Jurnal Teknologi Kesehatan (Journal of Health Technology)
Vol.20, No.2, Sept 2024, pp. 76~87
ISSN: 2613-9944 (Online)
ISSN: 0216-4981 (Print)

Association between Engineering Physics Laboratory Comfort and Sick-Building Syndrome among University Students

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Article Info

Article history:

Received Jun 14th, 2024
Revised Agt 28th, 2024
Accepted Oct 06th, 2024

Keywords:

human comfort
sick-building syndrome
relative humidity
illuminance

ABSTRACT

Humans spend most of their time indoors, making indoor comfort a crucial factor in supporting daily activities. Poor indoor environmental quality can trigger Sick Building Syndrome (SBS), leading to symptoms such as nausea, irritation, drowsiness, and reduced concentration among occupants. This study aims to analyze the relationship between physical comfort parameters, including temperature, relative humidity, and illuminance, and the occurrence of SBS in an Engineering Physics laboratory. A quantitative descriptive design was applied, with environmental parameters measured using the CEM DT-8820 environment meter, and SBS symptom data collected using a structured questionnaire distributed to 30 laboratory occupants.

The measurement results indicate that the laboratory temperature was below the recommended range of 24℃–27℃, relative humidity was within the recommended range at 55%–56%, and illuminance levels were below the 500 lux standard required for laboratory activities. Based on the questionnaire results, the most frequently reported SBS symptoms were drowsiness (66.7%), dry lips (40.0%), poor concentration (33.3%), and dry throat (23.3%). Correlation analysis showed a very weak negative correlation between temperature and SBS symptoms (r = -0.0156), a weak negative correlation between relative humidity and SBS symptoms (r = -0.1297), and a moderate negative correlation between illuminance and SBS symptoms (r = -0.4393).

These findings suggest that suboptimal environmental conditions, particularly inadequate illuminance, may contribute to the occurrence of SBS symptoms among laboratory occupants. Improving environmental conditions, such as maintaining appropriate temperature levels and ensuring adequate lighting, is essential to enhance comfort and support productivity in laboratory environments.

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1. INTRODUCTION

It is known that humans spend 70–80% of their time indoors doing activities (1). Maintaining room comfort is one of the aspects that must be considered while constructing buildings to support human activities (2,3). Room comfort can be assessed through various aspects such as temperature, humidity, and illuminance, which have significantly affected occupants (4). Inadequate comfort conditions can trigger sick-building syndrome (SBS), where occupants experience symptoms such as dizziness, headache, eye irritation, and difficulty concentrating, which subside after leaving the building (1,11,12).

Temperature, relative humidity, and illuminance are measurable parameters often used to analyze comfort and related symptoms inside a room. The standard for indoor temperature based on SNI 03-6572-2001 ranges from 20.5–27.1°C in various comfort categories, while acceptable relative humidity is 40–50% or 55–60% in fully occupied rooms (5,6). Illuminance, which describes the distribution of light in a room, has a recommended standard of 300–500 lux depending on the room type (Mustaqim & Haddin, 2017; Panjaitan et al., 2018). In Indonesia, these references are regulated in SNI 03-6572-2001, SNI 7062-2019, and SNI 6072-2020 to guide building planning to achieve a comfortable and healthy environment (10).

In relation to indoor comfort, SBS describes the appearance of symptoms in building occupants due to prolonged exposure to poor indoor quality (1,11,12). The main factors are commonly related to low air quality, inadequate ventilation, and environmental parameters inside the building (13). Several studies have shown that temperature, humidity, lighting, CO_2 levels, and pollutants contribute to SBS (1,13–15). Data from WHO indicates that about 20% of residents in the US and western countries experience SBS (1), while a 2008 study in Indonesia reported 50% of employees in 18 companies experienced SBS (1).

This study focuses on the Physics Engineering Laboratory at Multimedia Nusantara University, which is used for experiments and studies by approximately 30–40 students per session (19,20). Laboratory activities often involve prolonged exposure to indoor conditions and require high concentration, making environmental comfort crucial. Measurements in this study were conducted using the Environment Meter DT-8820 (21,22) to assess temperature, humidity, and illuminance, supported by a survey to evaluate SBS symptoms. This study aims to analyze the relationship between comfort parameters and SBS symptoms, providing reference data to improve laboratory comfort according to SNI standards and reduce potential SBS symptoms among laboratory occupants.

