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Assessments of Acoustical Performance of Classrooms and Teachers' Acoustical Comfort in The School Environment – A Case Study

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Abstract: Acoustic comfort in classroom is significant to protect the health and enhance scholastics performance of both students and teachers. The aim of this study is to evaluate the acoustic comfort in a primary school of Sekolah Kebangsaan Bukit Soga, Batu Pahat through objective and subjective evaluations. Field measurements were carried out to measure the background noise and reverberation time inside the classrooms. Six classrooms were tested to investigate the acoustic performance of the learning spaces of this school. Besides, questionnaires survey and interviews have also been conducted to assess the acoustic comfort of the teachers on the teaching and learning process. The measured background noise and reverberation times inside all the selected classrooms were very high comparing to the recommended values. The results from the survey showed that teachers were not satisfied with the acoustics comfort of this school's acoustic environment.

Keywords: Acoustic comfort, classroom, school environment, teacher

1. Introduction

Classroom is a space in the school that used for students to acquire knowledge from teachers. Good acoustical performance inside the classroom is vital for enhancing the learning process of the students [1]. Classroom with good acoustic performance provide comfortable teaching and learning environment for teachers and students. The teaching process can be free from repeating speech of teachers and emotional chaos in the classroom. Thus, the class delivery can be more efficient. Also, the classroom environment should have less noise interruptions so students can easily focus throughout the learning process.

The speech intelligibility in the classroom was affected by acoustic environment parameters like background noise and reverberation time [2]. The background noise level in the school environment is mainly caused by the internal and external noise from the surrounding. Dongre [3] and Mealings [4] had summarized the background noise level limits in the classroom for the different countries. Most of the recommended noise levels are around 40dBA. In addition, WHO [5] also set that the background noise level for the unoccupied classroom to below 35dB to reduce the acute effects of the noise interreference of the speech during teaching sessions. Unfortunately, based on some previous studies, most of the school environments were exceed the recommended background noise levels [6]-[9]. A single numeric value of noise criteria (NC) is commonly used as the rating of indoor background noise. For classroom interiors, the recommended noise criteria should be around NC25 to NC30 [10]. Reverberation time or sound decay is another

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important parameter that commonly used in assessing the acoustic quality of the classroom. This parameter is dependent on the noise spectrum, internal sound absorption and volume of the space. Various organizations or countries have set the recommended reverberation time between 0.6s and 0.8s [4], [11], [12].

There are two possible ways of noise sources in the classroom: internal and external environments of the classroom. These noises exposure varies in different school environments depending on the surrounding condition of the school. In school environments, main external noise sources may come from traffic and other external noise such as commercial constructions, and community activities while the internal noise sources may consist of noise produced in the building such as ventilation and machinery noises. Besides, the internal noise also consists of noise from the school activities such as student chattering, teaching sessions at the adjacent classrooms, and footsteps [13].

High noise level in the classroom provides significant impact to the teacher's performance [14]. The classroom environment is one of the important factors affecting students' learning and the teaching efficiency. Noise interruption in the classroom may led to massive health effects on teachers such as insomnia, headache, loss of concentration etc. [11]. The effort and awareness of acoustic comfort inside the classroom in Malaysia were limited comparing to the other developed countries.

The recent local studies [15], [16] outside few schools in the town of Batu Pahat showed that external noise levels of some schools exceeded the noise limit that had been set by the Malaysian Department of Environment [17]. From the previous studies, the external noise levels outside Sekolah Kebangsaan (SK) Bukit Soga were highest compared to the other schools in Batu Pahat. Thus, this study aims to evaluate the acoustical performance of the classrooms and the acoustic comfort of the teacher in SK Bukit Soga.

2. Objective and Subjective Measurements

In the present study, the acoustic performance of the classrooms in the primary school of SK Bukit Soga, Batu Pahat was investigated through objective field measurements of background noise and reverberation time. Besides, teachers' satisfaction on the acoustical condition of the classroom was evaluated using subjective assessment of questionnaire survey.

