INDOOR ENVIRONMENTAL QUALITY ASSESSMENT AND USERS PERCEPTION IN MERU SECONDARY SCHOOL (SMK MERU)

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Abstract
Research in Indoor Environmental Quality (IEQ) shows that IEQ is not just limited to indoor air and comfort but also the contribution factor and its effects. IEQ could give an impact to the level of performance and productivity. IEQ in educational buildings have been studied widely especially in the cold region climate, however, studies on IEQ in the tropical climate like Malaysia is still lacking. The factors, effects, and solutions vary from other countries due to different climate, culture and learning activities. It is still unknown whether the school users in Malaysia are aware that IEQ would affect their teaching and learning behaviour as well as their health and well-being if the IEQ in the teaching and learning spaces are in unacceptable condition. Therefore, this paper seeks to investigate the school users' perception on IEQ in SMK Meru located in the Klang valley, Malaysia. Methods of approach are the objective method measuring the physical environment, and the subjective approach focusing on the visual inspection and distribution of questionnaire to the school users including teachers, students and office staff. Acoustic quality was found to be the most contributing factor to the dissatisfaction level of the respondents which could affect the teaching and learning performance. Three major health problems that were noted are fatigue eyes, stress/tension and fatigue but the condition was not serious.

Key words: Indoor environmental quality, teaching and learning, satisfaction school users

INTRODUCTION

In the past, IEQ only focused on indoor air (primarily particles, chemicals and bioearosols) and comfort factors (temperature, ventilation and humidity) (Samet et al.,1998). There are quite a number of holistic IEQ researches carried out in school buildings elsewhere (Ali et al., 2009; Turunen et al., 2014; Dias et al., 2011). However, in Malaysia only research looking into thermal comfort (Hussein and Rahman, 2009; Makaremi et al., 2012), ventilation (Hassan and Ramli, 2010; Zain-Ahmed et al., 2005) and other factors were carried out independently. Since children and school users spend most of their time in the classrooms, the teaching and learning activities indoors are very important since good IEQ can affect performance in teaching and learning (Fromme, et al., 2007).

Based on the statistics given by the Ministry of Education (MOE, 2013), total number of government schools (primary and secondary schools) in Malaysia as of 31st January 2012 are 10,019 employing over 412,720 teachers with 5,086,180 number of students and statistic of population in Malaysia is 23,274,690. With the high amount of population in school buildings, it is crucial to ensure that IEQ should be at an acceptable level as approximately 23% of Malaysian population are being exposed to poor IEQ in schools (MOE, 2013; DOS, 2013). This rate is excluding those pupils and schools users from the preschool, kindergarten, private schools and higher education. Although population in schools is high, IEQ assessment is rarely undertaken in schools in Malaysia. Therefore the understanding of exposures and effects of IEQ to teaching and learning process remain unknown.

Various research on IEQ in school buildings were carried. Hellenic schools in Africa (Elena and Vasileios, 2010), a number of schools choose to represent the perception on the Italian primary schools (Valeria et al., 2012), London primary schools (Azadeh et al., 2011). Research found that inadequate/excessive in lighting give a deep impact on human psychological and physiological (Valeria et al., 2012). London Primary School near Heathrow tends to shut the window to reduce aircraft noise but it caused overheating in hot weather and poor indoor air quality due to lack of ventilation (Azadeh et al., 2011). Based on these researches, there are several contribution factors which affect the poor level of IEQ which could be the building designs itself, mechanical and electrical service, surrounding environment, weather, and occupants. Each research will report different environmental quality and level of adaptability by the occupants. Thus, it makes different effect to the activities that happen inside the building. Therefore, it is important to understand the characteristics of the building, the activities that takes place inside the building, weather and the surrounding environment.

A better IEQ can help learning process of students (ASHRAE, 2008). The statement made by ASHRAE is agreed because comfortable body will create a smart brain to absorb information and work efficiently. It is proved because there is evidence that high performance schools help teacher and student performance with improved indicators on standardized test scores, absenteeism, and college acceptance rates (Ley, 2006).Therefore, this research is trying to find users' perception in school selected in order to determine the problem and finding a solution to improve IEQ in school. This research was carried out in one of the secondary school in Selangor which is SMK Meru, to identify users' perception towards IEQ and its effects to teaching and learning process.

METHOD

The research objectives of this paper is to identify the elements of IEQ that caused dissatisfaction to the users, health related problems and effects of IEQ to teaching and learning Therefore, to achieve this objective and subjective approach are used for the research methods.

Objective approach

Objective approach focuses on measurement of wind speed, temperature and humidity. These 3 elements are part of factors that could contribute to poor comfort level. However, the purpose of measuring it, is to make a benchmark with the standards and guidelines provided. Measurements were taken at several locations in the learning environment using the grab sampling methods. Measurements were collected using Kestrel 4500 Pocket Weather Tracker. The location of the instrument during data collection is as shown in the Table 1, it is important to ensure maximum coverage.

