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Natural Lighting Evaluation in Health Vocational High School of Citra Semesta Indonesia, Kulon Progo

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ABSTRACT

The Health Vocational High School of Citra Semesta Indonesia, which continues to develop its infrastructure, can be categorized as a growing school. Therefore, it requires an evaluation of the buildings used to provide recommendations for further development. Required evaluations include those related to building physics for suitable learning spaces, as part of efforts to achieve energy savings. Recognizing the importance of visual comfort and the potential of natural lighting in educational environments, this research aims to analyze the natural lighting in three vocational school classrooms on the 2nd floor. The data collection was conducted by 1) observing the condition of the objects observed and the behavior of room users, 2) measuring light using a lux meter, and 2) interviewing students from the classroom regarding the visual comfort produced by natural lighting. Measurements in the three rooms show that 1) there is an excess of natural light, so it is excessive lighting in the two observation rooms because the room is positioned on the 2nd floor and is not obstructed by anything, and 2) the lighting is not evenly distributed in 1 observation room because the room only has openings on one side room. Therefore, this research concludes that the natural lighting at Citra Semesta Indonesia Health Vocational School is uncomfortable. This research suggests adding shading and implementing windows with dimensions and materials that can control the amount of natural light entering the classroom.

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1. INTRODUCTION

Classrooms as part of the school infrastructure must meet the terms and conditions to support learning activities, including a minimum lighting limit (Lampiran Peraturan Menteri Pendidikan Nasional Nomor 24 Tahun 2007 Tanggal 28 Juni 2027 Standar Sarana Dan Prasarana Sekolah/ Madrasah Pendidikan Umum, 2007) of 1) 350 lux, 2) color renderance 1 or 2, and 3) color temperature 3300 - 5300 K or 5300 K and above (Konservasi Energi Pada Sistem Pencahayaan, 2011). These conditions can be realized by utilizing natural lighting, which 1) can reach 50,000 - 100,000 lux (Idrus & Zainuddin, 2022), 2) provides good color rendering (Alrubaih et al., 2013), and 3) saves electrical energy so that it is appropriate to be utilized as optimally as possible in the educational environment. The use of daylighting in classrooms is essential to study because its quality affects student comfort (Pranasmara & Priyatmono, 2024), improves cognitive performance, and reduces tension (Jamrozik et al., 2019). Studies related to the use of daylighting in educational environments generally find a mismatch of lighting in classrooms with the standard recommended by SNI 6197 – 2011 (Athaillah et al., 2017; Christian & Octarino, 2018; Dora, 2011; Indrakesuma & Munawaroh, 2021; Jauza et al., 2022; Khoirunnisa, 2023; Masruchin & Mufidah, 2019; Mumpuni et al., 2017; Prihatmanti & Susan, 2016; Wibowo et al., 2017) of 350 lx (Konservasi Energi Pada Sistem Pencahayaan, 2011).

Health Vocational High School (HVHS) of Citra Semesta Indonesia in Kulon Progo can be categorized as a growing school (Norman et al., 2020). This is because the school has several rooms that have not been built permanently. Some other buildings that are still in the planning stage are accommodated by hitchhiking in other buildings under the same foundation's ownership. As a growing school that is still developing its infrastructure and facilities (Sunari, 2022), this school needs to consider the physical aspects of the building in planning learning spaces to conserve electrical energy (Norman et al., 2020). Located on a large area of land with no obstructions from other buildings or vegetation, the natural lighting entering the classrooms in this school can be excessive, disrupting the teaching and learning process. Therefore, this article aims to evaluate the daylighting conditions in the classrooms. The evaluation focuses on the brightness of daylight in the classrooms in relation to applicable standards for educational environments and how users respond to these conditions. The results from this study can serve as a basis for recommendations on the design of future HVHS buildings.

2. LITERATURE REVIEW

The brightness level of daylight entering the classroom, regardless of the weather conditions at the time of measurement (Indrakesuma & Munawaroh, 2021), can be caused by several factors, such as 1) the presence of obstructions, 2) shading effects, 3) opening design, and 4) building design. The first factor is the presence of obstructions to sunlight access into the room, which can be in the form of other buildings (Athaillah et al., 2017; Christian & Octarino, 2018; Indrakesuma & Munawaroh, 2021) that are too close (Wibowo et al., 2017), too high walls (Jauza et al., 2022) or fences (Wibowo et al., 2017), plants (Dora, 2011; Indrakesuma & Munawaroh, 2021; Wibowo et al., 2017) that are too lush, or the presence of corridors (Prihatmanti & Susan, 2016) that distance the access of light from its source. The second factor is shading, which can be caused by the roofs of other buildings (Wibowo et al., 2017) or horizontal shading (Prihatmanti & Susan, 2016) installed on the building itself. The third factor is the design of the openings, including the extent of the openings (Masruchin & Mufidah, 2019; Mumpuni et al., 2017), such as the Wall-Window Ratio

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(WWR), which is recommended to be at least 30% (Athaillah et al., 2017), the position of the windows (Jauza et al., 2022) on how many sides of the room, the height of the windows, and the transparency level of the glass material (Dora, 2011). The last factor is the building design, which can also affect the entry of sunlight, including the depth of space, layered rooms, inappropriate interior colors (Athaillah et al., 2017), building position and orientation (Iskandar et al., 2022), and furniture arrangement (Mumpuni et al., 2017).

