Educational Aspects of Crowdsourced Noise Mapping

Andrea Pődör and László Zentai

Abstract Examined here is a project-based method for integrating of crowd-sourced noise mapping in the teaching of geoinformatics. Practical examples of a GIS course are designed to use crowdsourced noise measurements in the curricula. The approach showed students how GIS integrates data acquisition, processing, analyses and visualization. Implementing noise measurement tasks in the curricula also helped students gain skills in detecting and resolving errors. The teacher acts as a mentor during the classes in order to help students acquire knowledge in a way that best suits them. A project like this is helpful because it makes the problem easily understandable and offers several cartographic visualization methods that the students can test and compare in practice. In addition, we found that the quality and the accuracy of students' performance improved during the semester. The students share their knowledge and their experiences. They also learn to cooperate because the success of their project is dependent on the collective work of each student. The most recent methods are presented to the students during the whole working process and lets them discover good and bad solutions.

Keywords Noise mapping · Project-based learning · GIS

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1 Introduction

Noise pollution is one of the main and growing environmental problems in urban areas. Noise affects everyday life; well-being and noise can cause severe psychological issues (Pődör and Révész 2014). According to the Environmental Noise Directive of the European Union 2002/49/EG (END), each agglomeration pursuant to article 7—with a population more than 250,000—should create a noise map. The Hungarian Government Decree 280/2004 (X. 20.) in 2004 directed all settlements with a population more than 100,000 to create a noise map and an action plan to reduce noise pollution exceeding the values set in the EU Directive. All these maps should have been prepared by 2012. An order prescribes that the maps should be renewed every five years from 2010 onwards (Pődör and Révész 2014). However, due to the lack of financial resources, local authorities have been unable to fund the renewal of their maps.

A possible method to regularly update noise maps is crowdsourced data collection. Thanks to the growing availability of location-enabled smartphones with a range of capabilities including sound recording, this data acquisition technique looks promising.

Teachers already have good experiences in project-based learning (Pődör 2011). Therefore, it seemed to be a practical idea to involve students in this activity who had received a scholarship from the gSmart project (http://em-gsmart.zgis.net/gsmart). The project offered mobility scholarships for Central Asian (CA) students until 2017. With the help of the project, students could participate in B.Sc. and M.Sc. courses in spatial sciences in the EU countries. Within the framework of the project, eight master students studied the basics of GIS at Óbuda University and at the University of West Hungary in Sopron.

The project-based learning (PBL) method, which is an effective alternative to subject-based teaching, has been widely used in secondary schools and in higher education. The method helps students learn by participating and completing projects (Demirci et al. 2011). As Enemark (2009) defined, the importance of this method is that it teaches students how to learn. The aim of the PBL process is to give to the students a broad understanding of interrelationships and to make them able to deal with new ideas and cope with unknown solutions. Barge (2010) defined the essence of the project as a complex effort in which problem analyses, planning, management and binding cooperation is necessary for a team on successful completion of the project. He also noted that a project is a sequence of different tasks resulting in a final product.

As Pődör (2011) described, a possible sequence of tasks in a GIS project could be as follows: Geodatabase design, Planning the field work, Data acquisition; Processing of the collected data, Control of the accuracy of the data, Analysis of the data, Querying of the data, and Publication of the data. Following this sequence, students are able to see how theories connect to empirical and practical knowledge. Projects in PBL should focus on problems, involve students in a constructive investigation, be student-centred and be realistic by focusing on real-life activities Thomas (2000).

The goal of involving Central Asian students in noise measurement activities was twofold. They would learn aspects of GIS including data acquisition, analysis and mapmaking. On the other hand, they would became familiar with the settlement that they were studying.

1.1 The Study Area

Sopron is a middle-sized Hungarian settlement with a medieval town centre and a population of approximately 60 thousand. Sopron and its surroundings include four small physical geographical regions: the Sopron Mountains, the Sopron Basin, the Fertő Hills and Lake Fertő.

Sopron lies near to two main roads of the Hungarian national network: road 84, leading to Lake Balaton, and road 85 that connects Sopron with Győr town. In addition, a railway line crosses the town. City administrators are aware of the environmental noise pollution caused by roads and the need to make traffic safer and faster. To address this, Sopron plans to construct a road bypass between Pereszteg and Sopron (Fig. 1). It is no surprise that the heavy transport has a significant effect on air and noise pollution (Sopron Municipality Sustainability Plan 2010).

