

Subjective perceptions of students and teachers to environmental noise in public schools

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ABSTRACT

Formal education takes place in the classroom, where learning involves intensive verbal communication between teachers and students. Therefore, classrooms must offer the necessary conditions for good teaching and learning activities, especially teacher-student communication. It is in this context that the importance of classroom acoustics is highlighted. Therefore, this work aimed to evaluate the acoustic quality in two classrooms. To this end, the perception of teachers and students about the noise inside and outside the classroom was investigated through questionnaires. Then, the background noise levels and the reverberation time values inside the classrooms were evaluated in situ. These results were compared with the assessment of the subjective perception of the questionnaires. The levels of background noise found in classrooms were above what NBR 10152 recommends. The subjective assessment showed that students and teachers perceive the noise in classrooms and consider them bothersome. According to the teachers, noise is a factor that negatively affects teaching. In conclusion, the results obtained in this work show the lack of acoustic comfort in classrooms and highlight the need for interventions.

KEYWORDS: Room acoustics. Reverberation Time. Acoustic quality. Questionnaires.

1 INTRODUCTION

Education is as essential in societies today as it was in the past. Formal education usually occurs in physical classrooms, in which the learning activities involve intensive verbal communication between teachers and students (Lubman, Sutherland, 2001). However, despite the eruptions of Information and Communication Technologies aided by multimedia resources, which are increasingly common, nothing replaces the teacher-student relationship that develops mainly in the classrooms. Therefore, classrooms must offer the necessary conditions for good teaching and learning activities. Zannin et al. (2012) highlighted the importance of classroom acoustics for both students and teachers.

Hagen et al. (2002) state: "High noise levels in the classroom make students more easily tired, interfering in a harmful way with their academic performance." Classrooms with good acoustics help learning, making it more efficient and enjoyable (Lubman and Sutherland, 2001). Maxwell and Evans (2000) showed that the exposure of preschool children to noise is linked to difficulties in learning reading and writing.

Finally, Tabuenca, Boerner, and Kalz (2021), examining the effects of chronic noise from the rail, and road traffic on the cognitive performance of school-age children, observed the following reactions of children exposed to environmental noise: deficits in sustained attention and visual attention; difficulty in concentrating - children exposed to noise compared to children from quieter schools, according to the teacher's report; worse auditory discrimination and speech perception; memory impairment for tasks that require high processing demands; worse reading ability and academic performance on national standardized tests.

Clark and Paunovic (2021) showed that the exposure of preschool children to noise is associated with difficulties in learning to read and write. For Zannin et al. (2019) and Paiva, Cardoso, and Zannin (2019), the environmental condition of urban planning influences the entire health of the population.

Minichilli et al. (2018) considered necessary the following steps in the assessment and control of noise in schools: (i) Identification of external and internal sound sources and their sound pressure levels; (ii) good constructive model; (iii) implementation of the school, i.e., (location and orientation); (iv) distribution of internal spaces and activities; (v) building elements with good sound insulation materials: windows, doors, walls, and floors, and (vi) specific acoustic treatment for special areas.

Notably, the quality of a school environment depends on several variables. Therefore, the objective of this work was to evaluate the acoustic quality of the school environment, using an analytical approach, where the perception of teachers and students concerning noise inside and outside the classroom was investigated through the application of questionnaires. Then, the *in-situ* background noise levels and reverberation time values within the classrooms were measured. Finally, these results were compared with the assessment of the subjective perception through questionnaires.

2 METHODOLOGY

2.1 Measurement of Reverberation Time and Background noise

Figure 1 shows the classroom patterns evaluated in two different schools, e.g., Alfredo Parodi and Luiza Ross schools. The Reverberation Time (RT) measurements were carried out according to the ISO 3382-2 (2008) standard specifications.

Figure 1: Facade of classroom blocks at Luiza Ross (left) and Alfredo Parodi (right) schools



Source: The Authors, 2021

In each classroom, measurements were taken at five different points, as shown in Figure 2. Three readings were taken for each point, and then the Brüel & Kjaer (BK) 2260 sound meter calculated the mean RT of each point. Subsequently, the measurement results were transferred to the Qualifier software (7830 – B&K) which calculated the average value of the reverberation time for each classroom.

Figure 2: Measurement equipment and classroom layout



Source: The Authors, 2021

The sound pressure levels of the background noise were obtained with measurements made with the BK 2260 analyzer, inside the classrooms and around schools. In both cases, the measurements followed the recommendations of NBR 10152 (2017), which regulates noise assessments in inhabited areas, aiming at the acoustic comfort of the community.

2.2 Subjective Evaluation

To assess the perception of teachers and students regarding noise in schools, questionnaires were designed for each group. The questions were developed based on Dockrell et al. (2001). Dockrell et al. (2001) studied the perception of students and teachers regarding acoustic comfort in the classrooms. The questionnaires used were developed from other similar studies conducted by Dockrell et al. (2001). The questionnaires were applied to (n = 71) teachers and (n = 1035) students from the public state education system in the city of Curitiba and Pinhais both in Brazil. Students from the fifth to the eighth grade, aged between 9 and 18 years old, were interviewed.

