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‘Serene Classroom’ Minimizes Noise for More Conducive Learning

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Abstract Noise pollution can be categorized as a danger in silence. In school, noise pollution inhibits the focus of learning, impairs learning and cognitive development, for example, students' skills to think and understand both oral and written comprehension may be hampered by noise. Many schools in Malaysia experience excessive noise pollution as their locations are very near busy roads. This will be one factor that hinders the implementation of the education system in producing holistic students in order to prepare for the 4IR era. Knowing the importance of this problem, a group of researchers from UTM GREENPrompt, School of Civil Engineering, Universiti Teknologi Malaysia together with industry partners have built a special class called 'Serene Classroom' through a community project to overcome this problem. A classroom on the second floor of Sekolah Kebangsaan Kampong Pasir, Johor Bahru that has traffic noise exposure from the Skudai-Johor Bahru highway was selected for this purpose. The community project is in collaboration with the Johor State Education Department, Ministry of Education Malaysia and industrial partners, such as Vibrant Echo Company, Sanjung Sempurna Sdn. Bhd. and DZAZ Collection. The implementation of the project, the lessons learned from the project and challenges for the implementation are discussed. Technically, Serene classrooms significantly reduce the level of noise pollution for more conducive learning and have received better perceptions from students and teachers. Therefore, hopefully more ‘Serene Classroom’ community projects can be implemented in schools, especially in urban areas affected by high noise levels as a way to reduce the renovation costs on schools.

Keywords: noise pollution; acoustic treatment; sustainable development; school noise.

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1. Introduction

Noise pollution is believed to be a danger in silence. Excessive noise exposure can affect the health and well-being of humans and their environment. The school environment is no exception to being exposed to noise problems. One of the main causes is noise from high traffic, especially in school areas located near roads (Bhang et al., 2018; Clark & Paunovic, 2018; Minichilli et al., 2018; Zijlema et al., 2021). Studies show that excessive noise problems in schools also occur in foreign countries, including Finland (Sala & Rantala, 2016; Toyinbo et al., 2018), Chile (Aguilar, 2019), Portugal (Pinho et al., 2016; Silva et al., 2016), Brazil (Dreossi & Momensohn-Santos, 2005; Zannin & Zwirtes, 2009), Iran (Ariani & Mirdad, 2015), the United States (Cheryan et al., 2014), Turkey (Bulunuz et al., 2017), and China (Wen et al., 2019).

In developing countries such as Malaysia, concerns over traffic noise exposure has gained attention as early as the 1980s starting in schools located in commercial areas in the Klang Valley (Haron et al., 2019). The findings of the study show that the sound level at that time exceeded 55 dBA, which is the equivalent continuous noise limit (L_{Aeq}), a standard allowed by the World Health Organization (WHO) (Berglund, Lindvall, & Schwela, 1999; Skarlatos & Manatakis, 2003). The dBA unit is a level of sound intensity that considers the sensitivity of the human ear (Kang, 2017; Knauert et al., 2016).

However, studies conducted in Malaysia since the 1990s show that more and more school environments are in areas with increasingly dense and high traffic flow. The results showed that the L_{Aeq} level in the school area was on average between 68.2 dBA to 73.7 dBA. This level of pollution is categorized as very high (Haron et al., 2019; Ismail, Abdullah, & Yuen, 2015; Saip et al., 2020; Segaran, 2019; Tong et al., 2017). The noise from the traffic flow is able to penetrate into the school building through the walls or through the openings of buildings, such as windows, doors and ventilation spaces which results in a noisy classroom as a result of background noise from the traffic flow. Therefore, there will be learning disruptions in the classroom if the background noise level in the classroom exceeds 35 dBA, which is the standard allowed by WHO (Berglund et al., 1999). Background noise is the level of noise in the classroom without the presence of students, teachers, and activities in the classroom (Shield & Dockrell, 2003; Woolner & Hall, 2010), which is the sound caused by lights, fans, air conditioning and external noise that permeates the classroom.

Classrooms on the second floor of Sekolah Kebangsaan Kampong Pasir, Johor Bahru are no exception to the problem of high noise exposure. Classes are exposed to road noise from the Skudai-Johor Bahru Highway from one side through louvres windows and ventilation

openings. The school was built in 1998 with standard louvres windows that occupy 60 % of the wall area. These louvres windows easily allow sound to enter the classroom due to the characteristics of the windows itself. Furthermore, the current noise barrier installation does not provide noise mitigation to the 2nd floor classrooms. This led to poor acoustic conditions of classroom that disrupts the learning process without being noticed by the school.

According to conversations with the headmaster and class teachers, exposure to high noise in the classroom also results in the teachers having to raise the voice level to higher than the normal level while teaching in the classroom so that it can be heard optimally by the students. The normal level for teacher's voice is 60–70 dBA, while according to research in urban school in Hong Kong, the average of a teacher's voice is 74 dBA (Chan et al., 2015). This means that a teacher teaches with an average level of voice above 74 dBA over the course of their teaching time. As a result, such teachers may experience physical health disorders, such as sore throats and headaches.

Based on a study conducted on the development of a school characterized by healthy buildings, noise impedes learning focus, impairs learning and cognitive development (Montiel et al., 2019). Cognitive development is the student's ability to think and understand both oral and written comprehension. This is greatly affected due to the students' lack of ability to concentrate and remember facts. In addition, the study found that these effects are more prominent in students that are less than 15 years old because they are still in the process of mind and language development (Montiel et al., 2019). Subjects that require a high level of understanding such as Language (Sarbu & Sebarchievici, 2013) and Mathematics (Cheryan et al., 2014) are severely affected as a result of high noise levels in the classroom. According to a study conducted in Sweden on students aged 12 to 14, the level of comprehension for reading tests is higher for quieter classrooms (Montiel et al., 2019). Meanwhile, a study in the United States showed lower grades of Mathematical test results for classrooms exposed to higher noise levels (Cheryan et al., 2014).