2.1 Field Measurements

The field measurements were conducted during daytime inside the classrooms of SK Bukit Soga Batu Pahat. This primary school (latitude of 1° 51' 48", longitude of 102° 57' 19") is located next to the junction of two busy traffic roads of Jalan Kluang and Jalan Parit Besar as showed in Fig. 1. Jalan Kluang is the federal route FT050 which connected the towns of Batu Pahat, Ayer Hitam and Kluang. From the recent statistics [18], Jalan Kluang recorded average daily traffic (ADT) of more than 40, 000 vehicles/ days started in year 2015 to 2018 and slightly reduced to 36,704 vehicles/ day in year 2019. Jalan Parit Besar is the state route which connect the residential areas nearby to the main road of Jalan Kluang. There is a newly built commercial centre was located nearby to the school, the locations are shown in Fig. 2. A total of six unoccupied but furnished classrooms were chosen for the investigation. These classrooms were chosen because they are on the different building blocks (2 classrooms for each block) such that the noise pollution impacts on the entire school environment can be fully evaluated. Fig. 3 shows the indoor environments of six tested classrooms, while Fig. 4 shows the outdoor scenarios of the classrooms. Other related information such as the dimension of the spaces, the partition wall between classrooms, types of chairs and desks used in the classrooms and the surrounding environment of the classrooms were tabulated in Table 1. All classrooms were equipped with louvre window systems and two leaves door systems.

Fig. 1 - Outdoor view of the school from the google map street

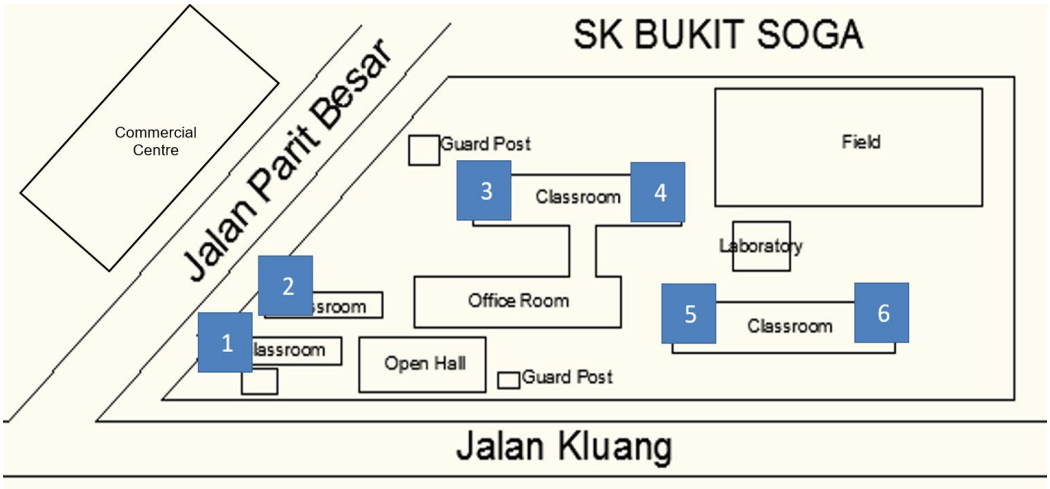

Fig. 2 - Layout of the school and the tested classrooms

(a) (b)

(c) (d)

(e) (f)

Fig. 3 - Indoor environment of the tested classrooms: (a) Classroom 1, (b) Classroom 2, (c) Classroom 3, (d) Classroom 4, (e) Classroom 4, and (f) Classroom 6

(a) (b)

Fig. 4 - Outdoor environments of measured classrooms: (a) Surrounding in front of classroom, (b) Corridor outside classroom

Table 1 - Summary of measured classroom information and conditions

	Dimensions (Length×Width×Height)	Desks /Tables	Chairs	Ceiling	Floor Finishing	Partition of Classroom	Surround of Classroom
Classroom 1	8.5 m × 7.2 m × 3.5 m	Wooden	Wooden	Gypsum board	Cement screed	Wooden	Next to Jalan Parit Besar
Classroom 2	8.5 m × 7.2 m × 3.5 m	Wooden	Plastic	Gypsum board	Tiles	Wooden	Next to Jalan Parit Besar
Classroom 3	8.5 m × 7.0 m × 3.4 m	Wooden	Plastic	Concrete	Cement screed	Concrete	Surrounded with classrooms
Classroom 4	8.5 m × 7.0 m × 3.4 m	Wooden	Plastic	Concrete	Cement screed	Concrete	School's field
Classroom 5	9.0 m × 7.0 m × 3.5 m	Wooden	Plastic	Concrete	Cement screed	Concrete	Next to the Jalan Kluang
Classroom 6	9.0 m × 7.0 m × 3.5 m	Wooden	Plastic	Gypsum board	Cement screed	Concrete	Next to the Jalan Kluang

