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Indoor Environmental Quality towards Classrooms' Comforts Level: Case Study at Malaysian Secondary School Building

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Abstract: The indoor environmental aspects of classrooms in secondary school buildings need to be determined to ensure that they meet the users' basic requirements. Students' efficiency and learning productivity can be affected if the classroom's indoor environment is of poor quality. The question raised here: how can we ensure that the comfort level provided to building users in terms of indoor aspects is up to their satisfaction? Post Occupancy Evaluation (POE) is an instrument to examine the success of building design and performance after occupancy. It indicates users' satisfaction and comfort level related with the indoor environment. Considering users as a benchmark, there is a large potential for improvement in buildings' indoor environmental aspects. As reflected by the title, the study's main purpose is to evaluate students' satisfaction and perception of their classrooms' comfort level along with recommendations to enhance the quality of their indoor environment. The survey method applied in this study is by distributing questionnaires to 382 students in classrooms where physical measurements were taken to determine how environmental aspects affect these students. This is because these students are highly correlated with the level of comfort and productivity in the classroom. To enhance physical satisfaction during the learning process, semi-structured interviews consisting of 35 experts in related fields were selected, of whom 17 experts are those with a technical background while the remaining 18 experts are from non-technical fields. The results of this interview will be integrated in finding the best methods to improve Indoor Environment Quality in the classroom. The paper recommends the adaptation of POE in order to evaluate the indoor environmental aspects of classrooms as significant learning spaces in school buildings that need to be managed and monitored continuously.

Keywords: indoor environmental quality; comforts level; classroom; school building; post occupancy evaluation

1. Introduction

A sustainable environment is necessary, more so for educational buildings such as schools, colleges, and universities. Besides that, the right comfort and efficiency levels in educational buildings may encourage users' productivity and focus during the teaching and learning process [1]. Classrooms are seen as a significant component of learning

spaces. Thus, school buildings normally need sufficient classrooms for student enrolment. A conducive classroom may be able to provide the right conditions for students to learn as the overall classroom environment can affect student learning [2]. Studies may become disrupted due to inadequate environmental classroom conditions, which then affect students' motivation and consequently, achievement [3]. According to [4], a classroom's physical environment can influence students' achievement and improve student performance. Thus, classrooms must be designed accurately, more so in terms of facilities such as lighting and ventilation. The requirements for lighting and ventilation according to Clause 39(3) [5] is that the classroom must be provided with natural lighting and natural ventilation by means of one or more windows having a total area of not less than 20% of clear floor area of such rooms and shall have openings capable of allowing a free uninterrupted passage of air of not less than 10% of such floor area. Besides that, cleanliness of classroom must be improved because dustiness of classrooms is one of the factors that influence student's well-being [6]. This is supported by [7] that classroom cleanliness could affect school students' stress levels in an educational environment.

Classrooms need to have scheduled assessments to ensure that their physical environment aspects are well-functioning. Is there any way that the assessment of physical environment aspects and the indoor environmental aspects be combined to form a student's overall assessment of a classroom's environment? The Post Occupancy Evaluation (POE) is one of the assessment tools on building sustainability after occupation, which means that it is also suitable for application in the specific area of study or classrooms in school buildings. Other than that, the POE is the collection of occupant satisfaction reviews based on a building's performance [3]. The building performance focuses on evaluating the quality of a building's environment and determining the level in which the building fulfil a user's requirement [8]. POE is a systematic evaluation of a building's performance after a short period of occupancy [9]. POE systematically analyzes the physical environment aspects of classrooms to identify the classroom's current condition, its successful design, and the environmental impacts it has on students.

Academic and learning development is synonym with healthy learning spaces for students, which is mainly provided through school facilities. Classrooms as learning spaces in school buildings need to be provided with safe physical and social environments for effective interaction between students and teachers throughout the teaching and learning process. Students' growth and development are the main factors as to why satisfaction in terms of classroom comfort level needs to be evaluated [10].

The occupant survey and interview in this paper's context is targeted on students as classrooms occupants as this group of respondents may provide additional information as users of classrooms [3]. Occupants' satisfaction cannot be measured using only one or two environmental aspects of the classroom as representative of the total environment. Therefore, this paper's purpose is to evaluate students' satisfaction on the quality of classrooms' indoor environment (IEQ) according to factors like (i) cleanliness level (ii) visual comfort (iii) thermal comfort (iv) noise pollution, and (v) air movement. This study was conducted on classrooms in selected secondary school buildings located in Selangor, Malaysia.

According to [11] from the Malaysian Meteorological Department, Malaysia's climate is categorized as an equatorial or tropical maritime climate with uniform temperature and is hot and humid throughout the year. Since year 1987, the country's temperature average has vacillated between 23 and 26 degrees Celsius. However, the average temperature for this country has changed to 27 degrees Celsius due to the El-Nino Southern Oscillation Index (ENSO) which happened in year 2017 and increased the average temperature to be higher than the normal average value. This new average temperature level may influence students' comfort during the teaching and learning process [12].

