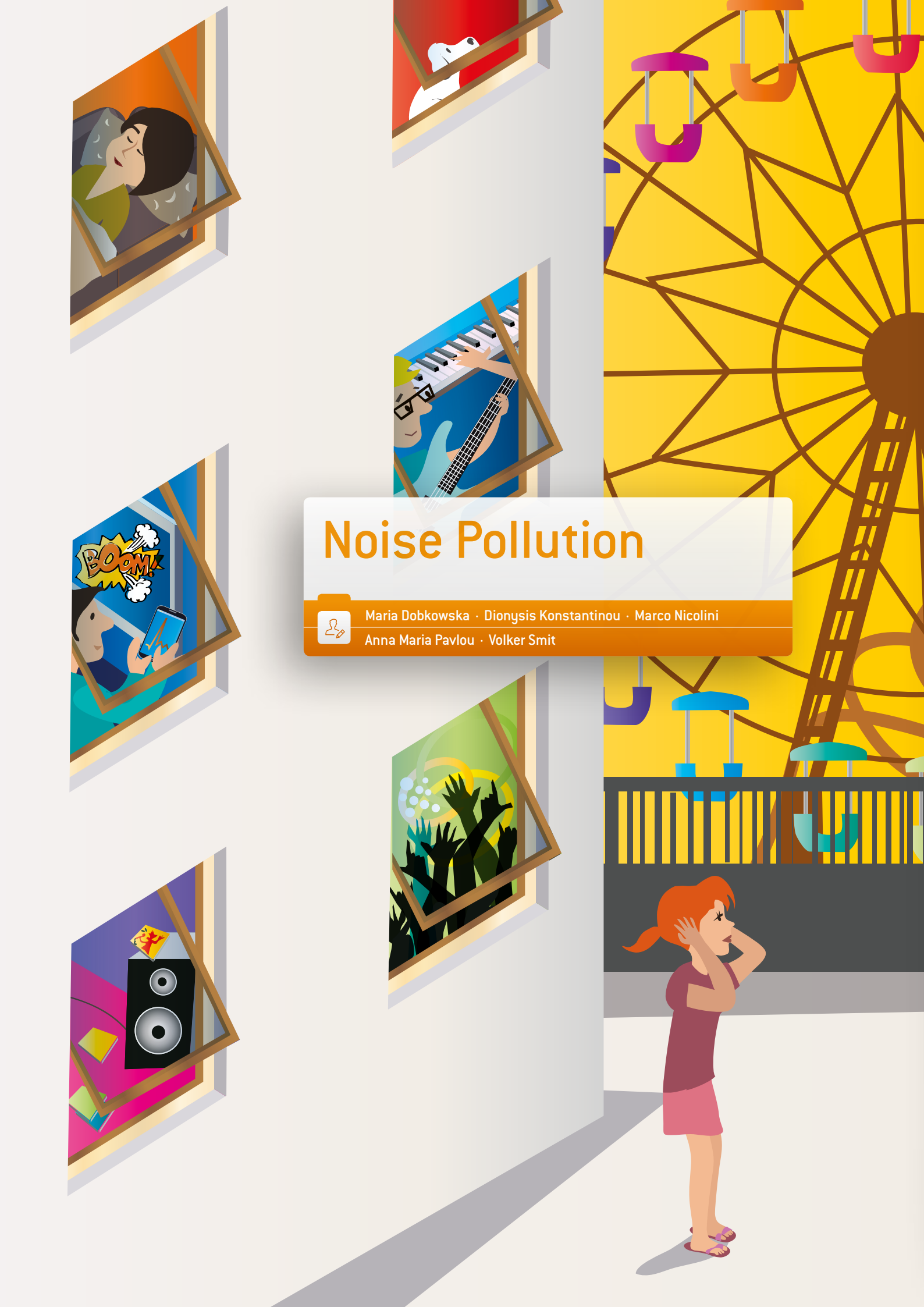

Noise Pollution

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1 | Summary

Creating a noise map of the school's surroundings based on the students' measurements and exchanging the results between students of different countries[1].

