STEAMCITY CURRICULUM

SOUNDSQUAD

Sensitive mapping of noises

thematic: environment, well-being and public health

Introduction

This protocol aims to explore noise pollution **in their city** in a **sensitive and scientific** manner. Through an interdisciplinary approach (science, urban planning, technology), students will first **express their subjective perceptions of noise** before using **measurement tools** to confirm or refute their feelings.

Thanks to this protocol, they will explore:

- **Health, well-being and social cohesion - What is health? What is well-being?**: Understanding the link between indoor and outdoor noise and public health and well-being issues within one's community (at the class level) and territory (at the city level)
- **From individual health to population health**: Understanding the transition from individual health concerns to broader public health issues related to noise pollution
- **Measurement through diverse indicators - Construction of an indicator, diversity, interests and relativity of indicators**: Multi-indicator approach using both qualitative and quantitative data, abilities to analyze results, document and understand correlations and their limitations
- **Diversity of health actors: Present the role of different actors in a health intervention and analyze the person's participation in a health action**: Identify the actors in the territory who have an impact or direct action on the public health issue related to urban noise and value one's civic action on a better understanding of citizens' feelings on the given issue

This activity allows for the development of both technical skills (use of sensors and data analysis) and more abstract skills (subjective analysis, emotional response). The progressive sequencing of steps leads students to build a comprehensive understanding of the correlation between noise and well-being.

Learn more about Noise*: Explore the* ***Going Further Section****.*

Interdisciplinarity

biology

technology and engineering

mathematics

arts

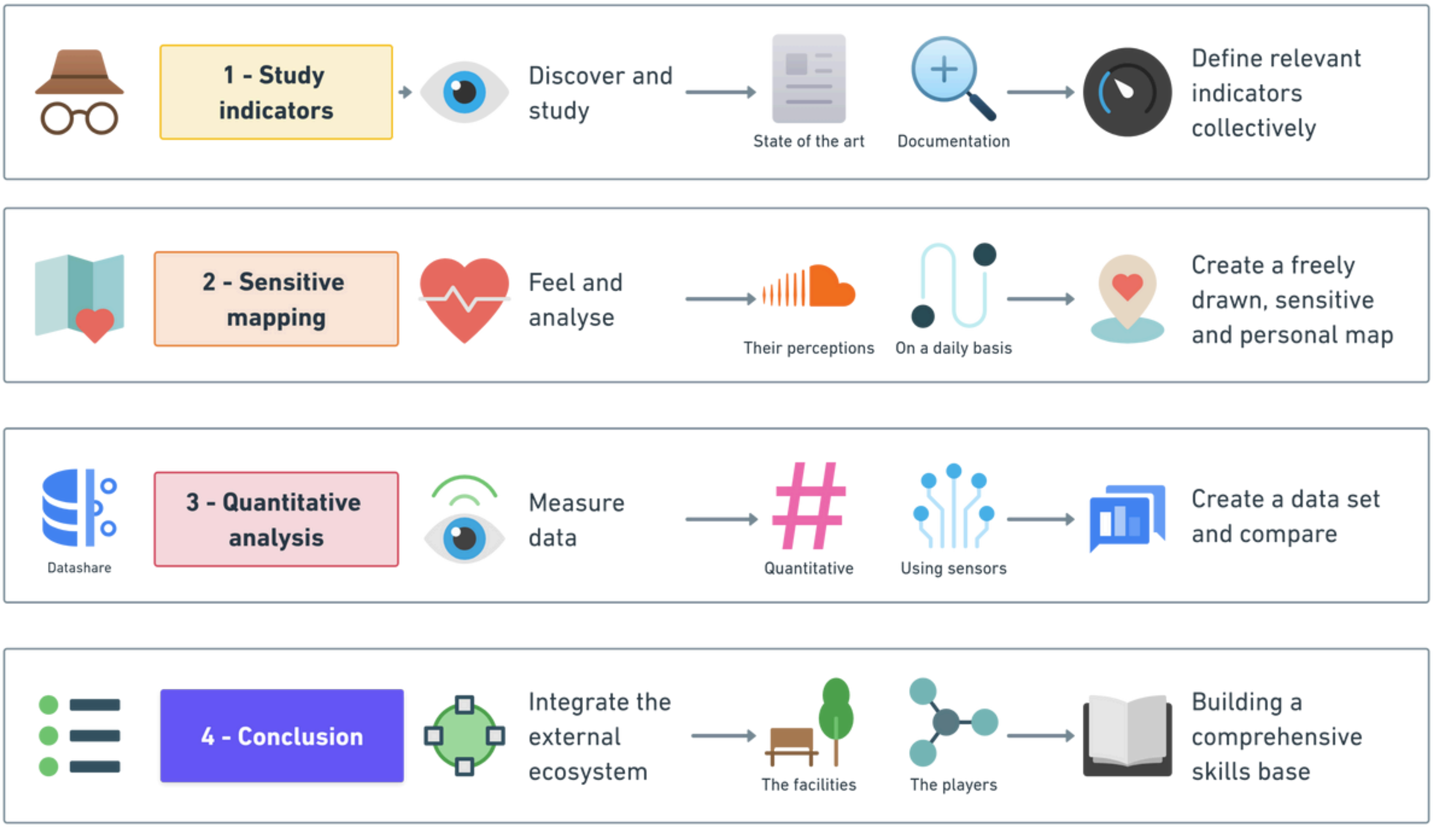
Sustainable Development Goals

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Overview

Protocol Structure



Step 1: Understanding the issue and defining indicators

Students will discover the issue of noise, explore different aspects of urban noise and its impact on quality of life. They will collectively develop **indicators** to assess noise, such as perceived intensity, frequency, type of perceived source, and impact on their well-being. These indicators will form the basis of a structured analytical framework for the rest of the activity.