The application of the questionnaires to students was carried out in their own classrooms. The questions were read to the students. The teachers who teach classes to the selected groups in this research answered a different questionnaire. The answers were given in the form of scores ranging from 0 to 3. As for the teachers, the objective of the research and the aiming of the questionnaires were stated. After, they filled out questionnaire individually without the help of the researcher.

2.3 Statistical evaluation of questionnaires

Statistical analysis of questionnaire responses was performed using two strategies. The first addressed descriptive analysis using contingency tables, showing the frequencies of individuals' responses as a function of two qualitative variables. This table was the first descriptive instrument to survey two hypotheses, whose general formulation is given by:

- a) hypothesis H0: there is no association between the two factors;
- b) hypothesis H1: there is an association between the two factors.

In the second strategy, statistical hypothesis tests were used to verify the significance of the association between different factors. The R software, developed by the R Development Core Team (2021) was used to calculate the association tests. The hypotheses raised during the first analysis strategy were verified by the Q and Qp statistics whose approximate probability distribution is the chi-square. According to Shan and Gerstenberger (2017) these statistics are adequate to measure and test the association between two qualitative factors. Decisions on hypotheses were taken with the confidence level set at 95%.

3 RESULTS

3.1 Acoustic quality

NBR 10152 (1987) establishes an optimum limit of 40 dB(A) as the sound level for comfort in classrooms, with 50 dB(A) being the acceptable value for the function of the environment. Measurements in empty rooms were carried out with windows open and doors closed. This is the usual condition of use in both schools. Table 1 shows the recommended measured background noise in both schools.

Table 1: Background noise measured in the classrooms

School	Leq – dB(A)	L _{max} – dB(A)	L _{min} – dB(A)
Alfredo Parodi	59.4	76.1	46.4
Luiza Ross	63.2	76.0	51.9

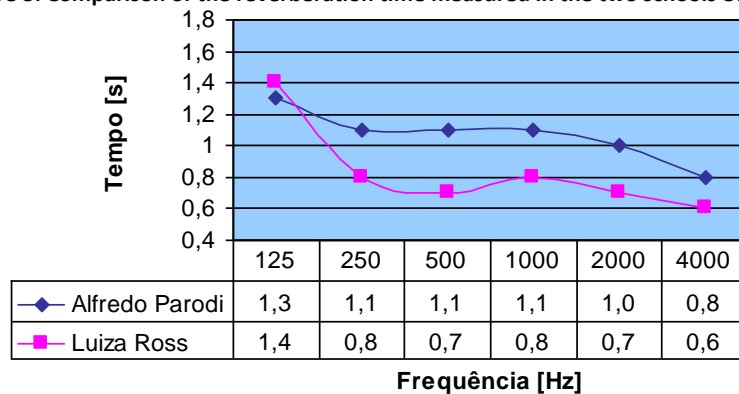
Source: The Authors, 2021

The measured sound levels are above those recommended by NBR 10152 (1987). According to Costa et al., (2018), in school establishments, high noise levels are detrimental to learning. The higher the level of background noise in a classroom, the worse is the reading ability displayed by students. Reductions in the sound pressure levels to 30 dB(A) result in increased concentration and attention, in addition to contributing to a participatory behavior in class.

Figure 3 shows the RT values for both classrooms. Accordingly, the reverberation times measured in the two schools demonstrate the absence of acoustic comfort. The deficiency of these environments impairs communication between students and teachers, as high reverberation times reduce speech intelligibility (LABIA, SHTREPI, ASTOLFI, 2020). The classrooms have a volume of fewer than 283 m³.

At Alfredo Parodi school, the RT in an empty classroom is higher than that recommended in the ANSI S12.60 (2010) standard and by the WHO (2001). Even with full occupancy, the assessed classroom did not reach the reverberation time specified by ANSI S12.60 (2010). Compared to the recommendation of the WHO (2001), only in the frequencies of 2000 Hz and 4000 Hz the RT comply to the limit value. In school environments, high noise levels are detrimental to learning.

Figure 3: Comparison of the reverberation time measured in the two schools evaluated



Source: The Authors, 2021

Therefore, the proper reverberation time at frequencies of 500, 1000 and 2000 Hz is 0.6 s. The values from Figure 3 indicates the inadequacy of RT according to standards, because the measured reverberation times are greater than that established by ANSI S12.60 (2010).

3.2 Analysis of the questionnaires submitted to students

Of the 1035 students interviewed, 61% say they hear the teacher's voice well, 38% say they hear somewhat and only 1% do not hear him well. In view of the low percentage of students who claim not to listen well to the teacher, it was grouped, then, to students who claim to listen. The result of this question was then crossed with the result of the question that checked whether students considered their classrooms silent or noisy. It appears that, despite hearing the teacher's voice well or not, the percentage of students who consider the classroom noisy is very high in both groups. Through the chi-square test ($Q_p = 5.809$, $p\text{-value} = 0.016$), it appears that this percentage is significantly higher among those who claim not to

listen well to the teacher. So, Table 2 shows the intersection between the question that checks whether students hear well or poorly with the position in which they generally sit in the classroom.