Both background noise and reverberation time were measured using Brüel & Kjær Type 2250 sound level meter. The sound level meter was calibrated using sound calibrator Brüel & Kjær Type 4231 before the measurement. Background noise was measured at the center of the classroom to capture the ambient sound of the selected classrooms. For the reverberation time measurement setup, the sound decays of the classrooms were obtained by connecting sound level meter output to omnidirectional sound source through a power amplifier Brüel & Kjær Type 2734 with wireless audio transmitter as shown in Fig. 5. A total of 5 measurement points in each classroom were selected to capture the average sound decays in the room. The omnidirectional sound source with height of 1.6m from the ground was placed in front of the classroom with the distance of 1.5 m away from the wall. The location of sound source was chosen as it is presenting the typical teacher position during the teaching and learning process in the classroom as shown in Fig. 6 All measurements points were placed at 1.5 m height with at least 1.2 m away from the walls to avoid the sound deflections effects. The measurement points were placed scattered in order to capture the average sound decays in the entire classroom. All measurements were carried according to the ISO 3382 [19].

2.2 Questionnaire Survey

The acoustic comfort of teachers of SK Bukit Soga, Batu Pahat was evaluated using questionnaires survey via Google Survey. Pilot test was carried out by experts before the questionnaires were distributed to all respondents. The questionnaires were sent to the Assistant Principle of SK Bukit Soga and distributed among all the teachers using sharable link by google survey. In the present study, 40 teachers took part in the questionnaire survey. The questionnaire consists of close-ended questions with multiple choices with 4 Likert scale (1. Strongly Disagree; 2. Disagree; 3. Agree; 4. Strongly Disagree). The questionnaire was divided into 3 parts as follows:

- Part A: Demographic of respondents and experience of noises in the classroom– multiple choices
- Part B: Factors of noise in the classroom – Likert scale
- Part C: Acoustic comfort to teachers inside the classroom – Likert scale

