones are necessary to improve spatial lighting uniformity. Compared with the classroom, the library exhibited lower illuminance contrast; however, lighting distribution remained inconsistent across the observation grid. Although the room average slightly exceeded the SNI benchmark, a considerable number of points, particularly along the lower and edge areas, still failed to achieve 350 lux. This condition suggests that the library experienced partial lighting adequacy rather than comprehensive visual comfort throughout the reading area. Similar findings have been reported in previous studies, which note that library lighting performance is strongly influenced by daylight penetration patterns, brightness contrast, and glare control within reading environments (Adzanti & Nurwidyaningrum, 2025; Fanpu et al., 2024; Voronkova & Podlasek, 2024). Accordingly, lighting improvement in the library should prioritize strengthening underlit zones while simultaneously reducing excessive contrast in brighter areas.

The comparison between the classroom and library confirms that each educational space requires a different lighting intervention approach depending on its spatial characteristics and daylight exposure patterns. Factors such as window orientation, shading conditions, interior surface reflectance, and luminaire placement likely contributed to the observed variations in illuminance distribution. Therefore, layered lighting strategies integrating daylight management and artificial lighting adjustment are considered more effective than uniform lamp addition alone. This study has several limitations. The analysis was limited to one classroom and one library observed during a single midday measurement period. In addition, the study did not include supporting indicators such as glare index, color rendering, correlated color temperature, or user perception assessment. Nevertheless, the use of dense measurement grids and repeated observations was sufficient to demonstrate that average illuminance values alone cannot adequately represent actual lighting quality within educational spaces.

## 4. CONCLUSION

This study evaluated the compliance of one elementary school classroom and one school library with the SNI 6197:2020 illuminance benchmark (Badan Standardisasi Nasional, 2020). Based on average illuminance, both rooms were compliant: the classroom achieved 510.12 lux and the library 377.91 lux. However, this result did not represent the real spatial condition of the work plane. The classroom had extreme concentration of brightness, with a uniformity ratio of only 0.05 and many points below 350 lux. The library was more moderate but still uneven, with a uniformity ratio of 0.28 and only 36.67% of averaged points meeting the benchmark. Therefore, the study concludes that both rooms were compliant in mean terms but not yet fully suitable in spatial terms for stable visual comfort. The classroom requires strong redistribution and daylight control to reduce hotspot dominance, while the library requires balancing between its bright upper zone and dimmer lower edge. Overall, the findings confirm that mean lux should be combined with point-based distribution and temporal analysis when evaluating school lighting quality.

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