Step 2: Sensory mapping

Students will create a **sensory map** by noting their perception of noise on a route from their daily life. They will identify areas perceived as noisy or quiet, based on their daily experience.

Each student will create their own "map", freely drawn, colored, and annotated according to their analysis of their daily experiences, using the indicators defined previously. This mapping will allow for a nuanced and structured analysis of their perception of the soundscape.

Step 3: Quantitative measurement with sensors

Students will program **noise sensors** and position them in areas identified as noisy and disturbing during the sensory mapping phase. These sensors will record actual sound levels (in decibels) over several days in multiple locations.

Students will feed their analytical framework with **quantitative indicators** based on these measurements, such as average sound level, noise peaks, and duration of quiet periods. The objective will be to **compare feelings (qualitative indicators)** with these **measurable data**, and examine whether certain perceptions are influenced by specific times of day or particular noise characteristics.

Step 4: Analysis of stakeholders' roles in addressing a public health issue

Students will examine the **aggravating factors** of noise in problematic areas (traffic, construction sites, businesses) and reflect on how urban planning and human activities influence noise pollution. They will study the **stakeholders involved** in noise management (municipalities, businesses, citizens, urban planners) and explore their respective roles in **reducing noise nuisances**.

They will become aware of the importance of **cooperation between these different actors** to improve quality of life in the city. If possible, a presentation of the maps created during the activity will be proposed to local stakeholders to showcase the actions taken by the students.

Getting started

Steps	Duration	Difficulty	Material
Understanding the issue and defining indicators	30 minutes	★☆☆☆☆	• Computers or tablets with internet access for documentary research • Whiteboard or large paper for collective creation of indicators • Markers of different colors • Post-it notes for brainstorming
Sensory mapping of noise	1 to 2 hours	★★★★★	• Large sheets of paper (A3 format or larger) for individual maps • Colored pencils, markers, pastels • Rulers, compasses (optional) • Base map for the collective synthesis map
Quantitative measurement with sensors	30 minutes for programming + 1 week of data collection + 30 minutes of analysis	★★★★☆	• Min. 5 programmable micro:bit cards with integrated sound level sensor • Computers for programming sensors and analyzing data • Data processing software (e.g., Excel, Google Sheets) • Mounting equipment for sensors (depending on the type of sensor used)
Analysis of stakeholders' roles	30 minutes	★☆☆☆☆	• Computers or tablets for research on local stakeholders • Whiteboard or large paper for mapping stakeholders • Colored pencils, markers, pastels to make the mind map attractive and turn it into a visual communication tool

Glossary

Keywords & Concepts	Definitions
Noise	Undesirable or disturbing sound, often characterized by its intensity, frequency, and duration.
Environmental noise	Set of undesirable sounds present in the outdoor environment, including transportation, industrial, and neighborhood noises. It includes noise produced by means of transport: road vehicles, trains, airplanes, boats; industries, construction sites and works; cultural, sports or leisure activities: music from nightclubs, shows and festivals; firearms; recreational vehicles, such as motorcycles, etc.; neighborhood: outdoors (air conditioning, motorized gardening equipment, etc.), indoors (parties, music, noisy household appliances, such as vacuum cleaners, etc.).
Noise pollution	Set of nuisances caused by excessive noise that can affect health and well-being.
Decibel (dB)	Unit of measurement for sound intensity. The higher the number of decibels, the louder the noise.
Sound level meter	Measuring instrument used to evaluate sound level in decibels, allowing for objective quantification of noise.
Sensory mapping	Subjective representation of a space based on individuals' emotions and feelings, without resorting to scientific measurements.
Emotion	Intense affective reaction, positive or negative, provoked by an environmental stimulus, such as urban noise, which can influence perception and behavior.
Stress	Physiological and psychological reaction of the organism to environmental pressure, which can be exacerbated by prolonged exposure to noise.
Cognitive abilities	Set of mental functions related to knowledge, including memory, attention, and reasoning, which can be affected by exposure to noise.
Urban well-being	Sensation of physical and mental comfort felt by city inhabitants, influenced by various factors such as noise, pollution, green spaces, etc.
Public health	Set of measures aimed at promoting and protecting the health of the population, including the management of noise nuisances and their impacts on collective well-being.