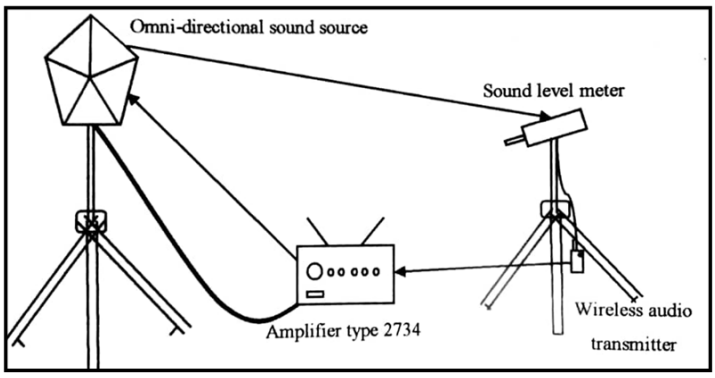

Fig. 5 - Setup of reverberation time measurement

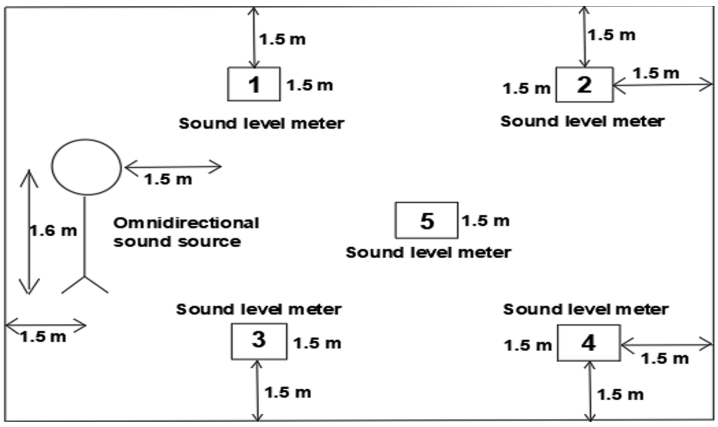

Fig. 6 - Selected locations of reverberation time measurement

3. Objective Measurement's Results

3.1 Background Noise

Table 2 shows the averaged background noise of the tested classrooms. From the results, all classrooms obtained high level of ambient noises of more than 40 dBA. All measured internal noise levels exceeded recommended background noise level of 35dBA in the school by WHO [5]. Obviously, under this high ambient noise condition, speech intelligibility during class will be affected. Students may not be able to hear clearly and understand the messages from their teachers during the class. On the other hand, teachers in this school must raise their voices to ensure that students can hear. From the distribution of the measured background noise levels inside the classrooms, it is observed that the traffic noise came from Jalan Parit Besar was more dominant comparing to that from Jalan Kluang. This, perhaps, is the reason that higher ambient noise level was recorded in the classrooms located near to Jalan Parit Besar (classroom 1, 2 and 3).

Fig. 7 shows the background noise rating curve of noise criteria (NC) values for six measured classrooms. The NC values were determined based on the sound pressure levels at octave band frequencies from 63Hz to 8kHz. From the results, NC values for all tested classrooms in the present study failed to meet the recommended NC value of NC 25 to NC-30 [10]. Four of the measured learning spaces obtained background noise rating over NC50. As they are located closely to the roads, the traffic noise from the surrounding is contributing to the high ambient noise in the school environment.

3.2 Reverberation Time

Fig. 8 shows the one-third octave band reverberation time of the six measured classrooms. In general, the sound decays in the tested classrooms were not the range of the recommended values of 0.6 - 0.8 second. From the results, the sound decays in classrooms 5 and 6 were longer compared to those of other classrooms. This is due to their larger volume. The single value of speech reverberation times calculated using Eq. (1) [20] are shown in Table 2. The reverberation time inside the classroom 3 is the shortest amongst all since this room is smaller and more absorption materials are presented in the room. From Fig. 3(c), the skirting cloth fixed around the tables probably is the main factor of the increasing overall sound absorption of the classroom. Longer reverberation times in the classroom will affect the speech intelligibility which make students being hard to perceive the messages from their teachers in class.

$$RT_{speech} = (RT_{250} + RT_{500} + RT_{1000} + RT2_{000} + RT_{4000}) / 5 \quad (1)$$

Table 1 - Background noises and speech reverberation time

Classroom	Average Noise Level (dBA)	RT_{speech} (s)
Classroom 1	**49.6**	**0.98**
Classroom 2	**46.9**	**1.04**
Classroom 3	**47.5**	**0.96**
Classroom 4	**46.3**	**1.14**
Classroom 5	**42.9**	**1.32**
Classroom 6	**43.9**	**1.30**