Previous studies conducted in the last two decades have developed and systematically implemented POE methods on buildings in order to provide high potential for building sustainability. POE does not merely reduce the environmental and financial costs of

enhancing the quality of a building's performance, but also enhances the occupants' quality of life [13]. However, constraints such as ventilation, air flow movement, and thermal comfort may cause a decrease in the indoor environmental quality, such as in classrooms. Accordingly, the corresponding research objectives have been formulated to suit the study's introduction and problem statement as expounded above. The objectives are the following: (i) to establish students' satisfaction and perception levels on the classrooms' indoor environment aspects such as cleanliness level, thermal comfort, visual comfort, noise pollution, and air movement and (ii) to propose ways to improve the classroom indoor environment, specifically for secondary school buildings in Malaysia.

2. Literature Review

Post Occupancy Evaluation (POE) generally emphasizes on building occupants' needs and satisfaction levels [9]. In latest studies, POE has been discussed in terms of user satisfaction, technical, and financial performance, and the effect of it on occupants' living or working conditions. Evaluations are usually made on occupied buildings where the POE is primarily conducted to evaluate user satisfaction rather than the other aspects [14]. POE is also important to be practiced in educational settings such as schools and higher educational buildings [15]. School buildings need to conduct the POE process to improve the indoor environmental quality of their learning spaces which may impact the learning behavior of students [16].

2.1. Process of POE

Post Occupancy Evaluation (POE) implementation is usually after a new or newly renovated building has been occupied for a period of 4 to 24 months [17] to ensure that the building's performance after occupation is satisfactory. However, according to [15], POE can be performed on a building at any stage to ascertain the comfort level of specific spaces and facilities. Also, according to [18], it is not necessary to conduct POE in between the time frame but POE can be implemented at any time in the life of a building. The evaluation process can show that the building under evaluation is well-functioning and its design fulfills the requirements for environmental improvement for the reduction of maintenance and operation costs [19]. The success of a building's performance depends on the process of evaluation, inspection, maintenance, and repair, all of which are related to indoor environmental factors that can be significant for all buildings [20].

Three main steps are included in the POE process to encompass the justification, activities, resources and results for different phases. The phases are: (i) planning (ii) conducting, and (iii) applying [9].

2.2. Classroom Comfort Level

The evaluation of a building's comfort considers its physical environment aspects, including thermal and acoustic factors to ensure that the building occupants are satisfied [21]. Comfortable classroom conditions can foster high levels of concentration during the teaching and learning process [2]. High occupancy levels in classrooms may cause distress and discomfort in students while the learning process is conducted. Thus, it is evident that physical aspects are important in creating a conducive learning environment in the classroom and to help generate students' motivation during teaching and learning. The quality of a classroom's physical environment is parallel to the good attitude and best achievement of students in the school [8].

3. Research Methodology

Three methodology phases are involved in this study. The first phase focuses on defining the study area and POE's overall scope and concerns by referring to previous studies through a review of related literature. The study's research problems were identified through the literature review, along with observations, visual inspections, unstructured interviews and study visits.

Next, the second phase is information gathering through the development and distribution of questionnaires to students as respondents and occupants of classrooms at secondary school buildings. The respondents were students aged between 13 to 17 years. To test the effectiveness of the POE application, a pilot test was first conducted on a small number of samples. A total of 382 students were involved in this survey, of which 181 students were male while the remaining 201 were female. The adequate sample size was adapted from Krejcie and Morgan [22], in which the 382 respondents were calculated through the number of sample measurements from the entire population which had less than 75,000 sample targets. The chosen building type was public school buildings located at various areas in Selangor due to the highest number of active secondary schools compared to other states which is 272 schools. For this study, a total of 10 schools in Selangor were selected based on the level of school damage that has been reported. Because the weather in Malaysia is hot and humid throughout the year, this research is not influenced by changing climate factors given that Malaysia has a relatively uniform weather. A sum of 382 questionnaires was distributed to occupants of the study's targeted buildings which are students that are very familiar with the classroom environment. All respondents answered the questionnaires in a standard size classroom in order to feel the classroom's real comfort level during the survey. A Likert scale which consists of 5 levels ranging from "1" for Strongly Disagree to "5" for Strongly Agree was used to indicate the responses given by each respondent for each question.

The collected data will be reviewed and analyzed to formulate research findings that meet the objectives of the research. Several factors were identified when the data was entered in manually. However, efficient data entering should make use of the Statistical Package for the Social Sciences (SPSS) computer software in order to obtain accurate data analysis depending on the population and sample size decided. Following the results and their analysis, the authors provide suggestions and recommendations on ways to improve the indoor building environment of classroom spaces reflecting the data analysis of this research. The last part, which is the third phase, focuses on concluding all the study's findings and includes recommendations for future studies.

