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Effect of Acoustic and Thermal Comfort to Support Learning Process in a University

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Abstract

Teaching and learning activities are the main part of success in implementing education at university. However, the existing condition of indoor acoustic and indoor thermal are factors that disrupt both to students and to lecturer in the classroom. This paper presents a study regarding effect of indoor acoustic and thermal towards comfort of students in classroom. The type of classroom involved in this study was based on their partition that used for separate the adjacent classroom, namely tacon partition (C1 room) and brick partition (C2 room). The phases of the study were consisted of two parts of the investigation where the first part was to measure the indoor acoustic to model its distribution and also measure indoor thermal to obtain the existing value. Additionally, the second phase is accomplished by distributing questionnaires simultaneously during the measurement period. Subsequently, the following part is to model the condition of indoor acoustic by using Surfer software v. 11. The findings indicate that the C1 room having intensity of noise within the range of 56.5-68.5 dBA while the C2 room having intensity of noise within the range of 62-96 dBA and it need to be insulated. In addition, the noise intensity doesn't meet the acoustical criteria for educational purpose, which is 55 dBA. However, the questionnaire results show that the respondents are feel comfort with the existing noise intensity level in those two rooms. Thus, it can be concluded that the comfort is a perception that is built in a everybody's mind and it can't be determined directly by threshold value. This study suggests that psychosocial aspect is also an important aspect that needs to be considered for an experiment which involves human behaviour. Finally, these two approaches between direct measurement and questionnaire survey give an useful perspective for building designer to design a building which is not only improve the building performance but also fulfils the needed of the building's occupants.

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Keywords: Acoustic comfort; sound intensity; thermal comfort; Surfer modelling

1. Introduction

Education is a process of learning and teaching with the aim of improving the quality of human resources. This is happening in an environment such as schools, colleges, and libraries. However, the educational process can be hampered if it located in noisy area.

The sound is a phenomenon which we cannot avoid in daily life, including workplaces and other activities. However, the occurrence of noise is frequently disrupt daily activities such as teaching and studying which takes place in university. That disruption is usually contributed from a high-frequency noise which risk to damage one's hearing and it will be bad for the human body if exposed at certain duration [1,2].

In addition, for supporting learning process, there are two requirements that students can listen well. The first is the condition of neighbourhood that is not noisy. Noise can come from the traffic on the road, the activity around the school, the sound of the next class, and the noise from the air conditioning system. The second is a low reverberation time, which is a parameter that indicates how fast the noise will disappear. The higher the reverberation time, it will be longer sound that survive indoors [3,4].

Subsequently, comfort in the classroom is not only by the noise, but the conditions of temperature and humidity of the room also affect the occupants of the room. The quality of the room environments serve as an assessment criteria that can be accepted

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by the occupants of the room or office environment [5]. Thermal environment representation regarding to temperature and humidity can be felt as heat, cold, damp or dry [6].

In Indonesia, the awareness to provide comfort environment in term of acoustic and thermal effects are less of concern. This condition had motivated authors to study regarding effect of acoustic and thermal comfort to support learning process in a university.

2. The object of the study

Measurements were carried out at classroom that partitioned with tacon (C1) and brick (C2) as displayed in Figure 1 and Figure 2 consecutively. Additionally, the C1 room have no carpet in its floor while the C2 room have carpet. The most obvious difference from these two classroom are the orientation of the C2 classroom that protrudes downward.

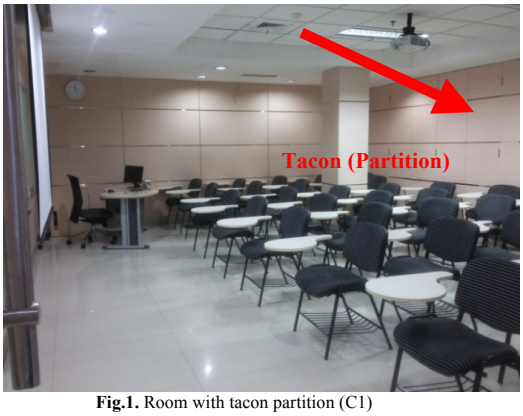

Fig.1. Room with tacon partition (C1)

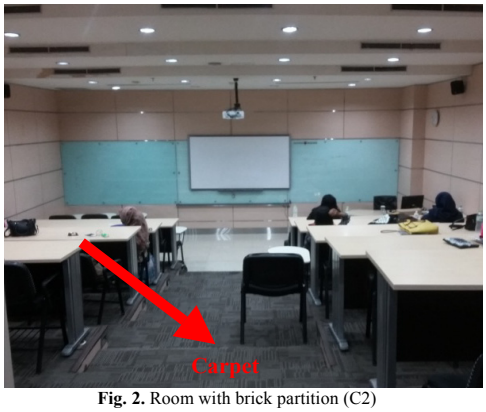

Fig. 2. Room with brick partition (C2)

3. Methods

3.1 Equipments

The measurement was conducted during activities of teaching and learning within a day. The intensity of noise was measured by sound level meter (SLM) whereas thermal condition was recorded by using hygrometer. These two equipments are visualised as in Figures 3 and 4 successively.