2. METHODS

In this study, a quantitative descriptive method was used by measuring room comfort parameters and distributing questionnaires to assess the emergence of sick-building syndrome symptoms among Physics Engineering Laboratory users. Sampling was conducted using purposive sampling by selecting students actively using the laboratory during the observation period from October to December. The questionnaire used was adapted from previous studies and has been tested for validity using Pearson correlation ($r > 0.3$) and reliability using Cronbach's Alpha ($\alpha > 0.7$). Measurement of temperature, humidity, and illuminance was carried out using the Environment Meter DT-8820 at several points in the laboratory at different times to capture representative conditions.

Data analysis was performed using IBM SPSS Statistics version 26. Descriptive statistics were used to present the distribution of respondent characteristics and SBS symptoms, while Pearson correlation tests were conducted to determine the relationship between room comfort parameters and SBS symptoms with a significance level of $p < 0.05$ and a 95% confidence interval. Prior to correlation analysis, normality tests using the Shapiro-Wilk method were conducted to ensure data distribution met parametric test assumptions. The analysis results were presented in tabular and graphical form to provide a clear interpretation of the relationship between indoor comfort and SBS in the Physics Engineering Laboratory.

Data Collection

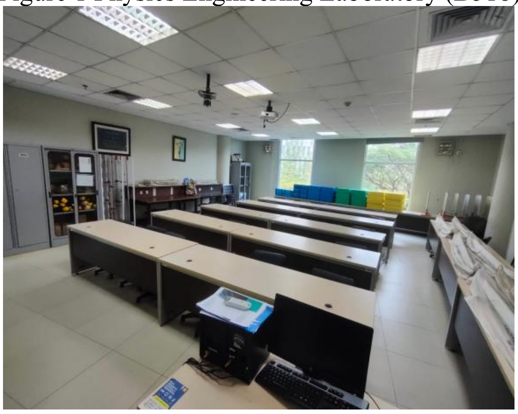
Data will be collected using the following procedure:

1. Design = The research is designed based on the problems that occur in the field. In accordance with the author's background, it is associated with the problem of room comfort to the emergence of symptoms of sick-building syndrome. Through the existing problems, a suitable location is sought, namely the Physics Engineering laboratory, as a room that is often used for activities. Therefore, this study will explain the factors of comfort (temperature, humidity, and lighting level) to the emergence of sick-building syndrome symptoms by residents of the Physics Engineering laboratory (students of Multimedia Nusantara University majoring in Physics Engineering and Electrical Engineering).
2. Observation = Measurements will be carried out in the Physics Engineering laboratory located in B Tower, room number 518 of Multimedia Nusantara University shown in Fig 1.1. Systematic observation of technical data will be carried out on the interior of the Physics Engineering laboratory to see the

number of lights, windows, air conditioners, air ventilation systems and the number of room occupants. It was obtained through observation that the number of lights was 24 (a pair at 12 points), 2 windows, and air conditioning using a chiller as many as 4 and air vents with 2 exhaust fans.

3. Measurement = Repeated measurements were made at 9 points 10 times for temperature and humidity and 36 points 3 times for illuminance. Measurements are made without and with the presence of B518 occupants from 13.00 to 15.00 in a separated consecutive day. The room condition on the second day was full of 30 people. The measurement points are placed evenly with each other. The measurement will use a measuring instrument called the CEM DT-8820 environment meter. This measuring instrument itself has 4 features, namely, to measure illumination, noise level, relative humidity and temperature. In this study, each variable will get the same repetition of measurements and predefined points.
4. Survey = In addition to observation and measurement, a survey was also conducted to 30 respondents from students of Physics Engineering and Electrical Engineering Universitas Multimedia Nusantara through data collection based on questionnaires. The data to be collected are the results of answers related to respondents' diagnoses related to symptoms of sick-building syndrome that appear such as runny nose, dry throat, dry skin, skin irritation, eye irritation, shortness of breath, chest tightness, watery eyes, dry lips, dizziness, headache, drowsiness, difficulty in concentrating, aches, nausea, flu/sneezing, fatigue, diarrhea, wrist pain, and back pain. In addition, respondents will also be asked about comfort levels for temperature (1 = very cold to 7 = very hot), relative humidity (1 = very dry and 7 - very humid) and illuminance (1 = very bright-glare and 7 = very dark-dim) on a Likert scale from 1-7. These results are collected and analyzed to show a correlation between SBS symptoms that appear against the comfort scale (23) . The results of this correlation will support the findings on the results of comfort measurements at temperature, relative humidity and illuminance which will then be processed further.