Subjective approach

Subjective approach includes visual inspection (building design and setting of case study) and a set of questionnaire related to (IAQ, acoustic quality, visual comfort, thermal comfort and effect of IEQ to teaching and learning process). In addition, a set of questionnaire was distributed to users (students, teachers and staffs) made to achieve the research objective on identifying a poor indoor environmental factors, health symptom and effect of IEQ to teaching and learning process. The questionnaire is divided into 4 parts which is socio-demography information, general perception on indoor environment, perception of indoor environmental quality and health related symptom to IEQ. Socio demographic is a word used to describe an element of a group within a society. The information gathered are gender, nationality, race, age, background, name of room, and duration of occupying the room.

To understand users general perception on their learning spaces, questions on the interior design practicality, interior colour scheme, practicality of space arrangement, the amount of artificial lighting provided, room ventilation, level of comfort, ability to conduct activity in the room such as work/study, cleanliness of the room and ergonomics were asked. The perception is obtained using a Likert scale (7 scale point) as it offers wider range of rating which is 1=very strongly disagree 2=strongly disagree 3=disagree 4=neutral 5=strongly agree 6=very strongly agree.

Subsequently questions on the perceived comfort level and other IEQ aspects were asked. Respondents sitting position was also determined to support reasoning for their perceived comfort. To determine the effect of IEQ to teaching and learning, students will have to select scale ranging from 1 to 10 on factors that contribute to the disruption of their leaning performance. Scale 1 indicates very disturbing and 10 very encouraging their learning performance. Finally, the severity of health symptom related to IEQ were investigated (i.e., are runny nose, rashes/itchy etc.). Sample size is determined by referring to table used to determine the sample size from the given population (Krejcie and Morgan, 1970).

The sample size is not derived from the school population but it is derived from the population inside the particular room/space as it is the unit of observation for this research. Population is different from room to room. For classroom, even the number of population is different, but the percentage of absence can be confirmed that it is not more than 20% in a day for each class; it can be conclude that 80% from population of each class became a respondent. In a way to obtain the correct sample size, it is a very critical issue because the sample size may be larger than or lesser than expected sample size. Larger sample size is more representative for that particular population. This help giving a significant different between the variables and give a better picture for analysis. For other room such as teachers' room, discipline room and office, the number of respondent are lesser. Small sample size can create a risk on the analysis of data because it will be not effective to be a representative of the population and it can be said as negligible data or insignificant but according to the (Gillham, 2000) the research is still valid and the analysis of data can still be proceed.

CASE STUDY

This research was carried out in SMK Meru which is located in Klang, Selangor. The selection is based on size of the school and large number of students of this school in Klang. It is a secondary school with students between the ages of 13 to 17. This school was built on the 18 acre land and started its operation since 1982. Previously, this school only have 12 classrooms that can accommodate only 674 students. Currently, there are 70 classrooms with 4292 students, 227 teachers and 32 staffs. This school was constructed by using frame structure, brick wall plastered and painted, and cement render floor finishes.

This school apply the open concept where open walkway provide means of connection between block; corridors and stairs are connecting the room within one block. This concept is applied because Malaysia is a country with an equatorial climate where the weather does not extremely change throughout the year. Therefore the design of building is adapting the environment such as natural lighting and ventilation.

This school have 17 blocks with minimum and maximum height of 1 and 4 levels respectively and 11 blocks are selected to become a representative of the whole school area. Apart from the school blocks, there are also hall, canteen, car park, and field within that school area.

The school blocks are A1, D, C, F, H, I, J, K, L, O and school hall. From all the rooms, there are 28 rooms that are selected to represent IEQ of the school. Block A1, H and School hall, each blocks are used as one space, block A1 is a teachers' room without any party wall and it is also same for block H and school hall. Block H is the computer laboratory. For the other block that consists of multiple rooms, the significant room is picked to have a significant representative. The classes chosen are at the both end of the block and one in the middle, every level must have at least one class to be representative for that level. This is to ensure that efficient representative. The details of every room are showed in the Table 1.

Table 1: Details of every room that have been investigated

Class	Floor Area (m^2)	Volume (m^3)	Windows		Doors	NV/ MV
			Panel Size (m^2)	Type		
TR	623.7 *the whole block A1 which consists of 3 level	1871.1	1.3	Glass louvered window	30 *10 at every level	NV
DR	41.58	124.74	1.3	Glass louvered window	2	NV
ER	83.16	249.48	1.3	Glass louvered window	4	NV
4L	41.58	124.74	1.3	Glass louvered window	2	NV
4J	41.58	124.74	1.3	Glass louvered window	2	NV
CL	83.16	249.48	0.36	Top Hung Window	4	MV
5I	41.58	124.74	1.3	Glass louvered window	2	NV
5N	41.58	124.74	1.3	Glass louvered window	2	NV
5L	41.58	124.74	1.3	Glass louvered window	2	NV
5F	41.58	124.74	1.3	Glass louvered window	2	NV
5H	41.58	124.74	1.3	Glass louvered window	2	NV
BL	62.37	187.11	1.3	Glass louvered window	2	MV
4N	41.58	124.74	1.3	Glass louvered window	2	NV
4T	41.58	124.74	1.3	Glass louvered window	2	NV
4M	41.58	124.74	1.3	Glass louvered window	2	NV
4F	41.58	124.74	1.3	Glass louvered window	2	NV
4E	41.58	124.74	1.3	Glass louvered window	2	NV
0	83.16	249.48	1.3	Glass window	2	MV
4R	41.58	124.74	1.3	Glass louvered window	2	NV
5S2	41.58	124.74	1.3	Glass louvered window	2	NV
5S5	41.58	124.74	1.3	Glass louvered window	2	NV
5S1	41.58	124.74	1.3	Glass louvered window	2	NV
5S	41.58	124.74	1.3	Glass louvered window	2	NV
5P	41.58	124.74	1.3	Glass louvered window	2	NV
5M	41.58	124.74	1.3	Glass louvered window	2	NV
5G	41.58	124.74	1.3	Glass louvered window	2	NV
5Q	41.58	124.74	1.3	Glass louvered window	2	NV
4E	41.58	124.74	1.3	Glass louvered window	2	NV
4H	41.58	124.74	1.3	Glass louvered window	2	NV