Fig. 3. Sound Level Meter

Fig. 4. Hygrometer

The SLM device have two modes of measurement in which for A mode the measurement of noise intensity is starting from 30-130 dBA whereas for C mode is starting from 35–130 dBA. The accuracy of this device is ±1.5 dB with the ability to measure the temperature within the range of -50 ºC to 50 ºC. During measurement period, these two devices are located 1 meter from floor by using a tripod. Additionally, to depict the real location of SLM and Hygrometer when the measurement was conducted then the sketch of measurement points is visualised as in Figures 5 and 6 successively.

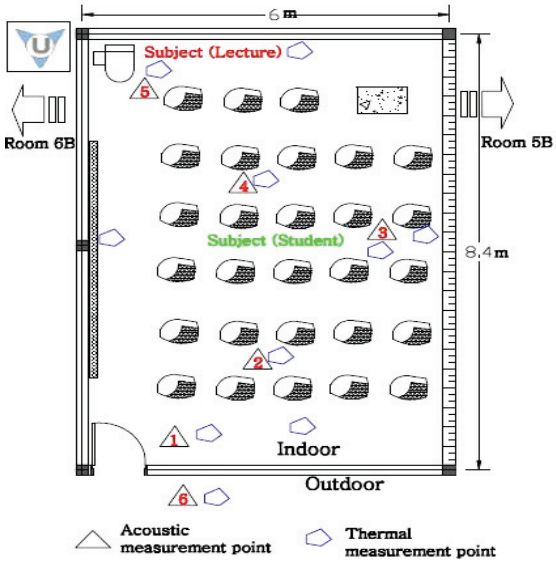

Fig. 5. Measurement room with tacon partition (C1)

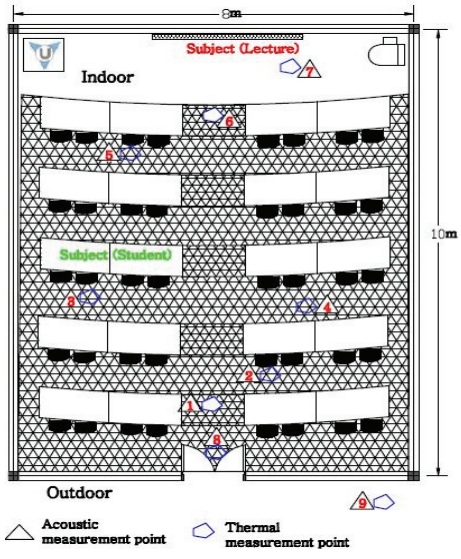

Fig. 6. Measurement room with brick partition (C2)

The measurement was carried out both outdoor and indoor to identify whether any influence from outdoor environment to indoor environment. For outdoor measurement both C1and C2,it is located 1 point to measure acoustic and thermal conditions. While, for indoor measurement, those two rooms had different measurement points which refer to the area that mostly occupied by students in the classroom. In which, the number of indoor measurement points of C1 room for acoustic and thermal is 5 points and 9 points consecutively as in Fig. 5. Besides, the number of indoor measurement points of C2 for acoustic and thermal is 7 and 3 points consecutively as in Fig. 6.

3.2 Subject

During measurement period, a number of 25 students occupied C1 room while 50 students at C2 room.

3.3 Questionnaire

A questionnaire survey was divided into three phases, in which the first phase was to obtain the perception regarding temperature while the rest of the questionnaire was to gain the perception regarding the humidity level and the existing noise intensity level during the measurement period.

4. Results and Discussion

4.1. Mapping acoustic in Surfer V.11

Once the existing acoustic level is measured, then the distribution of its level which is characterized by noise intensity can be mapped. This is aimed to show the distribution of noise intensity between those two rooms as in Fig. 7 and Fig. 8 respectively.