Figure 1 Physics Engineering Laboratory (B518)



Data Processing

The data collected are then arranged in tables and visualized into an average graph. Calculations for data processing will use statistical equations as follows (24):

a. Mean

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

The meaning will be used to see the average measurements at temperature, humidity, and lighting levels so that they will be compared with references from SNI.

b. Standard Deviation

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}} \quad (2)$$

Standard deviation will be used as part of the calculation of the iterative precision of this study.

c. Precision

$$Precision = 100\% \left(1 - \frac{3\sigma}{\bar{x}}\right) \quad (3)$$

Precision will be a reference to how similar the results of repeated calculations are in this study.

d. Correlation (Pearson Product Moment)

$$r = \frac{\sum_{i=1}^{n} x_i y_i - n\bar{x}\bar{y}}{\sqrt{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2}\sqrt{\sum_{i=1}^{n} y_i^2 - n\bar{y}^2}} \quad (4)$$

Correlation will be used as a reference to see the relationship between sick-building syndrome that appears on the measurement results. Correlation will be measured using a tool called R Studio software.

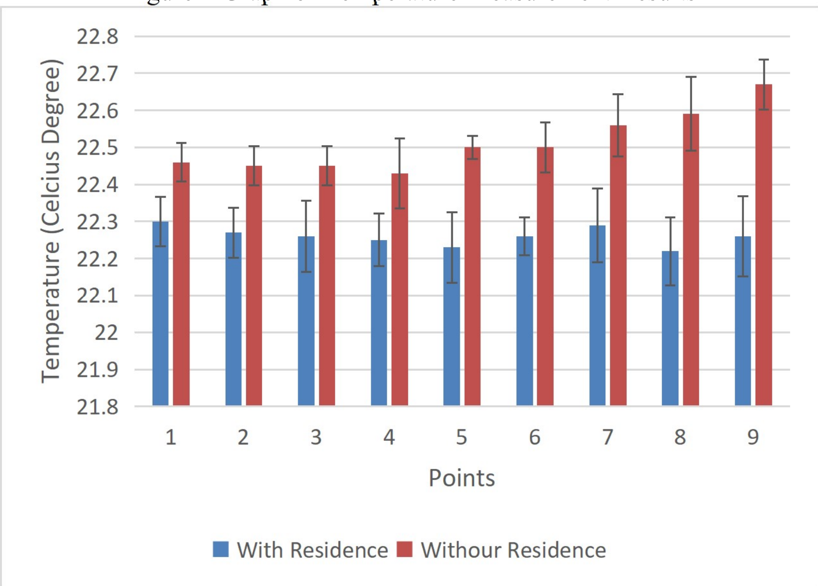
These results will then be compared with the reference (SNI) with the temperature standard in the room by 24°C-27°C, the relative humidity standard by 55% - 56% based on SNI 03-6572-2001 and the lighting/illumination level standard by 500 lux for laboratory based on SNI 6197-2020. The results of the comparison will be used in the analysis. In addition to measurement data, survey data that has been collected will also be arranged in tables and visualized into graphs. These two results will then be linked in the analysis section.

3. RESULTS

Physical Room Comfort Measurements

Measurements were conducted at nine points in Room B518 with ten repetitions at each point under two conditions (without and with occupants), focusing on temperature, relative humidity, and illuminance.