- **Keywords:** noise pollution, acoustics, decibel, sound, power, pressure, energy and sound pressure, amplitude, oscillation, resonance, waves, equation graphs, decibel scale, logarithms, file management, spreadsheet, graphs, health, ear and hearing, physiology of stress, resonance on the human body, small-scale maps, using GPS points for mapping
- **Disciplines:** environmental studies, physics, maths, ICT, biology, geography
- **Age level of students:** 12-19 years
- **Ages 12-14:** survey, measurement of sound levels, qualitative analysis, preparing graphs in relation to the health issue
- **Ages 15-19:** survey, measurement of sound levels, qualitative and quantitative analysis, preparing graphs, discussion of noise in relation to physiological stress and well-being (health issue)
- **Android apps:** Decibel Meter, Sound Meter
- **iOS apps:** Decibel Ultra

2 | Conceptual introduction

This project forms part of environmental studies, because it deals with characteristics of the environment—noise levels and noise pollution. The main objective is to sensitise students to the quality of their school environment regarding the noise level. It is meant to be experimental, giving the students opportunities to use different approaches, including Inquiry Based Learning[2] (IBL). The students will have to design the process of their research and specify the methodology they will follow in order to establish a geographic map of the noise levels in their school area. They will have to understand how noise is measured and how simple it is to measure noise by using a microphone and an app. During the working process some concepts from the fields of physics, biology, maths, geography and ICT will automatically surface in the students' minds and be discussed, depending on the students' approach and their own tasks and questions. If results are to be compared between schools, the methodology of the measurements has to be identical or at least very similar.

2 | 1 The science involved: Noise pollution and its impacts

Noise pollution is a big issue in modern society, and it has a major impact on the health of almost everybody. Nowadays we can no longer experience perfect silence unless we are in a soundproof room or in a desert (without any wind). If you live in a city, you cannot avoid hearing background noise 24 hours a day. Our ears are used to this. But our ears are also

FIG.1-3 **Screenshots: Decibel Meter, Decibel Ultra, Sound Meter**

delicate, and we must be aware of how noise can damage them. Young people tend to disregard the dangers of unhealthy behaviour with respect to their acoustic apparatus. Music concerts, amusement parks and parties are places and events where noise can reach dangerous levels. Moreover, in these situations the sounds do not peak—they are constantly at high levels.

On top of this, our schools, as working and living environments, deliver many more acoustic impacts that can strongly increase both short-term and long-term chronic damage to the health of teachers and students alike.

Our aim for this project is to finally sensitise the whole school community to this noise problem. Since the students are the major factor contributing to this noise pollution, they could be the solution to this problem as well.

Students attend school at least five days a week and spend a lot of time in schoolrooms and recreation areas within the school. This means that the noise level should be monitored in school environments in particular. The activity described here encourages students to measure noise and sound levels at school and shows them some simple and cost-free tools for checking acoustic environments. Last but not least, health issues at schools have become more and more important during the past 20 years, ever since a common set of European laws was proposed by the EU (http://ec.europa.eu/environment/noise/home.htm, last updated: 8/22/2014). Noise is among the parameters that must be assessed in order to guarantee a healthy school environment. In order to make such an assessment, the people who are responsible for health and safety at a school should consider supporting the activities described in this project.

2 | 2 Relation to the curriculum

Generally speaking, there are many different ways to incorporate this project into the different subjects of any given curriculum in any country. A teacher of any given country will easily find connections to his or her subject and others, and may even open up doors to inter-subject activities. Below you will find some ideas concerning how our international group would approach this task and how they would link it to their particular curriculum.

3 | What the students do

At the beginning there should be a short introduction to noise (e.g. showing an image of a worker wearing ear protection) to help students to create a connection between noise pollution and health issues. The amount of guidance provided to the students should depend on the group and the age level, leaving enough space for real inquiry. The students' activities could be supported by introducing the following questions:

- What do you see in your smartphone during the sampling time?
- Is there a difference between the samples recorded in the same place at different times?
- Can you infer a dependence or link between the noise level and what happened around you?
- Can you explain the dependence?
- Can you average the recorded values?
- How can you explain the value of the average? Is it close to the peak? Is it close to the minimum? Why?
- How could you create a Web-based map that incorporates your data?
- Could you expect any negative health effects for the people who are exposed to such noise? What do you find in other studies (literature)?
- What could be the short-term and long-term impacts to the human body? Could you measure such impacts?
- How could you present your findings to the school council?