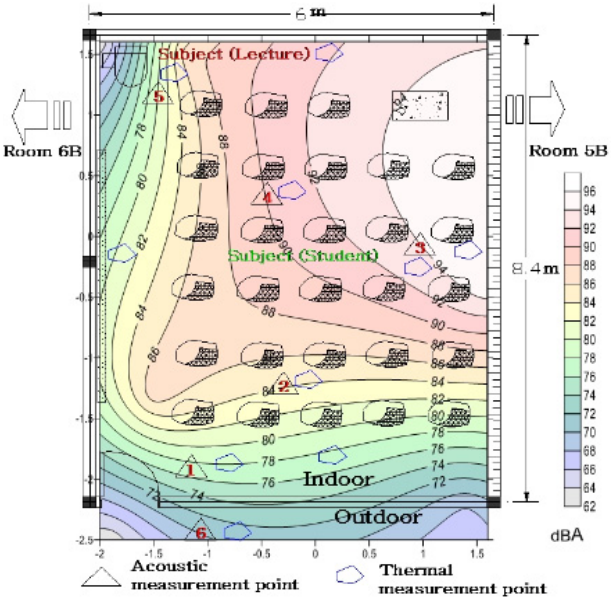

Fig. 7. Modeling in room with tacon partition (C1)

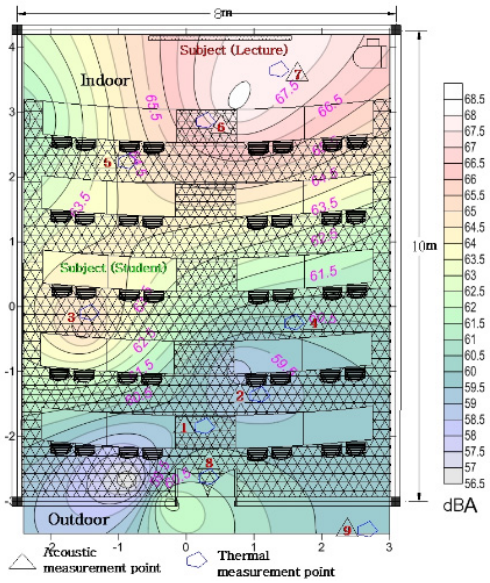

Fig. 8. Modeling in room with brick partition (C2)

For C1 room, it recorded when learning process in a classroom that the existing condition of noise intensity at all points exceed the threshold. When it seen from its distribution in the room, the factors that influence not only from external but also of internal space. The lowest noise intensity level recorded is at point 2 within the range of 78 dBA to 82 dBA and the highest noise intensity level recorded at point 4 to 5 is within the range of 82 dBA to 96 dBA. Additionally, the increment of noise intensity is also contributed by the imperfections in the wall surface that the sound waves can be transmitted through the slit.

Subsequently, for C2 room, the mapping approach illustrates that the lowest level of noise intensity to be around point 1 is represented by the blue colour contour ranging from 56 dBA to 60 dBA and the highest noise intensity on contour in line with red colour degradation. The noise intensity level recorded for measurement points of 5 to 7 are within the range of 64 dBA to 68 dBA. The increment of sound tends to be high in the front area of classroom which is influenced by the reflection of the sound source (lecturer) and the response from the other subject (student) at the time of learning period. Besides, the influence from the shape of classroom is that the voice can be collected in the room and it can be distributed to the room and it's also add the reverb time of noise in the classroom. The discrepancy level of noise intensity in the front and the back of the room is due to additional facilities carpet in the student area. It used to have a large enough surface area and has the ability to absorb sound waves, which is helpful to reduce noise intensity in a classroom.

4.2. Thermal measured

The thermal condition both outdoor and indoor were recorded and presented as in **Table 1.**

Table 1. Results of thermal measurements

	Room with tacon partition (C1)		*Room with brick partition (C2)*	
Point	*Temperature (°C)*	*Humidity (%)*	*Temperature (°C)*	*Humidity (%)*
1	22	56	23	58
2	22	62	22	62
3	23	63	22	62
4	23	63	22	58
5	23	62	23	60
6	23	63	23	58

A number of 6 points of thermal measured both C1 room and C2 room are compared as in Table 1 in order to determine the level of temperature and relative humidity. The results show that there are no significant difference for those two classrooms. Additionally, it results show that the conditions of humidity and indoor air temperatures meet with the standards of comfort [8]. The increment in temperature in the room tends to fluctuate which is influenced by the density of the room, and it gets colder

due to the higher densities in the room so that the reaction rate will be low-molecular and sound waves that come will not be low. Conversely, if a room has high room temperature, the lower density levels result in reaction rate occurs becomes high, so that the sound waves coming will occupy the vacant molecules that affect the increment of noise intensity due to space of classroom area.