4. Results and Discussion

Table 1 illustrates the respondents' satisfaction and perception levels on the classrooms' indoor environment at secondary school buildings in terms of percentage composition. Table 1 shows the distribution of descriptive numbers and percentage of students' responses by gender to clarify the comfort level in classrooms based on Indoor Environment Quality (IE) which are significant with learning space or specifically in learning environment. Comfort level in the classrooms is really influenced by Indoor Environmental Quality (IEQ), where from the students' perspective, the percentage of satisfaction of classroom condition by male is 47.4% (181 students), which is lower than females with 52.6% (201 students).

Table 1. Students' responses regarding comfort level in classrooms.

Students' Response	Gender	N	Percentage (%)
Satisfaction on Classroom Comfort Level	Male	181	47.4
	Female	201	52.6

Table 2 shows the distribution of descriptive numbers, percentage, and means of students' perception about different types of physical elements that may contribute to comfort level in the classrooms at secondary school buildings. The results of these students' perception may represent the current condition of classrooms prepared for the teaching and learning process; besides, it describes the feelings of students while in their respective classrooms. According to [10], a classroom's physical environment is important in creating conducive teaching and learning space for the students. The physical elements of class-

rooms will encourage students to be more motivated and then improve their achievements at school [13,23].

Table 2. Types of physical elements that contribute to classrooms' comfort level.

Classroom Physical Elements	Scale Frequency	N	Percentage (%)	Overall Mean
Furniture	Strongly Disagree	25	6.5	3.6937
	Disagree	32	8.5	
	Satisfied Agree	85	22.2	
	Agree	**133**	**34.8**	
	Strongly Agree	107	28	
Lighting	Strongly Disagree	46	12	3.4791
	Disagree	62	16.3	
	Satisfied Agree	20	5.2	
	Agree	**171**	**44.9**	
	Strongly Agree	83	21.7	
Ventilation	Strongly Disagree	12	3.1	4.267
	Disagree	24	6.3	
	Satisfied Agree	25	6.5	
	Agree	110	28.9	
	Strongly Agree	**211**	**55.2**	
Space	Strongly Disagree	47	12.3	3.6963
	Disagree	30	7.9	
	Satisfied Agree	40	10.5	
	Agree	**140**	**36.6**	
	Strongly Agree	125	32.7	

For basic classroom environment, the percentage and number of students identify the implementation of each category of physical elements in the current condition at secondary school buildings. Thus, the mean for each category of physical elements in the classrooms are as follows: furniture with 3.6937; lighting with 3.4791; ventilation with 4.2670, and space with 3.6963. Based on the mean value, ventilation is the highest category of physical elements that students have concern about in the current condition of classrooms. Meanwhile, furniture and lighting represent the two lowest categories of physical elements in the classrooms. School buildings have usually been provided with the standard furniture that is suitable for the teaching and learning environment, and it results in poor awareness if improper furniture is equipped in the classrooms. The condition of furniture needs to be decided either it can be used or disposed in order to consider its safety and health aspect specifically for students. The sufficient amount of furniture is the main concern of a school building to enhance comfortableness in the classroom environment [24]. Otherwise, an appropriate arrangement of furniture in the classrooms may also increase effective communication skills among students throughout teaching and learning activities [25]. The lighting receiving the lowest overall mean in contribute to comfort level in the classrooms at secondary school buildings. Fluorescent lamps in the classroom have been the standard choice for school systems to provide efficient and quality lighting. Building conditions such as lighting are important and significantly positively related to student's performance and attitude [26,27]. According to [28], the physical environment in classroom is important and student achievement is impacted by such factors as lighting, noise, and climate control. Usually, school sessions are conducted during the day, so the lighting factor becomes less important in contributing to the comfort level of students in the classroom.

Table 3 shows the distribution of descriptive numbers, percentages, and means of current comfort level at secondary school buildings based on several questions of different categories for Indoor Environment Quality (IEQ) in the classrooms. Each Indoor Environmental Quality (IEQ) construct contains one or two related questions, and each question has a mean as shown in Table 3. The overall mean refers to the overall mean of the constructs containing one or two of the questions. The overall mean values of each category of Indoor Environment Quality (IEQ) are cleanliness with 3.6675, visual comfort with 3.9987, thermal comfort with 2.2435, air movement with 3.6257, and noise pollution with 3.1597. This shows that visual comfort has highest mean as it achieves the most satisfied level on student perception towards indoor environment aspects in the classroom. Thermal comfort shows the lowest mean because this factor gives less comfort to students during learning sessions in the classroom. According to [29], it has been proven that thermal discomfort gave a negative impact on students' learning performance as it also affects students' well-being.

Table 3. Results of the current comfort level of classrooms at secondary school buildings.

