Reverberation Time of University of Mindanao Matina Campus Classrooms – A Basis for Acoustic Environment Enhancement

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Abstract

The quality of the learning environment in classrooms depends on various factors. Building acoustics would be one of these factors. The two most important issues as regards this learning environment are excessive background noise and reverberation. They both interfere with the ability of the students to hear, listen, and understand what is spoken. It can lead to an overall reduction in the level of learning. The research focused on reverberation time or RT60. Standards presuppose that the acceptable range is 0.4 to 0.6 seconds. One second would be the maximum acceptable limit. The study was conducted at the University of Mindanao, Matina Campus. This university is known for its open admission. This open admission means that all types of students are admitted with all the various levels of preparedness. It was interesting to note that in the 2015 study of that university, most of its new students are considered not ready. The acoustic environment can exacerbate the learning development of most of the students. This descriptive survey research used multistage sampling. The instrument used in determining the RT60 was an Android App called Reverberation Time Pro, installed on the ASUS Z00LD smartphone. Only eleven percent of classrooms are compliant. The features of these compliant classrooms served as a guide for enhancing the 89% that are not.

Keywords: acoustics, reverberation time, RT60, lecture rooms, speech intelligibility

I. Introduction

The quality of a classroom environment depends on several factors such as size, indoor air quality, thermal comfort, lighting, and acoustics (Evaluation and Education Policy Analysis, 2017). In the field of acoustics, two essential characteristics describe such quality. These are background noise and speech intelligibility (Baker & Bernstein, 2012). This study focused on the latter.

The measure of speech intelligibility is reverberation time. Literature defines reverberation time (RT) as the time it takes for the sound to decrease by 60 dB from its initial value, thus resulting in a technical term called RT60. The recommended range of reverberation time for classrooms can be as long as 0.4–0.5s (Bistafa, & Bradley, 2000). According to ISO 3382 as cited by NTi Audio, the recommended RT60 ranges from 0.4–0.6 seconds (Reverberation Time RT60 Measurement, 2019). The maximum acceptable value is 1s (Reverberation Demonstration, 2019). Reverberation times that are longer can cause discomfort and compromise speech intelligibility (Sarlatia, Harona, Yahyaa, Darusa, Dimonb, & Atharic, 2014).

The acoustic environment is critical to student learning and academic performance. Interestingly, as much as 60% of classroom activities rely on speaking and listening. Such a critical environment affects the teachers as well. It physiologically drains the teachers while they struggle to deliver understandable speeches and lectures. Their performance may also be negatively affected. Additionally, noise leads to more noise (Wolfrom, 2014).

The study shall be conducted at the University of Mindanao (UM). It is quite essential to understand the peculiar mission of this university for its philosophy of altruistic education - the admission is open to all. The said mission means that the students have varied intellectual capacities and readiness for baccalaureate education. The 2016 report of the Guidance Services and Testing Center (GSTC), Assessment for College Potential–Achievement Test, revealed that UM was beset with students having the proficiency level of 'not met standard' to 'progressing towards the standard.' Ninety-four percent of its freshmen in the school year 2015-2016 are not proficient.

This low proficiency level seems to be related to Wolfrom's observation. He found out that adults and older children can 'fill in the blanks' to plug in what would have been missed. They must have possessed a much broader context

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of intelligence and experience. Other factors may be related to their more extensive range of vocabulary and, to some extent, exposure to some foreign accent or intonation. They can predict and validate the word that they have missed. Younger ones seem to have a lesser ability to do this (2014). Younger ones here may refer to the non-proficient first-year students. This circumstance, all the more, makes the acoustic environment a critical issue to address.

The classrooms in the UM Matina campus are typically naturally ventilated, seven-meter by nine-meter dimension, and provided with ribbon windows on one side and a wall with two doors on the opposite side. The front and back walls, ceiling, and floor surfaces are made of concrete. These surfaces have a very low absorption coefficient (0.02 to 0.05), hence very reflective (Szokolay, 2004). This material tends to produce longer RT60's. However, few classrooms are air-conditioned and have been provided with a suspended acoustic ceiling.

The rationale of this research is premised on the necessity to determine the RT60's of the classrooms. If the RT60s are within the acceptable range, then at the very least, the research would be able to postulate that the classroom acoustic environment, among others, is satisfactory. If the study finds it otherwise, then there would be a basis for correction and further investigation on how, if ever, it compromises the teaching and learning delivery.

