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Assessment of noise exposure in primary school environment

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Abstract

Nowadays elementary school teachers and preschool often complain about the noise pollution into the classrooms, which could be an occupational risk for them.
In this cross-selection study are evaluated the acoustic climate of classrooms through the measurement of noise levels and reverberation time. These surveys were conducted in 24 classrooms belonging to three elementary schools or to a preschool one.
By noise levels measurements it was evident a noise pollution problem, which depended on the structural requirements of the classrooms or on the type of activity carried out. We have obtained a minimum value of Leq dB (A) 61.9 and the maximum of Leq dB (A) 103.4, with an overall median of 75 dB (A). The study findings indicated that 15.9% of elementary school teachers and 31.25% in preschool ones are exposed to Leq dB(A) values (exceeding the action level established by Legislative Decree, 81/08) that could cause vocal or auditory disorders.

Keywords: *Noise pollution; School; Occupational risk; Teachers; Acoustic measure.*

Introduction

Most classrooms and scholastic gymnasia in Europe are characterized by high noise levels excessive reverberation, which can reduce teaching, listening and education quality. The noise at school is considered as an annoyance, which has a strong relation with teachers and students' health. Usually the presence of noise annoyance in the classrooms is caused by a lack of minimum acoustic requirements, needed to make the buildings suitable to their function. The acoustic characteristics are necessary in learning spaces where communication is critical to the learning process where is essential to education, in fact an excessive background noise or reverberation may interfere with speech causing an obstacle to learning and vocal effort. (Giovinazzo R. et al., 2015) [6].

The World Health Organization (WHO) in the publication "Noise in schools" develops these problems also. In this issue the necessary minimum requirements are recommended. For example scholastic building must be erected farthest from noise sources caused by transport and factories. Furthermore indoor spaces must be organized in order to divide the noisy areas from the quiet ones. Each scholastic space must be soundproofing and a suitable reverberation according to their functionality. The maximum of the background noise level Leq permitted is established at 35 dB(A), while the reverberation time should not be less than 0.4 s and not more than 0.6 s. (WHO, 2001)[9].

Another reference on acoustic in scholastic buildings is represented by American National Standard Institute's standard (ANSI/ASA S.12.60 - 2010 / PARTE 1R2015). This standard establishes Acoustic performance criteria, design requirements, and guidelines for school, in which are considered reverberation time and background noise. Moreover this standard defines the background noise as noise from outside the building and the facilities [1].
According to European and American regulatory parameters, Italian standard establish the maximum allowable level of noise in classrooms during teaching activity in the range 35-45 dB (A) and the time of reverberation 0,4-0,6 s. Actually these values aren't respected and sound level in preschool reach the range 65-80 dB (A) and in elementary school the range 65-70 dB (A). (Brambilla G. et al., 2008) [2].

Materials and methods

Sample

The experiment was carried out during the spring semester in 37 Italian school classrooms in 3 Elementary schools (children in the age range 6-10 years) and in 1 preschool (age range 3-5 years) and engaged 60 teachers (all female).

Measurement of Noise Levels

A B&K 2250 multi-functional analyser measured noise level and the "APM Tool Lite" software for android measured reverberation times.
The Integrating Sound Level Meter is an instrument that measures sound energy over a period of time and converted sound pressure in dB value and gives us the Sound Exposure Level (Bruel&Kjaer, 2006) [3].
The "APM Tool Lite" software is produced by collaboration between "Suonoevita" (a Study of Acoustic Engineering) and a Masters of Polytechnic University of Milano (Italy) [10-11]. This software is based on international standards ISO 3382 and IEC 61672, its field tests guarantee good results from 250/500 Hz depending on the type of source used (balloon or clapping) and the noise of this fund during the acquisition of the pulses.
The official measurements have been preceded by tests in simulating environment to establish the time required in order that equivalent noise level gets stabilised (range of 8-10 minutes).

The teachers were monitored in occupied classrooms during school activities with a sound level meter. During the measurements the instrument was arranged on the tripod on the 1.50 m height near the chair and was directed towards students. For each teachers were executed three measurements in order to reduce the error measurement uncertainty. During the samples the number of the children that were in classroom and the activities carried out were reported.

Later the three sound levels obtained were included in the calculation table provided by the Guidelines for the assessment of noise ISPESL [7], which provides us as a result a single Leq dB (A) value of the initial ones.

