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Thermal comfort study for classroom in urban and rural schools in Selangor

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Abstract. Optimum comfort factors help in enhancing effective learning process in a classroom. The aim of this research is to study thermal comfort in school classroom for a more desirable learning process. Four schools consist of urban and rural schools in Selangor were selected for this study. Field measurement and questionnaires were used to measure the level of comfort and satisfaction of school teacher and student in classroom. Data was collected using Temperature data-loggers (SD500 Humidity/Temperature Data logger). The questionnaire was analysed based on Likert's scale rating. Result from both on-field measurement and questionnaire survey suggests that thermal comfort has greater importance to focus. All the schools tested higher temperature than the recommended value. This study also outlines several improvement suggestions for better comfort level such as better air ventilation system and smaller class size.

1. Introduction

Student behavioural growth is more affected by school environment compared to home environment [1]. Therefore, there is demand for comfortable indoor environment for humans to perform at highest performance level. Environmental comfort embodies four research areas which are thermal [2], acoustic [3], luminous [4] and Indoor Environmental Quality [5].

Due to climate change, humans spend most of their time indoors and it is crucial to have the most comfortable thermal condition. Good indoor environment comfort level will lead to positive impact to the user. The challenges faced by teachers is to give the best teaching experience and provide students with the best learning environment so they are able to concentrate and focus when classes are in session. The authorities also face challenges when constructing schools, as they need to consider comfort factors during construction.

Schools in Malaysia need to meet the basic requirement of satisfaction comfort level to improve teachers and student performance. Lack of awareness on the issue of comfort factor resulted in low performance by teachers and students due to neglected comfort environment. Comfort level can be improved by further study on the relationship between performance and environment condition.



Effective mitigation can help increase the building user safety and teacher productivity in teaching. This ultimately helps to improve student's performance in school.

2. Literature review

2.1 Thermal comfort

Thermal comfort is defined as the state of mind, which expresses satisfaction with the thermal environment [6] and it is the most important aspect for achieving overall satisfaction of indoor environmental quality [7]. Study shown that human is more affected to the variation of temperature compared to relative humidity [8] and have significant effect on its occupancy [9].

Thermal factors play a huge role in satisfaction level of human in a room or building. It is also ranked higher importance compared with other comfort factors such as visual, acoustic, and good air quality [7]. Study showed that optimum temperature range is between 27.1°C to 29.3°C [8].

2.2 Thermal comfort factor study

Thermal comfort factors are quite popular among Malaysian school comfort factor researchers. Majority of the study collected quantitative data through field measurement and questionnaire. Among notable study is by using physical observation where they determine temperature comfort ability based on the type of clothing the student and teacher choose to wear [9]. In addition, the study also conduct interview based on ASRHAE thermal sensation scale (Table 1).

Table 1. ASHRAE thermal sensation scale [9]

| Scale | Description |
|-------|----------------------|
| -3 | Cold |
| -2 | Cool |
| -1 | Slightly cold |
| 0 | Just right (neutral) |
| 1 | Slightly warm |
| 2 | Warm |
| 3 | Hot |

Alternatively, another study investigates thermal comfort by questionnaire survey using Teaching and Learning Classroom Thermal Comfort Inventory (TLCTI) instrument [6].

3. Methodology

3.1 Field measurement

Field measurement was conducted between 0800 until 1250 focusing on school morning session. Four schools were selected, two are considered as urban school which located near residential area, whereas another two schools are considered rural school (Table 2).

Table 2. Selected schools description

| School | Type | Description |
|--------|-------|--|
| SU1 | Urban | Located in urban residential area, near proximity with 2 other schools |
| SU2 | Urban | Located next to high volume highway |
| SR1 | Rural | Located near to hillside, near proximity with rural residential area |
| SR2 | Rural | Located next to river surrounded by forest |

Temperature data-loggers (SD500 Humidity/Temperature Data logger) were used for measuring the air temperature (Figure 1). This temperature data logger has a capacity of 30, 000 readings within 5-600s intervals and are capable of data storing for more than a month worth of data. The accuracy range is from 0°C-50°C.