4.3. Questionnaire

A number of 55 respondents are involved in this survey, 30 are males and 25 are females. In order to assess the perception of respondents regarding acoustic and thermal conditions, then the questionnaire was analyzed into three parts as following:

a) Temperature

To determine the temperature perception amongst respondents, they were requested to rate the level of temperature condition during measurement period which characterized by five scales such as: "very cold", "cold", "comfort", "hot", "very hot". The results survey are visualised as in Figures 9 and 10.

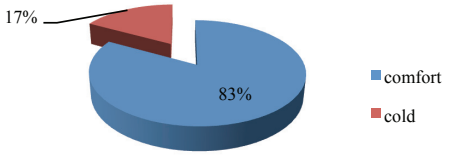

Fig. 9. The perception of respondents regarding temperature in C1

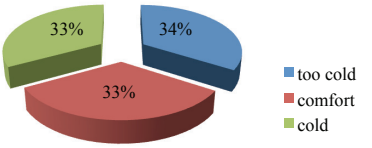

Fig. 10. The perception of respondents regarding temperature in C2

The results for C1 room shows that out of 83 % from 25 respondents feel comfort with the existing temperature, while only 17 % of respondents feel cold in that room. Additionally, for C2 room shows that a number of 34 % from 50 respondents feel that the temperature in that room are too cold. However, each of 33 % of respondents expressed the same vote both for comfort and cold in that room.

b) Relative humidity

Relative humidity is an aspect that require to be considered due to its effect for human health. The respondents in this study were asked to determine their feeling about relative humidity in C1 and C2 rooms based on several levels namely, "very dry", "dry", "comfort", "humid", "very humid". The results are shown as in Figures 11 and 12.

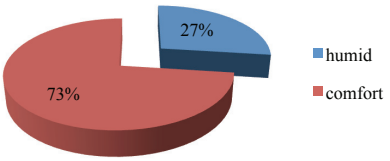

Fig. 11. The perception of respondents regarding humidity in C1

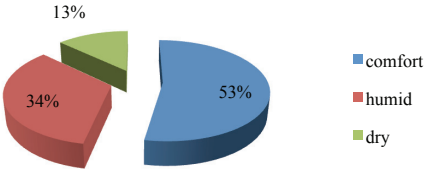

Fig. 12. The perception of respondents regarding humidity in C2

The results for C1 room shows that out of 73 % from 25 respondents feel comfort with the existing humidity, while 27 % of respondents feel humid in that room. Besides, for C2 room shows that a number of 53 % from 50 respondents feel comfort in that room, while the rest of respondents stated that the room are humid and dry as represented by the respondents percentage within the range of 34 % and 13 % consecutively.

c) Noise intensity

To obtain the perception regarding the intensity of noise, the respondents were asked to rate the level of noise which is rated in 5 scales such as: "too silence", "silence", comfort, "noisy", "too noisy". The results of questionnaire survey was shown as in Figures 13 and 14.

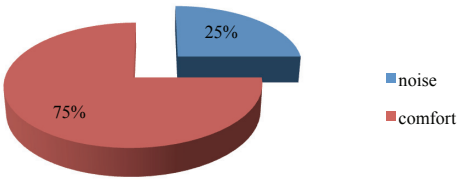

Fig. 13. The perception of respondents regarding noise intensity in C1

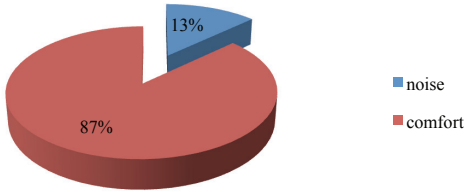

Fig. 14. The perception of respondents regarding noise intensity in C2

The results for C1 room shows that a number of 75 % from 25 respondents feel comfort with the existing noise intensity, while 25 % of respondents feel noisy in the room. Besides, for C2 room shows that a number of 87 % from 50 respondents feel comfort in the room, while the rest of respondents stated that the room are noisy as indicated by the 13 % of respondents.

5. Conclusion

A square-shaped auditorium of classrooms can give different results of noise intensity and indoor materials can help reduce the intensity of noise. It can be seen through the measurement and use of Surfer software v. 11 as a medium for visualising the pattern of noise intensity distribution in the room. From the results, it can be concluded that the utilization of tacon material is not suitable to be used as a room partition. Therefore, it needs a number of researches regarding materials as partitions that can help reduce noise intensity. Finally, bear in mind constantly that in having research which involves with human behaviour, the direct measurement of environment which surrounded the human is not fully represented of the existing human condition itself. It urgently needs the approach between experiment, modelling, and questionnaire survey as psychosocial tools.

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