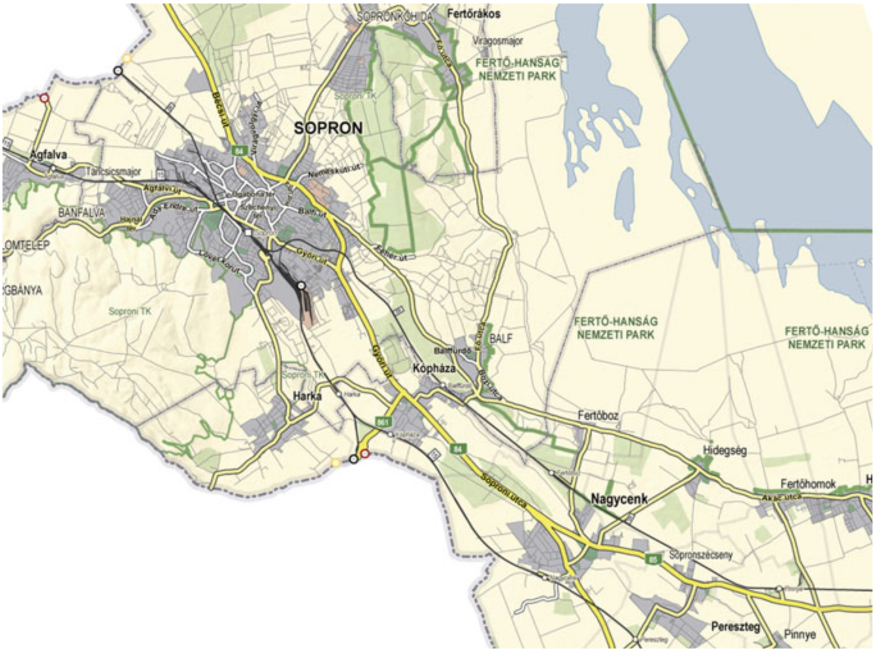

Fig. 1 Sopron and its surroundings (http://terkep.varosterkep.hu/map/)

2 Method

Students at the masters level worked with the same commercial GIS program during the semester. They learned about data modelling, database building, data manipulation, and processing and analyses of spatial data.

The noise measurement project was done over two years in a spatial data modelling course. The course consists of both theoretical and practical lessons. Four CA students started taking measurements in the spring semester of 2015. In the 2016 spring semester, five students repeated this work and made additional measurements.

Prior to starting the project, students learned about the theory and practice of official noise measurements, as well as about crowdsourcing. They also became familiar with database modelling tasks. During the project, the teachers acted as mentors to help the students fulfil the project goal in a way that best suited them. Students shared their knowledge and their experiences with each other and how to cooperate in a project.

2.1 Project Planning, Database Modelling and Fieldwork

The first, preparatory step of the project was a discussion how the students would organise the noise measurement of Sopron, specifically how they should perform the measurement based on the predefined existing points, how they should collect noise data, what time constraints would affect the measurements, etc. Then, we determined the places where measurements would be taken.

In the next phase, the students divided the area of Sopron into four parts, and they decided to form four groups. They also agreed that they would take the measurements twice a day: (1) in the afternoon from 13:00 to 15:00, and (2) on weekday evenings from 17:00 to 19:00. Then, still in the lab, they designed the structure of the database and defined what kind of attribute data would be gathered during the fieldwork. The project started with a detailed planning of the measurement points. In the fieldwork, they used a Trimble Juno SC GPS to identify these places. Noise measurement was performed by their mobile phone.

The objective of this part of the tasks was to gain skills to work with a GPS receiver and work with noise meter software on the mobile device. They measured three times on each point for 15 s, and they recorded the average of dB (A) values in the database.

2.2 Data Processing and Analyses

In the last phase of the project, the students returned to the lab. First, they processed their raw data in MS Excel. They calculated the means, correlations, and detected data outliers. After data processing, they started to create their GIS database. First, they used OpenStreetMap (OSM) to acquire the most recent customised, up-to-date layers of Sopron in a raw .osm format. They converted this data into an SQLite database. In the end, they created a layer (or multiple layers) that included only the feature types and tags. These layers could be used as shapefiles in QGIS.

Afterwards, the students continued with visualisation experiments (see Sect. 2.3). The process was followed by creating an interpolated map in ArcGIS using the IDW interpolation method and by implementing equal intervals in order to use a predefined colour scheme. This had to be as similar as possible to the symbology of professional noise maps, for which the symbolisation is defined in the END directive.