Therefore, the problem of noise pollution in the classroom is obviously an obstacle in the implementation of the new education system – Education 4.0 for producing holistic students in the 4IR era. Thus, it is the time to implement sound mitigation in the classroom. So far, many noise level studies have been done in the school area (Ismail, Abdullah, & Yuen, 2015; Saip et al., 2020; Segaran, 2019; Tong et al., 2017). However, no project showed the implementation of acoustic treatment. This may be due to the complexity and high cost of doing such renovation-noise abatement projects.

One way to reduce the renovation cost is to implement community projects with the involvement of the industry. Collaboration with industries can reduce the financial burden of the project. This method was used for a community engagement project to develop the serene classroom of Sekolah Kebangsaan Kampong Pasir, Johor Bahru. This project is a collaboration between Universiti Teknologi Malaysia (UTM) and the community with the assistance of the Johor State Education Department and the industries. Therefore, this paper discusses project implementation carried out through community engagement, impact measurements, lessons learned from the project and challenges.

2. Methods

Sekolah Kampong Pasir, Johor Bahru, Johor is a primary school under the National Transformation 2025 program where one of the goals is to provide harmonious learning and have a close relationship with the community. The school is located on the side of the Skudai-Johor Bahru highway (Figure 1). Although there is already a noise barrier, the 2nd floor classroom that is facing the road faces high noise pollution problems. The implementation of this project received good cooperation from the school administrators in view of the noise pollution problem. The project was carried out over a period of 18 months, starting from the planning stage to its implementation. Six bodies including the School of Civil Engineering, Universiti Teknologi Malaysia (UTM); Johor Department of Education, Ministry of Education Malaysia; Vibrant Echo Company; Sanjung Sempurna Sdn. Bhd.; and DZAZ Collection. Table 1 shows the names of the agencies involved and their contributions. The School of Civil Engineering, Universiti Teknologi Malaysia (UTM) is the owner of the project which also provides researchers and volunteers consisting of staff and students that total to 23 people. Sekolah Kampong Pasir and UTM are only 6.6 km away from each other.

Sekolah Kampong Pasir is under the auspices of the Johor State Education Department, Ministry of Education Malaysia; therefore, the ministry is the agency that approved this project. The target community is 20 people consisting of teachers, students, and parents of Sekolah Kebangsaan Kampong Pasir. Vibrant Echo is a company involved in sound insulation. The involvement of this company also provides thoughtful ideas related to the implementation of the Serene Classroom project, for example, contribution of ideas and supply of acoustic curtains. Sanjung Sempurna Sdn. Bhd., a construction company, supplied new chairs to replace the old ones that were damaged. Meanwhile, DZAZ Collection donated electrical appliances, fans and lights. There are also individuals who contributed to the form of donations, especially to paint the serene classroom.

Figure 1. Location of Sekolah Kebangsaan Kampong Pasir

Table1. Roles and contributions of agencies

No	Agency name	Contributions
1.0	School of Civil Engineering, Universiti Teknologi Malaysia	Project owner -Researchers -Volunteers (Staff and students)
2.0	Johor State Education Department, Ministry of Education Malaysia	Approval of project
3.0	Sekolah Kebangsaan Kampong Pasir	Targeted community Serene Classroom -Volunteers (Staff, parents and students)
4.0	Vibrant Echo	Acoustic consultant -Consultation, Soundproof curtain
5.0	Sanjung Sempurna Sdn. Bhd.	Loss Angeles Chair
6.0	DZAZ Collection	Electric appliances-Fan/lamp etc.
7.0	Personal donation	Painting

To facilitate the implementation of the project, a project management organization was formed involving UTM and the community from Sekolah Kebangsaan Kampong Pasir. The UTM team consists of lecturers, engineers, and technical staff. The community team is led by the head teacher, and assisted by the morning session senior assistant, the afternoon session senior assistant, and the assistant principal of the Parent-teacher association. The project is divided into planning, implementation, and measurement stages. Measurements are impact measurements covering noise reduction assessments and community impact surveys. The activities at each level are shown in Table 2.

Table 2. Project Activities

Stages	Activities	Remarks
Planning (see 2.1)	Activity 1&2	The first meeting for the preliminary survey with the community, 2nd meeting and visit to the 2nd floor classroom
	Activity 3	Noise pollution measurement for 5 classes on the 2nd floor and analysis by researchers from School Civil Engineering, UTM
	Activity 4	Discussions with Vibrant Echo company Discussions with the school community
Renovation (see 2.2)	Activity 5	Ceiling installation, table repair and painting
	Activity 6	Removal of louvres windows, installation of soundproofed windows, clean and repair walls
	Activity 7	Paint the floor and walls
Measurement (see 2.3)	Activity 8	Noise measurement after renovation and impact on the community

2.1. Planning stage

At the planning stage, a series of discussions were held to ensure the project runs smoothly (Table 2). Preliminary discussions were conducted twice, namely preliminary surveys to express the intention to develop a serene classroom project. At this point, the findings of the discussion were that permission from the Johor Education Department must be applied before the project can begin. The second discussion with the school was done after obtaining approval from the Johor State Education Department, Ministry of Education Malaysia, and agreement

with the school as a community. The 2nd stage discussions were held with the principal and senior school officials on the problem of noise pollution, followed by visitation of all classes on level 2. The current finding is that the school receives visits and appreciates our efforts; however, the school does not have the budget to improve the classes. The third activity is for UTM and volunteers consisting of students and researchers to measure noise pollution for three days to get the actual noise level. Measurements were made during the end-of-year school holiday season in order to obtain the background noise of the classes, in accordance with the guidelines given by the school acoustics by BB93 (Department for Education, 2015).