RESEARCH FINDINGS AND DISCUSSION

Measurement on thermal environment (wind speed, indoor temperature and relative humidity)
Figure 1 show the data on measurement of wind speed, indoor temperature and relative humidity at every room that have been investigated. From figure 1, it can be seen that the wind speed is high at room 5 Ikhlas, Teachers' Room and Biology Laboratory, the highest is at Biology Laboratory which is 1.1m/s. There are a few rooms with 0.0m/s wind speed and the rooms are Office, 5 Nilam, Computer Lab, 4 Nilam, 5 Setia, ERT Room, 4 Luhur, 4 Jujur, 5 Pintar, 5 Murni, 5 Gigih and 5 Qualiti. High wind speed will increase rate of ventilation which is good but too fast will interrupt the users' focus.

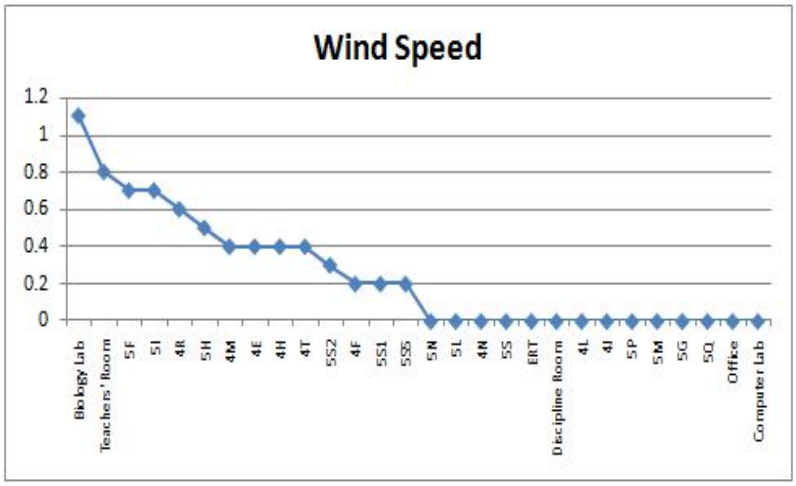


Figure 1: Measurement of wind speed

Figure 2 shows the data on measurement of indoor temperature. From the figure, it can be seen that temperature is between the ranges of 31.5 to 29 degree Celsius. 5 Setia recorded the highest temperature which is 31.1 degree Celsius followed by 5 Fikir and Teachers' room with temperature 31 degree Celsius. The lowest temperature recorded is at Office, Discipline Room, 4 Tekun and 4 Effisien with reading of 29 degree Celsius. Office and Discipline Room are mechanically ventilated.

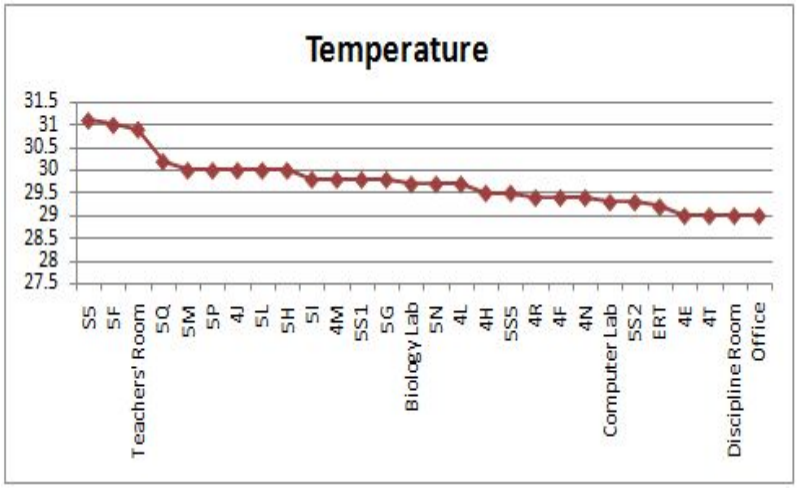


Figure 2: Measurement of temperature

Figure 3 shows the data on measurement of relative humidity. Most of the rooms have almost similar reading except for Office and Computer Laboratory. Both room show low percentage of relative humidity and the lowest is Computer Laboratory with the reading of 47.5%. The rooms with low relative humidity are mechanically ventilated rooms.