Protocol

Step 1: Understanding the issue and defining indicators

Background and description of the problem to be solved in this step: The main objective of this first phase of the urban noise protocol is to **understand the issue and define relevant indicators**. This initial phase allows students to familiarize themselves with the key concepts of urban noise and its impact on quality of life. The goal is to lead them to explore different aspects of noise and collectively develop indicators to evaluate it. These indicators, such as perceived intensity, frequency, type of perceived source, and impact on well-being, will form the basis of a structured analytical framework for the rest of the activity.

Learning Objectives: Through this activity, students will develop several key skills. They will learn to understand the complexity of the urban soundscape and its impact on quality of life, which will help them better grasp the importance of a balanced sound environment. They will develop skills in sensory analysis and sensory mapping, essential for subjectively apprehending noise. Additionally, students will learn to design noise measurement indicators, a crucial skill for any scientific approach. Finally, they will be led to analyze and visually represent their perceptions of the soundscape, which will allow them to develop their observation skills and creativity.

Conceptualisation

The central hypothesis that will guide this entire protocol is that **individual perceptions of noise vary according to areas and times of day**. This hypothesis directly falls within the framework of public health concerns.

To delve deeper into this hypothesis, students will first need to compile and structure a **documentary corpus** on the subject of urban noise and its effects. This corpus, composed of scientific articles, reports, and case studies, is **crucial for establishing a solid knowledge base** and understanding the current state of research on urban noise. The importance of this research work lies in its ability to provide a theoretical framework and justify the relevance of a study on noise perception in various urban contexts.

By exploring the concepts of **noise perception** and **qualitative indicators**, students will develop **methods for evaluating and analyzing urban sound experiences**. **Indicators**, such as perceived intensity, frequency, type of sound source, or emotional impact, are **essential for quantifying and qualifying sound experiences**.

The **construction and diversity of indicators** are crucial aspects to examine. The diversity of these indicators allows for a nuanced understanding of the urban soundscape, taking into account its spatial and temporal variations.

Students will need to understand how different types of qualitative indicators can complement each other to paint a complete picture of noise perception. For example, combining subjective evaluations of sound intensity with qualitative descriptions of noise sources and their effects on well-being offers a richer and more detailed perspective.

Finally, **the choice of method and data collection tools is fundamental to ensure the validity and reliability of the study**. Students will need to argue their methodological choices, taking into account the relativity of indicators and their relevance in different urban contexts.

The importance of the method lies in its ability to produce consistent and comparable data, essential for drawing meaningful conclusions about urban noise perception.

Students Investigation

Discover the issue of noise

This step will aim to introduce the topic of noise pollution and gather students' prior knowledge. The teacher can facilitate a class discussion, use visual or audio aids to illustrate different types of urban noises, and encourage students to share their personal experiences related to noise in their daily environment.

Conduct documentary research on the issue of urban noise

Students will carry out in-depth documentary research on the subject of urban noise. They will explore existing studies, official reports, and relevant articles to establish a solid knowledge base. This step will allow them to identify the main issues related to noise pollution in urban environments and complement their prior knowledge. This documentary investigation will also help understand the methodologies used in existing studies on noise prior to establishing their own indicators.

Construct a table of qualitative and quantitative indicators to address the issue in a nuanced manner

Students, guided by the teacher, will collectively develop a set of indicators to evaluate noise, drawing on their knowledge, feelings, and documentary research. This will ensure that the issue has been correctly understood by the students and engage them in structured data collection work. This may include qualitative and quantitative indicators: intensity, frequency (constant, intermittent, occasional), type of source (traffic, human activities, nature), impact on their well-being (annoying, neutral, pleasant). This activity will allow students to understand the different ways of measuring and evaluating noise, while developing a common vocabulary to describe their sound environment.

Conclusion & Further Reflexion

At the end of this phase, students will have gained an in-depth understanding of the urban noise issue, developed skills in documentary research, and collectively created a corpus of indicators to evaluate noise in a structured manner. To conclude the sequence, several questions can be opened:

- **How has your understanding of the urban noise issue evolved during this activity?**
- **What are the most useful sources of information in your documentary research? Why?**
- **How does the process of creating indicators help you better structure your approach to the noise issue?**
- **What challenges were encountered when developing the indicators? How did you overcome them?**
- **How do the indicators we have developed allow for a more nuanced analysis of urban noise?**
- **How do you think this corpus of indicators can be used to evaluate and improve the sound environment in your neighborhood?**
- **What aspects of the urban noise issue still seem difficult to capture with the indicators we have created?**

Step 2: Sensitive noise mapping

Background and description of the problem to be solved in this step: This phase focuses on creating a sensitive noise map in the students' daily environment. They will apply the indicators developed previously to evaluate and visually represent their perception of the soundscape on a familiar route. This practical step will allow students to translate their feelings into a free visual representation, while developing their sensitivity to the sound environment.

Learning Objectives: Through this phase, students will develop essential skills in mapping and visual expression. They will learn to translate their sound perceptions into graphic representations, thus strengthening their ability to analyze and express themselves. Creating personalized maps will allow them to understand the importance of subjectivity in the experience of noise. By practicing observation and self-evaluation of their daily sound environment, they will develop an increased awareness of their soundscape, crucial for their understanding of the impact of noise on their well-being.

This step can be done in partnership with art education.