On the 24th of September 2019, we had a discussion with Vibrant Echo acoustic consulting company to come together and come up with an idea once the sound level data was available. Since the source of the noise is from the outside, mitigation is quite difficult to do and requires a high cost. According to WHO, the noise level limit in the classroom must be 35 dBA (Berglund, Lindvall, & Schwela, 1999) and in order to meet this requirement, double-glazed windows must be used (Department for Education, 2015) . The consultant suggested that the construction of the serene class be done with the installation of double-glazed windows but that requires a high cost (which was about RM22,000). Several other methods such as acoustic ceilings, acoustic curtains and masking methods like 'Fountain' are proposed.

However, due to financial constraints, UTM researchers considered other alternatives, namely street-facing louvres or entrance noise sources modified with single-glazed windows along with the installation of soundproof curtains and acoustic ceiling; The cost is about RM 10,000 and the proposal was approved by Vibrant Echo company. Figure 2 is an overview of the classroom with a single-glazing window as a result of discussions with Vibrant Echo company. Based on BB93 (Department for Education, 2015) the propose selected glass windows with a thickness of 5mm have a sound insulation capability of almost half the capacity of double glazing. Finally, on the 30th of November 2019, we met again with the school's headmaster and senior assistant to discuss the initial picture of the class after the renovations. The school accepted this proposal because it understood the financial constraints faced and hoped the treatment would provide at least half the noise reduction.

Therefore, our objective is to halve the noise intensity in the classroom. According to acoustic rules, a reduction of more than 10 dBA will give a significant difference in human hearing. With consent from the school, we chose only one classroom for acoustic treatment, named 'Serene Classroom'. The school wants to make the serene classroom as an example of a soundproof room and will find the budget in the future to change 4 more classes similar to the serene classroom.

Figure 2. Perspective view of Serene Classroom at planning stage

2.2. Renovation stage

The previous room condition is shown in Figure 3(a). Renovations for acoustic treatment were made by installing ceilings and replacing windows, as well as repairing walls (Figure 3(b-d). The materials and their roles are shown in Table 3. Ceiling installation and window replacement were done by volunteers from UTM while wall and floor repairs were done by volunteers from UTM and the community. The serene classroom was developed with the concept of reducing traffic noise waves that permeate into the classroom to lower noise level readings. Thus, renovation work began with the replacement of the old asbestos ceilings with acoustic ceilings. Acoustic ceilings were used to absorb sound emitted from traffic noise (Figure 3(c)). After that, the louvres windows in the classroom were replaced with single glazing windows with aluminum frames (Figure 3(d)). Green glass and frosted glass with 5mm thickness were used. The frosted ones were installed in the second row of window panels to allow air circulation in the classroom while the green glass remains installed in the top row of window panels to allow natural lighting to enter the classroom.

Table 3. List of materials

List of materials	System	Role
Fiberglass panel	Acoustic ceiling	Absorb sound from class activities
5mm green glass	Single glazing window – top part	Block noise from the road

List of materials	System	Role
5mm frosted glass	Single glazing window – bottom part	Block noise from the road
Curtain	Soundproof curtain	Block noise from the road

The frosted glass installation prevents the students from looking out during learning sessions, especially if there was an ambulance or a noisy vehicle passing. Installing the single glazing system is the most difficult job of all the activities that have been carried out as it involves the removal of the louvres windows. The removal was carried out by volunteers from Universiti Teknologi Malaysia who are specialized in this work. With the replacement of this glazing window, the sound from the road can be blocked and reflected back towards the road because the glass has the property of reflecting sound. To increase the soundproofing, the window has silicone added around the installed aluminum frame. To further enhance the sound intensity, acoustic/soundproof curtains are installed covering the entire window to block the sound. This curtain is a kind of blackout curtain, which will make the class a bit dim (Figure 3(e)).

Figure 3. Condition of classroom before and after renovation, during renovation and cheering up works

After the renovation work is completed, the cheering up (Figure 3(f-h)) of the classroom was carried out including painting the walls and the floor with colors that match the color of the chairs. This work involved a lot of volunteers from the school including teachers, students and parents. The shaky wooden tables were repaired and repainted to look cheerful (Figure 3(f-g)). The surface of the floor was repaired and painted (Figure 3(h)). Meanwhile, the construction company, Sanjung Sempurna Sdn. Bhd. donated yellow Loss Angeles chairs to replace the old chairs. The arrangement of the classroom was carried out by the teachers to facilitate student-centered learning. The completed serene classroom is shown in Figure 3(i).

2.3. Measurement's stage

2.3.1. Noise level reduction

The impact of serene classroom development on the community was done by assessing the ability of the room to reduce noise levels. For that, noise measurements were done for both classroom conditions i.e., before it was renovated and after it was renovated to the serene classroom. The measurements were carried out by researchers and volunteers from School of Civil Engineering for 8 hours from 9.45 am to 5.45 pm when the class was empty using Type 1 and 2 sound level meters installed at each measurement point marked at points 1, 2 and 3. According to BS 8233: 2014, measurements should be made at 1.2 meters to 1.5 meters above the floor surface and away from other reflective surfaces. For this reason, the measurement position is performed at a distance of 3.5 meters to the side of the reflection surface. This method was also practiced by Wen et al. (2019) in the measurement of sound exposure in classrooms in China. Figure 4 shows the arrangement of the sound meter location arranged diagonally throughout the class. Measurements were recorded every 5 minutes for 8 hours and the L_{Aeq} for each measurement point was calculated. The data obtained was used to select the materials for the serene classroom.