The natural lighting conditions in a classroom can affect students' condition and productivity (Hapsari & Mutaqi, 2019). Poor lighting makes it difficult for students to read materials on the blackboard (Pranasmara & Priyatmono, 2024) and makes the eyes tired (Anjani, 2023; Kristanti & Rezalti, 2022; Witjaksono & Kurniasari, 2018). Poor lighting can make students sleepy (Samani & Samani, 2012), lack concentration, and stressed (Singh et al., 2014). Excessive lighting, on the other hand, will result in glare (Jauza et al., 2022; Lestari et al., 2023), headaches, eye irritation, and blurred vision (Singh et al., 2014). Moreover, incoming light often brings heat into the room and results in thermal discomfort (Sari, 2021) so daylighting needs to be well controlled (Idrus & Zainuddin, 2022). Proper lighting will increase concentration, which translates into higher grades and improved performance, making it easier to read and copy subject matter on the whiteboard (Singh et al., 2020). Therefore, lighting improvements are needed to reduce eyestrain (Ahadi et al., 2016) and student boredom (Sutarnitri et al., 2020) and increase focus of attention, better concentration (Wiraanjani & Griadhi, 2019), and student performance (Singh et al., 2014).

Previous research on natural lighting can be conducted using several methods, including measurement and simulation. Measurement of lighting conditions is carried out using tools to assess natural lighting conditions (Idrus & Zainuddin, 2022; Lestari et al., 2023; Mumpuni et al., 2017) in classrooms (Indrakesuma & Munawaroh, 2021), historic buildings (Prihatmanti & Susan, 2016) or special schools for people with low vision (Christian & Octarino, 2018). The measurement method can also be accompanied by (1) observation (Indrakesuma & Munawaroh, 2021; Prihatmanti & Susan, 2016) related to openings (Idrus & Zainuddin, 2022), (2) questionnaires and (3) interviews (Pranasmara & Priyatmono, 2024). The results can be followed up with simulations (Khoirunnisa, 2023; Lestari et al., 2023) to evaluate the effectiveness of 1) existing lighting (Jauza et al., 2022) and 2) recommended solutions to lighting-related problems (Amin, 2021; Athaillah et al., 2017; Iskandar et al., 2022; Masruchin & Mufidah, 2019) such as light reflectors (Asnawi et al., 2019). Interviews aim to collect user perceptions of natural lighting conditions (Idrus, 2020; Sari, 2021).

The factor of obstructing access to sunlight is the most influential cause of natural lighting conditions, because the addition of opening dimensions and replacement of room wall colors does not significantly improve lighting conditions (Khoirunnisa, 2023). Therefore, at the design stage, building masses and spaces should be designed so that they do not overshadow each other (Atthaillah & Bintoro, 2019). Other efforts can be made by reducing the plan ratio, room depth (Hapsari & Mutaqi, 2019), room height, and roof design (Masruchin & Mufidah, 2019). Building arrangement should also consider solar orientation in relation to the appropriate WWR of openings (Amin, 2021; Atthaillah & Bintoro, 2019). Openings can be improved in terms of their performance in introducing daylight (Athaillah et al., 2017; Dora, 2011).

3. METHODOLOGY

3.1. Research Object

HVHS of Citra Semesta Indonesia is located at Jl. Tentara Pelajar, Sawah Area, Beji, Kapanewon Wates, Kulon Progo Regency, Yogyakarta Special Region. This school has several

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rooms that can be used for the learning process. These spaces include four pharmacy classrooms, six nursing classrooms, one clinical and information pharmacy student practice room, one nursing assistant student practice room, two computer laboratory rooms, and one library room. The research was conducted in three classrooms: X Nursing 1 classroom, XII Nursing 1 classroom 1, and XII Nursing 2 classroom.

3.2. Data Collection Methods

1. Observation

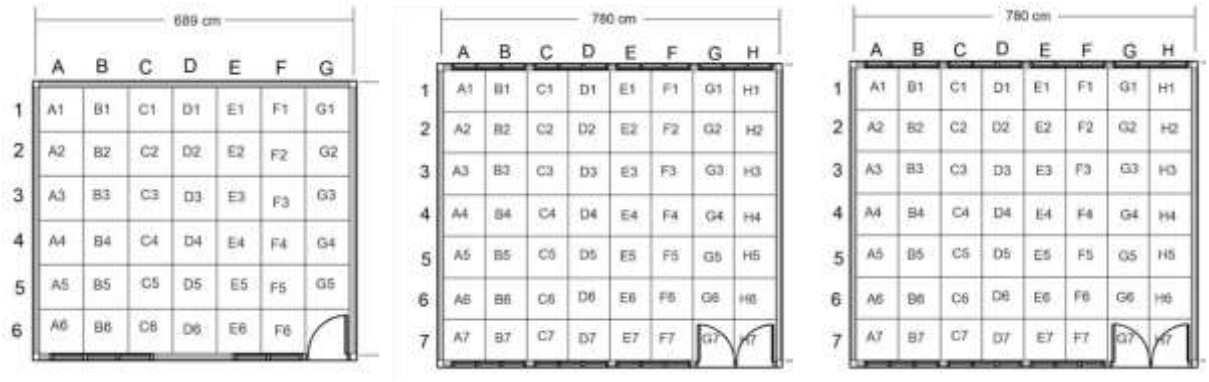
Observations were made by observing the condition of the building and the chosen room for this study. Observations focused on the building's orientation, the arrangement of furniture in the room, and the character of the window, which includes its dimensions and position. Observations were also made by studying the behavior of room users as they adapted to existing lighting conditions and documenting the adaptation behavior of space users in response to these conditions. Therefore, observations used tools such as cameras and roll meters.

2. Measurement

Measurements were taken from morning to evening on one day, as long as sunlight, the primary source of natural light, was present in the classroom, using a Luxmeter. Before measuring the natural light, the measuring points were first determined at 1 m² intervals, as shown in Figure 1. Details related to the measurement implementation are summarized in Table 1.