Conceptualisation

In this phase, students delve deeper into the central hypothesis formulated in phase 1, namely that **individual perceptions of noise vary according to areas and times of day**. Sensitive noise mapping allows for exploring this hypothesis in a more detailed and personal way.

Students will use sensors to precisely measure noise levels, while assessing their well-being and performance using the indicators developed previously. They will seek to establish links between sound fluctuations and variations in their well-being and performance indicators. This will allow them to move from theory to practice by directly testing their hypothesis in their daily environment.

The use of sensitive mapping offers a unique approach to explore this hypothesis:

- **Visual representation of perceptions:** By creating maps based on their feelings, students can illustrate how their perception of noise varies according to places and times, thus giving a spatial and temporal dimension to the initial hypothesis.
- **Subjective exploration:** This method allows going beyond quantitative measurements to include qualitative aspects of the sound experience, thus enriching the understanding of the variation in perceptions.

Through this exploration, students address crucial issues of the scientific method:

- **Collection and processing of subjective data:** Sensitive mapping involves collecting and organizing qualitative data, which allows students to learn how to structure and analyze subjective information systematically.
- **Critical analysis of measuring a health phenomenon:** By comparing their subjective perceptions, students develop a critical view on how to evaluate the impact of noise on health and well-being.

Students Investigation

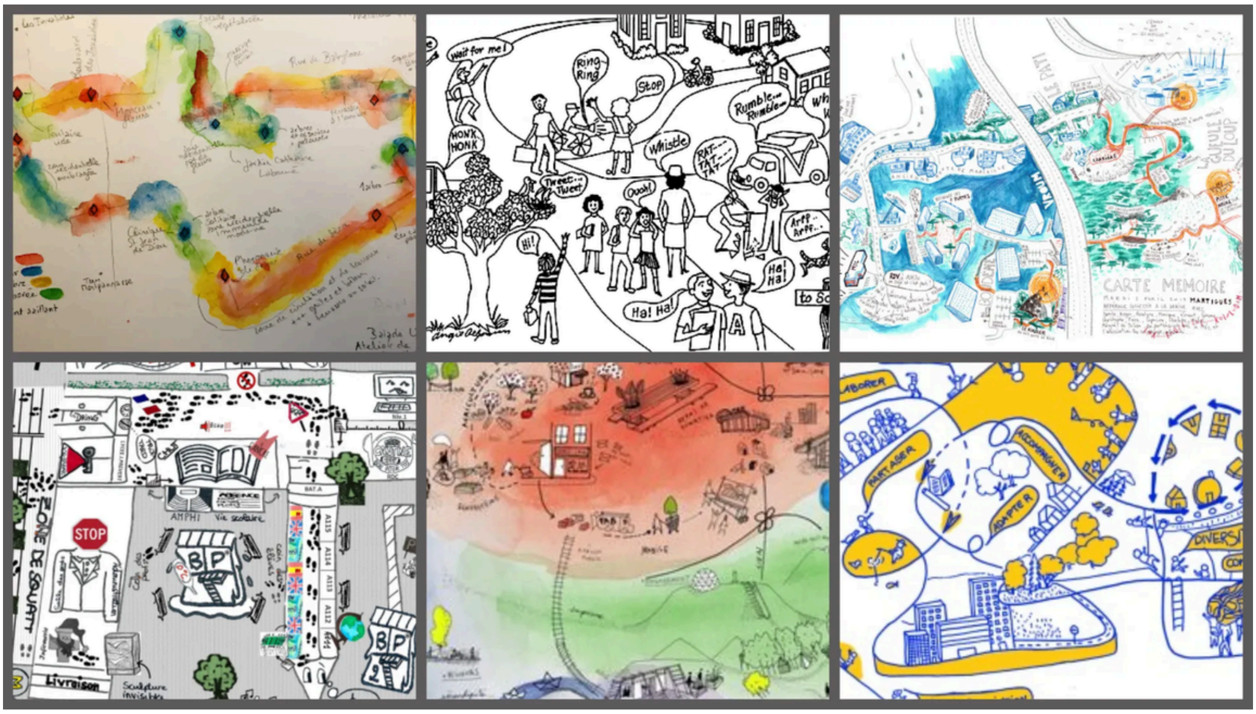
<u>Preparation of sensitive mapping</u>
The teacher will introduce the concept of sensitive mapping. This will involve visually representing subjective perceptions of the soundscape. The adopted approach will encourage students to break free from formal geographic constraints to focus on their feelings about noise. Each student will choose to represent a daily route (school/home, after-school/home, lunch break, etc.) in the form of a free drawing, which will not need to respect traditional mapping standards i.e. respect of scale, cardinal orientation, legend ... . The teacher will encourage students to consider the following elements when creating their map: zones of sound comfort or discomfort, variations in sound ambiance

(calm, lively, stressful), notable noise sources (positive or negative), emotions or sensations associated with certain places, based on the indicators defined in phase 1.

Methodological note. Sensitive mapping.

Sensory mapping is an approach that allows for representing the subjective experience of a territory. It aims to capture and represent the perceptions and sensations felt in a given space. It focuses on the effect that the environment produces on us. The main objective is to capture **the experience** produced by the territory, rather than the territory itself.

