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EFFECTS OF ENVIRONMENTAL NOISE IN SPANISH SCHOOLS

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1. INTRODUCTION

The schools are established to promote learning, which is acquired largely by voice and listening. Therefore, acoustic conditions are most important to determine how well the school buildings can serve their primary function (1).

A number of studies seem suggest that noise in the schools may have an effect on some of the academic skills children are expected to acquire. However, the results of some of these studies are somewhat contradictory. For example, a study carried out in several schools of California showed clearly that the students in the noisier schools attained lower reading achievement scores than students in quieter schools in the three grades tested (2). However, another study carried out in Los Angeles showed no differences between pupils from noisy and quiet schools in scores related with standard reading and mathematical tests, although there were differences in performance on a cognitive task (3).

In the case of external transportation noise (4), several mechanisms have been proposed to explain this potential effect. The explanation most often proposed is that the noise interferes and interrupts communication, particularly by the teacher, with the result that either members of the class do not hear what is said, or the teacher is simply not able to cover as much material in the noisy classrooms. For example, in a study carried out some years ago to study the effects of noise aircraft around London airport, it was reported that teachers paused during at least one aircraft flyover in four, and that they paused more frequently with increasing noise levels (5).

Another mechanism is related with behaviour and attentiveness in the classroom. It has been observed that the insulation of the classrooms to reduce outdoor noise improved pupils behaviour, and their social contact, and it was also assumed that their accomplishments in school (6).

Taken together, all these studies show that environmental

noise may be a serious problem in the school, but obviously much more work needs to be done to evaluate precisely the effects of interfering noise on educational activities.

There also exists a reason of practical interest to follow the study of this problem. The results obtained in this kind of studies should provide a most valuable information for the planning and design of new school buildings or for improvement of the existing ones. Of course, these studies should be based in large programs including all significant variables.

This paper reports the main results of an study carried out in a wide sample of primary and secondary schools of the province of Valencia (Spain), covering a wide range of different conditions. External noise measurements and identification of main noise sources have been carried out in all these schools. The attitudes of teachers to environmental noise have been also investigated through the responses to a questionnaire with many different questions (personal data, noise sources, noise effects, etc.).

2. NOISE MEASUREMENTS

The province of Valencia is situated in the east coast of Spain. In this province there are about 1600 primary and secondary schools. A reduced sample of 100 schools were random selected for the realization of the present study.

Our sample covers all range of schools. 75 of these centers are in the primary level: 8 nursery schools (pupils with ages about 4-5 years) and 67 general education schools (ages from 6 to 14 years). The remaining 25 centers correspond to the secondary level: 14 general high schools and 11 technical schools (ages from about 14 to 17 years).

On the other hand, 75 of these schools are public and the remaining 25 are private. The number of teachers in these schools shows a large variability: 48 of them have up to 20 teachers, 37 have from 21 to 50 teachers and 15 have more than 50 teachers. The number of students is also very different: 19 schools have up to 200 pupils, 64 have from 201 to 800 pupils and 17 have more than 800 pupils.

15 of these schools have been builded before 1940, 69 have been builded between 1940 and 1980, and the remaining 16 have been builded after 1980. The condition of the buildings can be considered "good" for about 80% of the schools and "fair"

or "poor" for the remaining 20%.

According with one of the objectives of this study (acoustic evaluation of the sites where the schools are located), the noise levels (equivalent sound level Leq) were measured near the external facades of all the selected schools. The instruments used were Brüel & Kjaer type BK2221 integrating sound level meter. All the noise level measurements were carried out during weekdays, always in periods with teaching activity. In order to make sampling as efficient as possible, in each school we have carried out 30 different measures of one minute period, in points regularly distributed along all building facade.

The results obtained in these 3000 measurements of 1 min are summarized in the following distribution table :

Leq < 40 dBA	0.1 %
40 < Leq < 50 dBA	7.1 %
50 < Leq < 60 dBA	31.1 %
60 < Leq < 70 dBA	46.6 %
70 < Leq < 80 dBA	14.6 %
Leq > 80 dBA	0.5 %

The minimum value of Leq(1 min) was 38.8 dBA and the maximum value was 83.5 dBA. About 61% of the Leq(1 min) values exceed 60 dBA, and about 15% of the data exceed 70 dBA.