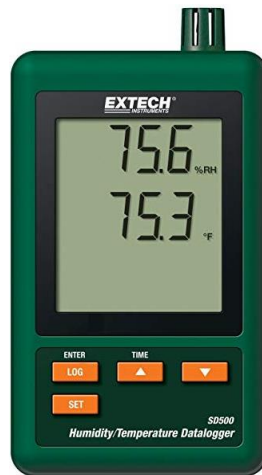


Figure 1. SD500 Humidity/Temperature Data logger.

The measurements were carried out between 10th of January until 22nd of January, 2019. The equipment was calibrated before taking any measurement. The equipment was set to measure air temperature (Degree Celsius, °C) every 30 second and the data were then collected and integrated for 40 minutes interval (period of 1 class session). The measurement was taken without interrupting the natural behavior of students and teachers in classroom.

3.2 Questionnaire distribution

Questionnaires were distributed among teachers and students in the selected classroom. Each respondent was brief prior to answering the questions since the respondent also consist of student age 10-12 years old. Although conducting questionnaire survey among youngsters age 8-12 are quite uncommon, however it is not out of the ordinary. There are multiple previous studies conducted based on questionnaire survey among school age children of 10-12 years old [11, 12].

This study used close-ended questionnaire consists of three main sections. Section A contains demographic survey for respondents. Section B list 6 questions related to thermal comfort, respondents were required to rank their agreement level according to 5 levels Likert’s scale (Figure 2).

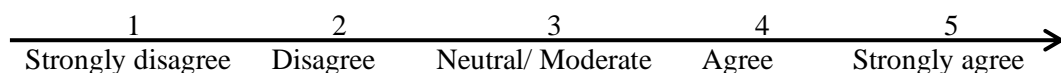


Figure 2. Section B questionnaire Likert’s scale.

Section C consists of four questions on respondent opinions about classroom comfort quality and improvement.

4. Result and discussion

4.1 Demographic profiling

Figure 3 shows respondent demographic in term of (a) status (b) gender and (c) school type. 57.1% of total respondent were students inside the selected classroom. Gender-wise, the analysis indicated that 42.9% are male and 57.1% are female respondents from various schools, which were randomly selected to participate in the survey. In term of school type, it is 67.1% for urban and 32.9% for rural school type.

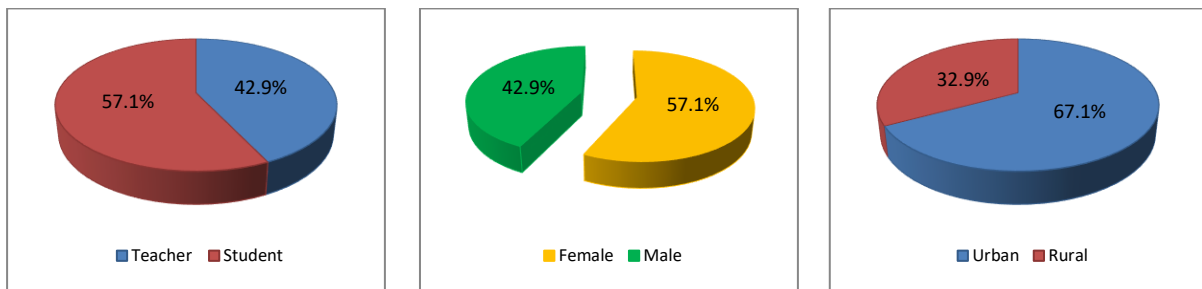


Figure 3 (a) Status.

(b) Gender.

(c) School type.

4.2 Thermal comfort measurement

Figure 4 shows the temperature reading for selected schools from 8.00 a.m until 11.00 a.m.