In the specific field of study, while a sound map can represent the sounds heard in a city, a sensory map will represent emotions, illustrating this by mapping spaces perceived as reassuring, worrying, annoying, etc. The sensory map typically **takes the form of a drawing**. This drawing escapes the norms of cartographic representation: disregard for scale, absence of cardinal orientation, absence of legend, subjective indications on the map, partial representation of reality. However, it is also possible to use an existing map and annotate it with drawings and graphic additions (pictograms, color flows according to feelings, drawings, etc.).



[Sensitive mapping - Klär.graphics]

[What is Sensitivity Mapping, and Why is it Important? | NOAA's Office of Response & Restoration Blog]

[An attempt to define perceptive and sensitive mapping through lived space experiments]

Creation of individual mapping

Each student will create their sensitive map based on their daily experience of the chosen route. They will use drawings, colors, symbols, or keywords to express their sound and emotional perceptions. This step will require reflection and analysis of their feelings, allowing them to think about their daily life in a new way around the issue of noise. The emphasis will be on free and creative expression of their subjective experience rather than on geographical accuracy.

Collective analysis of maps and creation of a synthesis map

Students will present their sensitive maps to the class and compare their results. This step will foster discussion and highlight similarities and differences in individual perceptions of noise, as well as common places that emerge from the different routes represented. Together, the class will be able to develop a more formal synthesis map that integrates key elements from individual sensitive maps. This map will combine subjective perceptions with a more traditional geographical representation, allowing visualization of sound "hot spots", quiet areas, and the most frequented routes. It will serve as a basis for the subsequent phases of the study.

Conclusion & Further Reflexion

To conclude this phase, students will reflect on the process of sensitive mapping and its results. To conclude the sequence, several questions can be opened:

- **What were the noisiest and quietest areas identified? Was there a general consensus or significant divergences?**
- **What factors seem to most influence the perception of noise in your environment?**
- **How has this sensitive mapping changed your understanding of your sound environment?**
- **What limitations did you encounter in this sensitive mapping approach?**
- **How could you use these results to propose improvements to your sound environment?**

Step 3 - Quantitative measurement with sensors

Background and description of the problem to be solved in this step: This phase focuses on the quantitative measurement of noise using sensors. Students will program and position noise sensors in areas identified as noisy during the sensitive mapping phase. These sensors will record actual sound levels (in decibels) over several days in various locations. The objective is to compare subjective feelings with measurable data, and examine whether certain perceptions are influenced by specific times or particular noise characteristics.

Learning Objectives: Through this phase, students will develop essential skills in sensor programming and quantitative data analysis. They will learn to use sound measurement tools and critically interpret the results. Moreover, by comparing objective measurements with their sensitive perceptions, students will strengthen their understanding of the complex nature of noise and its impact on the school environment.

This step can be done in partnership with technology and mathematics education.

Conceptualisation

In this phase, students continue to explore the central hypothesis formulated in the previous phases: **subjective perceptions of urban noise vary according to individuals and contexts**. The focus is now on comparing these subjective perceptions with quantitative noise measurements. This step is crucial to validate or nuance the results of the sensitive mapping carried out previously.

Additionally, a new complementary hypothesis is introduced: **Do the quantitative data related to noise closely correspond to the subjective perceptions mapped previously?** This hypothesis will allow for a deeper understanding of the relationship between objective measurements and subjective experiences of urban noise.

During this phase, students will address several key concepts and tools:

- **Collect, process, and analyze a set of data:** Students will learn to collect quantitative data using noise sensors, process it, and analyze it using statistical methods. They will develop data analysis skills to compare these objective measurements with the subjective perceptions mapped previously.

- **Take a critical look at measuring a health phenomenon:** By comparing quantitative data with subjective perceptions, students will develop a critical mindset on measuring noise as a health phenomenon. They will learn to identify the limitations of objective measurements and the importance of taking into account subjective experiences in assessing the impact of noise on health.

- **Analyze interactions between objective measurements and subjective perceptions:** Students will explore the correspondences and divergences between measured noise levels and mapped perceptions. They will learn to interpret these complex interactions and understand the factors that influence noise perception.

- **Visualize and communicate results:** Students will use data visualization tools to represent both quantitative measurements and subjective perceptions. They will learn to choose the most appropriate representations to highlight correlations or disparities between these two types of data.

This phase will allow students to develop essential skills in data collection and analysis, critical thinking, and scientific communication.

They will deepen their understanding of the complexity of urban noise assessment by integrating both quantitative and qualitative approaches.

Students Investigation

Introduction to sound measurements

The teacher will explain the basic concepts of sound measurement, including decibels (dB) and different measurement scales. They will also present the noise sensors that will be used, explaining their operation and limitations.

> **Advice for Teachers**: We recommend using a set of programmable Micro:bit cards to carry out this activity. They incorporate a sound level sensor and are easily available and programmable. To help you programming these boards, you have access to a "Practical Implementation" Section, in the form of an activity sheet enabling to use the Micro:bit boards and providing you the code to use if you want to realise this part of the procotol.