The average Leq values representative of each one of the 100 school locations (calculated as arithmetic mean of the corresponding 1 min values) show a similar distribution. In this case, the minimum value was 44.5 dBA and the maximum value was 76.6 dBA. The mean value of these 100 Leq(30 min) values is 61.9 dBA, with a standard deviation of 6.2 dBA.

With regard to the nature of the main noise sources existing in the school sites (subjectively appreciated by the people that carried out the noise measurements), our observations can be resumed in the following table:

Main noise sources	Frequency of detection
Road traffic noise	89 %
Building and public works	19 %
Farm machines	17 %
Train noise	15 %
Aircraft noise	11 %
Industrial noise	9 %

NOISE IN SCHOOLS

3. SOCIAL SURVEY

The attitudes and opinions of teachers about environmental noise and their effects on the educational process has been investigated through a social survey.

The relevant questionnaires were delivered personally to the principals of the schools, for distribution to all their teachers. The answered questionnaires were returned to our Laboratory by post; in the case of delay, one or more phone calls were done to the school to remember the distribution, collection and return of the questionnaires. 2849 questionnaires were distributed (one for each teacher in the 100 sampled schools). A total of 1093 answered questionnaires have been collected (response rate 38.4%).

About 44% of the respondents were male, and 56% female. The age range is very wide: younger than 30 years (21%), 30-40 years (42%), 40-50 years (26%), 50-60 years (10%) and older than 60 years (1%). About 41% of the respondents are teaching less than 10 years, 35% from 10 to 20 years, and the remaining 24% more than 20 years.

The number of pupils in the classrooms shows also a big variability. In about 21% of the cases, that number is less than 20 pupils. In 47%, there are 20-30. In the remaining 32%, there are more than 30 pupils.

A five point semantic scale has been used to rate the subjective evaluation of the classrooms conditions (in a general sense). About 10% of interviewed teachers declare that these conditions are "very good", 44% "good", 33% "fair", 10% "bad" and 3% "very bad".

The opinions about a number of significant conditions of the classrooms are summarized in the following table:

Spacious	69 %	Clean	64 %
Small	31 %	Dirty	36 %
Bright	91 %	Quiet	45 %
Dark	9 %	Noisy	55 %
Pleasant	74 %	Comfortable ...	60 %
Unpleasant	26 %	Uncomfortable .	40 %
Warm	49 %	Ventilated	93 %
Cool	51 %	Unventilated ..	7 %

NOISE IN SCHOOLS

According to the responses of the teachers, we could say that the average classroom is well ventilated, bright, pleasant, spacious, clean, comfortable, cool and noisy (qualifications presented in an ordered sequence). It should be observed that noise is the most negative factor.

In response to a question on the importance of environmental conditions in the schools, most of the teachers opine that these conditions are "very much" (73%) or "rather" (25%) important (the two upper categories in a five step semantic scale) to perform their educational task.

According to the teachers, the noise perceived in the classrooms is originated both outside the schools (45% of responses) and inside the schools (55% of responses).

In the following table the responses about the annoyance produced by three external and three internal noise sources (in the above mentioned five step scale, ranging from "very much" to "not at all") are summarized (in percentages):

Noise source	Very	Rath	Mode	Litt	Not
Road traffic	12	12	11	24	41
Trains	5	3	3	7	82
Aircraft	8	7	8	18	59
Own classrooms	8	24	35	27	6
Other classrooms	3	12	26	39	20
Courtyard	6	16	20	34	24

About the existence of any kind of sound insulation in the classrooms, 65% of the teachers answered "no", only 3% "yes" and the remaining 32% "do not know".