Indoor Environmental Quality (IEQ)	No	Questions	Scale Frequency	N	Percentage (%)	Mean	Overall Mean
Cleanliness	1	What is your perception on the level of cleanliness in this classroom?	Very Dirty	12	3.1	3.6675	3.6675
			Dirty	85	22.4		
			Medium Clean	19	4.9		
			Clean	168	43.9		
			Very Clean	98	25.7		
Visual Comfort	2	How satisfied are you with the natural day lighting in this classroom?	Too Dark	3	0.8	3.9948	3.9987
			Dark	82	21.5		
			Medium	20	5.2		
			Bright	86	22.5		
			Too Bright	191	50.0		
	3	How satisfied are you with the quality of artificial lightings in this classroom?	Too Dark	5	1.3	4.0026	
			Dark	28	7.3		
			Medium	12	3.2		
			Bright	253	66.2		
			Too Bright	84	22.0		
Thermal Comfort	4	How do you feel with the level of mechanical ventilation in this classroom (e.g.,: air-conditioning or fan)	Too Hot	84	22.0	2.2435	2.2435
			Hot	210	55.0		
			Medium	11	2.9		
			Cold	65	17.0		
			Too Cold	12	3.1		
Air Movement	5	How satisfied are you with the provision of air movement in this classroom (e.g.,: openings)	Very Unsatisfied	17	4.5	3.5236	3.6257
			Unsatisfied	84	22.0		
			Medium	28	7.3		
			Satisfied	188	49.2		
			Very Satisfied	65	17.0		
	6	What is your rate for the overall quality of indoor ventilation in this building, especially natural ventilation?	Very Poor	8	2.1	3.7277	
			Poor	62	16.2		
			Medium	48	12.6		
			Good	172	45.0		
			Very Good	92	24.1		

Table 3. *Cont.*

Indoor Environmental Quality (IEQ)	No	Questions	Scale Frequency	N	Percentage (%)	Mean	Overall Mean
Noise Pollution	7	How do you feel with noise control or vibration? (e.g.,: from vehicle, mechanical systems)	Very Quiet	26	6.8	3.4503	3.1597
			Quiet	92	24.1		
			Medium	25	6.5		
			Noisy	162	42.4		
			Very Noisy	77	20.2		
	8	What is your rate for the overall quality of noise control in this classroom?	Very Poor	35	9.2	2.8691	
			Poor	145	37.9		
			Medium	68	17.8		
			Good	103	27.0		
			Very Good	31	8.1		
Overall Comfort	9	What is your overall comfort level in your classroom area?	Very Uncomfortable	76	19.9	2.6152	2.1663
			Uncomfortable	155	40.6		
			Medium	27	7.1		
			Comfortable	88	23.0		
			Very Comfortable	36	9.4		
	10	To what extent do you think your productive learning is affected by poor indoor environmental conditions of the building?	Much Decreased	164	42.9	1.7173	
			Decreased	178	46.6		
			Medium	29	7.6		
			Increased	6	1.6		
			Much Increased	5	1.3		

Thus, the mean overall comfort is 2.1663, which illustrates that the current comfort level of classrooms is still under the lowest implementation and more improvement of physical elements in the classroom is necessary to achieve a conducive learning environment especially for students at secondary school buildings. This is related to the climate in Malaysia which is hot and humid throughout the year. Since the case study was conducted in a public-school building, no air conditioning was provided, and students had to rely on ceiling fan facilities, which affected their comfort levels to some extent.

The overall mean clearly illustrates that the highest mean is visual comfort (3.9987) and then followed by cleanliness (3.6675). This demonstrates that the current classroom condition is usually focused on the aspects of visual comfort which is related to lighting, either artificial or mechanical, for the classroom space. Whenever natural lighting is not sufficient, artificial lighting can be used for learning activities in the classrooms. Besides, maintaining the cleanliness of the classroom is a common routine, including sweeping the floors, wiping the window glass, cleaning the whiteboard, and arranging tables and chairs and usually students will ensure that their classrooms are clean and tidy to ensure a comfortable learning environment [10,30].

Overall, it is clearly shown that the majority of respondents feel comfortable in terms of visual comfort: artificial lighting (4.0026) and natural lighting (3.9948), quality of air ventilation (3.7277), classroom cleanliness (3.6675), and quality of air movement (3.5236). However, the students are uncomfortable with the classroom environment in terms of noise pollution and noise control (3.1597) and thermal comfort (2.2435).

Thus, there are several ways proposed by the authors to minimize issues related to the indoor environment of classrooms in school buildings:

(a) Visual comfort (daylighting)

1. Provide daylighting where natural lighting is incorporated with electrical lighting in the classrooms.
2. Provide the alternative to change the common louver window design with bigger and higher windows to increase daylight penetration.
3. Make available the option of changing the classrooms' windows to face the outdoor environment. This window placement allows for a greater penetration of natural daylight.
4. Avoid the use of curtains that cover classroom openings as they can reduce the penetration of natural daylight into the classroom space.

(b) Thermal comfort

This focuses on mechanical ventilation where fans are often used in classrooms in school buildings in Malaysia. The number of fans needed depends on the capacity of the students in a classroom. The standard capacity for each classroom in a secondary school is 30 students per class and this standard requires three fans. If a classroom's capacity is more than 30 students, additional fan units such as wall fans should be installed to ensure comfortable conditions during the teaching and learning activities. This is mainly to maximize students' thermal comfort in closed spaces.

