ASSESSMENT OF THE NOISE QUALITY OF SCHOOLS ROOMS WITHIN THE GIOCONDA PROJECT

Elena Ascari, Francesco Bianco

I-POOL s.r.l, spin off company of National Research Council of Italy, Ripa Castel Tretti 1, I-51100 Pistoia, Italy, e-mail:acustica@i-pool.it

Marco Chetoni

IPCF-CNR, National Research Council of Italy, via Moruzzi 1, 56124 Pisa, Italy

Luca Fredianelli

Department of Physics, University of Pisa, Largo Pontecorvo 3, I-56127 Pisa, Italy

Gaetano Licitra

ARPAT, Lucca department, via Vallisneri 6, 55100 Lucca, Italy
IFC-CNR, National Research Council of Italy, via Moruzzi 1, I-56124 Pisa, Italy

Liliana Cori

IFC-CNR, National Research Council of Italy, via Moruzzi 1, I-56124 Pisa, Italy

The main objective of the LIFE project GIOCONDA is to support the authorities with an innovative methodology that can effectively assist policies on environment and health by involving the young citizens in the decision-making processes. Gioconda combines two approaches: one based on air and noise pollution monitoring and the other based on the risk perception of teenagers and their willingness-to-pay (WTP). A web based platform will collect the data and will allow the interaction among the local stakeholders. The data have been collected in eight schools in four cities around Italy, where the Gioconda activities are carried out. The measurements of noise exposure, and building acoustics parameters have been carried out in 3 rooms in each school. The results of the monitoring campaigns have been analysed in order to present to students, to their parents and to policy makers the overall status of the pollution in the rooms and to inform them on the related consequences on the quality of the studying environment. The results shown in this work will enhance the awareness of the acoustics issues in schools in order to facilitate the participative processes. These results will be related to the risk perception of the students, and will contribute to produce recommendations to improve their environment through single behaviour and community policies.

1. Introduction

The GIOCONDA Project (i GIOvani CONtano nelle Decisioni su Ambiente e salute, Young voices count in decisions on env&health) is funded within LIFE + Environment Policy and Governance (LIFE13 ENV/IT/000225). The project tries to fill the gap between the young people and the institutions on environment and health issues, involving the younger in local decisions on urban planning, traffic, green areas, and more generally on industry and agriculture management. Their perception and behaviour on these issues will lead the environment and health of tomorrow.

The final goal of the project is to provide a tool (a platform) able to connect the two parts providing also environmental data relevant for the decisions. In the first year of activity, four areas involved all across Italy: Ravenna, Valdarno Inferiore (Castelfranco di Sotto, Montopoli in Val d'Arno, San Miniato e Santa Croce sull'Arno), Napoli and Taranto (see Figure 1). In each area, two schools are involved during the first year of the project: one First Grade Secondary School, age from 11-13, and one Second Grade Secondary School, age from 14 to 18. Partners of the project are the Municipality of Ravenna, the Environmental agencies of Emilia Romagna and Puglia (ARPA Emilia Romagna and ARPA Puglia), one of the University of Napoli (Università Suor Orsola Benincasa Napoli) and the Health Society of Valdarno Inferiore (Società della Salute Valdarno Inferiore). The coordinator is the Institute of Clinical Physiology of the National Research Council (IFC-CNR).

Figure 1. GIOCONDA implementation areas [1]

Since the project involves cities with several different pollution sources, an holistic approach is presented to students during lessons: students are asked to report their risk perception on noise, air, waste, water pollution and the relative "willingness to pay" (WTP), is tested. In conjunction with these subjective opinions about pollution, objective measurements of noise and air pollution are being acquired in order to understand the gap between perception and objective pollution. Noise and air parameters are being surveyed in the eight schools involved. The results of the monitoring campaigns have been analysed in order to present to the students, to their parents and to the policy makers the overall status of pollution of the schools and to inform them on the related consequences on the quality of the studying environment. This is in fact the working environment of students for a crucial period of their time. Then students should discuss and use these data in order to identify challenges and suggest solutions to local institutions.

