Using a smartphone to investigate classroom acoustics

Maria Jesús ELEJALDE-GARCÍA, Erica MACHO-STADLER

Department of Applied Physics 1, Bilbao Faculty of Engineering (University of the Basque Country UPV/EHU), Plaza Ingeniero Torres Quevedo 1, E 48013 Bilbao, Spain

Abstract. We present a proposal for active learning about environmental acoustics and room acoustics for high school and undergraduate students. Students work on the concepts of sound pressure level and reverberation time through a set of activities centered on speech communication in the school. For experimental work, they use smartphone applications for sound measurement. At the end of the work, students would be able to suggest some actions to improve the acoustic comfort in school. The students' interest increases as they focus on their own experience. Moreover, they can apply and test the solutions that they propose.

1 Introduction

Speech communication is an essential factor in the school. Undesirable acoustics can be a barrier to listening and learning in the classroom. With background noise, people may have trouble following conversations. Moreover, the comprehension of speech (intelligibility) gets worse with reverberation. Shield and Dockrell [1] found that the dominant source of noise in a primary school classroom is the noise generated by the pupils themselves as they take part in classroom activities. Therefore, the acoustic education appears as a key factor in the prevention of the noisy behavior to improve the acoustic comfort in the classrooms.

2 Background

In noise pollution, the noise level is the background sound pressure level (SPL) at a given location:

$$SPL = 10\log\left(\frac{p^2}{p_{ref}^2}\right) \quad (dB) \tag{1}$$

where p is the acoustic pressure and p_{ref} the reference value for airborne sound ($p_{ref}=2\times10^{-5}$ N/m^2). Decibels measure a scale from the threshold of human hearing (0 dB) upward towards the threshold of pain (120 dB). Sound level meters (SLMs) are tools designed for measuring SPL.

Reverberation is the buildup of sound within a room resulting from repeated sound wave reflections off all of its surfaces. It depends on the size, the shape and the materials used in the construction of the room. Reverberation can increase sound levels within the room as well as distort speech intelligibility. A parameter that describes reverberation is the reverberation time (RT60). In a room, RT60 is the time (in seconds) that it takes for a sound source to reduce in sound pressure level by a factor of 60 dB after that sound source has been silenced. In real environments, it is more common to use the RT30 or RT20 (time taken for the sound to decay by either 30 or 20 dB respectively) and this is then extrapolated to RT60.

For furnished but unoccupied classrooms, the American standard requirements [2] indicate that the "one-hour-average-A-weighted steady background noise level" cannot exceed 35 dBA, and the reverberation time cannot exceed 0.7 seconds.

With the increase in the use of smartphones, a range of acoustical software applications ('apps') for sound measurement and analysis are available: basic sound level meters, sound recording, frequency analysis applications, signal generators, room acoustic measurement applications, etc.

Some relevant studies have investigated smartphone applications for the measurement of environmental noise and/or reverberation [3-6]. Simply purchasing, downloading, and installing the app does not ensure adequate preparation to conduct the measurements. Ostergren and Smaldino [7] recommended calibrating smartphone and software using a reference SLM.

3 The active learning proposal

Students work on the concepts of sound pressure level and reverberation time through a set of activities. At the end of the study, they have to answer two questions.

3.1 Why sometimes we do not understand what other people are saying in the classroom?

To guide the students, the following activities are proposed:

1. Search for information on what factors affect speech intelligibility.
2. Study outdoor and indoor noise using SLM apps.
3. Study the effect of the background noise on intelligibility.
4. Study the reverberation time using room acoustic measurement apps.
5. Study the effect of the reverberation on intelligibility.
6. Study the joint effect of background noise and reverberation on intelligibility.

3.2 What can we do to get a comfortable acoustic environment in the classroom?

Based on the results obtained in the previous activities, students should point to the following actions: eliminate noise coming from the surroundings (close doors and windows), prevent and avoid noisy behaviors, and generate sound quality within the classroom (control the reverberation time, achieve sound field uniformity and adequate sound intensity).

4 Conclusion

At the end of the project, the students discover some simple strategies that they can apply to get a comfortable acoustic environment: to install curtains or cork sheets on some walls, to use chair/table leg glides for smooth gliding and to keep the noise level acceptable using classroom noise monitor. Their interest increases as they focus on their own experience and they can apply and test their own solutions.

References

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