Subsequently, they continued with the analysis of maps and data. They used visual interpretation and some statistical analyses in R program (a free software environment for statistical computing and graphics.) The objective of this part was to gain skills in data processing, create a noise measurement map of Sopron town, and draw conclusions.

2.3 Visualization

This part of the project aimed at helping the students to understand the importance of correct visualization for perfect interpretation. They realized that if someone raises the question of where the noisiest areas are, the most convincing answer is to show these areas on a map.

Different cartographic thematic mapping methods (Fig. 2) were used to show the measurements on the map. As the students already had a course in cartography, they had now the opportunity to discuss the advantages and disadvantages of each mapping technique.

Experiment with various classifications of the acquired data were done using the built-in classification methods in the software. Students needed to understand each method or risk choosing an inappropriate method that would have produced thematic maps with misleading results. In interpreting the differences between the various classification methods, histograms were found to be useful. The x-axis of histograms shows the range of values in the fields, the y-axis is a count of features. ArcGIS has six classification methods. We analysed the impact of the different classification methods with the help of noise measurement data.

By this time, the students had learnt that the visualization of a professional or a strategic noise map is strictly regulated. Although the students did not prepare an “official” noise map, they were asked to follow pre-defined rules for noise map construction. The classification of noise data requires an equal interval representation as each five-decibel change results in a new colour code in END.

IDW interpolation was used for the interpretation of noise measurement data. This form of interpolation leads to a better understanding of Tobler’s first law of Geography. Students tested different interpolation methods and understood that,

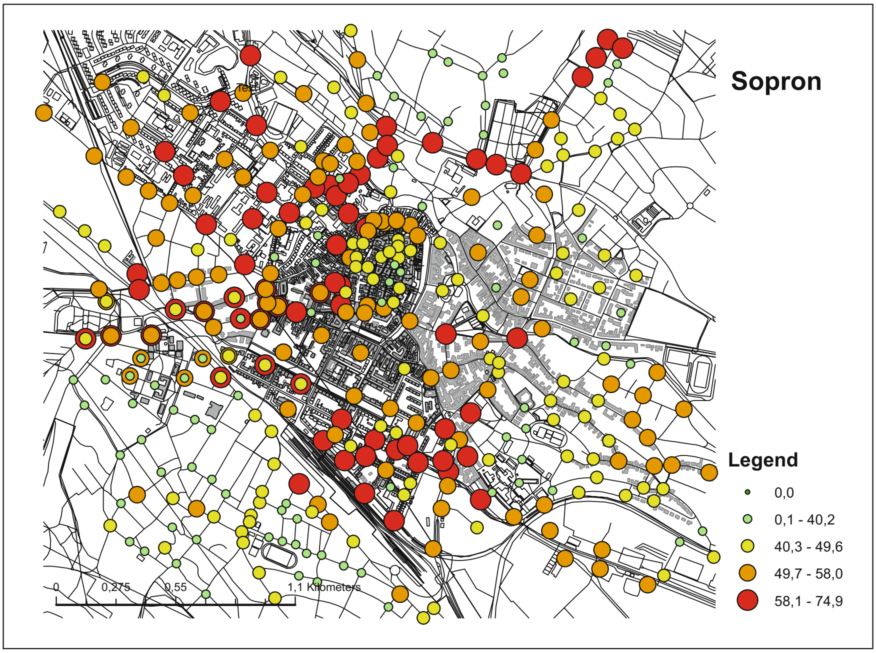

Fig. 2 Noise measurements visualized with graduated symbols

although, cartographers can use several cartographic methods, displaying the spatial context was most important. 3D maps were also made using the TIN model from the measurements and added other 3D objects such as houses, trees, rivers and lakes to their map (Fig. 3).

The project demonstrated to students that several mapped representations could be appropriate. There are different visualization methods for decision-makers, for noise measurement experts, and for the local citizens. Students could discuss the various visualization methods used by other students, either in the same class or from previous years. The teacher could give the students guidance on the visualization methods by presenting their advantages and disadvantages.

A discussion of good and bad practices can be the best solution from a didactive perspective. Noise mapping can also be a good example of testing the use of different colours and their effect on the visualization, and making students understand all aspects of visualization. Teachers can also emphasize for the students the difference between eye-catching and effective representational methods. Both approaches have relevance depending on the kind of users for which the maps are intended.