Table 1. Calculation table of ISPESL

	A	B		C
	Sample	LAeq,Ti - dB(A)		es
	n.	measured		
	1	78,4		0,7
	2	81,7		
	3	77,6		
LAeq,Ti Equivalent sound level			79,8	dB(A)
e(LAeq,Ti) the total equivalent level uncertainty			1,5	dB
eA(LAeq,Ti) environmental uncertainty on the equivalent level			1,4	dB

In the months of September and October were executed reliefs into certain empty classrooms to analyse the background noise and the external noise to observe in which area the schools are situated. In fact, according to DPCM (Italian Republic President of the Council of Ministers' Decree) dated 14/11/1997 [4], the schools must be established in the "specially protected area" in which daily input values can't exceed the 50 dB (A).

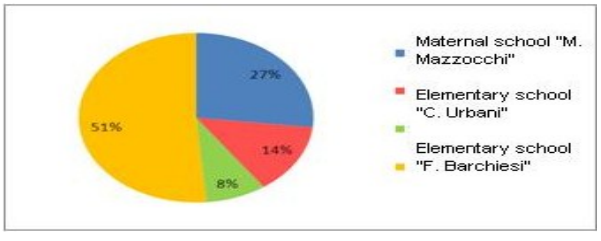
Measurement of reverberation time

Reverberation time was measured by "APM Tool Lite" software for android. The smartphone was arranged on the chair and at a distance of up to 3 meters an operator clapped his hands three times to obtain a complete measurement on the display and he recorded the results.

Results

Noise levels

The total of the recorded sound level measurements, relative to the 60 teachers in question is 179 and are distributed in the various schools as shown in **Graph 1.**



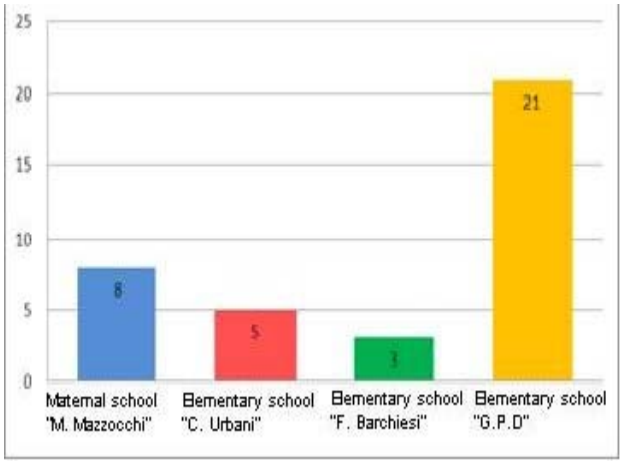
Graph 1. Teachers' distribution in the various schools

The 51% of the measurements was performed in the Elementary School "Gerardo Parodi Delfino (G.P.D.)", because it is the largest building school under review.

Always according to the school complex varies the number of teachers. Just over half, 52% (31 teachers), of 60 total teachers was monitored in Elementary school "G.P.D.", the other half was distributed in the other scholastic complexes. The 8% (5 teachers) represented the elementary school "F. Barchesi", the 13% (8 teachers) the elementary school "C. Urbani" and the 27% (16 teachers) the preschool "M. Mazzocchi".

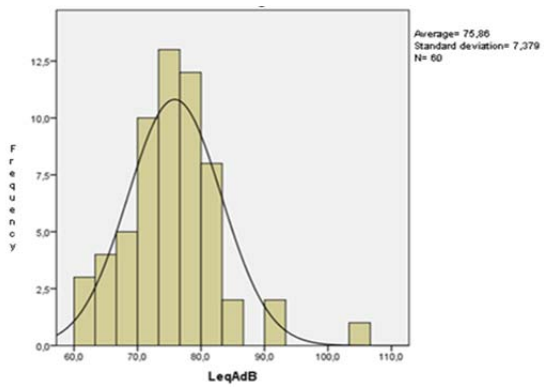
Overall the classrooms, in which were monitored the Leq dB (A),are 37 and are distributed in each school as shown in the **Graph 2.**

Graph 2. Classrooms distribution in each school



Every teacher has 3 measurements of the 179 total, except in a case where there are only two. Following, the three equivalent sound levels (in dB(A)) obtained were included in the calculation table of Lex8h which provided us as a result a single LAeq dB for every teacher.

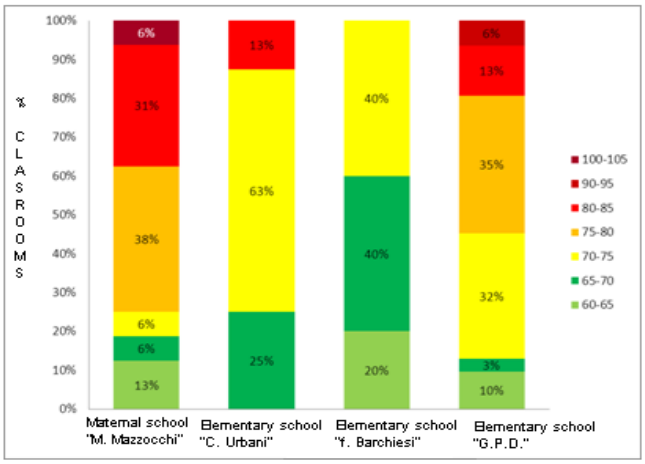
The equivalent sound level, obtained by the calculation table, is taken as reference for all other considerations. For example in the **Graph 3** it's shown how often every Leq dB(a) occurred.