Figure 2 Graph of Temperature Measurement Results

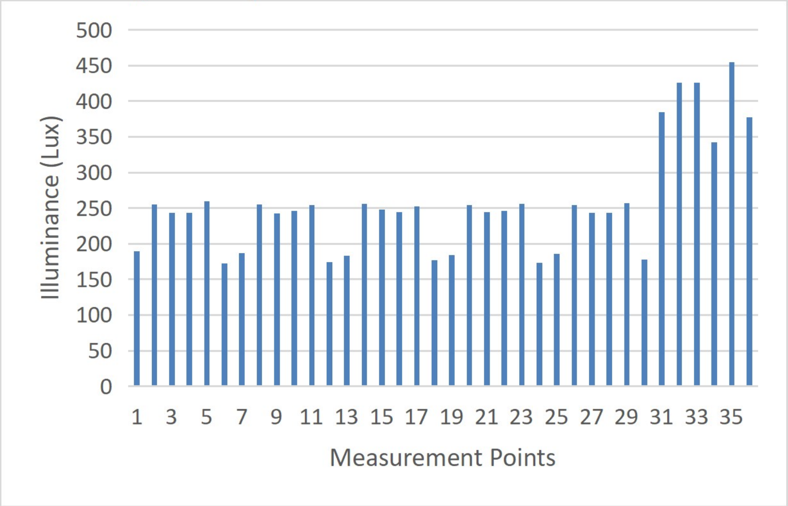


The temperature when the room was unoccupied ranged from 22.22°C to 22.30°C across all points with low variability, indicating stable thermal conditions. When the room was occupied, the temperature slightly increased to 22.43°C–22.67°C due to occupant activity and equipment heat generation. These values remained within the cool to optimal comfort range based on SNI 03-6572-2001.

Figure 3 Graph of Relative Humidity Measurement Results

Relative humidity when unoccupied ranged from 53.15% to 53.78%, while during occupancy, it increased to 55.17%–56.02%, indicating the influence of human presence and activities on moisture levels. The values were within the acceptable range for fully occupied spaces (55–60%), showing that humidity conditions in the laboratory were appropriate for comfort.

Figure 4 Graph of Illuminance Measurement Results



Illuminance measurements conducted under natural and artificial lighting showed that all measured points had values below the laboratory standard of 500 lux, with the average not exceeding 250 lux. This indicates inadequate lighting for laboratory activities, which may affect occupant comfort and concentration levels.

SBS Symptoms Among Occupants

To support the measurement findings, SBS symptoms were assessed through questionnaires. Table 1 summarizes the frequencies and percentages of reported symptoms.

Table 1 SBS Symptoms from Physics Engineering Laboratory Occupants

SBS	Number of Symptons	Percentage (%)
Runny Nose	3	10.0%
Dry Throat	7	23.3%
Dry Skin	4	13.3%
Skin Irritation	0	0.0%
Eye Irritation	3	10.0%
Difficult in Breathing	0	0.0%
Chest Tightness	0	0.0%
Watery Eyes	1	3.3%
Dry Lips	12	40.0%
Dizziness	4	13.3%
Headache	4	13.3%
Drowsiness	20	66.7%
Difficulty in Concentrating	10	33.3%
Aches	5	16.7%
Nausea	0	0.0%
Flu-Sneezing	4	13.3%
Fatigue	8	26.7%
Diarrhea	0	0.0%
Wrist Pain	1	3.3%
Back Pain	5	16.7%

The most frequently reported symptoms were drowsiness (66.7%), dry lips (40.0%), difficulty concentrating (33.3%), fatigue (26.7%), and dry throat (23.3%). These symptoms indicate potential SBS emergence within the laboratory environment, especially related to insufficient lighting and air circulation.

Correlation Between Room Comfort and SBS Symptoms

Data normality was tested using the Shapiro-Wilk test, which showed that the data were normally distributed ($p > 0.05$), allowing for the use of Pearson correlation tests to determine the relationship between room comfort parameters and SBS symptoms.

Table 2 Correlation Between Temperature, Relative Humidity, and Illuminance with SBS Symptoms

Standard (Physical)	Pearson Correlation
Temperature	-0,0156
Relative Humidity	-0,1297
Illuminance	-0,4393

Interpretation:

The correlation between temperature and SBS symptoms was very weak and not significant ($r = -0.0156$, $p = 0.938$).

The correlation between relative humidity and SBS symptoms was weak and not significant ($r = -0.1297$, $p = 0.512$).