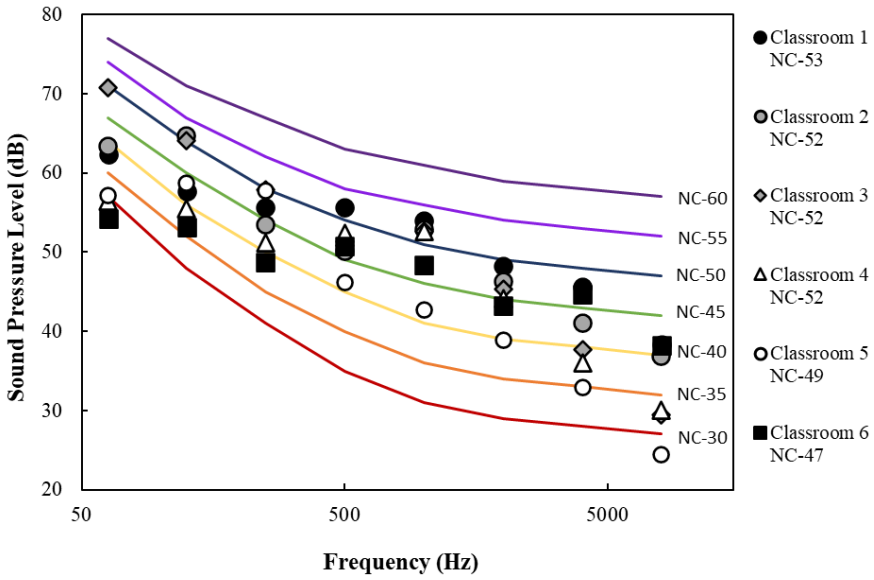

Fig. 7 - Noise Criteria (NC) Curves of tested classrooms

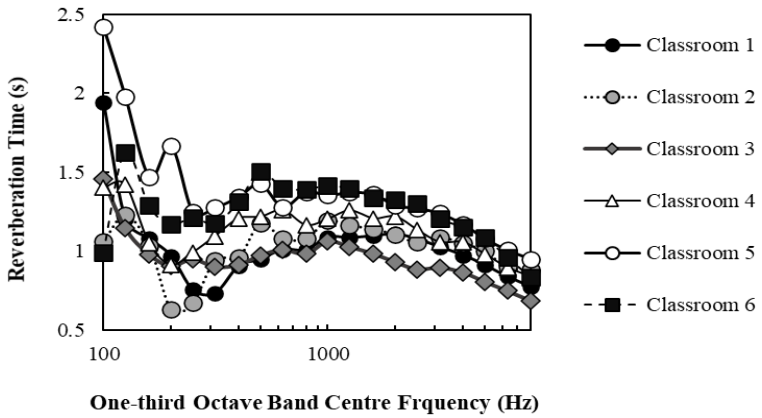

Fig. 8 - Average reverberation time inside six tested classrooms

4. Subjective Evaluation's Results

4.1 Demographic of Respondents and Experience of Noises in The Classroom

Table 3 shows the background information and the noise disturbance experience of the respondents. Among the 40 teachers participating in the survey, 31 of them were female. Most of the participating teachers were veteran and age more than 51 years old. From the survey, almost 70% of the respondents have been teaching this primary school for more than 5 years. Obviously, the noise pollution in the school gives great impacts to the teachers as 95% of the

respondents agreed that they experienced noise disturbance while teaching in this school. Almost half of the teachers responded that they faced noise disturbance every day.

Table 3 - Background of the respondents

Sex	**Frequency**	**Percent (%)**
Male	9	22.5
Female	31	77.5
Ages of Respondents	**Frequency**	**Percent (%)**
20 to 30	4	10.0
31 to 40	11	27.5
41 to 50	8	20.0
51 and above	17	42.5
Experience Teaching in SK Bukit Soga	**Frequency**	**Percent (%)**
Less than 2 years	5	12.5
3 to 5 years	8	20.0
5 to 10 years	15	37.5
More than 11 years	12	30.0
Experience of Noise Disturbance	**Frequency**	**Percent (%)**
Yes	38	95.0
No	2	5.0
Frequency of Noise Disturbance	**Frequency**	**Percent (%)**
1 to 2 times a week	15	39.5
3 to 4 times a week	5	13.2
Everyday	18	47.4

4.2 Factors And Effects of Noise in The Classroom

Fig. 9 shows the ten factors identified as causes of noise in the classroom of SK Bukit Soga. The noise was categorized into two types: internal noise and external noise. Internal noises are noises that are originated from the school compound. In contrast, the external noise came from the outside of the school environment. Majority of the respondents agreed that traffic noise from the roadways next to the school causes the noise disturbance in the classroom where the mean value obtained from the survey was 3.50.

Fig. 10 shows various effects from the noises in the classroom which the teachers are facing in SK Bukit Soga. Most of them agreed that the noise in the classroom brought them dissatisfaction and have a loss of interest in teaching in the noisy environment of the classroom. Besides, respondents strongly agreed that they felt tired from raising their voice during class to make sure students can hear their voice clearly. Teachers also agreed (with mean value of 3.23) that their vocal health is affected due to the need to raise their voice to overcome the noise in the classroom with high background noise.