This research is poised to address the following objectives: (1) determine the RT60 of the classrooms in Matina Campus; (2) Categorize them according to the degree of conformance to the acceptable range; (3) recommend ways to meet an acceptable level.

II. Methods

This research used a quantitative descriptive – survey design. The proponent surveyed all the buildings in Matina Campus that have lecture rooms. Afterward, an inventory of these lecture rooms was developed. This step was greatly aided by referring to the evacuation plans posted on a wall of the classrooms. A sample of this illustration is shown in Figure 1. These evacuation plans indicated the room identifications. It was easy to determine whether a classroom is used for lecture activities or not because the proponent was familiar with the premises.

The sampling process proceeded after the preparation of the inventory. The sample size was determined using the Internet-based calculator named Raosoft.com. This website recommended a sample size based on the proponent's acceptable margin of error and needed confidence level. Roasoft.com yielded a sample size of 133 based on the acceptable margin of error of 5%, confidence interval of 90%, and population size of 260. Refer to Figure 2. It was then decided to increase the sample size to improve the margin of error, confidence level, or both.

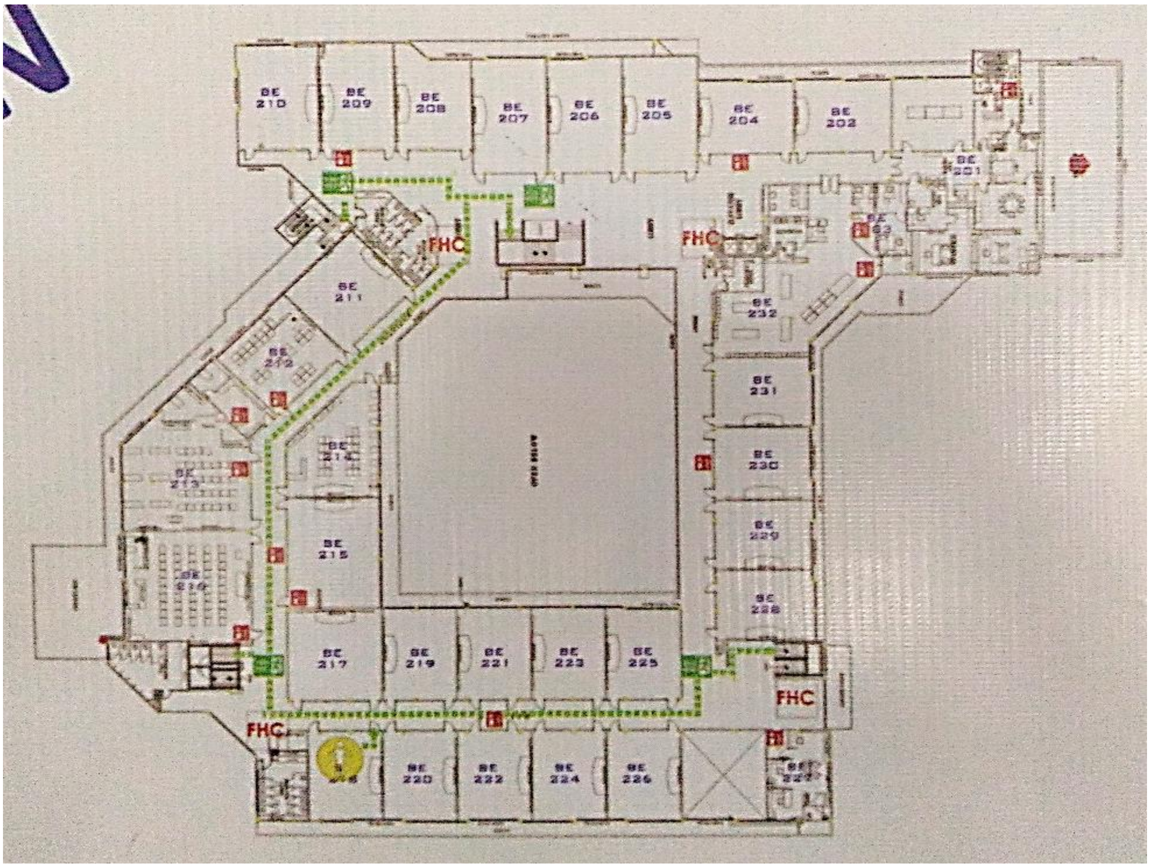

Figure 1 Example of an evacuation plan which is posted in the classrooms

The actual number of lecture rooms that were tested exceeded the recommended 133. The proponent went back to Raosoft.com and recalculated the margin of error and confidence level. The values that came out were 4.93% and 94%, respectively. This recalculation resulted in a slight improvement. The larger the sample size, the more accurately it represents the population (Wilson & Morgan, 2007).