Experiencing different thematic cartographic methods for presenting a certain theme proved to be a good tool in analysing how users interpret the maps depending on their experience and previous knowledge (Pődör et al. 2015).

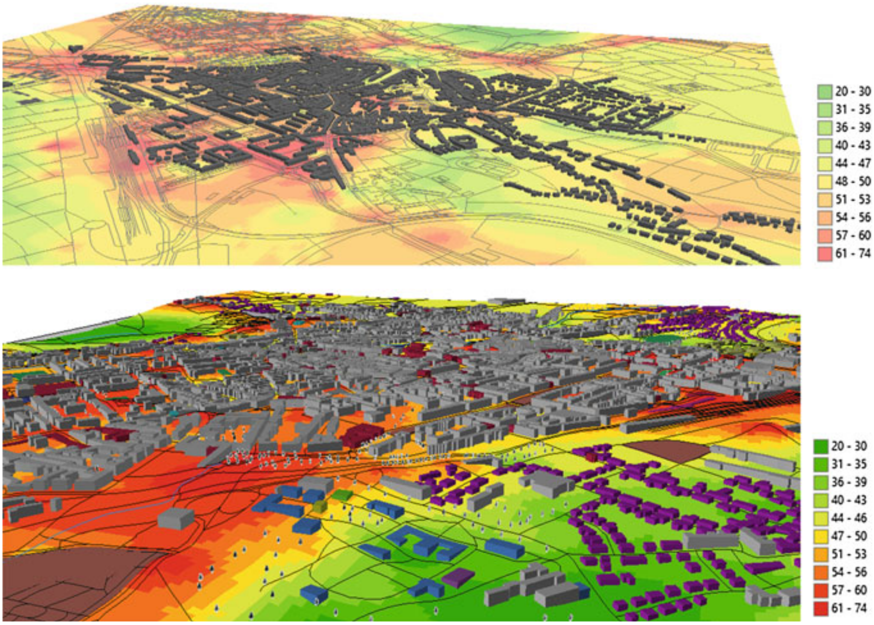

Fig. 3 Two solutions for the 3D visualization of buildings and measured noise

3 Results

Long ago, John Dewey promoted the idea of learning by doing in *In My Pedagogical Creed* (1897). Project-based learning supports this type of learning process, but in our case, we had other results as well. This type of project-based learning produced significant results in two areas: exploring the noisy and quiet areas in the city, and deepening the students' GIS knowledge by improving their practical skills.

In this process, the students produced an extensive noise measurement campaign, which resulted in a complex noise measurement map (Figs. 4 and 5). The students measured 343 points in 2015. In the following year, 370 measurements were taken at the same points. Two maps were prepared in each year—one for the rush hour and one for a quieter tie in the early afternoon. With mentorship of the teachers, students analysed the problem areas. It was revealed that the noisiest areas were associated with the main arterial roads (road 84 and the railway). Also, the main and busiest roads had the highest decibel values.

Comparing the results of 2015 to that of 2016, each measurement showed that the highest measured values could be found at the intersections of the roads. Unfortunately, the measurements could not be fully comparable because measurements in 2015 were in the morning and in the afternoon, while afternoon and evening were used in 2016. Comparing the results, we found that the quietest period is the morning, the noisiest is the evening (Fig. 6).