Most louvres windows do not work well so the measurements before renovations were done with both open and closed louvres windows. Serene classroom measurements were performed under three different conditions, namely when windows were 50 % closed, windows were 100 % closed and windows were 100 % closed together with application of soundproof curtains. In addition, wind speed was also measured to ensure the accuracy of the sound level measurement because the meter can only function well if the wind velocity is less than 5 m/s. The data sets found at points 1, 2 and 3 were analyzed to obtain the background sound or 90 % of the noise available in the class using cumulative distribution. At a reading of 90 % of this curve, the L90 readings for Point 1, 2 and 3 were found and compared with the background noise allowed in

the classroom according to WHO standards, which is 35 dBA during class. This limit is higher according to the British standard of BB93 if the class uses natural ventilation that is 40 dBA (Department for Education, 2015). Thus, in this project, BB93 was used as a guideline since the classroom has natural ventilation.

(a) Measurement location (b) Sound level meter set up

Figure 4. Location of measurement in classroom and sound level meter setting up

2.3.2. Community perception surveys

The Serene classroom is occupied by a total of 62 students. The school is a two-session school, so this room is used by year 5 students (11 years old) in the morning and year 3 students (9 years old) in the afternoon. These students' reactions were obtained by answering a set of survey questions. All students were involved, which includes those sitting in the front, in the middle, and behind. Questions consisted of classroom noise conditions, cause of noise in the classroom, levels of comfort, disturbance on classroom activities, and effect on subject taught (Table 4). Delivery of subjects such as mathematics and English were affected by the level of noise in the room (Cheryan et al., 2014; Department for Education, 2015; Kahkashan & Shivakumar, 2015; Sarbu & Sebarchievici, 2013), so the questionnaire also had a question on the perception of students in Mathematics, English language, Malay language and Science. Students answered the questions according to the answer of yes or no except for questions that are related to the level of comfort, they used '1 = Uncomfortable', '2 = Slightly comfortable', '3 = Neutral', '4 = Comfortable', '5 = Very comfortable'.

Table 4. Survey to Students

Item	Questions	Previous classroom	Serene classroom
1	*Is your classroom condition quiet or noisy?*	(Yes/No)	(Yes/No)
	Quiet		
	Noisy		
2	*What is the cause of the noise in your classroom?*	(Yes/No)	(Yes/No)
	Noise inside the classroom		
	Noise from inside the school area		
	Noise from passerby		
	Noise from vehicles		
3	*Do you feel comfortable with your current classroom conditions?*	Tick (/)	Tick (/)
	1 = Uncomfortable',		
	'2 = Slightly comfortable',		
	'3 = Neutral',		
	'4 = Comfortable',		
	'5 = Very comfortable'		
4	*Which classroom activity is the most affected by the noise?*	(Yes/No)	(Yes/No)
	When you are reading		
	When you are doing exercises or tests		
	When teacher is speaking		
	When you are doing mathematics or comprehension		
	When you are memorizing		
5	*Are the following subjects affected because of the noise?*	(Yes/No)	(Yes/No)
	Malay Language		

Item	Questions	Previous classroom	Serene classroom
	English Language		
	Mathematics		
	Science		

Apart from the student community, the teacher community was also asked for their opinions on the acoustic treatment that had been carried out. 10 teachers were involved. These teachers were selected because they were the class teachers for the year 5 students in the morning session and year 3 in the afternoon that occupied the serene classroom. The details of the questionnaire are shown in Table 5. The questionnaire for the students was adapted from previous research by Wen et al. (2019) whereas for the teachers, it was developed based on their knowledge of changes before and after the project as suggested in the community engagement evaluation guideline by UTM. Teachers answered the questions related to the level of their knowledge by using the four-point Likert scale '1 = Disagree', '2 = Slightly agree', '3 = Agree', '4 = Strongly agree'. The questions involved the opinions of teachers about their knowledge on noise pollution in the classroom, knowledge on acoustic treatment and impact of project. Answers from the students and teachers were compared with the findings from previous studies and the sound level quality conditions obtained from the measurements.

Table 5. Survey to teachers

Before renovation				
'1 = Disagree', '2 = Slightly agree', '3 = Agree', '4 = Strongly agree'	1	2	3	4
I know how to properly insulate sound in the classroom				
I know what a soundproof window is				
I know what an acoustic ceiling is				
I know what a soundproof curtain is				
After renovation (Serene Classroom)				
I know previous classes are prone to noise pollution				
I know noise pollution can disturb students				
I know noise pollution causes students to lose focus on what is being taught				
I know noise pollution causes me to always raise my voice when teaching				
I know noise pollution causes sore throat and stresses me out while teaching				

I know how to properly insulate classroom noise
I know what a soundproof window is
I know what an acoustic ceiling is
I know what a soundproof curtain is
I am satisfied with the community engagement program
Classes are now suitable for teaching/learning
The school will continue its efforts to create soundproof classes in other classes if funds are sufficient

3. Results and discussion

3.1. Noise reduction by serene classroom

The previous class had an equivalent noise level, L_{Aeq} highest at point 1 which is between 69.7 to 71.4 dBA. Point 2 has a value between 66.6 to 69.6 dBA and point 3 with a sound level value between 68.8 to 70.1 dBA. It was found that the highest noise level around 2 pm was due to the large number of vehicles using the Skudai-Johor Bahru Road due to the peak movement of vehicles. For point 3, even though it is the furthest from the road, the sound level exceeds point 2 due to sound reflection from the walls. Sound level readings from these three points result in an average reading of 70 dBA, which is far above the level of 55 dBA set by the World Health Organization (WHO) in the school area.

The effect of serene classroom development is shown in Table 6. A reduction of 12 dBA in the average noise level occurs if the glass window in the serene classroom is closed by 50 %. The level decreases further by 5 dBA if the window is tightly and neatly closed. This shows that the installation of a single layer glaze can reduce the noise by 18 dBA. This reduction is said to be significant in terms of acoustics where it can be felt by everyone. The use of acoustic curtains adds another 4 dBA noise reduction implying that it can be very significant and felt by everyone.

Table 6. Noise level and noise reduction in classroom.