Table 1. Measurement Implementation Details

	Class X Nursing 1	Class XII Nursing 1	Class X Nursing 2
Measuring number	42 points	56 points	56 points
Date of measurement	May 7, 2023	May 13, 2023	May 13, 2023
Morning measurement	10.20 sunny conditions	09.30 sunny conditions	09.30 sunny conditions
Afternoon measurement	13.00 sunny conditions	13.00 sunny conditions	13.00 sunny conditions
Evening measurement	16.15 cloudy conditions	15.30 sunny conditions	15.30 sunny conditions



(a) (b) (c)

Figure 1: Measurement Points in (a) X Nursing 1, (b) XII Nursing 1, and (c) X Nursing 2 Classrooms

Source: Drupadi, 2024

3. Interview

The interviews conducted were semi-structured, utilizing a research instrument in the form of a list of questions, which allowed for a more focused approach. Interviews can be tailored to meet the specific conditions and information needs required, ensuring they are fit for purpose and remain focused on the research problem. In this study, the interviewees were students from HSVS Citra Semesta Indonesia, specifically 10 children

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per class, who were selected based on their seating position. The selection of respondents based on sitting position is intended to obtain information from students who sit in the front row, back row, centre row, and the edge of the class. This is related to the position of light entering the classroom.

4. RESULT AND DISCUSSION

4.1. Observation Result

The school runs from east to west, facing north. The north side of the school is located on Jalan Tentara Pelajar. The east side and the south side are directly adjacent to rice fields, while the west side is adjacent to rice fields and the Sadewa Kindergarten school building. HVHS Citra Semesta Indonesia has 10 buildings within a single complex, as well as several additional rooms that share the second floor of Sadewa Kindergarten. Figure 2 below is a plan of the school, showing the location of the classrooms that are the subject of research.

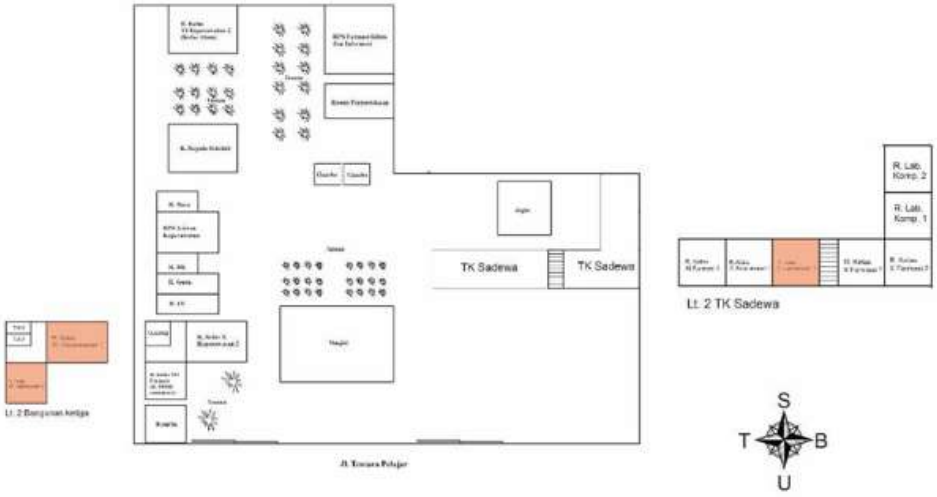
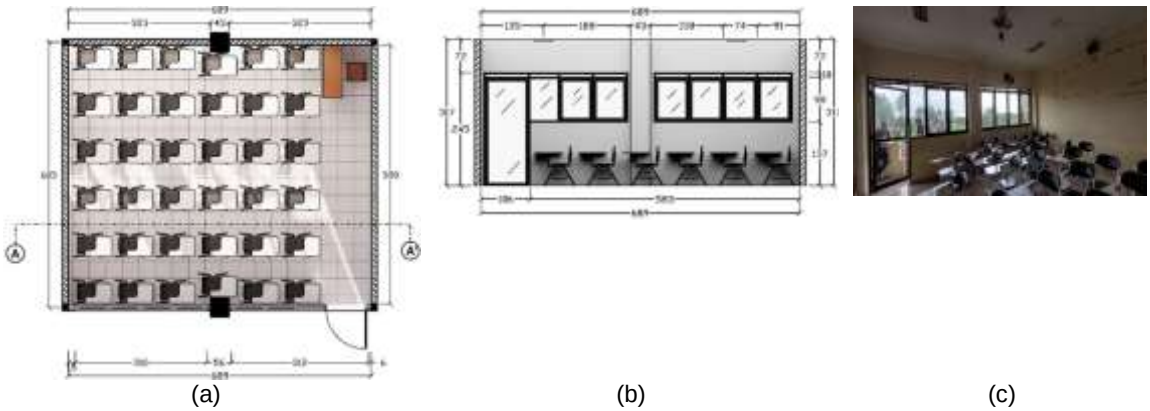


Figure 2: Site Plan of Citra Semesta Indonesia Health Vocational School
Source: Drupadi, 2024

4.1.1. Observation Results of X Nursing 1 Classroom

This classroom is located on the 2nd floor of the Sadewa Kindergarten building, with the door facing south. Openings in the X Nursing 1 classroom are only found on the south side. The view from the outside of the room is of the sky, as there are no obstructions. Figure 3 below shows the layout, section, and view from the windows of the X Nursing 1 classroom.