The opinion of teachers on some effects of noise on the educational process ("distracts the attention of pupils", "difficults the communication teacher-pupils" and "obliges to raise the voice of teacher"), measured also in a five step scale, are given in the following table:

Noise effect	Very	Rath	Mode	Litt	Not
Attention	32	42	11	10	5
Communication	41	35	8	10	6
Voice raising	46	32	8	9	5

The results obtained in the three cases are very similar. About 75% of the respondents consider que these effects of

noise are "very" or "rather" important. Taken altogether, these results seem to show that the teachers are fully conscious (probably on a intuitive or qualitative basis) that environmental noise is a negative factor in its work.

4. DISCUSION

The measurements carried out in the external facades of a wide sample of schools have revealed that noise levels in the corresponding locations are quite high. The mean value of equivalent sound level Leq(30 min) is 61.9 dBA. We can estimate that about 36% of schools have classrooms exposed to an external noise level over 65 dBA (Leq). Obviously, the situation in Spain seems to be worse that found by Sargent et al. in a study carried out some years ago in secondary schools of the United Kingdom (7): these authours estimated that only about 18% of schools in a sample of 300 had any classroom exposed to an external noise level over 65 dBA (L10).

In any case, assuming that the average noise insulation of the building facades is about 15-20 dBA, it could be concluded that the immission noise levels in many classrooms of our sample are well above the recommended limit for educational activities (in Spain this limit value is 40 dBA).

Obviously, the origin of the problem is that the location of many schools is not adequate. As it seems, the decision of the location of schools depends mainly of variables such as social demand, density of population, land availability, etc. The consideration about the noise levels existing in the location seems not be relevant for the decision-makers.

In particular, we have observed in this investigation that many schools are located very close to important motorways or roads, without take any measure to reduce the noise immission (noise barriers, sound insulation, etc.).

Road traffic is, of course, the most important noise source observed in the school sites. In order of importance, other noise sources are the building and public works, farm machines, trains, aircraft and industries. Obviously, the presence or not of the different noise sources depends of the specific characteristics of the location. For example, the impact of the aircraft noise is specially important in all the schools located near the Valencia airport.

Regarding to the results obtained in the social survey, we

would like to comment first that the opinions of the teachers about a number of specific conditions of the classrooms are quite positive in general. However, the classroom noise background deserves a negative evaluation. Of course, this evaluation is more or less negative depending of the conditions existing in the corresponding school.

Anyway, we must remember that we are analyzing here a social survey, with "subjective responses" to a number of questions. The variability in the individual responses can be related to objective differences in the physical situation (for instance, in a same school, some classrooms can be located in the most exposed facade and other classrooms can be located in a much more quiet area) but also to personal differences in the attitude towards noise.

In particular, about 21% of the teachers declare to be "very" sensitive to noise, and 5% "little or not at all" sensitive. We have observed that this specific characteristic affects to the responses of many questions about noise and its effects. A detailed statistical analysis of this subject is now in progress. Our first results coincide with those obtained some years ago by Sargent et al. (7): the proportion of teachers who claim to be not sensitive to noise and who are bothered at a given level of noise is significantly less than the proportion of other teachers.

It is also important to comment the effort of many teachers to overcome the noise problem in the classrooms. For example, about 25% of the respondents declare that they keep windows closed often in warm weather (in Spain!) to reduce the external noise immission.

The teacher's practice of raising the voice to overcome the noise in classrooms (see the previous section) seems to have a high cost: about 75% of the respondents declare to suffer often some throat disease (aphonia, hoarseness, etc.).

Most of the teachers consider that noise disturbs significantly the attention of the students and interferes also the communication teacher-students. Consequently, the high noise levels existing in many locations can affect negatively the educational activities in the corresponding centers.

Our Laboratory is carrying out at present a large research programme to study the problem of acoustical conditions in schools (8)(9). Noise levels (internal and external) is only an aspect of the problem; the reverberation time and speech

intelligibility of the classrooms are others. Our preliminary results show that the high noise levels and reverberation times that characterize many classrooms (low speech intelligility) are most negative factors in schools. These factors should be carefully considered by the education responsibles in the future.

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