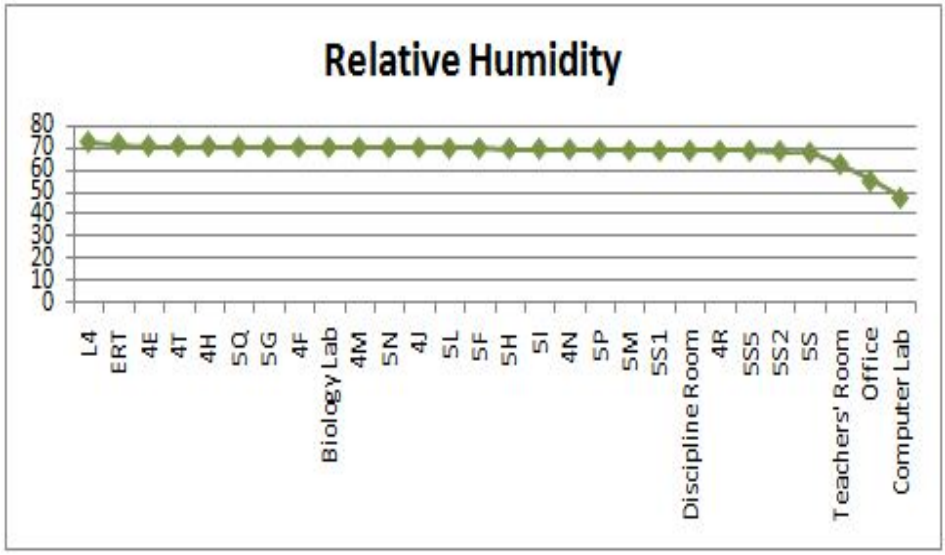


Figure 3: Measurement of relative humidity

Table 2: IEQ parameter, measurement recorded and ASHRAE Standard 55-2010

Parameter	Measurement	ASHRAE Standard 55-2010
Wind speed	0-1.1m/s	Draft:>0.152m/s
Relative humidity(indoor)	47.5-72.2	30%-60%
Temperature	29.0°C-31.1°C	23°C-26°C

ASHRAE provide a standard for level of relative humidity, temperature and wind speed as shown in table 2. Standard for wind speed are more than 0.152 m/s and the wind speed measured is from 0 to 1.1m/s as shown in figure 4.1. There are 14 rooms that have 0 wind speed, 2 out of 14 is a mechanical ventilated room. Wind speed that is less than 0.152 m/s is classified as static air. Static air is not favourable to maintain IAQ because particles that exist together with the air particles are stagnant and it can affect the health condition of the occupants. On top of that, wind speed could encourage the rate of air ventilation.

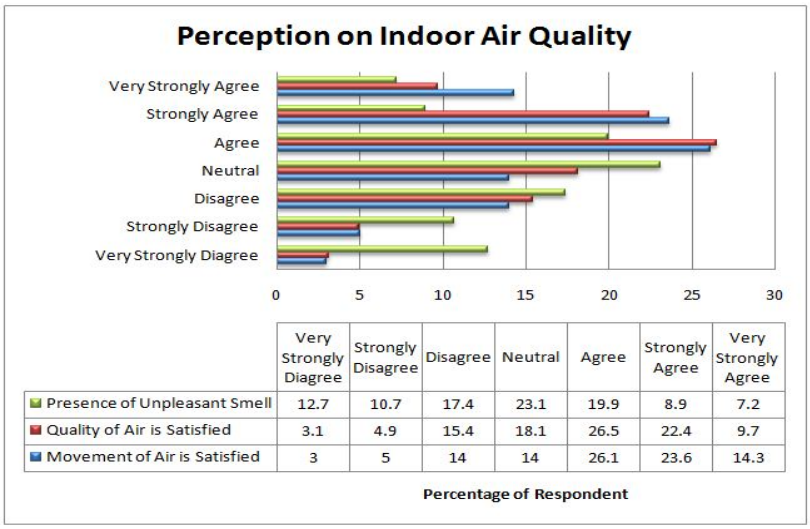
Next is the relative humidity, the relative humidity standard is 30% to 60%. Measurement collected from all the rooms investigated show readings between 47.5% to 72.2%, 26 out of 28 rooms recorded a relative humidity more than 60% which exceeding the ASHRAE standard. The other 2 rooms that recorded a relative humidity lower than 60% are mechanical ventilated.

For temperature, AHRAE standard is 23°C - 26°C (during summer) and temperature recorded is between 29.0°C to 31.1°C. Standard for temperature made by ASHRAE is not applicable to Malaysia due to difference in climate pattern. Temperature recorded is totally out of the standard range. The range of temperature in Malaysia is 7.8°C (Cameron Highlands on 1998) to 40.1°C (Chuping, Perlis 1978) as recorded by Malaysian Metrological Department (MOSTI, 2010). Petaling Jaya (station id: 48648) has a nearest metrological station to this school and the recorded temperature range is between 24.5-31.5°C. The acceptable standard of temperature need to be determined based on the perception made by the occupants. One standard is not applicable to all occupants because of different in climate, individual perception, activities and clothing.

Indoor air quality (IAQ)

IAQ refers to the air quality inside a building; IAQ can be divided in two conditions, indoor factor or outdoor factor. Indoor factor is referring to production of pollutants occur inside a building, for example furniture, paints, carpets and etc. For outdoor factor, outdoor air conditions are transport and affect the indoor air quality, this occurs through means of ventilation, and room with natural ventilation will be greatly affected compare to the rooms that are using mechanical ventilation.