(a) (b) (c)

Figure 3: X Nursing 1 Classroom (a) Layout, (b) Section A-A', and (c) South Side View
Source: Drupadi, 2024

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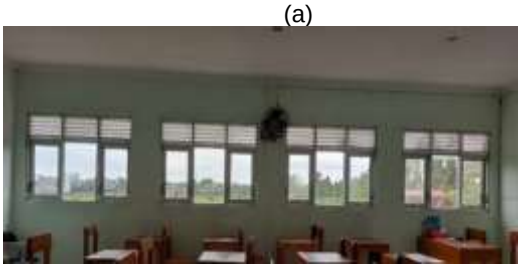
4.1.2. Observation Results of XII Nursing 1 Classroom

The XII Nursing 1 classroom is located on the 2nd floor of the eastern building of HVHS Citra Semesta Indonesia. In this classroom, there is furniture in the form of a teacher's desk and chair at the front of the room, facing east. There are 30 sets of student desks and chairs facing west, and a whiteboard is attached to the west wall, parallel to the door. Figure 4 below shows the layout and section of the XII Nursing 1 classroom. This classroom has a door facing the north. On the north and south sides of the room, some windows and vents provide access to natural light. The view from the inside to the outside of the room on both the north and south sides is the sky, as there are no obstructions (Figure 5).

(a) (b) (c)

Figure 4: XII Nursing 1 Classroom (a) Layout, (b) Section A-A', and (c) Section B-B'
Source: Drupadi, 2024

(a)



(b)

Figure 5: View of XII Nursing 1 Classroom (a) North Side and (b) South Side
Source: Drupadi, 2024

4.1.3. Observation Results of XII Nursing 2 Classroom

This classroom is located on the 2nd floor of the eastern building of HVHS Citra Semesta Indonesia. The XII Nursing 2 classroom features furniture arranged as follows: a teacher's desk and chair at the front of the room, facing north; 30 sets of student desks and chairs facing south; and a whiteboard affixed to the south wall, parallel to the door position. Figure 6 below shows the layout and section of the XII Nursing 2 classroom. XII Nursing 2 classroom has a door facing west. On the west and east sides of the room, windows and vents provide access to natural lighting. The view from indoors to outdoors is the sky and part of the roof on the north side of the building, but does not cover the openings (Figure 7).

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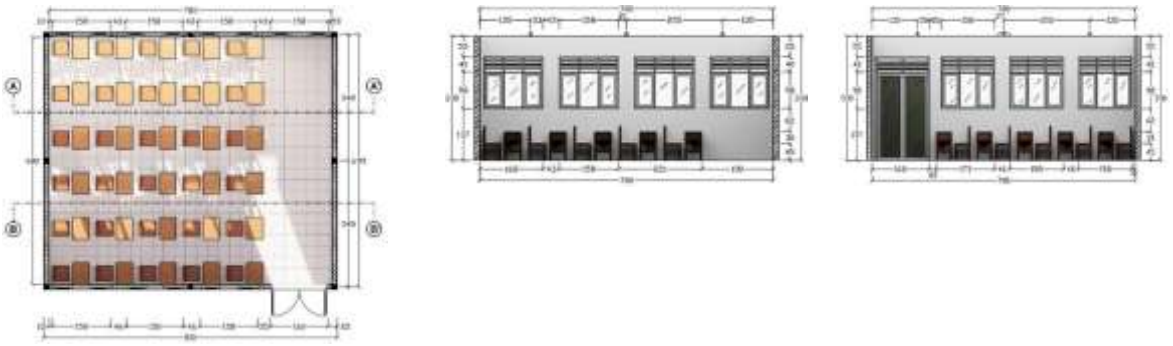
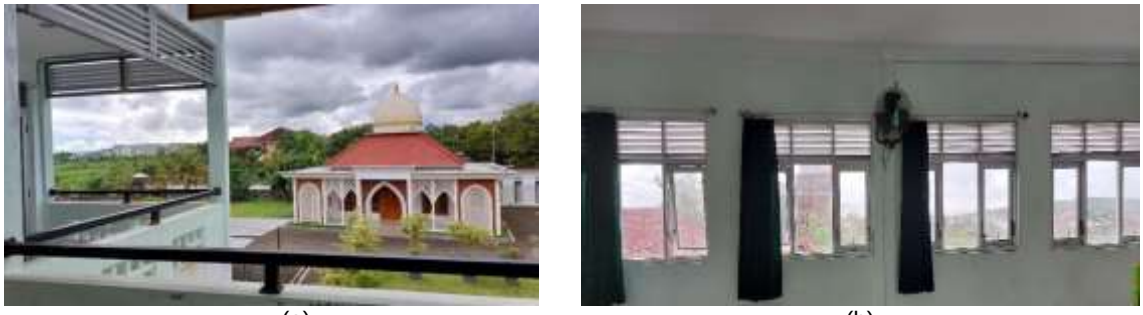


(a) (b) (c)

Figure 6: XII Nursing 2 Classroom (a) Layout, (b) Section A–A', and (c) Section B–B'
Source: Drupadi, 2024



(a) (b)

Figure 7: View of XII Nursing 2 Classroom (a) West Side and (b) East Side
Source: Drupadi, 2024

Table 2 summarizes the results of observations in three classrooms related to room size, dimensions, number, position, Window-to-Wall Ratio (WWR), and Window-to-Floor Ratio (WFR) of windows and vents.

Table 2. Condition of the Object of Observation

Description	X Nursing 1 Classroom	XII Nursing 1 Classroom	XII Nursing 2 Classroom
Room size (l x w x h)	6.9 m x 5.9 m x 3.7 m	7.8 m x 6.8 m x 3.3 m	7.8 m x 6.8 m x 3.3 m
Room area	40,71 m2	53,04 m2	53,04 m2
Window dimensions (w x h)	0.74m x 0.98m	0.52 m x 0.98 m	0.52 m x 0.98 m
Number of windows	7 pieces	21 pieces	21 pieces
Ventilation dimensions (w x h)	0.74 m x 0.1 m	0.52 m x 0.4 m	0.52 m x 0.4 m
Number of vents	7 pieces	25 pieces	25 pieces
Glass door dimensions (w x h)	2.45 m x 0.8 m	-	-
Total opening area	7,55 m2	15,9 m2	15,9 m2
Opening position	South	North and South	East and West
Window - Wall Ratio (WWR)	29.6 %	31 %	31 %
Window - Floor Ratio (WFR)	18,5%	30 %	30 %

4.2. Measurement results

The measurement results are displayed in a table, where green indicates that it meets the standard, yellow indicates that it does not meet the standard, and red indicates that it exceeds the standard limit for classrooms.