Of course there are many more questions that could be asked. What are yours?

Steps in the practical process:

- Download and install the required app
- Calibrate the app on all the smart devices being used

In order to be able to compare the measurements within your group or between different groups in different countries, you have to calibrate the app (iOS or Android) of all the smartphones involved to the same standard. This calibration is a crucial requirement and needs some extra preliminary attention. You should consider broaching the issue of calibration in a short unit in order to explain the problems and the impor-

FIG.4 Students calibrating their smartphones

FIG.5 Example of school map
Source: Hellenic Cadastre and Mapping Agency s.a.; http://www.ktimatologio.gr/sites/en/Pages/Default.aspx

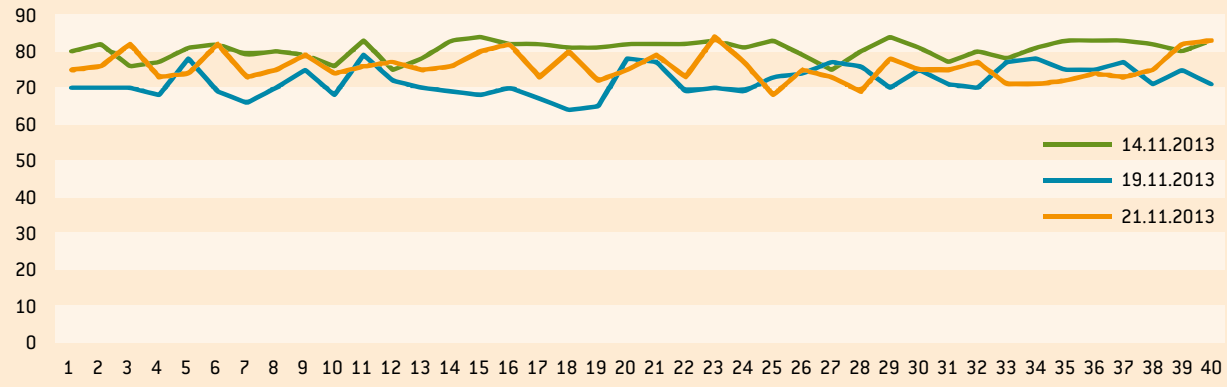
FIG.6 Students taking measurements outside the school area

FIG.7 Students taking measurements within a school classroom

tance of this issue—once again, depending on the age group. The Web-based calibration process we suggest here has the great advantage of being independent of the place where you do your survey. It was suggested by the experts at the Institute of Environmental Protection of the National Research Institute in Warsaw, Poland. To guide you through the calibration process, please take the following steps:

- Find a quiet and peaceful spot (this could be the most difficult bit).
- Find the YouTube video "pink noise" and use this noise as a reference to calibrate all the smartphones; https://www.youtube.com/watch?v=fguGuABgm-0.
- Turn on your computer's external speakers to the maximum level (speaker power 2-3 W).
- Find out where the microphone is fitted in your device.
- Start to measure this noise with your app, keeping a distance of 1 m between the smartphone and the loudspeaker and pointing the microphone toward the speaker. You should then see on your smartphone screen the value of about 86 dB (if it is less or more, use the +/– function of the app to calibrate the microphone of your device).

FIG.8 Sound level diagram (x-axis: measurement point; y-axis: dB)



- Select the measurement points within the school and/or the surrounding area[3].
- Design and use a recording sheet for reporting the measurements.
- Within the same class or project, agree that everyone will use the same sampling procedures, e.g. sampling intervals, continuous recording with average values etc.
- Process the data for presentation in graphs and/or statistical analysis.
- Review and compare the findings with the literature.
- Draw conclusions and make suggestions concerning changes in the school environment.

4 | Cooperation option

An international flash mob could be staged on the same day at the same time in order to draw people's attention to the issue of noise pollution and ensure a healthier work atmosphere in the school. The students could start the noise detection app together, sampling the noise levels and holding their phones high in order to make people aware of the high levels of background noise and the related health topics. With some precautions, media coverage could also be provided.