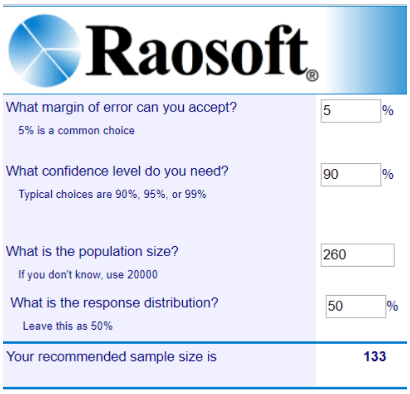

Figure 2 Screenshot from http://www.raosoft.com/samplesize.html

A multi-stage sampling type was used. This type ensured representation from all buildings (stage 1) and floor levels (stage 2). The number of samples was proportionately distributed according to the number of lecture rooms at a specific floor level in the building.

Reverberation Time Pro was used in determining the reverberation time (RT60). This paid Android app was installed on a smartphone ASUS Z00LD, with Android Version 6.0.1. This app was developed by Prof. Dr. Wolfgang Kröber (Krober, 2017), University of Koblenz, Germany, a university of applied sciences.

The first issue that had to be resolved was the validity of the app. Dr. Kröber compared the app with Norsonic 140 and Norsonic 830 (older equipment) and found that the results were the same through email correspondence. He further mentioned that RT uses the decay/Gradient of the sound pressure level. He added that microphones' different sensitivities might influence the level but not of the decay/gradient. The latter is the one used in RT.

He also gave some recommendations, such as taking the average of four to ten trials per setting and the clapper to device distance of one to two meters.

We also had the opportunity to compare two results using NTi XL2 Acoustic Analyzer, which was acquired much later. This analyzer would have been the instrument used but was not yet available during the data gathering period. The high cost of this NTi instrument was one of the reasons for not acquiring it sooner.

We test the most reverberant room (BE 321) in the list using NTi Minirator MR Pro. The RT60 of the said room was 2.74 seconds and 2.79 seconds from the NTI XL-2 and Reverberation Time Pro, respectively. It was interesting to find out that the difference was only 0.05 seconds.

The conditions and recommendations for determining RT60 were adopted. They are listed below. (NTi Audio Webinar - RT60 with XL2, 2018).

1. The room must be quiet before and after the measurement

2. Not more than two persons should be in the room during the process.

3. This process would expose the person measuring the RT60 to many loud claps. It is imperative to wear hearing protection such as foam earplugs and earmuffs (worn simultaneously).

4. The distance between the smartphone (RT60 App) and the wood clapper is determined using the critical distance d_c.

$$d_c = \sqrt{V/cT}$$

V = volume of the room (m3), typically 189m3;

c = speed of sound at 30˚C (m/s); 349 m/s; and T = expected RT60 of the rooms (sec), typically 1.8 seconds. Hence, the critical distance is 1.10m (Reverberation Time RT60 Measurement, 2019)

5. Generate consistent loud claps.

6. The RT60 is taken as the average from at least among six trials.

The steps in determining the RT60 are listed below.

1. Set a first-person with the wooden clapper at the stage (this simulates the position of the lecturer)

2. Set the second person with the smartphone two meters away from the first one toward the middle part of the room.

3. Launch the app, and when ready, press the "start measurement" from the app.

4. Immediately, let the first person generate the clap.

5. Wait (some 3 to 10 seconds) for the app to display the result.

6. Repeat at least six times and get the average.

Figure 3 Reverberation Time Pro showing RT60 (0.58s)

II. RESULTS AND DISCUSSIONS

The campus has eight academic buildings, namely, (1) Professional Schools (PS), (2) Dolores P. Torres (DPT), (3) Guillermo P. Torres (GET), (4) Business and Engineering (BE), (5) MM, (6) Elementary High School (EHS), (7) FEA, and (8) HRM. Table 1 shows the total number of lecture rooms and samples taken from each academic building. For greater appreciation, a campus plan showing the eight academic buildings is presented in Figure 4.