Planning measurements

Based on the synthesis map created in the previous phase, the class will identify key points where to take measurements, according to the number of available sensors. The goal will not be to collect a large number of measurements, but to understand how to take measurements and question their feelings about noise. These points should include areas perceived as the noisiest and quietest. The class will be divided into groups, each responsible for a specific measurement point. A sensor positioning table will be created to organize data collection:

Location	Zone type	Measurement duration	Responsible	Observation from sensitive mapping
Léa's garden	Quiet residential area	1 week	Group 1	Space perceived as quiet and relaxing
In front of the school	High traffic area	1 week	Group 2	Area commonly perceived as noisy
Municipal park	Green space	1 week	Group 3	Natural and soothing sound ambiance
Shopping center	Busy commercial area	1 week	Group 4	Dynamic sound environment, sometimes tiring
Main intersection	High traffic intersection	1 week	Group 5	Area perceived as very noisy and stressful

This table will allow for efficient organization of data collection by identifying key locations, zone type, measurement duration, and groups responsible for each measurement point.

Data collection

The sensors will be programmed and then positioned at the identified points. Care should be taken to select a safe location (for example, in a student's garden, in a shop...). The sensors will be programmed to take readings at fixed times, for example once per hour, day and night. This data will be sent to a central server. It will be important to measure continuously over a given period (for example, a week including a weekend) to analyze variations.

> **Advice for Teachers**: You will find below a "Practical Implementation" Section, in the form of an activity sheet enabling to use the Micro:bit boards and providing you the code to use if you want to realise this part of the procotol. Various collection methods can be organized:
>
> - Option 1 (**multiple boards**): Use 5 Micro:bit boards to collect data simultaneously from 5 students for a week, then repeat the operation with 5 other students the following week.
> - Option 2 (**single board - less expensive**): Use a single Micro:bit board and rotate it among students. Collect data for 2 days from each student, over a total period of 15 days, to obtain a representation of multiple collection points.

Data analysis

Once the collection period is over, students will compile the CSV files from the various positioned sensors to analyze the data.

A CSV (Comma-Separated Values) file is a simple text file format for storing tabular data. Each line represents a record, with values separated by commas. It is easily readable by spreadsheets and commonly used for data exchange.

They can create an analysis table such as:

Location	Average sound level	Daily average	Nightly average	Peak	Initial perception	Observations
Léa's garden	52	55	45	60	Quiet, relaxing area	Generally low sound level, occasional peaks due to gardening activities
In front of the school	62	70	40	85	Area initially perceived as noisy	Generally low levels, very high peaks at student entry/exit times
Municipal park	57	60	50	65	Pleasant space, soothing natural sounds	Average level higher than expected, influence of recreational activities
Shopping center	72	75	65	80	Lively atmosphere, sometimes tiring	High sound levels but perceived as less annoying than traffic
Main intersection	82	85	75	90	Very noisy, uncomfortable area	Highest sound levels, confirms initial perception

Based on the analyses and tables, students can create graphs and visualizations to represent measured noise levels and periods. They will compare these quantitative results with their sensitive mapping, discussing similarities and differences, exploring possible reasons for discrepancies between objective measurements and subjective perceptions. They will also reflect on the limitations of quantitative measurements and the importance of considering both objective data and subjective experiences in assessing urban noise.

Conclusion & Further Reflexion

To conclude this phase, students will reflect on the quantitative measurement process and its results. To conclude the sequence, several questions can be opened:

- **How have the quantitative measurements confirmed or challenged your initial perceptions of noise in your environment?**
- **What factors could explain the differences between objective measurements and subjective perceptions?**
- **What are the limitations of quantitative measurements in assessing the impact of noise on quality of life?**
- **How could you combine qualitative and quantitative approaches for a more comprehensive understanding of the sound environment?**
- **What recommendations could you make to improve the sound environment in your neighborhood, based on your measurements and observations?**

Step 4 - Analysis of stakeholders' roles in addressing a public health issue

Background and description of the problem to be solved in this step: To conclude the noise study protocol, the final phase aims to analyze the role of different actors in managing urban noise nuisances. Students will examine the aggravating factors of noise in problematic areas identified, study the impact of urban planning and human activities on noise pollution, and explore the roles of actors involved in noise reduction. The objective is to understand the importance of cooperation between these actors to improve quality of life in the city. This step is important to conclude the protocol as it allows students to put their work into perspective, understand its implications for the community, and synthesize the knowledge acquired throughout the study.

Learning Objectives: During this phase, students will develop skills in public policy analysis and applied research. They will learn to identify the main factors of urban noise, understand the role of different stakeholders in its management, and explore potential solutions. This step will strengthen their critical thinking, ability to solve complex problems, and understanding of issues related to urban noise and the importance of a collaborative approach.