This paper presents the results of the noise measurements campaigns performed for the characterization of the exposure of students to external and internal noise sources. The internal noise quality has been also evaluated in terms of structural characteristics of the classrooms. Internal measurements and some of the external ones have been carried out and are detailed in this paper.

The results shown in this work will enhance awareness of acoustics issues in schools, to facilitate participative processes and to improve the sound quality in schools. Thus, a unique indicator is used to compare the results of the different rooms and schools. In fact, these results, together with those of the air pollution monitoring, will be related to the risk perception of the students, and will contribute to produce recommendations to improve their environment through single behaviour and community policies.

2. Methods

Within the four areas, a common set of noise parameters have been established. The following features have been monitored:

- Exposure to external sources:
  - External noise monitoring (continuous if possible)
  - Internal spot measurements (2 points per classroom)
- Building acoustics characteristics:
  - Façade and wall insulation
  - Reverberation Time
  - Speech intelligibility (RASTI)

The external noise monitoring has been carried out with different duration and systems in the eight locations, due to the different equipment availability and to security constraints. However, the external measurements are mainly used for the evaluation of the time evolution of noise during day period. Thus, it provides the correction to be applied to internal spot measurements carried out inside classrooms to correctly evaluate internal exposure on reference time. Spot measurements in classrooms have been performed in two different positions (one at the centre of the room and the other one at 1 m from the windows) for 15 minutes with open windows. The Leq levels have been elaborated and the average values per rooms are provided for the GIOCONDA project. This kind of parameters are used to evaluate the noise that may affect students leaving the windows open. This level influences the lessons because the teachers may have to raise the level of their voices to be heard by students. The main noise source is generally road traffic, no railways are located in the proximity of schools. However, in Napoli the anthropic noise (markets and public spaces) affects also the students' sound environment and in Taranto the industrial sources have been also found.

In addition to external sources of exposure, interior sound quality depends also on the building characteristics [2] so façade isolation is tested. In particular, the standardized level difference $D_{2m,nT}$ parameter according definition in [3] has been monitored using a pink noise generated by a dodecahedron emitter [4]. This measurement allows the evaluation of the room isolation from external noises. In addition, similar measurements have been carried out to evaluate the isolation between adjacent rooms and corridors through the R parameter [3].

Finally, the structural characteristics of the rooms have been evaluated: the reverberation time [5] and the RASTI [6] have been monitored through MLS signal. All the measurements have been performed in the afternoon, without students in the classrooms.

3. Measurement campaigns

At the present stage of the project, the exposure levels of Valdarno Inferiore and Napoli areas and the buildings acoustics characteristics of Valdarno, Ravenna and Napoli have been already analysed. Taranto results are not ready yet, but the measurement campaign has been carried out, allowing some former qualitative evaluations that are reported in this paper.

It has to be noticed that internal exposure estimation in Napoli has not been performed with a simultaneous long-term external monitoring station. In this case, an estimation of the average diurnal exposure has been carried out through some spot measurements in the morning, according to the guidelines of the Tuscany Regional Environmental Agency [7].

Different conditions have been found in the four areas in terms of noise pollution, building quality and general status of the surrounding areas. Napoli and Taranto are very large cities with high traffic pollution and anthropic (the first) and industrial (the second) noise. Ravenna and Valdarno area are smaller towns, but the pollution varies a lot across schools. In Figure 2 some photos are provided in order to show how the middle schools (MS) and high schools (HS) look like.

Figure 2. Schools views from Google Street

In Table 1 a summary of the general characteristics of the schools with a qualitative judge of its noise pollution grade is reported.