Graph 3. Frequency of Leq dB(A)

This is similar to normal distribution, except of a tail on the right which corresponds to a value of 103 dB(A) measured into preschool "M. Mazzocchi". In this case the frequency represents the number of Leq dB(A) values measured which are included over the related LAeq range.

In the **Graph 4,** it's shown the classrooms distribution, in each scholastic complex, according to equivalent sound levels in dB(A) measured.



Graph 4. Classrooms distribution according to equivalent sound levels in dB(A) measured

As can be seen from the above graph in the 37 % of preschool classrooms Leq dB(A) are high, lowest percentages characterize elementary school "C. Urbani" (13%), "G.P.D." (19%) and "F. Barchiesi" (0%).

The Leq dB(A) measured exceed the 80 dB(A), lower value of action above which, according to Article 193 of Decree-Law 81/08 [5], it's scheduled the provision of personal protective equipment because the level could cause hearing damage .

Table 2 shows the minimum level and the maximum one found in each school, the average, the median and standard deviation of the different values. The Median, which is the value separating the higher half of a data sample from the lower half, was highlighted and organized in increasing order.

The box plot (**Grahp 5**) shows Leq dB(A) distribution in each school.

The thicker line inside the box represents the median, which is the value that is exactly in the middle of the distribution. In this study data analysis regards

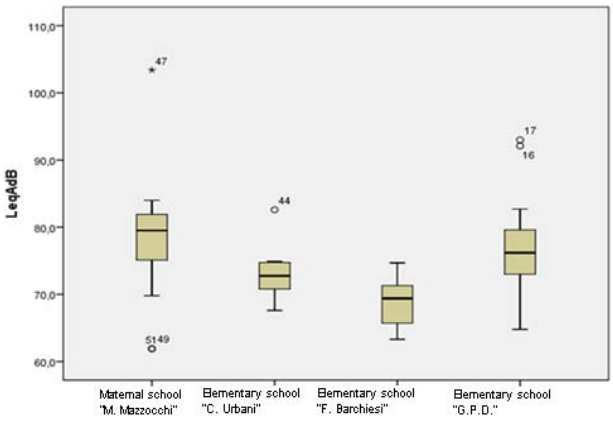
logarithmic values and it would be incorrect to calculate their average, for this reason we considered the median.

Furthermore, the Graph 5 shows immediately that the median elementary school G.P.D. it's greater than the maximum value (obtained by adding the mean and standard deviation) of elementary schools "F. Barchiesi" and "C. Urbani". At the same time the median oh elementary school "F. Barchiesi" is about the same height as the minimum value (obtained by subtracting the average standard deviation) of preschool M. Mazzocchi. Moreover, we note that 50% of the values below the median elementary school G.P.D. it includes 100% of elementary school F. Barchiesi values.

It has also conducted a study to verify the correspondence between the acoustic zoning adopted by the municipality in which school are located and the measured values outside buildings. Most of the values corresponds to those that refers to the class II- mostly residential area, with daytime input value up to 55 dB (A). Only in four locations of measurement values correspond to those that the law provides for specially protected areas in which we should find schools (according to DPCM 14/11/1997) [4].

School	Average	N	Std. deviation	Median	Minimum	maximum
Preschool M. Mazzocchi	78,544	16	9,5239	79,500	61,9	103,4
Elementary School C. Urbani	73,350	8	4,4890	72,750	67,6	82,6
Elementary School F. Barchiesi	68,880	5	4,5069	69,400	63,3	74,7
Elementary School G.P.D.	76,245	31	6,3660	76,200	64,8	93,0
Total	75,858	60	7,3790	75,000	61,9	103,4

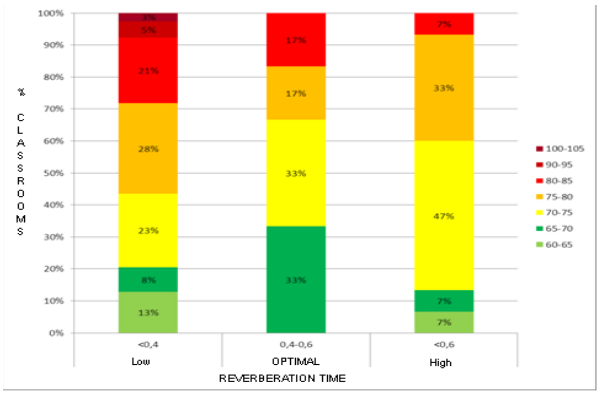
Table 2. Minimum level and maximum one found in each school, average, median and standard deviation of the different values.