Condition	Point 1	Point 2	Point 3	Average
	$L_{Aeq\ (8hr)}$ (dBA)	$L_{Aeq\ (8hr)}$ (dBA)	$L_{Aeq\ (8hr)}$ (dBA)	(dBA)
Previous Classroom				
Mixed -open & closed – Louvres window	70.9	67.8	69.5	68.5
Serene Classroom				
50% closed window	58.3	55.7	56.4	56.3
100% closed window	52.9	51.5	52.2	51.9
100% closed window + Curtain	49.6	48.6	49.5	48.3
Reduction of noise				
50% closed window	12.6	12.1	13.1	12.1
100% closed window	5.4	4.2	4.2	4.5
100% closed window+ Curtain	3.3	2.9	2.7	3.6
Total reduction of noise				
100% closed window+ Curtain	21.3	19.2	20	20.2

The value of L90 or background noise at all points in all conditions are as shown in the Table 7. It was found that all three locations in the serene classroom experienced background noise reduction. A decrease of 12 dBA in the average background noise level occurs if the glass window is closed by 50 %. It is decreased to 16 dBA if the window is tightly and neatly closed, while a reduction of 20 dBA occurs if the window is completely covered with curtains. From these data, it shows that the L90 for the class is getting closer to the permitted values allowed by WHO and BB93. If the window is completely closed and the acoustic curtains are installed, the value of L90 does not differ very significantly from the limit allowed by BB93.

Table 7. Background noise in classroom.

Conditions	LA90 (dBA), Point 1	LA90 (dBA), Point 2	LA90 (dBA), Point 3	Average, LA90	Exceedance from WHO limit >35 dBA	Exceedance from BB93 limit >40 dBA
Previous classroom- Louvres						
Mixed -open & closed windows	69.2	65.5	67.8	67.5	32.5	27.5
Serene Classroom						
50% window closed	57.2	54.2	56.2	55.9	20.9	15.9
100% window closed	51.5	50.9	52.1	51.5	16.5	11.5
100% window closed + Curtain	48.3	47	46.8	47.4	12.4	7.4
Reduction of noise						
50% window closed	12	11.3	11.6	11.6		
100% window closed	5.7	3.3	4.1	4.4		
100% window closed + Curtain	3.2	3.9	5.3	4.1		
Total reduction of noise						
Total Reduction	20.9	18.5	21	20.1		

3.2. Community perceptions

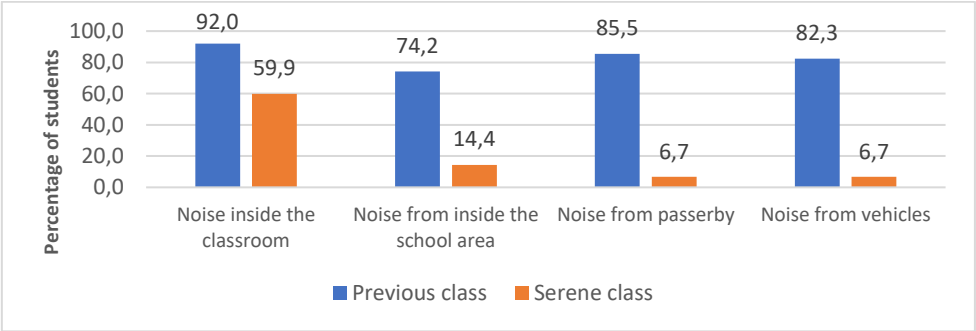
3.2.1. Student community

It was found that 100 % of the students considered the previous class to be noisy. However, after the class turned into a serene class, 96.8 % (n = 60) students reported that they could clearly hear their teacher's voice during class, while 3.2 % (n = 2) reported having difficulty

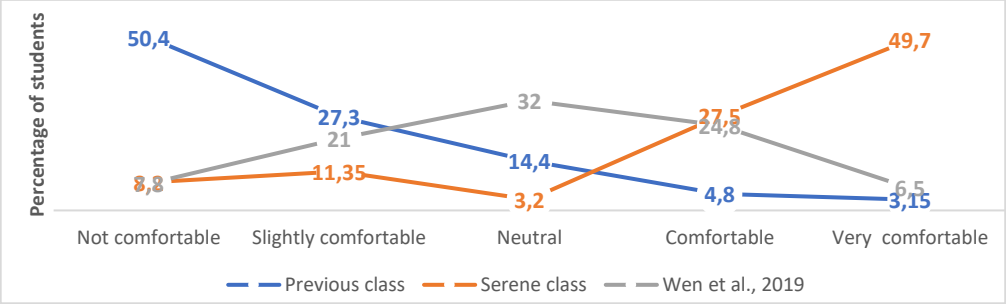
listening to the teacher. It can be said that most students agree that the class is considered "silent" after treatment.

Causes of noise in the classroom consist of four factors, noise in the classroom itself, noise from passerby, noise from vehicle and noise from within the school grounds. All factor except noise in the classroom are categorized as background noise. Figure 5(a) shows the serene classroom has significantly changed the perception of the student community as only 6.7 % of the students reported that the noise from passerby and vehicles caused the noise pollution while playground noise as much as 14.4%. On the other hand, 59.9 % of students are now more aware that the noise that occurs in serene rooms is mostly caused by noise in the classroom itself. Previous research by (Shield et al., 2015) also showed that noise in classroom consist of combination of background noise and internally generated noise in the classroom itself.