Conceptualisation

In this final step, students focus on an opening question that will allow them to synthesize the learning acquired during this protocol and broaden the reflection towards wider societal issues: **How do urban planning and human activities influence noise pollution, and what is the role of different actors in its management?**

To answer this question, students will explore several key concepts:

- **Identify public health concerns:** Students will analyze how urban noise is recognized as a public health issue by examining its effects on the physical and mental well-being of residents.
- **Analyze how a society identifies a health risk:** They will study the process by which noise has gone from being a simple nuisance to a recognized health risk, exploring the role of scientific studies, media, and public awareness.
- **Present the role of different actors:** Students will identify the actors involved in urban noise management (local authorities, urban planners, associations, citizens) and analyze their respective responsibilities and actions to mitigate noise pollution.

This work will allow students to develop a comprehensive understanding of the urban noise issue, integrating their field observations, data analyses, and broader reflection on societal issues and governance in public health.

Students Investigation

Mind map of conclusions and aggravating factors

Students will create a mind map synthesizing their conclusions on the characteristics of urban noise, based on their previous data analyses and observations. It can take an A3 or A2 format and be used to communicate about the class's achievements in the field of noise. The main sources of noise will be identified (road traffic, commercial activities, construction sites, noisy individual behaviors) and detailed according to the study's observations. They will be qualified by integrating their intensity, frequency, and impact on well-being. For each type of noise, the responsible or impacted actors will be identified. This may include the municipality, local businesses, residents, urban planners, or neighborhood associations. This branch will help understand who can act on each noise issue.

Analysis of actors' actions

Students will study how each actor addresses (or not) the noise issue. They can conduct research on existing policies, contact the city hall, consult official documents, or interview local experts. The objective will be to conclude on the effectiveness of public action in the field of noise.

Presentation to local actors (optional)

If possible, students can organize a presentation of the study results (mind maps, analyses, conclusions) to the identified local actors. This will allow valorizing the students' work and potentially influencing local noise management policies.

Conclusion & Further Reflexion

This phase will serve as a conclusion to the study work by understanding how actors address the noise issue at the territorial level. Students can explore several axes to evaluate their learning during the protocol:

- **How has this activity changed your understanding of urban noise and its impact on public health?**
- **How can citizens play an active role in reducing urban noise?**
- **What skills have you developed during this project (data collection, analysis, communication, etc.)?**
- **What was the most surprising or interesting aspect of this study for you?**

Practical Implementation

Programming your Micro:bit for measuring sound level

Material and tools needed

To program a micro:bit board to measure sound level, you will need:

- **Micro:bit V2 Boards and its built-in sensors**: The main programmable board including a built-in sound level sensor - Around 19 EUR per micro:bit (check prices here)
- **Micro-USB Cables**: For powering and programming the micro:bit
- **Battery Packs** (optional): For portable operation if the micro:bit needs to be untethered - You can check the official micro:bit battery back available for purchaising around 2,20 EUR per pack here

Depending on the collection methods you opt for, you will need:

- **Option 1 (multiple boards): 5 Micro:bit boards** to collect data simultaneously from 5 students for a week, then repeat the operation with 5 other students the following week.
- **Option 2 (single board - less expensive): 1 Micro:bit board** and rotate it among students. Collect data for 2 days from each student, over a total period of 15 days, to obtain a representation of multiple collection points.

You can purchase Micro:bit V2 kit including the USB cable and battery pack for 21 EUR per kit (check here), or 177 EUR for 10 kits (check here).

- **Computer or Tablet**: To write and upload code.
- **Programming Environment**: MakeCode Online Editor

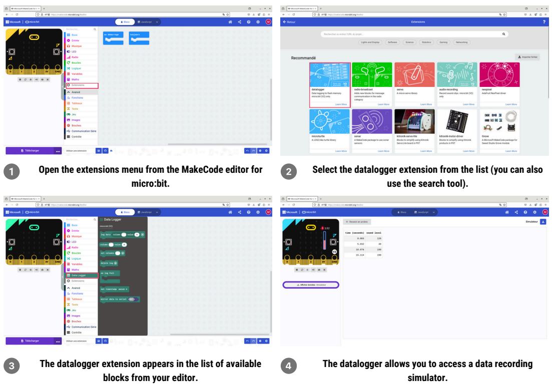
Instructions for wiring and using the micro:bit board

Step 1: Programming the Micro:bit

Connect the Micro:bit board: With your USB Cable, connect the board to your computer by using the **micro-USB connector**. Once connected, the micro:bit board will appear on the computer as a removable drive (e.g., "MICROBIT").