(c) Noise pollution

Noise pollution in classes refers to two main sources, which are mechanical noise or vibration, and internal sounds such as from communication or interaction between students in the classroom itself. Noise coming from mechanical sources or vibration can be reduced by having scheduled maintenance for the mechanical equipment to avoid any critical damage as the components have a high possibility in contributing to noise pollution.

Communication or interaction can also produce noise pollution if uncontrolled, so the authors recommend that the location of classrooms should be quite far from the assembly area, canteen, field and hall. This initiative will be able to ensure the students' concentration during the teaching and learning process conducted in the classroom.

To minimize assumptions about the underlying distribution of the data, two related dependent samples were tested in a nonparametric test (NPar) using SPSS Version 24 as shown in Table 4. These tests are used when the usual analysis of variance assumption of normality is not viable and provide several methods for testing the hypothesis of equal means or medians across groups. The hypotheses can be tested even when certain classical assumptions, such as normal distribution and interval measurements are not met [31]. Through this test analysis, it may control the overall error rate for pairwise comparisons. The hypotheses were statistically tested with a two-tailed alpha level of 0.05. Thus, this analysis was conducted to identify which hypothesis can be accepted based on the following hypotheses:

Table 4. Ranking of test between students' overall comfort with classroom learning process.

		N	Mean Rank	Sum of Ranks
Overall Comfort Level in the Classroom-Learning Process is affected by the Poor Indoor Environmental Condition in the Classroom	Negative Ranks	11 [a]	2.9	32
	Positive Ranks	342 [b]	89.5	3042
	Ties	29 [c]		
	Total	382		

[a] Overall comfort level in the classroom < Learning process is affected by the poor classroom physical environment conditions. [b] Overall comfort level in the classroom > Learning process is affected by the poor classroom physical environment conditions. [c] Overall comfort level in the classroom = Learning process is affected by the poor classroom physical environment conditions.

Hypothesis 0 (H0). *The learning process is not affected due to students' comfortability in terms of poor classroom physical environment conditions.*

Hypothesis 1 (H1). *The learning process is highly affected due to students' comfortability in terms of poor classroom physical environment conditions.*

Because the data ranking the test between students' overall comfort with classroom learning process were not normally distributed, a different test was used in the non-parametric method, namely the Wilcoxon test as shown in the Table 5. Wilcoxon Signed Ranks Test are used to compare two sets of scores that come from the same participants or categories to investigate any change in scores from one time point to another. Based on Table 4 above, there is a difference in the value of overall comfort level in the classroom and learning process is affected by the poor indoor environmental condition in the classroom. Since p value is $p = 0.0033$ (two-tailed test) which is less than 0.05, the H0 which states 'the learning process is not affected due to students' comfortability in term of poor classroom physical environment conditions' got rejected. Judging from the mean rank value, it can be seen that the positive rank value of 89.5 is greater than the negative rank. So, it is clearly reported that there is enough evidence to conclude that the learning process is highly affected due to the poor condition of a classroom's physical environment.

Table 5. Statistics tests between two related dependent samples (Wilcoxon Signed Ranks Test).

	Overall Comfort Level in the Classroom—Learning Process Is Affected by the Poor Indoor Environmental Condition in the Classroom
Z	−4.690 [a]
Asymp.Sig. (2-tailed)	0.0033
a. Based on the negative ranks	

To achieve the objective of improving the classroom indoor environment, specifically for secondary school buildings in Malaysia, a semi-structured interviewed was conducted that involved 35 experts, consisting of 17 technical and 18 non-technical participants. Building experts who are classified as technical participants include the building surveyor, civil engineer, architect, quantity surveyor, building controller, and facilities manager. Meanwhile, non-technical participants include the lecturer, teachers, school principal, and counsellor. The expert participants selected in this study were those with more than 8 years of experience to obtain good and reliable opinions. In the semi-structured interview, 35 respondents had to answer 'Yes' or 'No' to the methods that have been proposed to enhance physical satisfaction during the learning process as shown in Table 6 below.

Table 6. Methods to improve indoor environment quality in classroom due to enhance physical satisfaction during the learning process.

Methods to Improve IEQ in Classroom	Total Experts (n = 35)			
	Technical (n = 17)		Non-Technical (n = 18)	
	"Yes"	"No"	"Yes"	"No"
Limitation on Classroom Capacity	16	1	18	0
	94%	6%	100%	0%
Additional Unit of Mechanical Ventilation	17	0	17	1
	100%	0%	94%	6%
Enhance the Building Openings	17	0	16	2
	100%	0%	89%	11%
Standard Quality of Building Materials	14	3	15	3
	82%	18%	83%	17%
Accurate Illuminance Level of Artificial Lighting	17	0	16	2
	100%	0%	89%	11%
Control the Cleanliness	17	0	17	1
	100%	0%	94%	6%
Schedule School Building Maintenance	17	0	18	0
	100%	0%	100%	0%

Based on each method to improve IEQ in classroom, each method is based on these following references and statements below:

Limitation on Classroom Capacity: Table 6 shows the limitation on the classroom capacity gain exceeds 94%, as it can improve the level of satisfaction among students during the teaching and learning process. According to Economic Planning Unite (EPU) guidelines (2015) the number of students should be less than 30 per classroom. This specifically refers to the typical classroom size.