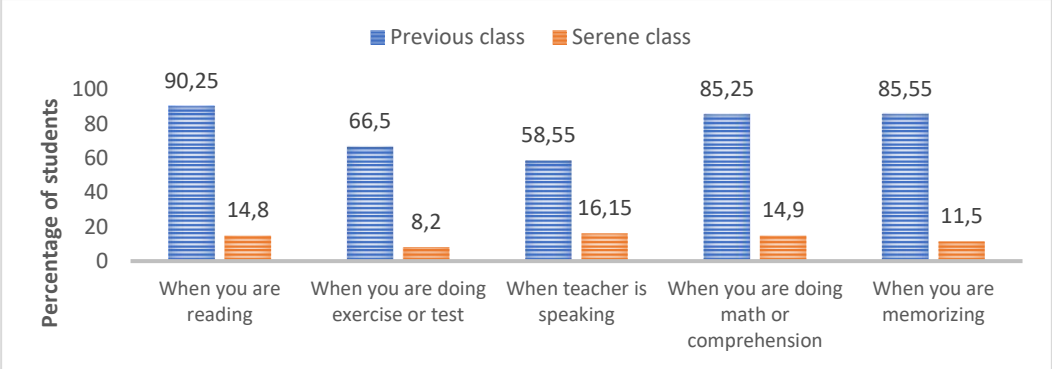
In terms of comfort, students' perceptions of the serene classroom are shown in Figure 5(b). The percentage of students who feel very comfortable studying in the serene classroom is higher than the previous classroom which is 49 % compared to 3.15 %. In comparison, the comfort trend is reversed when compared to the previous room. The previous class acoustic comfort trend was also found to be different from the study in China (Wen et al., 2019) due to the differences in geography and the perception of sound level comfort.



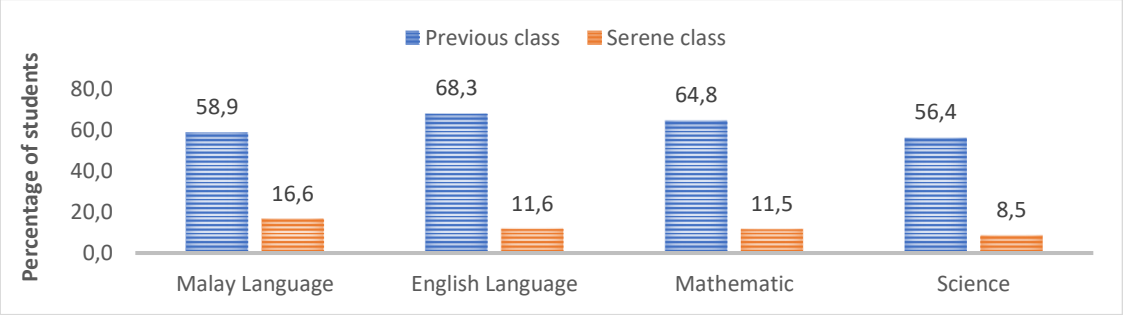
a) Cause of noise in classroom



b) Student evaluations of acoustic comfort in their classrooms



c) Effects on classroom activities



d) Effects on subjects taught

Figure 5. Student's perception

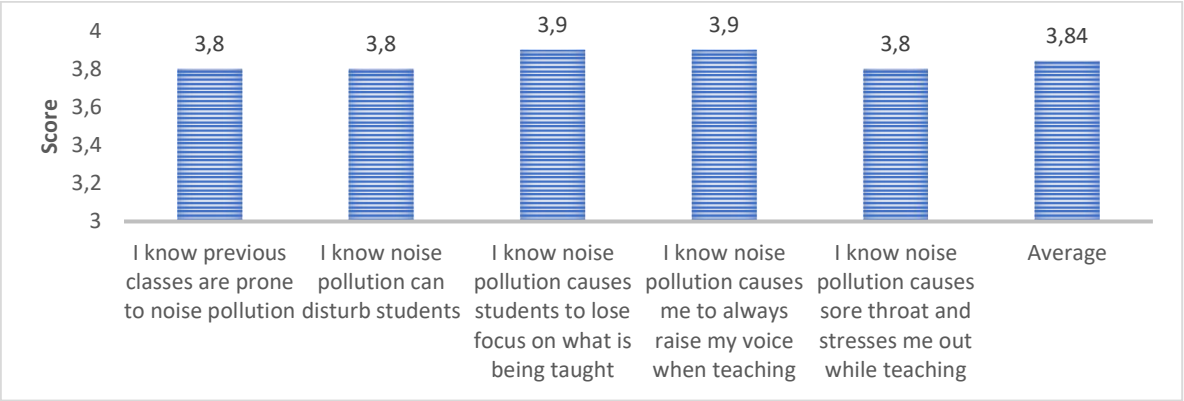
The Serene classroom also helps the community reduce the effects of noise disturbances encountered such as listening to teacher's conversations, doing exercises, conducting tests or activities and memorizing (Figure 5(c)). The results obtained show that using serene classrooms decrease the effects of noise disturbance to below 16 %. This data shows that noise from the road interferes with all activities in the previous classroom especially when reading, learning mathematics, remembering facts and interrupting teachers to speak.

In general, serene classrooms provide easier understanding of the subjects taught. It was found that in the serene classroom, the percentage of students who felt they were having problems with their teacher's delivery in certain subjects changed significantly (Figure 5(d)). For example, for the English subject, the 68.3 % of students who found it difficult to understand the teacher's presentation in the previous classroom decreased to 11.6 % in the serene classroom. This shows that the serene classroom allows students to have better focus than the previous classroom.