For this research, the air quality is not determined by measuring the contents of air particles that exist inside the room, it is generally based on the human sense to detect the factor that caused occupants discomfort on matter related to air movement, quality of air and presence of unpleasant smell.



	Very Strongly Diagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
Presence of Unpleasant Smell	12.7	10.7	17.4	23.1	19.9	8.9	7.2
Quality of Air is Satisfied	3.1	4.9	15.4	18.1	26.5	22.4	9.7
Movement of Air is Satisfied	3	5	14	14	26.1	23.6	14.3

Figure 4: Occupants perception on IAQ

Figure 4 illustrated the perception of occupants on IAQ. For movement of air, highest percentage says they agree the movement of air is satisfied is 26.1%, followed by strongly agree 23.6% and very strongly agree 14.3%. Tendency of perception is towards the right where most of the occupants are satisfied with the movement of air inside the room they occupy. For quality of air, the highest percentage of agree that the air quality have met their level of satisfaction is 26.5 % followed by strongly agree 22.4% and disagree 15.4%. Based on the data collected, condition of air is divided into 4 which are too windy, comfortable, static air and dry air. It is found that 17% says that air in the room is static followed by dry air 10%, too windy 3% and the remaining is comfortable.

Static air can be avoided by having mechanical equipment to encourage the air circulation such as exhaust and ceiling fan. This equipment will create a force to overall circulation. This condition occurs at several rooms due to room location and surrounding building. Further analysis is done to detect the location.

For presence of unpleasant smell, by omitting the percentage of neutral, the highest percentage is 19.9% which agree that there is a presence of unpleasant smell followed by disagree 17.4% and very strongly disagree 12.7%. The tendency of perception is towards the left (refer Figure 5) where no presence of unpleasant smell. However, by omitting the percentage of neutral, the different on total percentage of agree (36%) and disagree (40.8%) is only 4.8% which can be concluded that even the percentage is toward disagree but the percentage of agree is also significant. Therefore, further investigation is done, cross tabulation between factor and location to determine the location of occupants that contribute to the percentage of agree.

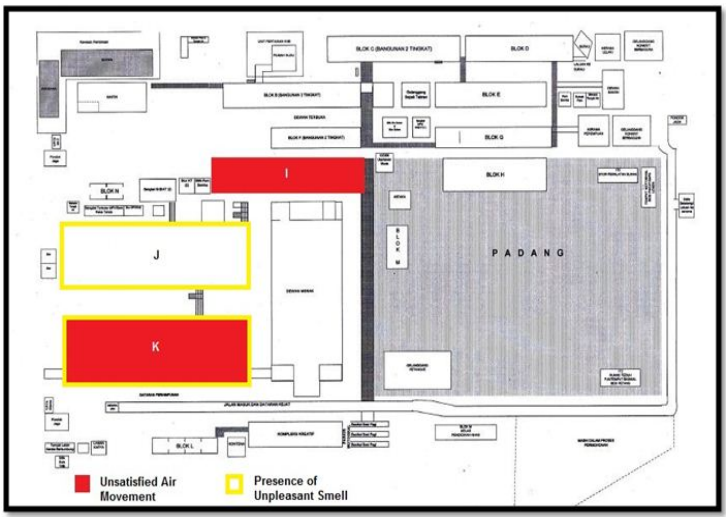


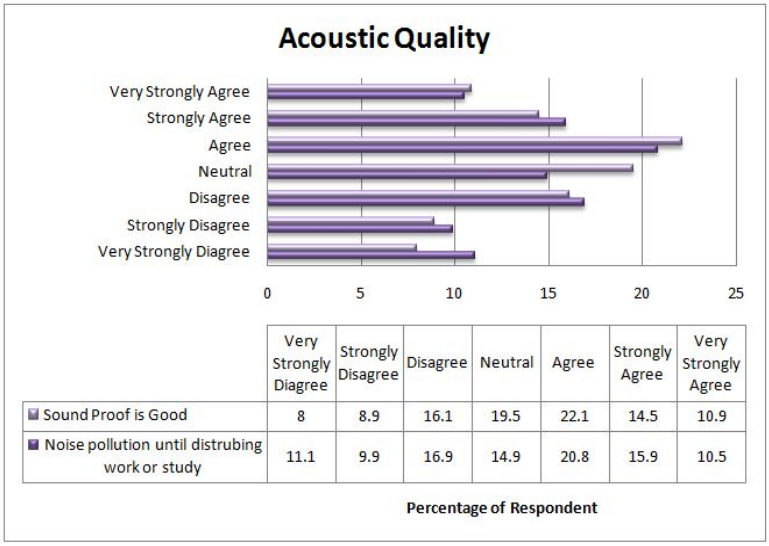
Figure 5: Summary on the IAQ

Any rooms that have percentage more than 40%, is selected because it seems to be significant because most of the occupants in that particular room have the same perception. The room that have a significant percentage are teachers' room, 4 Luhur, 5 Harmoni, Biology Lab, 4 Tekun, 4 Effisien, 4 Rajin, 5 Science 5, 5 Quality and 4 Harmoni. The highest percentage is 4 Rajin with 72.41%. Most of the rooms that show significant percentage is from block J with 4 classrooms, followed by block K with 2 classrooms. Location of these two blocks is near to each other.