Graph 5. Leq dB(A) distribution

Reverberation time

Another value that has been considered in the study it's the reverberation time. In Graph 6 we see how the classrooms are distributed according to the bands of the reverberation time and Leq dB (A) values.



Graph 6. Reverbaration time distribution

The reverberation time was recorded in classroom and then all values have been grouped into three bands:

- Values <0.4 s, it produces a diminution of sound
- Values between 0.4 and 0.6 s, optimal values
- Values> 0.6 s, an excessive reverberation leads to overlapping of different syllables at the expense of understanding.

In 66% of cases of reverberation times which fall in the optimal range, with values of LAeq <75 dB, it's possible that the geometry of the classrooms may have some influence on LAeq dB. Always in optimal values we find different LAeq dB values, which can depend by the type of activity carried out in the classroom during the measurement and not by the geometrical characteristics of the classroom.

Table 3. Acceptability of measurements

	Reverberation time (s)	m^2	
Reverberation time (s)	Pearson's correlation	1	,287*
	Sig. (2-code)		,026
	N	60	60
m^2	Pearson' s correlation	,287*	1
	Sig. (2-code)	,026	
	N	60	60

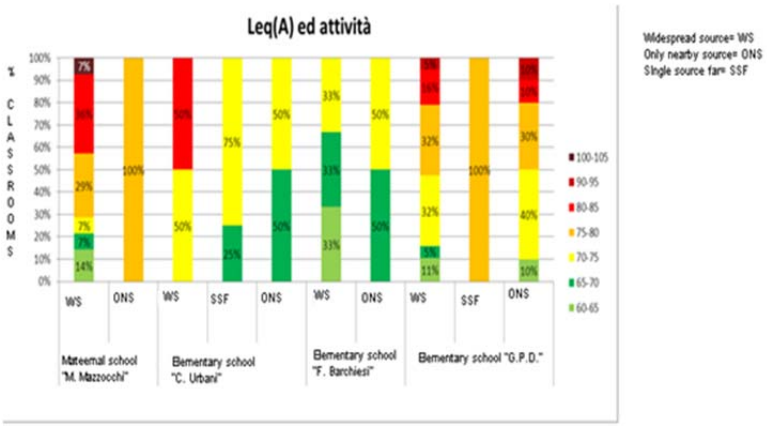
*. The correlation is significant at the 0.05 level (2-code).

Table 3 shows that the measured values are acceptable because there is a correlation of 0.026, or 97.4%, between the values of the reverberation time and those of m^2.

Troughton the monitoring phase it is also recorded the activities conducted in the classrooms during the measurements. Obviously the activities are very different and are divided according to the position of the sound source with respect to the sound level meter position (chair) in:

- Widespread Source: eg. drawning, teamwork, exercise with comparison;
- Only nearby source: eg. teacher explaining or pupil who has questioned at the chair;
- Single source far: eg. query from the place, reading a passage in turn by the pupils.
-

According to different activities and scholastic complex the Equivalent levels dB(A) changes, as it's showed into graph.



Graph 7. Leq dB(A) distribution according to different activities and scholastic complex

Conclusion

From the analysis of objective data it was found a serious noise problem, which may depend on structural aspects, but also on the type of activity carried out in the classrooms.

In particular, we recorded a minimum value of Leq dB (A) equal to 61.9 dB and the maximum Leq dB (A) equal to 103.4. In general the climate noise measured in classrooms is high, with a median of 75 dB (A), in agreement with other studies (Brambilla et al., 2008) [2].

This element is sufficient to speculate that the teachers are exposed to a vocal strain during teaching.

The above data show also that 15.9% of elementary school teachers are exposed to LAeq values that could cause damage in addition to vocal tract even to the auditory one (exceeding the action level established by Legislative Decree., 81/08); this percentage rises to 31.25% in preschool teachers.

Our analysis of the phenomenon dependence by structural requirements, although conducted with a not particularly validated tool (App APM Tool Lite for android) has nevertheless provided us of reverberation times, which compared with the surfaces of the classrooms, show a linear correlation [10-11].

In addition to the acoustic quality of scholastic environment, it might also be interesting to analyse the microclimate inside the classrooms as was done in the study "Indoor air quality in school facilities in Cassino (Italy)" (Langiano E., La Torre G. et al., 2008) [8].

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