The study acquired samples from 152 classrooms. This size is 21 more than the initial sampling target of 133. The distribution is shown in Table 1. The same table indicates that the actual percentage share in the samples of each building approximates the percentage share in the population.

Figure 4. Campus plan showing the various buildings

Table 1. Inventory of rooms and number of samples

Building ID	Total number of lecture rooms	Share	Number of samples	Actual share in the sample
BE	74	28%	39	26%
GET	51	20%	30	20%
DPT	73	28%	38	25%
HRM	4	2%	4	3%
FEA	10	4%	4	3%
EHS	7	3%	7	5%
MM	6	2%	4	3%
PS	33	13%	26	17%
Total	260	100%	152	100%

Only one of the 152 samples got into the recommended range of 0.4–0.6 seconds. Only seventeen or eleven percent had a reverberation time that was less than one second. All these belong to the PS building. The rest of the buildings got all their rooms beyond 1.0 sec. Refer to Table 2. It is interesting to note that the longest RT60 was 2.8 seconds (Room BE 321). This length of time is way too much for a classroom.

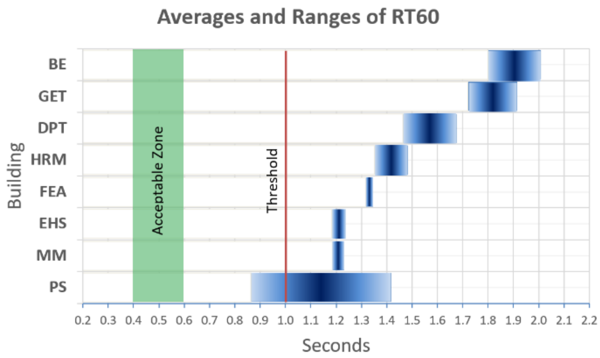

Figure 5. Result of the RT60 tests

Table 2. Compliance Tabulation

Building	Complied 0.4-0.6s	Acceptable 0.6-1.0s	Not Complied >1.0s	Total
BE	-	-	39	39
GET	-	-	30	30
DPT	-	-	38	38
HRM	-	-	4	4
FEA	-	-	4	4
EHS	-	-	7	7
MM	-	-	4	4
PS	1	16	9	26
Total	1	16	135	152
	>1%	11%	89%	

Another finding worth noting is why the range of RT60 in PS Building seems to have a wide range compared with the rest. It was interesting to discover that all the classrooms belonging to the fourth-floor level use vinyl-line gypsum boards (1.87 seconds) and not the fine-fissured mineral boards (0.76 seconds) used on the second-floor and third-floor levels.

As much as 89% of the lecture rooms are beyond the 1.0-second threshold of acceptable RT60. These classrooms belong to the three largest campus buildings: BE Building, GET Building, and DPT Building. The mean and standard deviation of RT60 of these rooms are 1.70s, and 0.29s, respectively.

In effect, there could be at least 231 of all the 260 lecture rooms, which need serious acoustic treatment, and around 29, which requires some minor treatment.

IV. CONCLUSIONS AND RECOMMENDATIONS

Numerous classrooms are highly reverberant. This acoustic issue must have influenced the level of learning of thousands of students who attended this university. The present state must be affecting those who are currently enrolled.

The data itself reveals that much can be learned from the few rooms compliant with the recommended RT60. It is just a matter of finding out these rooms' physical makeup and imitating them in the rest of the rooms.

The acoustic recommendations are:

1. Install high sound-absorbing ceiling materials. This material is like the one installed on the second-floor and third-floor levels of the PS Building. This type is technically called a suspended ceiling grid system with fine-fissured acoustic boards. These boards have a high absorption coefficient.
2. If the ceiling treatment is not enough, install sound-absorbing materials (same as the fine-fissured) on the walls, starting with the upper part of the rear wall then on the sides.

Recommendations for further studies are:

1. Conduct a follow-up study now that the lecture rooms have been air-conditioned. Since the glass pane windows are currently closed, this may even lengthen the reverberation time, worsening acoustics.
2. Conduct a similar study on the other campuses of the university.
3. Conduct a study on the perception of teachers and students regarding the acoustic environment of the lecture rooms.
4. Conduct noise criteria (NC) analysis.

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