In conclusion, overall perception on IAQ is satisfied by most of the occupants but there is exception on few rooms where the IAQ does not meet the level of satisfaction. The location is as shown in figure 5, block I and K experienced unsatisfied air movement; block J and K experienced presence of unpleasant smell.

Acoustic quality

Acoustic quality is referring to an acceptable range of sound that does not caused any disturbed feeling. This study focus on sound proofing and whether noise disturbed occupants activities or not.



	Very Strongly Diagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
Sound Proof is Good	8	8.9	16.1	19.5	22.1	14.5	10.9
Noise pollution until distrubing work or study	11.1	9.9	16.9	14.9	20.8	15.9	10.5

Figure 6: Perception on acoustic quality

Figure 6 shows the result on the perception of acoustic quality, for perception related to whether noise pollution disturbing work or study, by omitting the neutral percentage, the highest percentage is agree with the statement where noise pollution is disturbing work/study with percentage of 20.8% followed by disagree 16.9% and strongly agree 15.9%. The total percentage of agree is 47.2% and disagree is 37.9% where it shows that the tendency of perception is towards the right where noise pollution is disturbing work/study.

For sound proofing, from the figure it can be seen that the highest percentage is agree the sound proofing is good with percentage of 22.1% followed by disagree 16.1% and strongly agree 14.5%. Total percentage of agree is 47.5% and disagree is 33%, this shows the tendency of perception is towards the right where the sound proof is good. Factors that contribute to noise pollution are divided into two major factor which is human and transportation. Major factor is human with the highest percentage of 58% followed by vehicle 30% and none 12%. Further investigation is done to determine the location of noise pollution. The cross tabulation is done between the noise pollution is disturbing work /study with the room location. The rooms have been shortlisted based on the percentage of respondent from each classroom.

From 28 rooms, there are 12 rooms that experienced this problem. Discipline room, 5science2, Computer Laboratory, and 5 Fikir have high percentage of noise pollution which is 77.77%, 76.32%, 76% and 71.05% respectively. However most of the rooms listed are from block I. Most of the rooms that faced noise pollution is caused by human factor except for Block A1, where the statistic shows that the noise pollution is highly caused by transportation. That block previously planned to be used as classrooms but due to noise pollution that disturbing teaching and learning process, the room is changed and used as teachers' room.

Figure 7 shows the location of blocks that have high percentage of noise pollution which is block A1, D, C, H, I, K, O, and J. Acoustic quality is affected by human factor for most of the blocks except for block A1 where the noise pollution factor is transportation. That block is located near the

main road which is Jalan Meru Tambahan, the road traffic is congested and heavy transportations are also using that road. The frequency of lorry is 4-5 lorries per minute which is high, and bad road condition increase the noise level produced when heavy transportation pass by. This is the fact that students suffered from external noise which caused by traffic movement at road nearby (Ali et al., 2009).

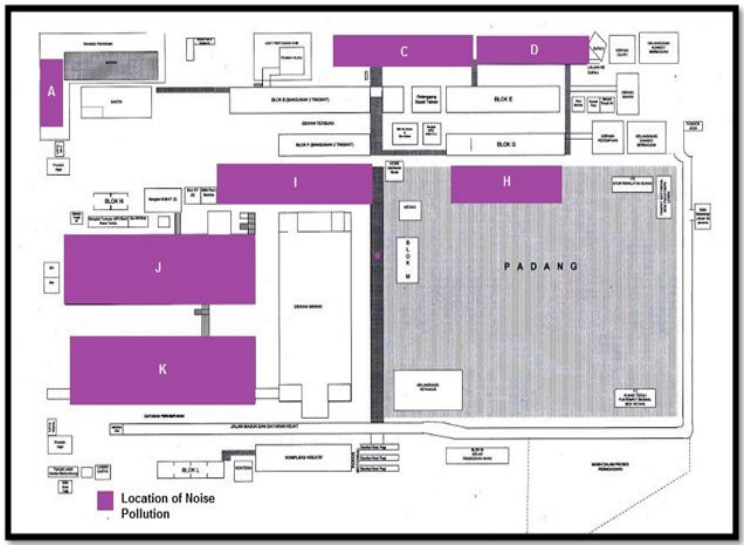
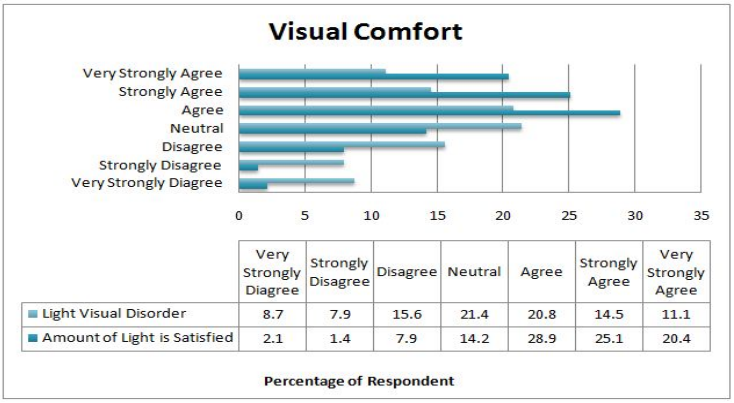