4.2.1. Natural Lighting X Nursing 1 Classroom

Tables 3, 4, and 5 below show that the lighting conditions in X Nursing 1 classroom have a diverse and uneven level of natural lighting at each measuring point, both in morning, afternoon, and evening measurements. The highest lighting intensity in the morning was 1,638 lux, while the intensities in the afternoon and evening were 1,598 lux and 1,113 lux, respectively. The lowest lighting intensity in the morning, afternoon, and

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evening was 168 lux, 129 lux, and 69 lux, respectively. Measurement points that meet the lighting standards in the morning amounted to 8 points, in the afternoon amounted to 7 points, and in the evening amounted to 8 points. Measurement points that do not meet the recommended standard can be either below or above the recommended standard.

Table 3. Morning Measurement of Natural Lighting Condition in X Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G
1	176	222	274	253	263	208	227
2	168	174	365	237	296	312	264
3	185	174	384	513	311	398	364
4	279	212	572	462	492	578	556
5	511	421	679	667	827	945	794
6	565	950	828	714	667	983	1638

Table 4. Afternoon Measurement of Natural Lighting Condition in X Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G
1	169	270	333	311	207	199	199
2	191	201	402	290	299	287	198
3	129	199	403	516	418	518	401
4	201	250	499	612	558	680	498
5	519	521	791	716	679	896	851
6	401	620	553	604	766	673	1598

Table 5. Evening Measurement of Natural Lighting Condition in X Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G
1	81	107	92	84	82	69	147
2	129	138	124	105	151	159	144
3	84	127	145	108	193	205	280
4	290	276	336	269	239	442	311
5	410	198	477	149	94	119	231
6	468	470	477	317	311	518	1113

4.2.2. Natural Lighting Condition in XII Nursing 1 Classroom

Tables 6, 7, and 8 below show that the lighting conditions in the XII Nursing 1 classrooms can be very bright, exceeding 350 lux. The highest lighting intensity in the morning was 1,998 lux, while the afternoon was 2,768 lux and 1,978 lux, respectively. The lowest lighting intensity in the morning was 341 lux, in the afternoon was 396 lux, and in the evening was 364 lux. There is only one measurement point that meets the standard, and it is only obtained in the morning measurement.

Table 6. Morning Measurement of Natural Lighting Condition in XII Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	811	846	718	797	895	724	341	685
2	422	528	417	561	745	840	674	618
3	386	449	416	438	719	799	687	517
4	407	423	492	508	733	832	729	605
5	386	418	478	515	715	859	852	860
6	409	450	441	679	724	908	1174	1012
7	397	486	452	682	800	957	1897	1988

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Table 7**.** Afternoon Measurement of Natural Lighting Condition in XII Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	796	955	684	915	992	964	463	1186
2	625	622	577	739	834	846	708	714
3	468	559	438	555	834	596	755	648
4	414	484	539	594	650	902	824	763
5	396	430	733	639	854	960	995	961
6	474	548	583	729	965	1315	1319	1347
7	471	520	566	781	721	1355	2555	2768

Table 8. Evening Measurement of Natural Lighting Condition in XII Nursing 1 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	686	612	581	696	638	583	528	827
2	425	529	608	582	527	539	528	503
3	394	379	461	480	491	461	508	373
4	364	367	381	449	441	539	543	451
5	370	617	372	462	640	653	680	601
6	493	576	500	563	639	868	953	986
7	530	742	557	714	619	933	1498	1978

4.2.3. Natural Lighting XII Nursing Classroom 2

Tables 9, 10, and 11 below show that the lighting conditions in the XII Nursing 2 classroom can also be very bright, exceeding 350 lux. The highest lighting intensity in the morning was 1,727 lux, while the afternoon was 4,098 lux and 4,939 lux, respectively. The lowest lighting intensity in the morning was 346 lux, in the afternoon was 587 lux, and in the evening was 643 lux. There is only one measurement point that meets the standard, and it is only obtained in the morning measurement.

Table 9**.** Morning Measurement of Natural Lighting Condition in XII Nursing 2 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	818	1799	891	1824	1113	2011	645	2362
2	630	855	822	792	592	917	964	802
3	441	563	405	481	612	582	680	552
4	447	451	383	418	446	498	525	516
5	513	443	384	363	390	496	508	591
6	650	537	426	398	368	489	608	964
7	752	482	346	366	281	472	1119	1727

Table 10. Afternoon Measurement of Natural Lighting Condition in XII Nursing 2 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	723	795	731	772	773	707	593	706
2	630	678	746	760	755	801	681	723
3	587	669	711	759	786	838	780	688
4	647	717	765	836	939	968	862	818
5	781	830	916	931	1119	1262	1087	1072
6	1038	1091	1188	1164	1360	1395	1464	2025
7	1373	973	945	1388	1015	1461	2912	4098

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Table 11. Evening Measurement of Natural Lighting Condition in XII Nursing 2 Classroom (lux)