Additional Unit of Mechanical Ventilation: UBBL 1984 stated that the size of the classroom should be considered for any mechanical installation. The standard classrooms in a school building only use a fan system. Classrooms that have 3 units of fans are often referred to as the standard classroom size for secondary school buildings. However, the use of air conditioning depends on the financial capability of the school. The use of these air conditioners is only approved by the Ministry of Education (MOE) and the Public Works Department (PWD) when the school can bear the monthly electricity bill and its maintenance costs. Because public school in Malaysia is funded by the Government, each school has a limited specific allocation in spending the funds for school facilities and maintenance. In contrast to public school management, private schools obtain facility funds from the high fees charged to students. Therefore, most private schools have air conditioning facilities. However, the school management can propose the use of air conditioning if they have sufficient allocation to cover the burden of electricity and maintenance bills and need to get the approval from the MOE and PWD. The use of air conditioning in schools usually is only available in a few areas such as libraries, computer labs, and offices. Usually, wealthy families prefer to send their children to private schools to get better facilities. However, students who come from low-income families will get an education in public schools because of the very low education fees compared to private schools. Nonetheless, students' families are welcome to donate towards air conditioning if the Parents and Teachers Association agrees to raise funds for the facility. It all depends on the initiative of the school as well as the allocation received in ensuring the comfort of the students. Therefore, the majority of respondents answered 'Yes' regarding the need

to improve mechanical ventilation through the use of fans or air conditioners to ensure the students comforts in the classroom. In addition, the weather in the peninsula is often warmer than other localities.

Enhance the Building Openings: Referring to UBBL 1984, building openings, including window and door openings must allow for natural ventilation and natural lighting. The average value of humidity: 40–70%, air-flow rate: 0.15–0.50 m/s, and temperature: 23–26 °C for classrooms in the secondary school building (MS 1525 2014: ASHREA 2009b and Department of Health and Safety 2010). Building opening enhances natural ventilation and maximize air movement in the indoor spaces of the school building.

Standard Quality of Building Materials: There are 82% (technical) and 83% (non-technical) participants who agreed to enhance the quality of building materials for educational buildings. However, public school buildings in Malaysia used the standard materials stated by Public Works Department (PWD) and the contractor will follow the specifications of standard materials.

Accurate Illuminance Level of Artificial Lighting: This standard is normal for classroom use in Malaysia. The suggestion illuminance level of classroom by the Department of Occupational Safety and Health (DOSH) is 300 Lux. However, based on the survey field for this project it is stated that the average illuminance level of lighting (for both, natural and artificial lighting) is 226 Lux.

*Standard size of classroom size = Height (H) × Length (L) × Width (W) = 3.60 m × 9.23 m × 7.31 m = 242.89 m.

*Standard installation of artificial lighting = 9 fluorescent light cover, 18 units fluorescent bulb.

Control the Cleanliness & Schedule School Building Maintenance: Cleanliness and maintenance are important aspects that need to be considered in enhancing the performance of the classroom as a good learning environment. Daily cleaning and regular maintenance of the building can increase the level of satisfaction regarding cleanliness in a classroom. The frequency of building maintenance is usually once every six months or twice a year.

Referring to Table 6, seven methods have been proposed to improve indoor environment quality in classroom due to enhance physical satisfaction during learning process. For limitation on classroom capacity, all non-technical respondents agreed with the method proposed except one of technical respondent who disagreed. Secondly, another method proposed is additional unit of a mechanical fan. Based on the results, all 17 respondents from the technical field agreed except one respondent from non-technical field who disagreed with the recommendation. Thirdly, method on enhancing the building openings shows that all technical filed respondents agreed with the proposed way in improving IEQ except for two respondents from non-technical fields who felt that the method should not be developed. Fourthly, referring to the standard quality of building materials, the results show that 82% of respondents from technical fields and 83% of respondents from non-technical fields agreed with the proposed method. Fifthly, all technical field respondents agreed while two non-technical field respondents disagreed with the method on the accurate illuminance level of artificial lighting in enhancing physical satisfaction during learning process. Sixthly, the method to control cleanliness showed that all respondents in the technical field agreed while one respondent in the non-technical field did not agree with the proposed method. Finally, both respondents from the technical and non-technical fields agreed that schools should have regular maintenance schedules as a proposed method. In conclusion, all 7 proposed methods were agreed by a majority of the 35 respondents in improving indoor environment quality in classroom due to enhance physical satisfaction during learning process.