Table 1. School characteristics

School	Surroundings	Building status	Noise pollution
MS Valdarno	Suburban main road	Good	High
HS Valdarno	Hilly local road	Fair	Low
MS Ravenna	Urban main road	Good	Medium
HS Ravenna	Urban secondary road	Good	Low
MS Napoli	Urban area with car parking	Poor	High
HS Napoli	Urban area with public bus	Good	Medium
MS Taranto	Suburban area with industrial plant and high-way traffic noise	Fair	High
HS Taranto	Urban secondary road	Fair	Low

4. Results

4.1 Exposure to external sources:

The exposure results are available only for the schools in Valdarno and Napoli. The results of the external measurements confirm that all the four schools exceed the limits of their zone classification (55 dB(A) of diurnal level). However, the MS Schools are both in worse conditions than HS Schools, and generally the HS school in Valdarno area, not being in urban context, are less noisy. In Table 2 the exposure levels at the main façade (1 m from the wall, 4 m height) is reported as diurnal period estimation together with internal levels in classrooms. In Table 2, also internal levels are reported with the indication of the position of the classroom. The levels reported have been corrected considering the diurnal time evolution of the noise at the external reference point to obtain average diurnal internal levels.

Table 2. Classrooms exposure levels

School	External Level [dB(A)]	Room	Floor	Position	Internal Level [dB(A)]
MS Valdarno	71.0	A	1st	Main road	60.1
		B	1st	Main road	62.6
		C	Ground	Back yard	48.0
HS Valdarno	60.5	A	2nd	Internal yard	45.0
		B	2nd	Internal yard	48.7
		C	2nd	Main road	56.1
MS Napoli	71.0	A	Ground	Main road	56.9
		B	1st	Main road	49.2
		C	1st	Main road	48.2
HS Napoli	67.5	A	2nd	Main road	37.5
		B	3nd	Internal yard	34.4
		C	2rd	Internal yard	34.6

The external situation is critical for all schools and in each case it exceeds the law limits. However, at the HS Valdarno most of the noise is caused by the students themselves, especially during the opening and closing time. Differently, the internal values vary a lot according to the location of the classroom respect to the main road. With the measurements of only three classrooms per school, it is possible to affirm that these classrooms are representative of the rooms on the same façade.

It is evident how lessons are seriously affected by noise in the classrooms A and B of the MS Valdarno school when windows are open. This clearly affects the school activities and the students wellbeing, especially in spring.

4.2 Acoustical characteristics of the buildings

In Italy, a national law [8] establishes the limits for the façade isolation parameter $D_{2m,nT,w}$ and for the wall isolation parameter R. In particular for school buildings $D_{2m,nT,w}$ should be more than 48 dB(A) and R more than 50 dB(A). Moreover, a law regarding classrooms specifies the optimal values also for the reverberation time as a function of frequency and volume of the room [9]. Finally, no limits are set for RASTI, but a scale of reasonable values is available [10] and it can be used to evaluate the results. Table 3 presents the values measured in Valdarno, Ravenna and Napoli and the related limits overcoming.

Table 3. Acoustical characteristics of the classrooms: all values exceeding the existing limits are in red.

School	Room	$D_{2m,nT,w}$ [dB(A)]	R_w [dB(A)]	RT [s]	RASTI
MS Valdarno	A	16	34	2.45	0.44
	B	15	38	1.45	0.51
	C	31	46	1.77	0.53
HS Valdarno	A	22	31	2.03	0.48
	B	20	37	1.78	0.49
	C	27	44	2.32	0.46
MS Ravenna	A	30	49	1.45	0.58
	B	29	27	1.34	0.54
	C	31	43	1.60	0.53
HS Ravenna	A	35	43	0.92	0.66
	B	43	21	1.58	0.52
	C	25	42	0.88	0.68
MS Napoli	A	32	27	2.28	0.44
	B	28	43	2.05	0.49
	C	29	49	2.36	0.49
HS Napoli	A	26	49	1.27	0.62
	B	33	27	2.40	0.42
	C	33	43	2.88	0.40

The HS in Napoli has very large reverberation time values due to the height of the rooms, more than 4 meters, except for room A, which has a false ceiling installed. Similar values in MS Valdarno are reached because of the large windows. The isolation from façade and from walls between the classrooms shows values all below the law limits [8]. It appears that the isolation are better between the rooms than between rooms and corridors, for which all values are below 30 dB(A).