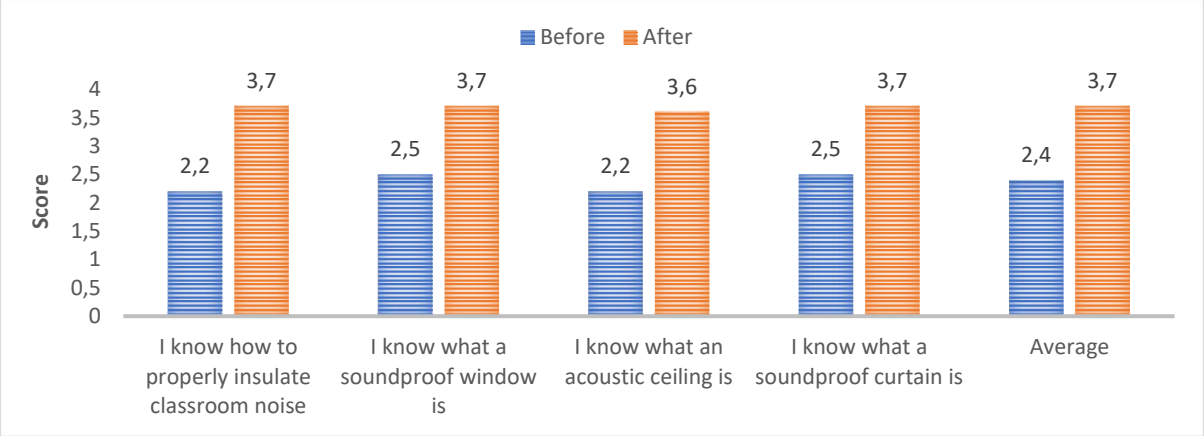
3.2.2. Teachers community

After the renovations have completed and teachers used the serene classroom, the teacher community understands or agrees that previous classroom conditions were prone to noise pollution, and as a result, causes students to lose focus from learning. Teachers also knew that due to noise pollution, they had to raise their voices during teaching, and this causes them stress and sore throat. Their understanding on class condition effects score can be seen in Figure 6(a) with all of the items reaching 3.8 and above with an average of 3.84 answering agree to strongly agree.

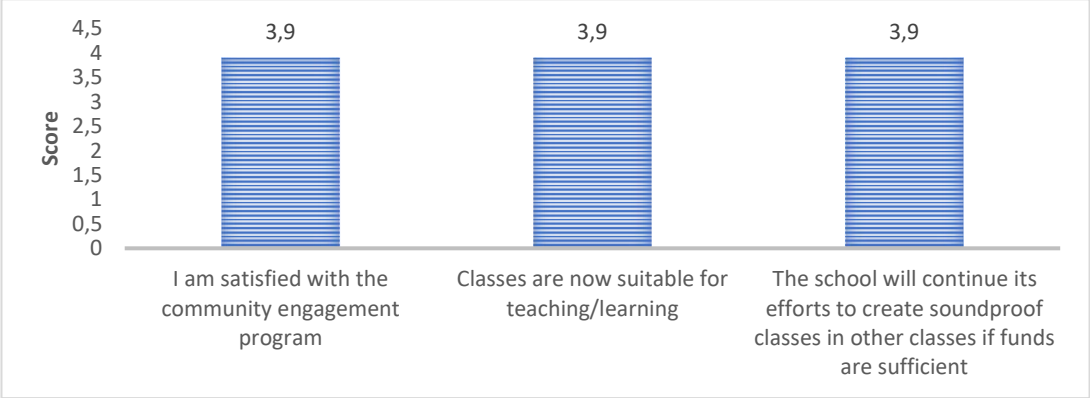
Interestingly, before the program was implemented, almost all respondents have low knowledge of soundproof windows, acoustic ceilings, soundproof curtains and method of acoustic treatment. Knowledge on soundproof windows, acoustic ceilings, soundproof curtains and how to treat the classroom to have good acoustic quality is below 2.5 and the average of all the scores is 2.4. After the serene classroom was successfully developed, the findings of all these items increased and the average rocketed to a score of 3.7. The knowledge of how to treat the class for noise abatement (Figure 6(b)) also increased to 3.7; thus, indicating that they have acquired knowledge and skills of noise abatement.



a) Knowledge level on noise pollution



b) Knowledge level on material used in abatement and the of Abatement



c) Impact of Serene Classroom

Figure 6. Teachers' perception (scale '1 =Disagree', '2 = Slightly agree', '3 = agree', '4 = Strongly agree')

Teachers also have the aspiration to continue this project to other classes that have the same problem with a score of 3.9 from score 4, which is from agree to strongly agree (Figure 6(c)). This is because they are satisfied with this project with a score of 3.9 or 98 % agreeing that the classroom is now conducive for teaching and learning.

3.3. Lessons from the implementation of the serene classroom

Noise pollution in these schools has been going on for years and the impact on students and teachers has gone unnoticed by the community. Through this project, the University as a research center really needs to help the community in solving their problems by transferring the existing technology. A very important lesson is that although acoustic treatment is very expensive, but with the help of agencies such as UTM and the industry, the problem can be

solved at a reasonable cost. Costs only involve the purchase of building materials as they do not involve labor costs and consulting costs. Labor costs are carried out by volunteers and so is consulting and research, which are done by UTM in collaboration with the industry. A typical class can be converted to a soundproof system that uses common and inexpensive materials that can be installed in the classroom with a total cost of only about RM 10,000. Despite the low cost, the serene classroom can be produced successfully with a reduction of 21 dBA.

In fact, through this project, the community learned the construction of a soundproof classroom system and together had the opportunity to carry out renovations. As a result of this innovation, the school community has the skills and knowledge to assess acoustic quality on their own. The Serene classroom innovation is sustained when the community is able to apply the concept of other facilities that are vulnerable to extreme noise pollution from the road. For example, they have successfully transformed the teachers' meeting rooms that were once highly vulnerable to noise pollution into more conducive meeting rooms. The community is also learning new knowledge to improve school infrastructure. These skills are very important in order to improve the quality of infrastructure and the quality of students and schools as recommended by the Ministry of Education Malaysia through the School Transformation Program 2025 (TS25).