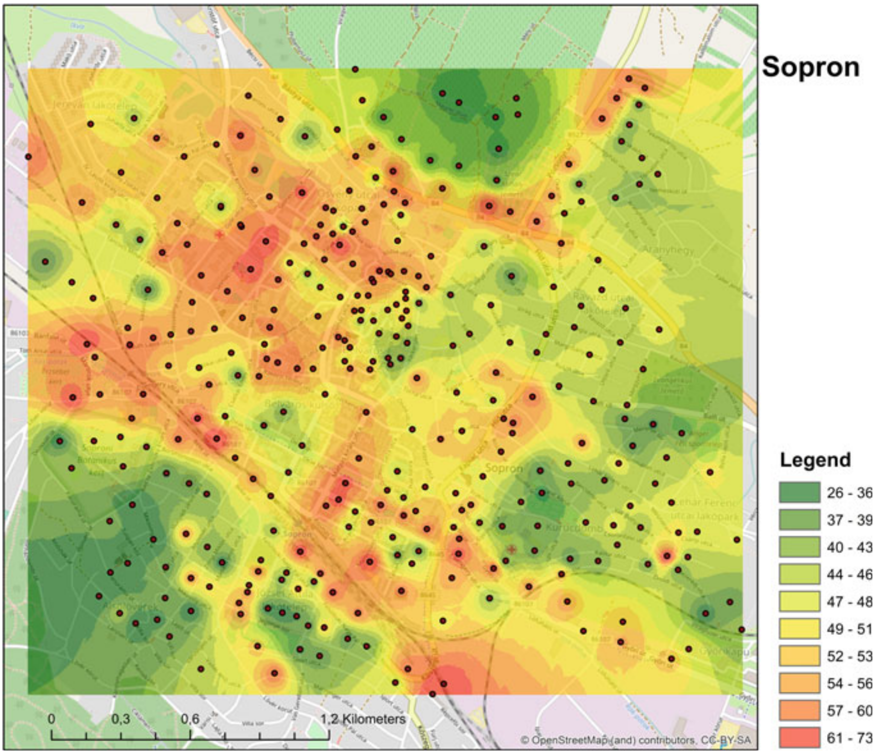

Fig. 4 Noise measurement map of the city of Sopron in 2015

This project-based learning method improved the skills of the students in many fields. First of all, this approach enhanced the collaborative activity of the students and it augmented the quality of their work. In addition, students deepened their knowledge in using open source and commercial software. At the same time, they learned how to access OpenStreetMap data as the base map for their study area. They acquired certain specific skills in noise measurement as well. They are now able to make a distinction between noise maps and noise measurement maps as well as identifying accuracy problems and discrepancies in measurements.

In general, they gained greater understanding of concepts and a broader knowledge base. With the integrated collaborative work, they improved communication and social skills, with some enhancing their leadership skills as well. They needed to find creative solutions to solve problems. These activities helped the student to engage in investigations in a student-centred way. During the analysis of their results, they applied their knowledge in an interdisciplinary way. They not only used GIS software, but also became familiar with statistical programs such as R or ggplot2. They created boxplots (Fig. 6), scatter plots and histograms (Fig. 7) for an in-depth understanding of the data they gathered, so they understood and drew their own conclusion through creative experimentation.