Measurement Point	A	B	C	D	E	F	G	H
1	643	847	724	820	1026	1096	944	1717
2	727	842	918	1010	1135	1628	1509	1667
3	705	840	1007	1099	1299	1562	1601	1702
4	791	921	1024	1481	1469	2485	1753	1946
5	1093	1154	1092	1551	1720	2458	2105	3465
6	1629	1266	1247	1495	1540	2226	2364	3451
7	1235	942	1072	1391	1622	2184	3061	4939

4.3. Interview Results

All respondents from the XII Nursing 1 class interviewed stated that every morning, they often partially close the curtains because they are bothered by the glare of the sunlight (Sari, 2021) especially when it is sunny. During the day, 8 out of 10 children in the classroom expressed discomfort because the sunlight was too bright. This excess light disrupts learning activities in the classroom. Some students found it difficult to read the material on the blackboard due to the reflection of the sunlight. Exposure to the glare also causes eye fatigue. Because of this, when entering the afternoon, they tend to close all the curtains, which they feel is enough to reduce the sunlight entering. The same condition was also found in the XII Nursing 2 classroom, where nine out of ten students interviewed reported the same issue.

The windows of the X Nursing 1 classroom have not been equipped with curtains. This causes glare problems for students with seating positions that are directly exposed to sunlight, namely in the centre and north of the room. Five out of ten children in the classroom reported feeling glare every morning, while the other five out of ten stated that the morning lighting was quite comfortable. This result indicates the uneven distribution of lighting as perceived by the room's users. During the day, 7 out of 10 children interviewed expressed visual discomfort with the natural lighting because, as the day progressed, more sunlight entered the room. This excess light disrupts the learning activities in the classroom. They complained of difficulties in the learning process caused by the reflection of sunlight onto the blackboard. This glare distraction can cause tired eyes.

(a) (b) (c)

Figure 8: Window Conditions (a) without Curtain in X Nursing 1 Classroom, (b) One Sided Closed in XII Nursing 1 Classroom, and (c) Closed on Two Sides in XII Nursing 2 Classroom. Source: Drupadi, 2024

4.4. Discussion

4.4.1. Evaluation of Natural Lighting Suitability

The uneven natural lighting in the X Nursing 1 classroom is due to its single opening on the north side. Some areas of the room are under-lit, reaching 81 lux in the afternoon, while the other half is over-lit, reaching 1,638 lux in the morning. This resulted in some parts of the room being too bright, others a little dark, and others quite comfortable in the morning if all the openings were opened. In the morning and afternoon, the

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overexposed areas are larger than the underexposed and standardized areas. In the afternoon, the underexposed areas are larger than the standardized and overexposed areas. The overexposure is due to the window of one wall exceeding 25-50% of the recommended minimum WWR standard (Pemerintah Provinsi DKI Jakarta, 2012) which is 29.6% and exceeds 1/6 of the floor area as the minimum WFR standard (Masruchin & Mufidah, 2019) which is 1/5 of the floor area. These opening dimensions can be optimized and produce even lighting if windows with the same WWR and WFR are applied on both sides of the room (Dora, 2011; Jauza et al., 2022).

Natural lighting in XII Nursing 1 classroom has openings with an area exceeding the recommended standard of 1/6 of the floor area (Masruchin & Mufidah, 2019) by 3/10 and 25 - 50% WWR (Pemerintah Provinsi DKI Jakarta, 2012) by 31%. Moreover, the windows are located on the north and south sides of the building. The incoming lighting exceeds the standard of 350 lux (Konservasi Energi Pada Sistem Pencahayaan, 2011) evenly distributed in almost all parts of the classroom. The same thing happens in the XII Nursing 2 classroom, which has openings on the east and west sides. This condition results in the room being too bright if the curtains do not cover all openings. This is very likely to happen because of the position of the room on the 2nd floor, with clear glass windows and no obstructions (Dora, 2011). This excessive light problem can be solved by reducing the incoming light, such as by adding shading elements (Wibowo et al., 2017) in the form of hanging plants, reducing the transparency of glass (Dora, 2011) for example, by using sandblasting glass, minimizing the window field, and adding shading in the room (Jauza et al., 2022) and controlling the incoming light (Idrus & Zainuddin, 2022).

4.4.2. Visual Comfort Evaluation of Natural Lighting

The X Nursing 1 classroom only has openings on the south side, so that the north area is not reached by natural lighting. The openings have not been equipped with curtains, allowing natural lighting to enter without being blocked, which can cause glare problems in areas exposed to sunlight (Lestari et al., 2023). This classroom becomes uncomfortable in the aspect of visual comfort of natural lighting due to the uneven distribution of natural lighting, so lighting controls (Idrus & Zainuddin, 2022) are needed for areas that get excessive light and light reflecting components (Jauza et al., 2022), such as light shelves (Asnawi et al., 2019; Kusumawanto et al., 2020) for less bright areas.

The XII Nursing 1 classroom has openings on both sides of the room, specifically on the north and south sides. The openings are expected to maximize the entry of sunlight, which makes the XII Nursing 1 classroom uncomfortable in terms of visual comfort due to natural lighting, because excessive light causes glare (Jauza et al., 2022). Therefore, it is necessary to add horizontal (Atthaillah & Bintoro, 2019) shading (Athaillah et al., 2017). The same thing also happens in the XII Nursing 2 classroom, which has openings on both the west and east walls of the room. This similarity aligns with other studies that recommend different WWRs for various positions (Amin, 2021; Atthaillah & Bintoro, 2019).