5. Discussion

The presented results are going to be shown to the students in order to improve the awareness of pollution and the perception of health risks. Results will foster the use of the Gioconda platform to share environmental data, opinions and ideas to improve the future environment. Therefore, the need of a single indicator or at list a qualitative judgment of the overall noise situation arose. In order to provide a score for each parameter that could be summed to obtain a complex common scale of evaluation, the analysed parameters have been compared to the reference values from technical norms, laws and common knowledge. In Table 4, the established scores in Likert scale for single parameters are reported.

Table 4. Score ranges

Score	Likert	External L_{eq} [dB(A)]	Internal L_{eq} [dB(A)]	$D_{2m,nT,w}$ [dB(A)]	R_w [dB(A)]	RT [s]	RASTI
5	Very Good	< 50.0	< 45.0	> 48.0	> 50.0	< 0.80	0.75 - 1.00
4	Good	50.0 - 52.5	45.0 – 47.5	45.1 - 48.0	47.1 - 50.0	0.81 - 1.00	0.60 - 0.75
3	Fair	52.5 - 55.0	47.5 – 50.0	42.1- 45.0	44.1 - 47.0	1.01 - 1.20	0.45 - 0.60
2	Poor	55.0 - 57.5	50.0 - 52.5	39.0 - 42.0	41.0 - 44.0	1.21 - 1.40	0.30 - 0.45
1	Very Poor	> 57.5	> 52.5	< 39.0	< 41.0	> 1.40	< 0.30

Using the sum of each score, for example on the Valdarno area, we obtain a rating system for each class (see Table 5) through a “Total Score”. This will allow the students to compare their classroom or school with the others using simple metrics, not difficult for young students. In fact, the highest is the “Total Score”, the best would be the environment of the classroom. The range of total values go from 6 to 30, where the lowest values are the worst. As foreseen, the classes on the main road are the most polluted.

Table 5. Scores for Valdarno Area

School	Room	External L_{eq} [dB(A)]	Internal L_{eq} [dB(A)]	$D_{2m,nT,w}$ [dB(A)]	R_w [dB(A)]	RT [s]	RASTI	Total Score	Likert
MS	A	1	1	1	1	1	2	7	Very Poor
	B	1	1	1	1	1	3	8	Very Poor
	C	1	3	1	2	1	3	11	Poor
HS	A	1	4	1	1	1	3	11	Poor
	B	1	3	1	1	1	3	10	Very Poor
	C	1	1	1	2	1	3	9	Very Poor

Finally, it clearly appears that the analysed schools have several problems, especially in terms of reverberation time, façade isolation and external exposure. The use of these scores could also help students to identify single problems and to encourage the local administrations to solve them. The project also intends to stimulate students to take actions whenever their own behaviour could improve their environment. Therefore, specific advices could be given during and after the project to improve the specific noise problems.

6. Conclusions

The results shown in this paper confirm that noise in schools is a serious issue that should not be neglected by local administrations. The GIOCONDA project on these areas is a pilot study that aims to contribute with a useful tool to be used by other schools and local authorities to highlight problems, discuss ideas and find solutions about environmental problems [11]. The set-up of a web platform for sharing data and ideas is a concrete goal of the project.

Noise in schools is often a huge problem since it affects a lot of young vulnerable children and also the work environment of many teachers. Improving the education needs a good environment for learning and listening, for which a good sound quality is needed. Sometimes, easy and low-cost solutions could be implemented while at the same time it is not always true that costly mitigation of external noise sources are the most effective solution. It may happen that the worst source of noise pollution are the structure of the classrooms themselves and the internal sources. Thus, even a good maintenance of windows and doors could improve the isolation [12], which is indeed lacking in almost all measured rooms. Moreover, the installation of false ceilings is demonstrated to improve RT values, which appears to be the most serious problem related to the learning process.

The results provided by this project and the tools for sharing data could be hopefully useful for other projects and could contribute to spread the awareness of environmental health issues.

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