Since thermal comfort was recorded as the lowest mean for comfort level of classrooms at secondary school buildings, research on the ambient temperature and weather at the study site was conducted. Table 7 below shows the average monthly value of air temperature, air flow rate, and relative humidity on location of the survey from January until December. Based on the data, it clearly can be seen that between August until

December the temperature becomes higher, and the ambient weather becomes warmer (31.09 °C–32.09 °C). Temperatures become normal and relatively low at the beginning of the year, from January to July. The highest temperature is in December (32.09 °C) while the lowest temperature is in June (29.54 °C). For relative humidity, it has shown a high percentage of humidity at the end of the year in October until December (66.69–66.79%) while the lowest relative humidity is in June (60.61%). If seen from the data, the higher the temperature, the higher the percentage of relative humidity. The temperature recorded was due to the influence of the monsoons in Malaysia where the studied area generally recorded a higher temperature during the months of August until December and make students uncomfortable to study in their class with the high temperature outside.

Table 7. Average monthly value of temperature, air flow rate and relative humidity on site.

Month	Time (Hour)	8.00–9.00	9.00–10.00	10.00–11.00	11.00–12.00	12.00–1.00	1.00–2.00	2.00–3.00	3.00–4.00	Total	Average
January	Temperature (°C)	28.70	29.32	29.84	30.44	31.02	31.64	31.99	32.21	245.14	30.64
	Air Flow Rate (m/s)	0.10	0.12	0.14	0.15	0.19	0.21	0.25	0.29	1.44	0.18
	Relative Humidity (%)	71.88	70.22	67.12	64.76	61.74	59.09	56.39	53.57	504.75	63.09
February	Temperature (°C)	28.8	29.4	29.7	31.5	31	32.1	31.1	32.6	246.2	30.78
	Air Flow Rate (m/s)	0.10	0.20	0.30	0.20	0.00	0.10	0.20	0.20	1.3	0.16
	Relative Humidity (%)	73.4	72.2	70.6	68.7	65.4	61.1	55.5	53.1	520	65.00
March	Temperature (°C)	29.25	29.58	30.125	31.26	31.72	31.89	32.03	32.22	248.075	31.01
	Air Flow Rate (m/s)	0.10	0.10	0.20	0.20	0.20	0.20	0.30	0.20	1.5	0.19
	Relative Humidity (%)	70	68.5	65.2	63.5	62.1	60.7	59.2	55.1	504.3	63.04
April	Temperature (°C)	28.1	28.9	29.2	29.6	30.9	31.5	32	32.1	242.3	30.29
	Air Flow Rate (m/s)	0.10	0.00	0.00	0.10	0.20	0.40	0.30	0.30	1.4	0.18
	Relative Humidity (%)	68.5	66.3	64.6	65.4	63.9	60.5	57.8	56.2	503.2	62.90
May	Temperature (°C)	29.33	29.56	29.99	30.02	31.45	31.69	31.88	32.07	245.99	30.75
	Air Flow Rate (m/s)	0.10	0.20	0.20	0.00	0.10	0.10	0.20	0.3	1.2	0.15
	Relative Humidity (%)	69.2	67.8	66.2	65.8	64.2	60.5	58.6	57.6	509.9	63.74

Table 7. *Cont.*

Month	Time (Hour)	8.00–9.00	9.00–10.00	10.00–11.00	11.00–12.00	12.00–1.00	1.00–2.00	2.00–3.00	3.00–4.00	Total	Average
June	Temperature (°C)	27.1	28.3	28.5	29.2	29.8	30.4	31.2	31.8	236.3	29.54
	Air Flow Rate (m/s)	0.10	0.20	0.20	0.00	0.10	0.20	0.20	0.3	1.3	0.16
	Relative Humidity (%)	72.2	68.5	62.5	59.3	53.4	54.1	56.8	58.1	484.9	60.61
July	Temperature (°C)	28.8	29.7	29.9	30.5	31	31.4	32.2	32.9	246.4	30.80
	Air Flow Rate (m/s)	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20	1.4	0.18
	Relative Humidity (%)	68.5	66.8	66.4	65.1	63.9	61.5	59.6	57.6	509.4	63.68
August	Temperature (°C)	29.8	29.9	30.2	30.9	31.6	31.8	32	32.5	248.7	31.09
	Air Flow Rate (m/s)	0.20	0.10	0.10	0.20	0.20	0.30	0.40	0.4	1.9	0.24
	Relative Humidity (%)	72.9	66.7	65.5	64	62.9	61.3	59.2	57.3	509.8	63.73
September	Temperature (°C)	30.3	30.7	31.1	31.9	32.1	32	32.7	31.5	252.3	31.54
	Air Flow Rate (m/s)	0.30	0.30	0.20	0.10	0.30	0.10	0.40	0.30	2	0.25
	Relative Humidity (%)	68.5	66.3	64.6	65.4	63.9	60.5	57.8	56.2	503.2	62.90
October	Temperature (°C)	30.1	30.5	30.9	31.5	32.2	32.3	32.7	32.9	253.1	31.64
	Air Flow Rate (m/s)	0.10	0.10	0.00	0.00	0.10	0.30	0.30	0.40	1.3	0.16
	Relative Humidity (%)	72.5	71.7	70.1	68.5	65.5	63.2	63.1	58.9	533.5	66.69
November	Temperature (°C)	30.5	31.4	31.8	32.2	32.3	32.6	32.8	33.1	256.7	32.09
	Air Flow Rate (m/s)	0.20	0.10	0.10	0.20	0.20	0.30	0.40	0.4	1.9	0.24
	Relative Humidity (%)	73.2	72.8	70.5	68.7	66.9	64.3	62.9	60.5	539.8	67.48
December	Temperature (°C)	30.7	30.8	31.5	32.3	32.5	32.7	32.9	33.3	256.7	32.09
	Air Flow Rate (m/s)	0.20	0.10	0.20	0.20	0.20	0.30	0.40	0.4	2	0.25
	Relative Humidity (%)	69.9	69.7	68.2	67.2	66.1	65.5	65.2	62.5	534.3	66.79