5. CONCLUSION

Based on the evaluation of daylighting in the classrooms of SMK Kesehatan Citra Semesta Indonesia in Wates, Kulon Progo, it can be concluded that (1) the natural lighting in the studied classrooms does not meet the comfort standards for educational buildings due to the uneven distribution of light and excessive brightness, which causes glare, (2) the existence of openings on the north side without obstructions is insufficient to allow for adequate lighting, as some areas still receive substandard lighting, and (3) the existence of openings on both

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sides of the room, without barriers, allows for much light to enter, and as a result, room users tend to close the openings with curtains. This excessive light problem can be solved by reducing the amount of incoming light, adjusting the transparency of the glass, and controlling the amount of light that enters. This research recommends having different WWRs for various positions.

REFERENCES

Ahadi, A. A., Profile, S., Ali Khanmohammadi, M., Masoudinejad, M., Alah, A., ∗2, A., Khanmohammadi, M., & Alirezaie, B. (2016). Improving student performance by proper utilization of daylight in educational environments (Case study: IUST 1 School of Architecture). In *Acta Technica Napocensis: Civil Engineering & Architecture* (Vol. 59, Issue 1).

Alrubaih, M. S., Zain, M. F. M., Alghoul, M. A., Ibrahim, N. L. N., Shameri, M. A., & Elayeb, O. (2013). Research and development on aspects of daylighting fundamentals. *Renewable and Sustainable Energy Reviews*, *21*, 494–505. https://doi.org/10.1016/j.rser.2012.12.057

Amin, A. R. Z. (2021). Evaluasi pencahayaan alami dan buatan pada ruang kuliah Fakultas Sains dan Teknologi, Unika Musi Charitas; Studi kasus: ruang 202, 204 dan laboratorium komputer 4. *Arsir*, *5*(2), 77–89.

Anjani, F. S. (2023). *Hubungan Intensitas Pencahayaan dengan Keluhan Kelelahan Mata Siswa di Tiga SD Negeri Kelurahan Tanah Sirah Piai Nan Kota Padang tahun 2023*. Politeknik Kesehatan Kementerian Kesehatan Padang.

Asnawi, M., Vidiyanti, C., & Ismoyo, A. D. (2019). Kinerja reflektor cahaya dalam mengoptimalisasi pencahayaan alami di kelas Sekolah Budi Mulia. *Vitruvian*, *8*(3), 111–122. https://doi.org/10.22441/vitruvian.2019.v8i3.002

Athaillah, A., Iqbal, M., & Situmeang, I. S. (2017). Simulasi pencahayaan alami pada gedung Program Studi Arsitektur Universitas Malikussaleh. *NALARs*, *16*(2), 113. https://doi.org/10.24853/nalars.16.2.113-124

Atthaillah, A., & Bintoro, A. (2019). Useful Daylight Illuminance (UDI) pada ruang belajar sekolah dasar di kawasan urban padat tropis (Studi kasus: SD Negeri 2 dan 6 Banda Sakti, Lhokseumawe, Aceh, Indonesia). *Langkau Betang: Jurnal Arsitektur*, *6*(2), 72–86. https://doi.org/10.26418/lantang.v6i2.33940

Christian, I., & Octarino, C. N. (2018). Evaluasi aspek kenyamanan pencahayaan Sekolah Luar Biasa (SLB) Helen Keller Indonesia. *SENADA 2018 STD Bali*, 307–312.

Dora, P. E. (2011). Optimasi desain pencahayaan ruang kelas SMA Santa Maria Surabaya. *Dimensi Interior*, *9*(2), 69–79.

Drupadi, N. S. (2024). *Pencahayaan Alami di Ruang Kelas SMK Kesehatan Citra Semesta Indonesia, Wates Kulon Progo*. Universitas Sebelas Maret.

Hapsari, A., & Mutaqi, A. S. (2019). Kajian performa pencahayaan alami dan pengaruhnya terhadap produktivitas pengguna di ruang kelas (Studi kasus pada bangunan kampus FMIPA UGM). *Seminar Karya & Pameran Arsitektur Indonesia (SAKAPARI 2019): Sustainable in Architecture*, 32–43.

Idrus, I. (2020). *Model Pencahayaan Alami Ruang Kelas Berbasis Persepsi Visual Siswa Sekolah Dasar dan Menengah di Area Tropis*. Universitas Hasanuddin.

Idrus, I., & Zainuddin, S. (2022). Studi "daylight comfort" untuk bangunan pendidikan yang berkelanjutan. *Jurnal Linears*, *4*(2), 93–100. https://doi.org/10.26618/j-linears.v4i2.6174

DOI: https://doi.org/10.17509/jare.v7i1.84458
p- ISSN 2776-9909 e- ISSN 2580-1279

Indrakesuma, F. G., & Munawaroh, A. S. (2021). Analisis kenyamanan pencahayaan alami di ruang kelas SMKN 2 Bandar Lampung. *Jurnal Ilmiah Penelitian Marka*, *4*(2), 88–98. https://doi.org/10.33510/marka.2021.4.2.88-89

Iskandar, Suparwoko, Sugini, & Zacky, Z. (2022). Desain ruang belajar sekolah dasar di Lhokseumawe yang optimal terhadap pencahayaan alami. *Arsitekno*, *9*(2), 82–95. https://creativecommons.org/licenses/by/4.0/

Jamrozik, A., Clements, N., Hasan, S. S., Zhao, J., Zhang, R., Campanella, C., Loftness, V., Porter, P., Ly, S., Wang, S., & Bauer, B. (2019). Access to daylight and view in an office improves cognitive performance and satisfaction and reduces eyestrain: A controlled crossover study. *Building and Environment*, *165*(March), 106379. https://doi.org/10.1016/j.buildenv.2019.106379

Jauza, A. R., Setiawan, A., & Suryanti, N. (2022). Evaluasi kinerja pencahayaan alami dalam ruang pada bangunan sekolah pasca pandemi. Studi kasus: SD Muhammadiyah 1 Ngawi. *Seminar Karya & Pameran Arsitektur Indonesia*, 458–470.