In addition, the implementation of this project further strengthens the relationship between UTM, Industry and Schools as well as the Johor State Education Department, Ministry of Education Malaysia. Through this innovation project, UTM and the community understand that industry involvement is very important in community work because the industry can give the appropriate contribution. In this project for example, Vibrant Echo contributed joint ideas, Sanjung Sempurna Sdn. Bhd. contributed new, more comfortable chairs while the company DZAZ Collection contributed electrical appliances and learning equipment. This situation eases the financial burden not only for the implementation of the project but the school's finances as well. We were able to learn how to get industry support. For example, the method used is to approach companies that are well known and enquire if they are willing to get involved in the project. Companies that agree will be given privileges, such as display of their company name in the university media or local media in appreciation of their contribution.

In turn, this program reinforces the goal of 9 sustainable development-infrastructure-perfect learning space. Community focuses on the construction of learning spaces that take into account the health and well-being of teachers and students that should be in line with the country's educational aspirations. The high noise pollution in the classrooms experienced by some schools in Malaysia and its impact on teachers and students is a major obstacle to the

implementation of the education system today. Thus, these innovations foster awareness among the educator communities and authorities on the importance of school planning and design and the need to use insulation and sound absorbers optimally for building construction and study space renovation in line with the national educational aspirations and Sustainable Development Goals (SDGs).

3.4. Challenges to the development of serene classroom

There are a number of challenges that need to be overcome to ensure the success of the project. Among them is to get approval from the State Education Department because this project involves the safety of school children and the learning process. They have imposed conditions and by following all the conditions, the project was successfully approved. Selection of the best mitigation method is also very difficult due to limited finances. The method recommended by the noise pollution reduction consulting company requires a higher cost. Therefore, due to limited finances, researchers from UTM and Vibrant Echo company used a method based on the concept of "reflective and absorbing" sound, which uses the cheapest materials but with optimal noise pollution reduction.

Furthermore, the biggest challenge is that the implementation of this project can only be done during the end of the school holiday season so as not to disrupt the class and other classes because the project involves carpentry work. Therefore, the project was implemented regardless of time that included weekends as delays will cause disruption to the learning of students who will use the serene classroom in the next school session. Due to the school holidays, there were very little participation of volunteers from the school especially from the parents' association as most of them had pre-booked their holidays. So, the school volunteers who were present were only made up of teachers, students and parents who were free. However, this problem is overcome with the cooperation of UTM volunteers consisting of staff from the school of Civil Engineering, UTM, and undergraduate/postgraduate students. Since the school is also close to UTM, there is no hospitality problem.

In addition, obtaining industry partners is also a big challenge. Their support is very important whether in the financial or moral form. However, the industry usually sees the success of a prototype first before they are willing to help. There are companies that think the finances should be borne by the Department of Education even though the project is a community project. Furthermore, the relationship with the industry also has its challenges because the industry involved is outside Johor Bahru. However, to determine the smoothness of the project, discussions on project implementation were conducted using various methods.

Apart from face-to-face discussions, online methods were also used to avoid logistical problems, especially for the industries outside Johor Bahru. In addition, separate and staged meetings (without the industry) are often held between UTM and the community to discuss problems to speed up solutions. The solution taken is then communicated to the private companies. This is because the private sector is quite busy, and therefore gave the freedom to UTM and the Community to make important decisions. For example, determining the concept and color of the room in accordance with the learning process.

3.5. Benefits of community engagement to agency and industry

A serene classroom was developed for a school exposed to high traffic noise pollution and would be considered as a prototype classroom for other schools that experience the same problem. Through the involvement of the Department of Education, it is hoped that more 'Serene Classroom' projects can be implemented in many schools, especially in urban areas. This is to overcome bad quality acoustics, which is an obstacle in the implementation of the education system for producing holistic students in the 4IR era.

For Vibrant Echo, this project shows the Department of Education, Ministry of Education and also the school community that good acoustic quality in schools is important. Acoustic aspects should be considered as important criteria during the planning stage of a school construction. Therefore, in the future, acoustic consultants can play an important role in designing a school. Including the acoustic aspect in the planning stage would be better as it will not cause expensive expenditure. The contributions from Sanjung Sempurna Sdn. Bhd. and DZAZ Collection are very much appreciated. This project will further strengthen their company's reputation as the project has been recognized by the community and aired on prime-time news on TV and in the newspaper.

4. Conclusion

Researchers from the School of Civil Engineering have undertaken a community project to produce a special classroom called 'Serene Classroom' aimed at reducing noise pollution in the classroom for more conducive learning. Community projects involving the industries have resulted in an innovation that is at an affordable cost. This paper describes the implementation of this project as a result of collaboration from government agencies, industries and the community, and the lessons learned, and the challenges encountered from this community engagement project.

The most difficult challenge is in facing the lack of volunteers from the school. Technically, the serene classroom has proven to reduce noise levels significantly in excess of 20 dBA, indicating improved acoustic quality. The impact was felt by the community of teachers and all students who used the room. Students can hear the teacher's speech and understand it better while the teachers do not have to raise their voices. The success of this community project has brought a new dimension in community-industry relations and a new perception by teachers regarding noise pollution and the treatments necessary to obtain conducive classroom conditions.

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Declaration of Conflicting Interest

The results of this study were obtained from the measurements and have no conflict of interest.

Author Contribution

Conceptualization, Zaiton Haron and; Methodology, Nadirah Darus, Rifa Rafida Rifki, Noramera Nabila Amir Nizam, and Nur Syalyana Malek; Validation, Helmi Kamaludin, and Syamsul Hafiz Yaakob; Formal Analysis, Norelyza Hussien and Ain Naadia Mazlan; Investigation, Zaiton Haron; Resources, Rafidah Mohd Yussup; Data Curation, Mohammad Ismail; Writing – Original Draft Preparation, Zaiton Haron; Writing – Review & Editing, Zaiton haron and Rozana Zakaria; Visualization, Ahmad Syakir Farhan A Kassim; Supervision, Abdullah Zawawi Awang; Project Administration, Khairulzan Yahya; and Funding Acquisition, Sheikh Izat Azhar Sheikh Ahmad and Zaliza Haron.

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