Figure 7: Summary on acoustic quality

Visual comfort

Figure 8 shows the perception on visual comfort related to satisfaction on amount of light and light visual disorder. For the satisfaction on the amount of light, the graph shows that the highest percentage of agree that amount of light has achieved the level of satisfaction is 28.9% followed by strongly agree 25.1% and very strongly agree 20.4%. Total percentage of agree is 74.4% and disagree is 11.4% where the difference is high. This clearly shows that the tendency of perception is greatly towards agree. For light visual disorder, the highest percentage of agree that there is a light visual disorder is 20.8% followed by disagree 15.6% and strongly agree 14.5%. The total percentage of agree is 46.4% and disagree is 32.2%, the tendency of perception is towards agree with different of 14.2%. From this data, it can be seen that 46.4% of respondent facing a light visual disorder.



	Very Strongly Diagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
Light Visual Disorder	8.7	7.9	15.6	21.4	20.8	14.5	11.1
Amount of Light is Satisfied	2.1	1.4	7.9	14.2	28.9	25.1	20.4

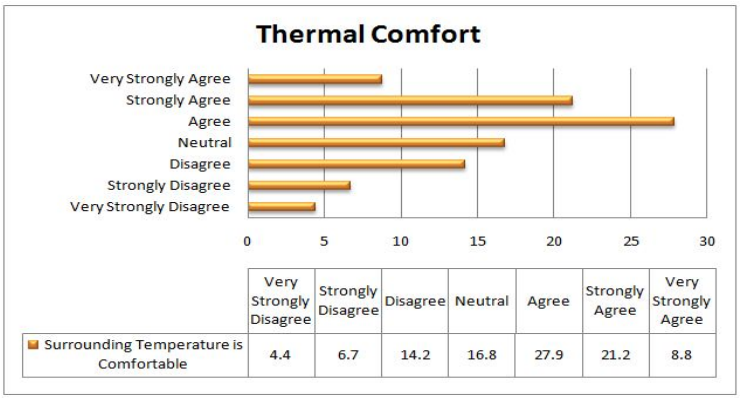
Figure 8: Perception on visual comfort

Further research is done to know the factors that contribute to visual discomfort. The range of visual condition is divided into 4 which is not enough light, comfortable, too bright and glare. From the graph, it can be seen that most of the occupants are comfortable with the visual condition with percentage of 72% and the remaining are facing the visual discomfort which is glare 20%, too bright 4% and not enough light 4%. For occupants that experienced glare, most of the occupants are sitting near the window which 46% followed by near door 13% and none 41%. This can be concluded that most of the occupants that experience glare are sitting near the openings. In conclusion, the amount of light is

achieving the occupants' level of satisfaction. As pointed out by Health and Mendell (2002), sufficient light increase the performance of students in schools. However, a few occupants experienced the light visual disorder but the percentage contributes are not too high and most of them are sitting near the openings.

Thermal comfort

Based on the measurement in figure 2, it shows data on measurement of indoor temperature, it can be seen that indoor temperature is between the range of 29 to 31.5 degree Celsius. Based on figure 9, the highest percentage of agree that the surrounding temperature is comfortable is 27.9% followed by strongly agree 21.2% and disagree 14.2%. Total percentage of agree is 57.9% and disagree 25.3%. Tendency of perception is towards agree. The range of thermal comfort is divided into 5 which is very hot, hot, normal, cold and very cold and from the study, 68.6% says that the thermal comfort is normal, 17.2% says it is hot, and 9.8% cold. Further analysis is done to determine the location of unsatisfied thermal comfort.



	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
Surrounding Temperature is Comfortable	4.4	6.7	14.2	16.8	27.9	21.2	8.8

Figure 9: Perception on thermal comfort

The cross tabulation of data between thermal comfort and name of the room are done in order to determine the location of unsatisfied thermal comfort. Rooms that are shortlisted are the room that have a percentage of perception more than 50% out of the room population. The rooms are 5 Setia, 5 Murni and 5 Gigih. All of these rooms are near to each other and the location of the room is as shown in figure 10