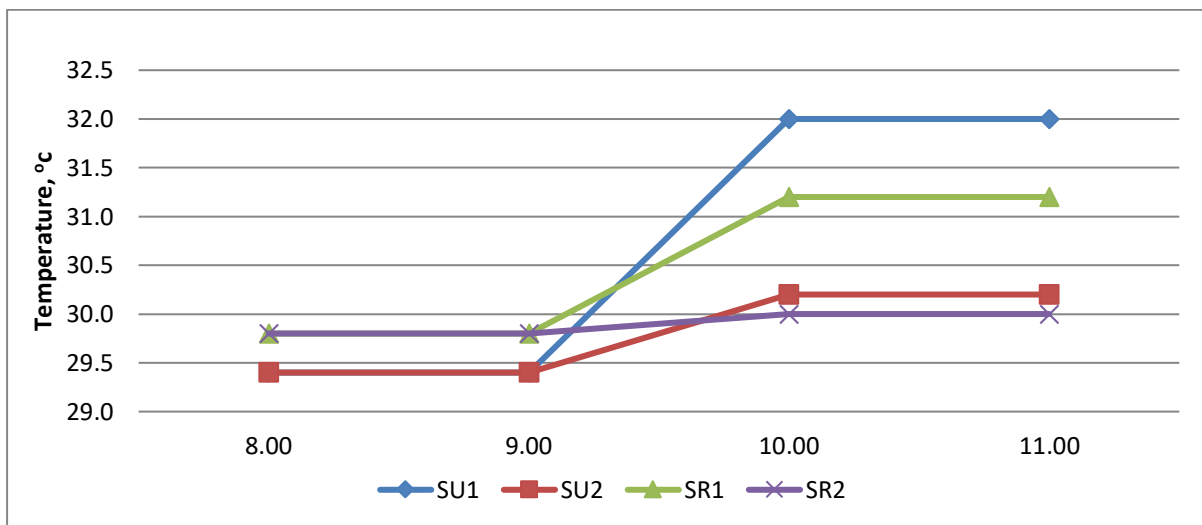


Figure 4. Temperature data logger reading.

The lowest temperature was recorded in the morning at 29.4°C located at SU2. The highest temperature was recorded near to the afternoon at 32.0°C at SU1. In general, the temperature is higher in the afternoon rather than in the morning is because classroom floor, walls and other objects have been collecting heat up all day and releasing heat [13]. All the schools tested higher temperature than the recommended value. As mention previously, the optimum temperature range is between 27.1°C to 29.3°C [8].

Although there is no significant differences between urban school and rural school type, SR2 shows consistent increment compared to dramatic incline demonstrated on urban school type (SU1). Buildings and other artificial materials can store more radiation energy than natural vegetation and

soil. Study has shown bigger cities tended to experience a greater difference in temperature for day and night temperature, compared with the rural area [14]. This phenomenon is term as urban heat island.

4.3 Questionnaire result

Figure 5 show the agreement level for the statement “I feel hot in class”. This statement refers to the teacher and student thermal comfort level in their classroom. Description for the analysis is further discussed below.

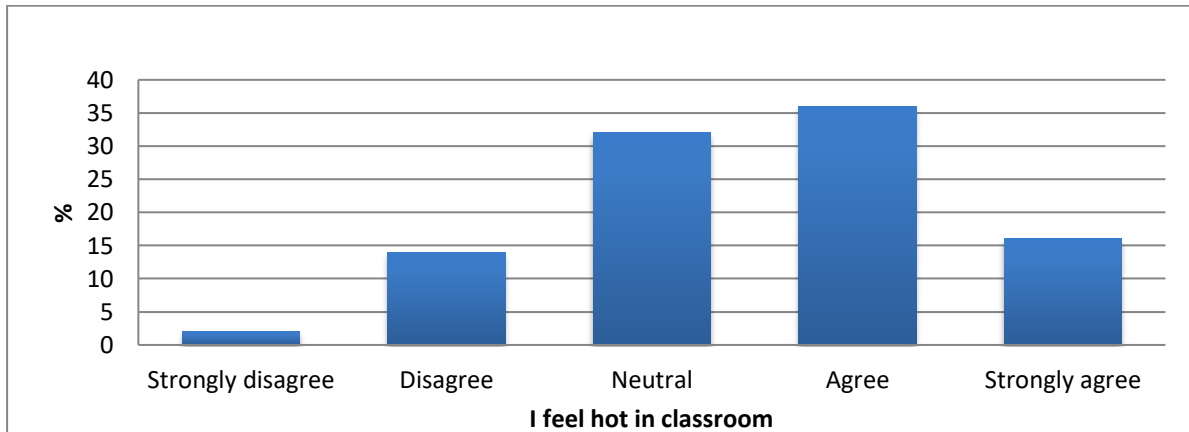


Figure 5. I feel hot in class statement analysis.