A comparison of the results obtained in the different countries would be possible if the participants have comparable teaching situations prior to the project.

It would be feasible to compare the noise levels within the context of the different legislation in place in the respective countries. What average sound levels can one be legally exposed to?

Students from different schools could discuss project ideas and share data via moodle, eTwinning or other social media. There are also apps that link sound levels to online maps such as noise watch or geovibes.

Finally, the participants could conduct a discussion of the consequences of their project and make suggestions about further activities. It would be especially interesting to discuss ways to lower the students' exposure to noise in the school environment.

5 | Conclusion

5 | 1 What are the students expected to gain from the project?

- Participating in a school survey
- Cooperating with each other in a group
- Sensitising the school community about noise pollution
- Applying and using a smartphone application in an authentic school project (not only for fun but in a way that reflects on our daily life)
- Understanding the connection of noise pollution to our health
- Possibly even getting an idea about how to initiate political changes within a community

5 | 2 Personal experience

The teacher should present some sort of introduction, depending on the subject and the age group. For example, you could introduce the basics of the physics of sound and sound processing in the human ear. Using an image of a person wearing ear protection and working with a jackhammer on the road could start a discussion. This could become controversial, e.g. the students might start to discuss whether one should wear ear protection or not. Some students might argue that ear protection is not necessary, since some workers do this job without any ear protection at all. However, once students know about the sensitiveness of the human ear they could conclude that wearing the protection would make sense. The questions below can be helpful as means of linking the image previously mentioned to the school situation as a working environment for students and teachers.

- What does the picture of the road worker tell us about our life in the school environment?
- Have you ever had a headache? When did this happen?
- What do you think was the reason for your headache?
- Could you imagine that noise can be a cause of headaches?

Before starting the measurements, a major issue was the calibration. There are different methods of calibration. In addition to the calibration procedure mentioned above, one can use a digital sound level meter to calibrate each of the students' smartphones. We believe our results should resemble reality quite well.

Another aspect to be mentioned is the processing of the noise. Any device will have a threshold in terms of reaction time. In addition, this processing time (probably processor-dependent) will be different for different smartphones. We strongly recommend lowering this threshold by closing all unnecessary applications prior to the start of any measurement.

We furthermore recommend that a project group should stick to the same sampling and measuring protocol (e.g. take a screenshot every 15 seconds; measure at exactly the same spot; point all the smartphones in the same manner). In some apps it is possible to send the whole measurement as a data file, e. g. per e-mail or social media after the measurement is done, usually leaving behind a csv file for further processing.

In order to establish comparable studies between our schools, of course we had to direct the students to use comparable approaches, thus narrowing down their idea-generating process.

The project was very well accepted by the students. During the working process all of them were very eager to do all sorts of measurements. They felt especially important because they received personal permits with the teacher's signature that allowed them to use their smartphones to make measurements within the school and the classrooms.

If you start examining noise in an upper secondary school, you might want to introduce logarithms in order to enable the students to understand the decibel scale and the dependence of the perceived noise on the produced noise. It is also useful to explain to the students the concept of zero noise and the way they are constantly subjected to background noise 24 hours a day.

An introduction to the human hearing range and human sound perception and how these are affected by background noise could be a good starting point for discussion. These topics could then be linked to other disciplines such as medicine and law. An introduction to the logarithmic Weber-Fechner law of human perception could also be a good starting point.

Footnotes

1 Keeping in mind that the sound source is producing a higher intensity of sound, we focus here on the receiver of the noise, using the SI unit dB for our recordings.

2 Inquiry-based learning emphasises constructivist ideas of learning, where knowledge, especially socially based knowledge, is built from experience and process. On the basis of this premise, learning develops best in group situations. The progress and outcomes are generally assessed according to how well people develop experimental and analytic skills, and often according to how well they work in groups [http://en.wikipedia.org/wiki/Inquiry-based_learning].

3 Some places to study:

- The school's main hall during the break
- The corridor and staircases during the break
- A classroom during a lesson / during the break
- The gym hall
- The school canteen
- The library
- The schoolyard during exercises / games
- The streets in the neighbourhood around the school
- The swimming hall.