5. Conclusions and Recommendations

To conclude, the results of this study achieved two objectives that were set at the beginning of the research. Objective 1 successfully determined students' satisfaction and perception levels on the classrooms' indoor environment aspects. The results of measurements and analysis conducted have found that visual comfort (3.9987) illustrates the highest mean, followed by cleanliness (3.6675), air movement (3.6257), noise pollution (3.1597), and thermal comfort (2.2435). From the data collected, it can be concluded that the mean of overall comfort is 2.1663, which illustrates that the current comfort level of classrooms is still under the lowest implementation and needs to be improved. Thermal comfort which achieves the lowest mean is influenced by the hot and humid climate in Malaysia throughout the year in addition to the aspects of facilities provided in the classroom. Since the case study was conducted in a public-school building, no air conditioning facilities were provided, and students had to rely on ceiling fan facilities. Nevertheless, to achieve good thermal comfort in the classroom, the use of air conditioning should be implemented to ensure that students can study in a comfortable environment even with hot weather conditions based on lower the result achieve on thermal comfort. The use of ceiling fans only improves the air temperature sensation, however, at high air temperatures and humidity levels, air fans do not achieve the thermal comfort desired by students. If the use of air conditioning cannot be provided in every classroom, the school needs to find other initiatives to ensure that students can study in comfortable conditions such as moving towards green school development by planting trees as an alternative to reduce the temperature. Tree planting can reduce the heat stress of students by providing the benefits of evatranspiration cooling and shading [32]. This is because individual trees can reduce the ambient temperature between 1.1 and 2.8 °C in summer [33] and are able to eliminate large amounts of shortwave radiation through reflection and transmission through their leaves to reduce the ambient air temperature [34]. These initiatives are cheaper and can last for a long time as well as less maintenance is required. However, majority of the respondents feel comfortable in terms of visual comfort: artificial lighting (4.0026) and natural lighting (3.9948), quality of air ventilation (3.7277), classroom cleanliness (3.6675), and quality of air movement (3.5236).

To achieve Objective 2, several methods were proposed to improve the classroom indoor environment, specifically for secondary school buildings in Malaysia. The method used was to conduct semi-structured interviews with 35 experts consisting of 17 technical and 18 non-technical respondents. Among the methods proposed in increasing physical satisfaction during the learning process are having a limitation on the classroom capacity, additional unit of mechanical ventilation, enhance the building openings, standardize the quality of building materials, ensure an accurate illuminance level of artificial lighting, control the cleanliness, and schedule school building maintenance.

To conclude this study, it can be said that POE has a substantial impact on improving building performance. This study only focuses on classrooms at public-school buildings specifically from two approaches; the first is by collecting and tabulating feedback on the current condition of classrooms at secondary school buildings which lead to awareness by the schools' building management. From the data collected, it is clear that the quality of classroom indoor environment needs to be improved to ensure the comfort of learning spaces, more so for students who spend more than 5 h in classrooms. Secondly, this study provides a benchmark for classroom comfort levels at secondary school buildings that can be used to enhance building evaluation by considering occupants' or users' sensitivity. This can be adapted into a buildings or space's design and its indoor environment management. According to [16] having an effective implementation of POE in school buildings, especially in classrooms as common learning spaces and as a significant area in managing the enrolment of students, can enhance student motivation and the quality of learning activities at the school level.

POE proves the positive relationship between building condition and occupants' or users' satisfaction level. In this case, the evaluation of the classroom indoor environment

comfort level can significantly impact students' concentration, motivation, achievement, discipline, and attitude. Here, it is relevant to propose that the POE evaluation should be applied in Malaysia, primarily on educational buildings such as schools, colleges, universities, and polytechnics as these types of buildings must maintain their performance for the long run as they play a major part in the development of human beings. POE programs need to be implemented continuously to identify problems in building performance, for instance, in terms of defects or deterioration. They may also enhance buildings' efforts towards achieving a sustainable environment. For example, classrooms as major learning spaces still need to consider sustainable aspects in order to ensure satisfaction in terms of the students, teachers and other users' condition and comfort levels [12]. POE can be implemented at the strategic level to maintain a sustainable environment and successful building performance.

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