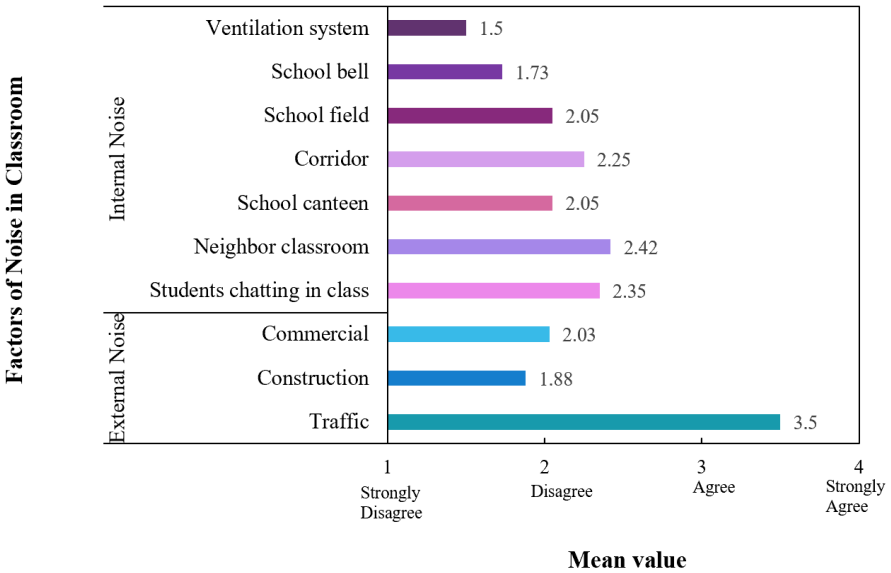

Fig. 9 - Factors of noise in classroom

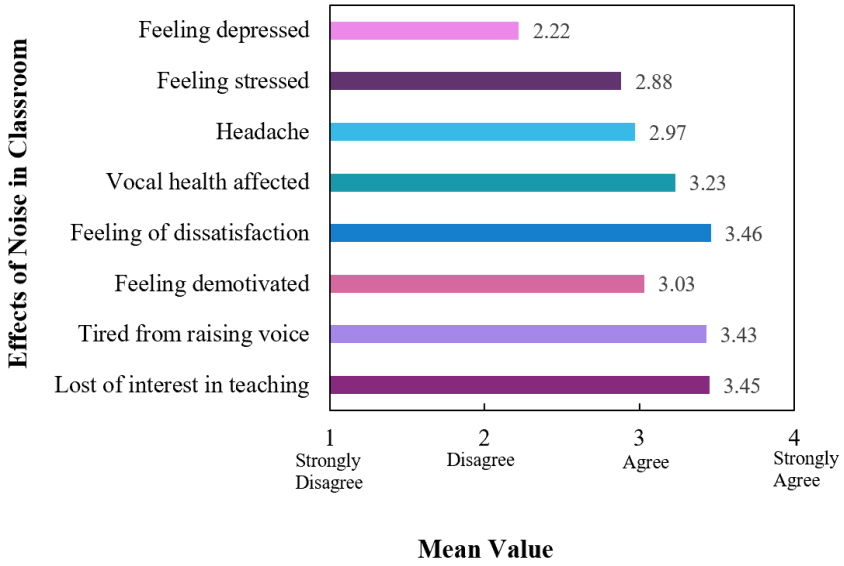

Fig. 10 - Effects from the noises in the classroom

5. Conclusions

Objective and subjective evaluation of the acoustic comfort in the classroom of SK Bukit Soga has been carried through field measurement and questionnaire survey. The background noise and reverberation time at SK Bukit Soga was very high comparing to the recommended value set by WHO. The average background noise levels recorded in the tested classroom were higher than 40dBA, which is considered as high ambient noise level for the learning spaces. All measured classrooms obtained NC values of more than NC45, which indicated that the indoor environment of the classrooms was interrupted by noise pollutions. In addition, the reverberation times of all tested classrooms recorded are longer than the recommended value of 0.8 second. The noise inside the classrooms become more worst when there are excess noises reflection in the enclosed space and affected the clarity of the teachers' speech.

From the subjective evaluation, it was found that most of the teachers were not satisfied with the acoustic comfort of the classroom. Most of the teachers experienced disturbance from noise pollutions in the learning spaces. Traffic noise was the main factor of noise affecting the acoustic quality of the classrooms. From the survey, most of the respondents experienced losses of interest in teaching, were tired of raising their voice during the teaching sessions and affected their health.

As conclusion, the acoustical performance of classrooms and the acoustical comfort in the school environment amongst the teachers in SK Bukit Soga is found unsatisfactory. Noise mitigations and strategies in the school environment should be carried out to reduce the impacts of the environmental noise, especially traffic noise to the students and teachers.