Table 2: Crossing between questions: position in which the student sits x how well they listen to the teacher

Sitting arrangements of the student in the classroom	Do you hear well?	
	Yes	No
In front	218 (35%)	119 (29%)
In the middle	197 (31%)	129 (32%)
In the back	216 (34%)	156 (39%)
% Of a total 1035 students	631	404

Source: The Authors, 2021

Table 2 allows us to observe that students who listen well to the teacher are evenly distributed throughout the classroom. This is verified among those who responded that they did not listen well. This data allows us to verify that the analyzed classrooms do not have critical points for speech comprehension. The chi-square statistical test ($Q_p = 3.318$, $p\text{-value} = 0.190$) confirms the above analysis, indicating that there is no association between the position in which the student sits and their hearing condition.

Regarding noise sources present in the classroom, the voice of colleagues was identified as the noise that causes the greatest discomfort for 75% of respondents. This fact is related to reverberation time. The results of the RT measurements in the construction standards indicated that the classrooms did not comply with what the standards, thus confirming the result of the subjective assessment, as previously shown in section 3.1.

The results for the question that investigated the origin of the most bothersome noises indicated that students do not feel bothered by external noises, a result confirmed by the measurements in the surroundings of the schools, which the Leq ranged from 51.8 to 68.4 dB(A), according to Table 1. The external noise, pointed out by 96% of the interviewed students, that most disturbs the classroom originates from the railway noise. Also, this vehicle passes very close to the boundary wall at the back of the school. The Leq measured during its passage was 71.8 dB(A).

3.3 Questionnaires submitted to teachers

The questionnaires given to the teachers were composed of six closed questions, where the answers were given in the form of scores ranging from 0 to 3. Where 0 meant “nothing”, 1 - “little”, 2 - “medium” and 3 - “very” regarding the noise perception. The average age of teachers, according to the descriptive analysis, is 36.9 years and 70% are women. The analysis showed that 21% of respondents had already been absence from work due to noise-related health problems.

The first question asked to teachers the concerns the noise produced at school that most disturbs the classroom. Table 3 presents the result for this question. It was found that students from neighboring classrooms are the main source of external noise interfering within classroom activities. The second most expressive type of noise pointed out by the teachers comes from conversations in the school yards.

Table 3: Perception of noise sources by students

Sitting arrangements of the student in the classroom	0	1	2	3	Total	Average score
Produced by students from another class	4	22	27	18	71	1.8
Teacher's voice from the next room	27	34	8	2	71	0.8
conversations in the hallway	21	29	13	8	71	1.1
Conversations in the school yard	20	18	13	20	71	1.5
Noise of people moving in the hallway	20	33	10	8	71	1.1
Sound equipment, TV used in neighbouring classrooms	46	17	8	0	71	0.5

Source: The Authors, 2021

The teachers' response to this question confirms the students' responses when asked about a similar question. The score of 1.8 obtained for this option indicates that the noise coming from students in the neighboring classrooms has a moderate influence on the classrooms. The scores by constructive pattern for the noise produced by students in neighboring classrooms, this being the most significant, according to Table 3. The result of the figure suggests that this type of noise is more perceived by teachers in schools of pattern 010 and 022. The chi-square test ($Q_s = 4.167$, $p\text{-value} = 0.654$) showed no association between the constructive pattern and this option.

The chi-square test ($Q_s = 2.649$, $p\text{-value} = 0.266$) indicates that there is no association between the constructive pattern and the influence of noise on learning. This means that, regardless of the constructive pattern, 51% of teachers consider that noise has a great influence on school performance. The background noise values 73.7 dB(A) and 74 dB(A) indicate that teachers should raise their voice to ensure understanding of the content of the classes, which harms vocal quality.

4 CONCLUSIONS

The analysis of the acoustic quality of the classrooms was based on measurements of acoustic parameters, such as background noise and reverberation time. The questionnaires made it possible to know the perception of students and teachers regarding existing noise in schools. Background noise levels found in classrooms were above what NBR 10152 recommends. The results obtained were values much lower than those determined in the American standard ANSI S12.60. The subjective evaluation allowed to prove that both students and teachers has a high awareness of noise in the classrooms and consider it as uncomfortable. According to the teachers, noise is a factor that negatively affects teaching and learning.

The results obtained in this work reveals the lack of acoustic comfort in classrooms and highlight the need for interventions. Such results does not concern only the schools evaluated in this research, but all others built according to the standards discussed here. It should be remembered that acoustic deficiencies present in one school will probably spread to all others, impairing the learning of hundreds of students across the state. Acoustic comfort is not the only, nor the most important indispensable factor in the academic education of children and adolescents. However, as with other factors related to education, it is one of the pillars that supports this process and, therefore, should not be neglected.

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