The correlation between illuminance and SBS symptoms was moderate, negative, and statistically significant ($r = -0.4393$, $p = 0.016$, $p < 0.05$).

The moderate, significant negative correlation for illuminance suggests that lower lighting levels are associated with higher occurrences of SBS symptoms, such as drowsiness and concentration difficulties, as found in the questionnaire results. In contrast, temperature and humidity, which remained within acceptable comfort standards, did not show significant contributions to SBS symptoms in this setting.

4. DISCUSSION

Based on the first graph, the increase in temperature inside the laboratory can be attributed to the heat produced by the occupants' bodies and electronic equipment used during activities, which is consistent with heat transfer processes through conduction and radiation from walls or windows, as well as convection within the room environment. Notably, points 7, 8, and 9 showed higher temperatures, likely due to the concentration of occupants and the proximity to equipment clusters in these areas, resulting in localized heat zones. However, these measured temperatures remained below the reference standard of 24–26 °C (ESDM, 2012), which indicates the laboratory environment may feel cold to some occupants, potentially affecting thermal comfort perception during activities.

From the second graph, it was observed that points 1, 2, and 3 recorded higher relative humidity compared to other measurement points. This condition is influenced by the lower temperature in these areas, as higher temperatures from occupant concentration and internal heat sources can reduce relative humidity, consistent with the thermodynamic relationship between air temperature and moisture capacity (26). Other contributing factors include air pressure variations, sunlight penetration, artificial lighting heat, and air conditioning usage (26). The results indicate that relative humidity measurements without occupants did not meet the standard of 55–56% but approached these standards during occupancy (ESDM, 2012), suggesting that occupancy and equipment usage contribute to maintaining relative humidity within an acceptable comfort range.

Illuminance measurements shown in the third graph revealed that most points did not meet the minimum standard of 500 lux, with averages not exceeding 250 lux. This inadequacy is likely due to insufficient daylight access, suboptimal artificial lighting design, shading from structural and furniture elements, and low internal surface reflectivity. These factors collectively limit the laboratory's lighting quality, which can affect visual comfort, concentration, and alertness during laboratory activities, potentially contributing to the emergence of SBS symptoms.

The questionnaire data revealed that the most reported SBS symptoms were drowsiness (66.7%) and dry lips (40.0%), indicating a pattern that aligns with previous findings associating poor lighting and dry indoor conditions with increased fatigue and discomfort (Selvanathan et al., 2020). The dominance of drowsiness as a symptom may be explained by insufficient illuminance levels, which can reduce alertness and disrupt circadian rhythms, especially during prolonged laboratory activities requiring high focus. Additionally, dry lips may result from low humidity levels and prolonged talking during group discussions or presentations, common in laboratory settings. It should be noted that the use of self-reported scales for comfort and symptom assessment may introduce subjectivity and recall bias, as respondents might overestimate or underestimate their discomfort based on daily mood and environmental sensitivity.

The correlation analysis indicated a very weak negative relationship between temperature and SBS symptoms, a weak negative correlation with relative humidity, and a moderate negative correlation with illuminance, with illuminance showing a statistically significant relationship ($p < 0.05$). This suggests that inadequate lighting is a more critical factor contributing to SBS symptoms, particularly drowsiness and concentration difficulties, within the laboratory environment.

Practically, these findings underscore the need for campus facility managers to prioritize improvements in laboratory lighting systems by increasing illuminance to meet recommended standards and reduce SBS symptoms. Additionally, the management should monitor and adjust relative humidity levels to maintain comfort while ensuring that laboratory temperatures align with thermal comfort standards. Theoretically, this study contributes to understanding how physical comfort factors specifically affect SBS symptom emergence in educational laboratory environments, providing a targeted reference for future environmental health assessments within university settings.

5. CONCLUSIONS

The first aid actions done by the families when their children have a febrile seizure include letting the febrile seizure run, observing, putting something in the children's mouth, and asking for help from others. The results of the research are expected to provide input for nurses in providing nursing care to families with children who have a history of febrile seizures and help in performing the emergency first aid at home.

ACKNOWLEDGEMENTS

I extend my heartfelt appreciation to Multimedia Nusantara University for the support provided in the research process for this journal article. Both in terms of facilities and funding, we truly appreciate it.

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