References

[1] Sarlati S., Haron Z., Yahya K., Darus N., Dimon N. & Athari P. (2014). The importance of acoustic quality in classroom. Jurnal Teknology, 70(7), 71–76. https://doi.org/10.11113/jt.v70.3581

[2] Bistafa S. R. & Bradley J. S. (2000). Optimum acoustical conditions for speech intelligibility in classrooms. Noise & Vibration Worldwide, 31(9), 12–17. https://doi.org/10.1260/0957456001498020

[3] Dongre A. R., Patil A. P., Wahurwagh A. J., Kothari A., Burchundi K. & Manohare M. P. (2017). Acoustical characteristics of classrooms of tropical climate. Applied Acoustics, 121, 46–55.

[4] Mealings K. (2016). Classroom acoustic conditions: Understanding what is suitable through a review of national and international standards, recommendations, and live classroom measurements. Proceeding of the Second Australasian Acoustical Societies Conference, Brisbane, Australia.

[5] World Health Organization (2000). Guidelines for community noise. In Berglund B., Lindvall T., Schwela D. & Goh K. T. (Eds.), Stockholm University and Karolinska Institute, pp. XIV.

[6] Shield B. & Dockrell J. E. (2008). The effect of classroom and environmental noise on children's academic performance. Proceedings of the 9th International Congress on Noise as a Public Health Problem (ICBEN 2008), Foxwoods, USA.

[7] John J., Thampuran A. L. & Premlet B. (2016) Objective and subjective evaluation of acoustic comfort in classrooms: A comparative investigation of vernacular and modern school classroom in Kerala. Applied Acoustics, 104, 33–41. https://doi.org/10.1016/j.apacoust.2015.09.017

[8] Puglisi G. E. et al. (2015). Acoustic comfort in high-school classrooms for students and teachers. Energy Procedia, 78, 3096–3101.
[9] Tong Y. G., Abu Bakar H., Mohd Sari K. A., Ewon U., Labeni M. N. & Fauzan N. F. A. (2017). Effect of urban noise to the acoustical performance of the secondary school's learning spaces-A case study in Batu Pahat.IOP Conference Series: Materials Science and Engineering, 271, 012029. 10.1088/1757-899X/271/1/012029
[10] Raichel D. R. (2006). The science and application of acoustics (2nd Editon). Springer.
[11] Zannin P. H. T. & Marcon C. R. (2007). Objective and subjective evaluation of the acoustic comfort in classrooms. Applied Ergonomics, 38 (5), 675–680. 10.1016/j.apergo.2006.10.001
[12] Daheng Y. & Qi L. (2012). Research of computer simulation of reverberation time in classroom. Physics Procedia, 33, 1677–1682.
[13] Ozan Gokdogan Md. & Cagil Gokdogan (2016). Determination of the level of noise in nurseries and pre-schools and the teachers' level of annoyance. Noise Health, 18(84), 256-259. 10.4103/1463-1741.192475
[14] Enmarker I. & Boman E. (2004). Noise annoyance responses of middle school pupils and teachers. Journal of Environmental Psychology, 24(4), 527–536.
[15] Segara V. C., Tong Y. G., Abas N. H., David Daniel B., Nagapan S. & Kelundapyan R. (2020). Traffic noise assessment among residential environment in Batu Pahat, Johore, Malaysia. IOP Conference Series: Materials Science and Engineering, 713(1), 012049.
[16] Mohmadisa H., Hairul F. M., Yazid S., Nasir N. & Mohamad S. Y. C. N. (2014) Analisis bunyi bising trafik persekitaran sekolah di Bandar Batu Pahat, Johor, Malaysia. Geografi, 2(2), 66–79.
[17] Department of Environment (2019). The planning guidelines for environmental noise limits and control (3rd Edition). Putrajaya, Ministry of Environment and Water, pp. 28.
[18] Ministry of Transportation Malaysia (2019). Malaysia Transportation Statistics. Ministry of Transport Malaysia, pp. 20.
[19] BS EN ISO 3382-2 2008 (2008). Acoustics - Measurement of room acoustic parameters - Part 2: Reverberation time in ordinary rooms. The International Organization for Standardization.
[20] Tang S. & Yeung M. (2004). Speech transmission index or rapid speech transmission index for classrooms? A designer's point of view. Journal of Sound and Vibration, 276 (1–2), 431–439. http://dx.doi.org/ 10.1016/j.jsv.2003.10.036