# Acoustics of Classrooms in Brazilian Public Schools – A Case Study

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## Introduction

This work is aimed at studying the acoustical quality of classrooms standard 023 from FUNDEPAR, the Institute of Educational Development of the Parana state [1]. There are several studies of classroom acoustical quality [2, 3, 4, 5, 6], and this one will consider only the 023 standardized classrooms. This standard is compounded by a central circulation aisle with two classrooms in each side. Each edification, thus, have four classrooms. The aisle has a 6-m high zenithal skylight. All public schools in Parana state projected by FUNDEPAR have the same standard.

This project has considered lightning and ventilation for the classrooms, but the acoustical quality suffered. The central aisle and the classroom walls are compounded by non-absorbing materials, which have increased the reverberating time in the classrooms.

Figure 1 shows the central aisle with some classrooms, and figure 2 shows the layout of the school.

**Figure 1: Central aisle**

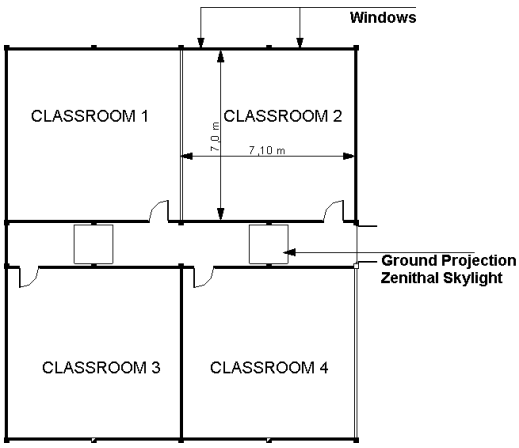


**Figure 2: Layout of the four classrooms**

The Brazilian Standard NBR-10152 [7] states optimum reverberating times for several internal environments, along with the comfort and acceptable equivalent noise levels for these environments. Table 1 brings the values for schools.

| | dB(A) | NC |
|---|---|---|
| Libraries | 35 – 45 | 30 – 40 |
| Classrooms | 40 – 50 | 35 – 45 |
| Aisles | 45 – 55 | 40 - 50 |

**Table 1: Noise levels for classrooms according to NBR-10152. Lower value is for comfort, upper level is acceptable.**

## Objective

The goal of this paper is to study the quality of the classrooms standard 023. In order to perform this, measurements of the reverberating time in several classrooms under different occupational ratios have been carried out, as well as equivalent noise level measurements. These levels have been compared to the Brazilian Standard 10152, which states about the comfort noise levels for different environments. The measurements have been done in only one school, because the same standard is applied to all of them.

A second goal is to gather information on the perception of the students and teachers of the standard 023 by means of a questionnaire. Two models have been elaborated: one for the students and one for the teachers.

## Methodology

The following equipment have been used for the measurements:

- Bruel & Kjær 2260 Analyser;
- Bruel & Kjær free field microphone 4189;
- Bruel & Kjær 2716 power amplifier;
- Bruel & Kjær omni directional noise source 4296.

For the reverberating time, the noise source has been placed where the teacher normally speaks. This measurement has been done in one of the classrooms under three conditions: empty classroom (during a holiday), 20 pupils and 40 pupils (full). An equivalent noise level measurement has also been carried out in the aisle with three full classrooms, and the background equivalent noise level has been measured in an empty classroom with all the other three under normal activities. The frequency range of the measurements has been from 100 Hz to 4000 Hz.

The microphone has been positioned in three points inside the classroom, and for each position three measurements have been done. All the data has been downloaded into the

software B&K Qualifier 7830 and one single result has been obtained for each occupational ratio.

For the second objective of this study, two models of questionnaires have been elaborated, for teachers and students. A total of 15 teachers and 185 pupils have been interviewed.

## Results

Figure 3 shows the reverberating time for the classroom number 1 under three different occupational ratios: empty room, 20 pupils and 40 pupils (full).

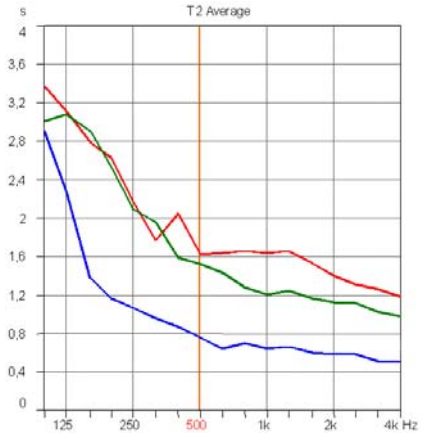


**Figure 3: Reverberating time for classroom 1 under empty, 20 pupils and 40 pupils conditions**

The above values are the averages of all measurement points inside the classroom.

For the frequency of 500 Hz the reverberating times were:

- Empty room: 1.65s;
- 20 pupils: 1.15s;
- Full room: 0.76s.

The reverberating time decreases with the increase in the number of people in the classroom. Under full room conditions, the reverberating time is close to the optimum reverberating time according to the Brazilian Standard NBR-10152. Nevertheless, the acoustical project of a classroom must consider the worst situation, in other words, empty room. Also, the World Health Organization recommends a reverberating time of 0.6s for a frequency of 500 Hz.

The equivalent noise level measurements in the aisle have revealed a value of 70.3 dB(A). The Brazilian standard NBR-10152 states that circulating aisles should be in the 45 – 55 dB(A) range. The Leq measurement of the empty classroom with all the other three under normal activities have shown a value of 63.1 dB(A) to 63.3 dB(A). The NBR-10152 states that the comfortable background noise level for a classroom should be 40 dB(A), whereas the acceptable background noise level should be 50 dB(A).

For the questionnaire evaluations, teachers and pupils were asked to answer some questions by using an intensity scale, ranging from 0 (none) to 6 (extreme). When asked about the noise sources that caused annoyance, teachers have answered that the pupils of other rooms were the main source of annoyance. Table 2 brings more information. It presents the average intensity level for all the answers.

| | Other classroom students | Other classroom teachers | Noise from the same classroom | Traffic noise |
|---|---|---|---|---|
| Weighted answers | 4.1 | 3 | 1.9 | 1 |

**Table 2: weighted answers for the question "What noise sources bother you?" – teacher's answers**

Table 2 shows that the main noise source is the noise generated in neighbouring classrooms. Traffic noise is not a problem since the school is located in a calm area of the city.

The pupils were asked about their impression of the classroom regarding the external noise. A total of 30% of them have answered that they do not consider their classroom a noisy environment, whereas 70% of them have answered that they do consider their classroom a noisy environment.

## Conclusions

The classrooms belonging to the Standard 023 do not satisfy the acoustical requirements of the Brazilian Standard NBR-10152. The reverberating time of the classrooms is high, reaching 1.65s for an empty room. The background equivalent noise level surpasses 60 dB(A) in an empty room, considering normal activities in the three other classrooms. And it surpasses 70 dB(A) in the aisle. All these results agree with the dissatisfaction degree of teachers and pupils, according to a questionnaire applied to them. The Standard 023 should be reviewed in order to improve the acoustical quality of the classrooms, such as adding absorbing materials on ceilings.

## References

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