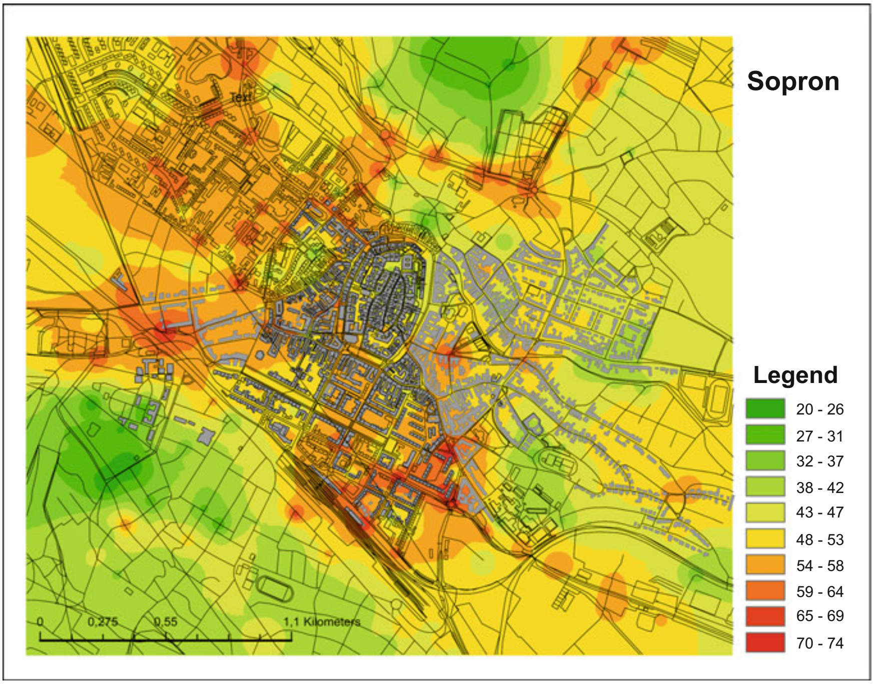

Fig. 5 Noise measurement map of the city of Sopron in 2016

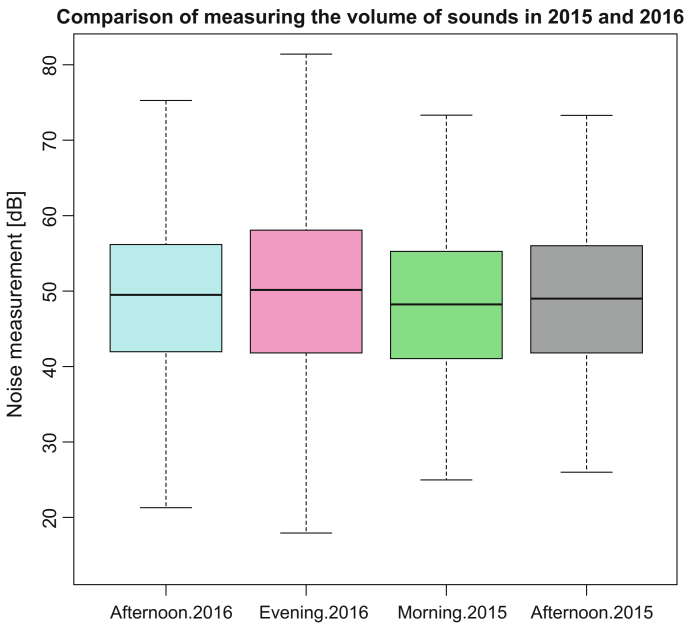

Fig. 6 Comparison of noise measurement in 2015 and 2016 in Sopron

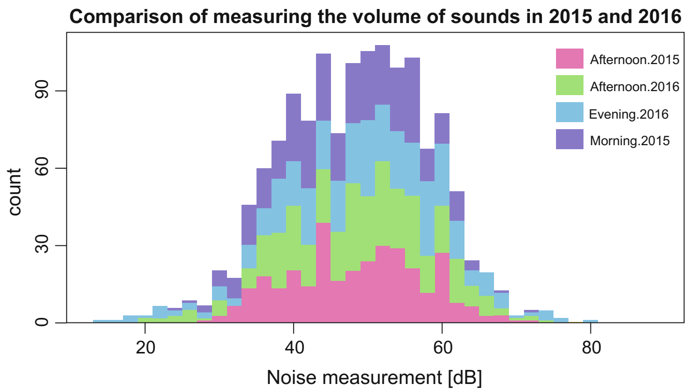

Fig. 7 Histograms of noise measurement in 2015 and 2016 in Sopron

At the end of the semester, we made a formative assessment. We identified that students had improved in team-work and visualisation, in understanding the importance of database design, planning, and publication of the results. Also, we analysed their feedback on the strong and weak sides of the noise measurement project methods. They said the strong side of this project was that it gave them the chance to:

- work in teams;
- following a project from the beginning to end;
- test different interpolation methods;
- visit unknown and beautiful places.

Students reported that the main disadvantage of the project was that different mobile devices produced different noise measurement results. Therefore, the accuracy could not be judged. In this process, the students became able to select information, form hypothesis and make decisions. On the other hand, the teacher had a different role. The teachers had to transform lesson resources into a form that the students could understand and they had to encourage the students to gain experiences on their own and to get engaged in dialogues (Pődör 2011; Pődör et al. 2015).

According to Enemark (2009), 90% of the lesson learned in PBL may be retained with problem simulations. This is because of the fact that knowledge accomplished by ourselves will be easily recalled and learnt.

4 Conclusion

The findings demonstrate that implementing crowdsourced noise measurement in a GIS course has several advantages. The pilot project revealed that during one semester we could reach concrete results detecting where the noisiest areas were in Sopron city. These findings help the local authorities implement the results in actions and to reveal environmental problems for the citizens. The results confirm the hypothesis that crowdsourced noise measurements can identify problem areas, although they are not fully substituting official noise measurements. We conclude that this type of noise measurement campaign can help other municipalities as well.

Besides these results, we can confirm that this type of project-based approach as underlined in other studies (Blumenfeld et al. 1991; Thomas 2000) is appropriate to engage students in investigation: they should apply what they had learnt during the lessons and they are able to acquire skills that cannot be learnt from textbooks.

This project-based approach is also very helpful to understand the whole process of map-making, especially to practice the cartographic visualization in a GIS course. A collection and presentation of good and bad practices can be one of the best tools from the didactical aspect. The re-evaluation and comparison of the maps created by other student groups and/or by other providers can enhance the visualization skills of the students. Practicing cartographic visualization in different software environment can also enhance the students' skills and makes them understand the essential elements and aspects of thematic cartography.

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