36% of the respondents agree that they felt hot in the classrooms. Meanwhile, 16% felt strongly agree with the statement. All of the selected classroom were using equipped with ceiling fans and all of the windows are open for air circulation. However, students and teachers still felt hot in the classroom. Due to over capacity of pupils, the arrangement of desk and chairs are too close together causing higher temperature in class.

Figure 6 show the agreement level for the statement “I loss focus if it too hot in classroom”. This statement refers to the teacher and student performance in their classroom.

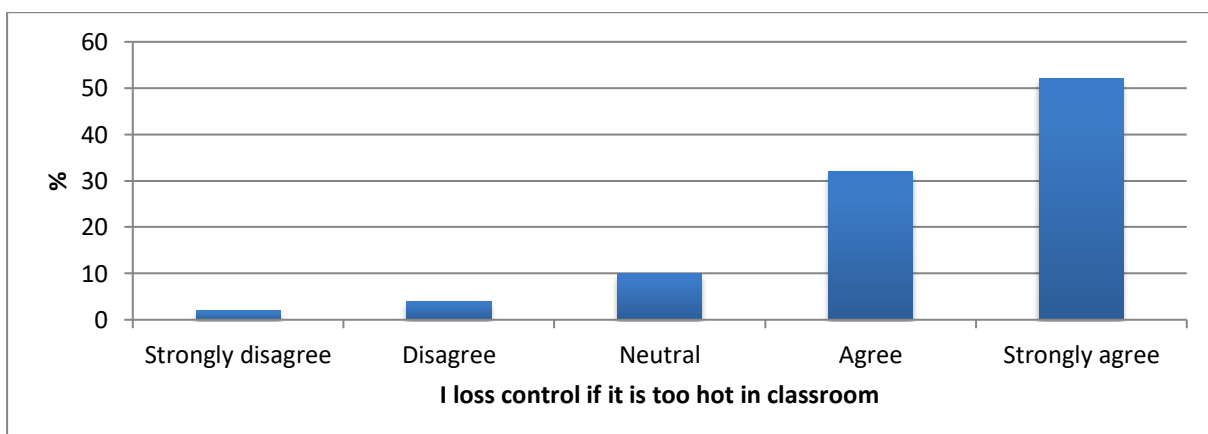


Figure 6. I loss control if it is too hot in classroom.

Most of the respondents (53%) strongly agree with the statement. Meanwhile, only 10% felt neutral to and 2% of the respondent strongly disagree with the statement. This aligns with previous study that

show student complaints of headache, difficulties in breathing and stress while in hot classroom. This condition reduces concentration, making the learning environment less conducive [6].

4.4 Improvement strategies

This study discovered that all the selected classrooms have higher temperature than the recommended value, regardless whether it is in rural area, or urban area. Yet, differences between mornings temperatures with afternoons temperature are bigger observe at urban school area due to urban heat island situation. Among strategy to improve the thermal comfort is to upgrade air ventilation systems of the classroom especially for urban school type. Next, the seating layout in the classroom also has to be modified. It is recommended that the class only have around 30 pupils per class. Human body provides heat transfer or heat loss. If the seats are too close or too near with each other, the students will experience discomfort.

This research also recommends a more thorough study on urban heat island in urban schools. Suitable engineering strategy on the construction material used for building school such as using material that does not absorbed heat are needed. Future studies that plan for passive cooling approach also are recommended.

5. Conclusion

The purpose of this study is to contribute knowledge for better satisfaction and improvement on comfort level of students and teachers in classroom school in Malaysia. The on-site data collection was conducted in addition to questionnaire distribution. Findings show that these classrooms have higher temperature than the recommended standard. Questionnaire analysis also reported that the respondents are not satisfied with the condition of the classroom. The relationship between temperature and performance (as shown in Figure 6) were briefly explored and consistent with previous studies.

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