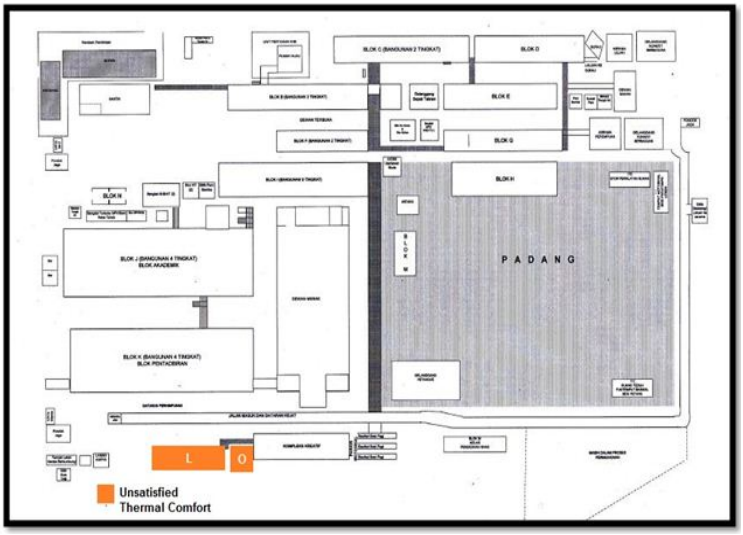


Figure 10: Summary on thermal comfort

Health symptoms

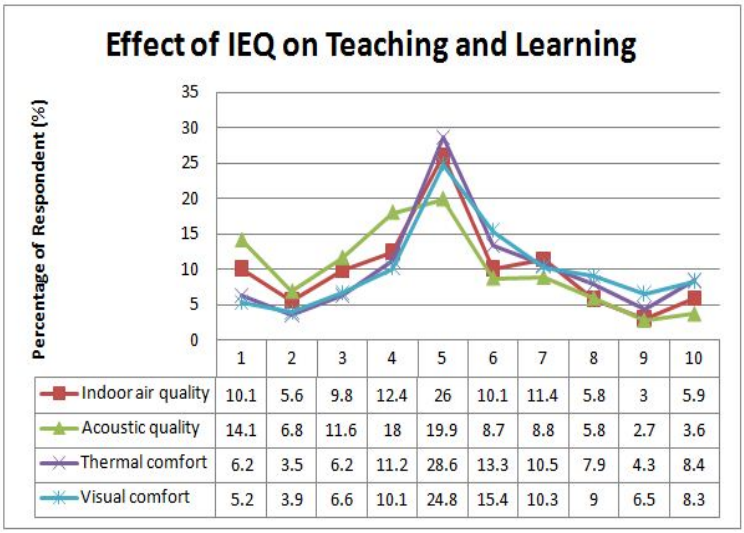
Based on the analysis, most of the mode for every symptom is 1 which 1=none. However, there are a few symptoms that have mode more than 2 such as fatigue eyes, stress/tension, fatigue where

2=experience the symptom but not serious. On the day when this research is done, result shows that 44% experienced symptoms listed and 56 % are not experienced any. From the percentage of occupants that experienced it, it is found that 68% suffer health problem during occupying the room, 23% after and 9% before.

In conclusion, there are 3 symptoms that most of the occupants experienced it, which are fatigue eyes, stress/tension and fatigue but the condition is not serious. The probability on contribution of IEQ to the poor health condition is high, because occupants experienced symptoms when occupying the room. As explained by Ali et al. (2009), poor IEQ can affect student's learning and negatively affect student health. Ali et al. (2009) further explained that school hold an important place with healthy environment because students spend half of their wakening hours in school.

Effect of IEQ on teaching and learning

Further study is done to see the effect of IEQ to teaching and learning. The scale to measure the effect is 1 to 10. 1 is equals to very disturbing and 10 is very encourage with median 5.5. Referring to Figure 11, factors of IEQ are indoor air quality, acoustic quality, thermal comfort and visual comfort. 3 factors except acoustic quality show the same pattern, most of the occupants are choosing 5 which mean the IEQ not very disturbing.



	1	2	3	4	5	6	7	8	9	10
Indoor air quality	10.1	5.6	9.8	12.4	26	10.1	11.4	5.8	3	5.9
Acoustic quality	14.1	6.8	11.6	18	19.9	8.7	8.8	5.8	2.7	3.6
Thermal comfort	6.2	3.5	6.2	11.2	28.6	13.3	10.5	7.9	4.3	8.4
Visual comfort	5.2	3.9	6.6	10.1	24.8	15.4	10.3	9	6.5	8.3

Figure 11: Effects of IEQ to teaching and learning

For acoustic quality, the percentage of disturbing is very high. There are more occupants that are choosing 1 to 4. The effect is parallel with the study on perception of the acoustic quality previously. The quality does not meet the satisfaction level of occupants and this chapter found that it does affect teaching and learning of the occupants. If the objective is to increase level of productivity or performance, graph need to hike between 6 and 10 where improvement of IEQ is needed.

CONCLUSION

From this research, it is proved that the level of IEQ is not very disturbing and very encourage. If the objective is to increase the level of productivity or performance, IEQ need to be seriously improved to meet occupants' level of satisfaction. Since the major factor that contributes to poor IEQ in this school is acoustic quality, further research can be done by getting a scientific data on acoustic quality to have a better/strong judgement to support the perception made by the occupants. The research outcomes can be referred by the relevant parties such as government and building designers to improve IEQ in school by considering the factors identified and its effect on teaching and learning.

In conclusion, the research findings have met the objectives of this research. Factors that can affect the indoor environmental quality is determined and been investigated. The factors are indoor air quality, acoustic quality, thermal comfort and visual comfort. Among the 4 factors that have been investigated, acoustic quality is the factor that contributes the most that caused poor IEQ in this school.

Health symptoms have been identified, where none of the occupants experienced serious health symptom. 3 major health problems are fatigue eyes, stress/tension and fatigue. These major

health problems that experienced by the occupants during occupying the room which can be seen that the probability on contribution of IEQ to poor health condition is high.

Lastly, the effect of IEQ on teaching and learning is obtained. IEQ is affecting teaching and learning, and acoustic quality is contributing the most. In overall view, IEQ of this school is classified as not very disturbing but also not encourage the occupants to do their activities.

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