Khoirunnisa, A. (2023). *Analisa Pencahayaan Alami Ruang Kelas pada Sekolah SMA Negeri-1 Tanjung Pura Menggunakan DIALux Evo 11.1*. Universitas Malikussaleh.

Konservasi Energi Pada Sistem Pencahayaan, Pub. L. No. SNI 6197: 2011, 34 (2011).

Kristanti, S. G., & Rezalti, D. T. (2022). Analisis pengaruh intensitas pencahayaan terhadap kelelahan mata mahasiswa menggunakan metore regression statistical analysis dan analisis deskriptif. *Industrial Engineering Journal of the University of Sarjanawiyata Tamansiswa*, *6*(1), 18–24. https://doi.org/10.30738/iejst.v6i1.12897

Kusumawanto, A., Aryani, S. M., & Setyowati, M. (2020). Feasibility of METSI UGM office as a workplace in natural lighting availability and its occupants' adaptive behavior. *AIP Conference Proceedings*, *2217*. https://doi.org/10.1063/5.0000666

Lampiran Peraturan Menteri Pendidikan Nasional Nomor 24 Tahun 2007 Tanggal 28 Juni 2027 Standar Sarana Dan Prasarana Sekolah/ Madrasah Pendidikan Umum, Pub. L. No. No. 24 (2007).

Lestari, Alhamdani, M. R., Muazir, S., Nurhamsyah, M., & Chairiah, A. (2023). Performa pencahayaan alami ruang kelas sekolah di Kota Pontianak. *Jurnal Arsitektur ARCADE*, *7*(4), 580–587.

Masruchin, F. R., & Mufidah. (2019). Optimasi pencahayaan alami pada studio arsitektur di Universitas 17 Agustus 1945 Surabaya. *Jurnal Hasil Penelitian*, *04*(02), 159–165.

Mumpuni, P. W., Widayat, R., & Aryani, S. M. (2017). Pencahayaan alami pada ruang baca perpustakaan umum Kota Surabaya. *Vitruvian Jurnal Arsitektur, Bangunan & Lingkungan*, *6*(2), 71–78. https://www.researchgate.net/publication/348637882

Norman, Indra, M., Kahuripan, O., Sukardan, D., Thurhayat, A., Khaironisa, A., & Trinovia, E. (2020). *Panduan Pengembangan Bangunan SMA* (U. Wismono, W. Astuti, & D. Pangarso, Eds.). Direktorat Sekolah Menengah Atas, Kementerian Pendidikan dan Kebudayaan.

Pemerintah Provinsi DKI Jakarta. (2012). Sistem Pencahayaan. In *Panduan Pengguna Bangunan Gedung Hijau Jakarta* (Vol. 3, Issue 38, p. 29).

Pranasmara, N. B., & Priyatmono, A. F. (2024). Pengaruh pencahayaan alami terhadap kenyamanan belajar siswa. Studi kasus ruang kelas 1 dan 2 SMP N 6 Surakarta. *SIAR V 2024: Seminar Ilmiah Arsitektur*, 867–873. http://siar.ums.ac.id/

Prihatmanti, R., & Susan, M. Y. (2016). Lighting performance pada ruang kelas di bangunan bersejarah. *Aksen*, *2*(1), 39–57.

Samani, S. A., & Samani, S. A. (2012). The impact of indoor lighting on students' learning performance in learning environments: A knowledge internalization perspective. *International Journal of Business and Social Science*, *3*(24). www.ijbssnet.com

DOI: https://doi.org/10.17509/jare.v7i1.84458
p- ISSN 2776-9909 e- ISSN 2580-1279

Sari, L. P. (2021). *Persepsi Siswa terhadap Pencahayaan dan Penghawaan Sekolah Menengah Atas Negeri 1 Peudada Bireun*. Universitas Islam Negeri Ar-Raniry.

Singh, P., Arora, R., & Goyal, R. (2020). Impact of lighting on performance of students in Delhi schools. *Lecture Notes in Civil Engineering*, *60*, 95–108. https://doi.org/10.1007/978-981-15-1334-3_11

Singh, P., Singh, M. P., & Arora, R. (2014). Classroom illuminance: Its impact on students' health exposure & concentration performance. *International Ergonomics Conference HWWE*. https://www.researchgate.net/publication/311301869

Sunari. (2022, March 11). *Keindahan CSI akan selalu di hati*. https://smkkescsi.sch.id/read/54/keindahan-csi-akan-selalu-di-hati

Sutarnitri, N. P. D., Citrawathi, D. M., & Sutajaya, I. M. (2020). Perbaikan pencahayaan ruang kelas menurunkan kelelahan mata dan kebosanan belajar peserta didik pada pembelajaran biologi di SMA. *Jurnal Pendidikan Biologi Undiksha*, *7*(3).

Wibowo, R., Kindangen, J. I., & Sangkertadi. (2017). Sistem pencahayaan alami dan buatan di ruang kelas sekolah dasar di kawasan perkotaan. *Daseng: Jurnal Arsitektur*, *6*(1), 87–98.

Wiraanjani, B., & Griadhi, I. P. A. (2019). Perbedaan konsentrasi belajar mahasiswa Fakultas Kedokteran Universitas Udayana di ruang SGD (Small Group Discussion) sekat dan permanen. *E-Journal Medika*, *8*(2).

Witjaksono, A., & Kurniasari, W. (2018). Gambaran intensitas pencahayaan dan kelelahan mata pada siswa SDN Pagadean Subang tahun 2017. *Jurnal Sehat Masada*, *XII*(1).

DOI: https://doi.org/10.17509/jare.v7i1.84458
p- ISSN 2776-9909 e- ISSN 2580-1279