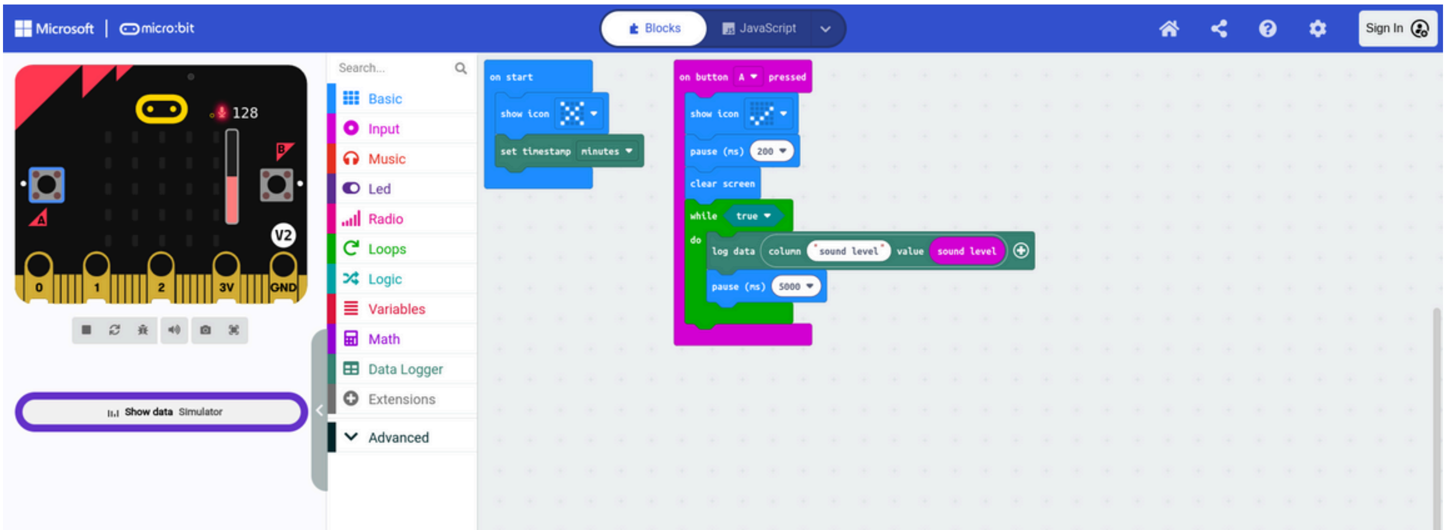
Write the Program: Open the MakeCode editor to create a program that collects light, noise, and temperature data using the built-in sensors of the Micro:bit V2 programming board. Give a clear name to your project before starting.

Once on the editor, and after creating your new project, you will get the default "ready to go" screen shown here and will need to install an **extension**. **Extensions** in MakeCode are groups of code blocks that are not directly included in the basic code blocks found in MakeCode. Extensions, like the name implies, add blocks for specific functionalities. There are extensions for a wide array of very useful features, adding gamepad, keyboard, mouse, servo and robotics capabilities and much more. In the block display columns, click on the **EXTENSIONS** button. In the list of extensions available, search for the **Datalogger extension** that will be used for this activity. Click on the extension you want to use and a new block group will appear on the main screen.

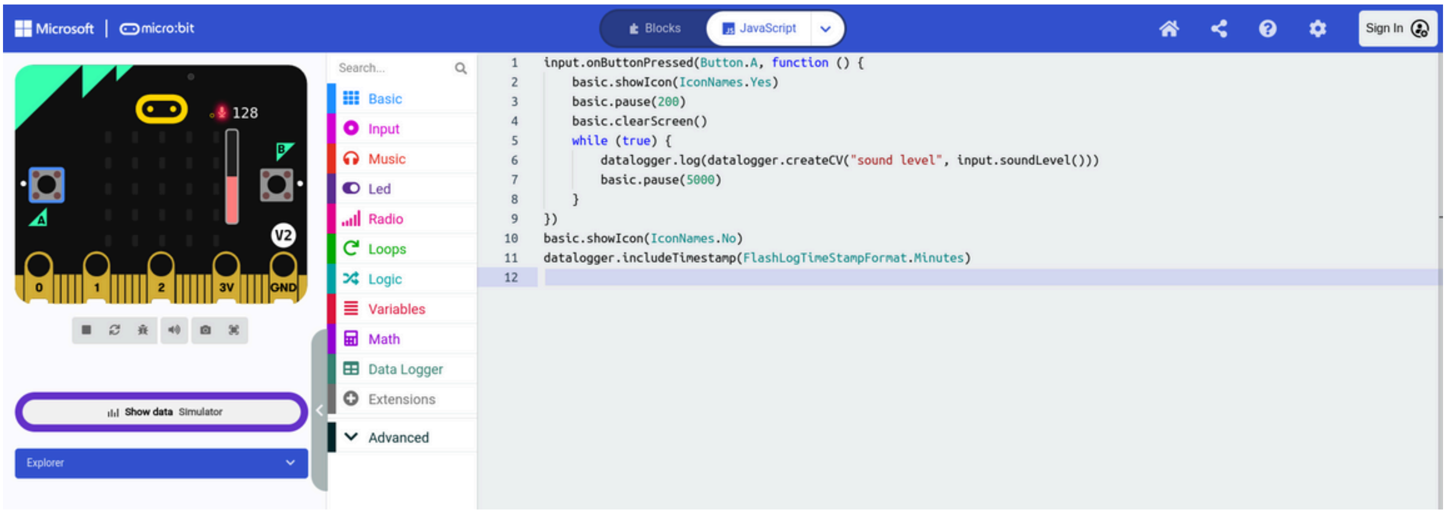


1. Open the extensions menu from the MakeCode editor for micro:bit.
2. Select the datalogger extension from the list (you can also use the search tool).
3. The datalogger extension appears in the list of available blocks from your editor.
4. The datalogger allows you to access a data recording simulator.

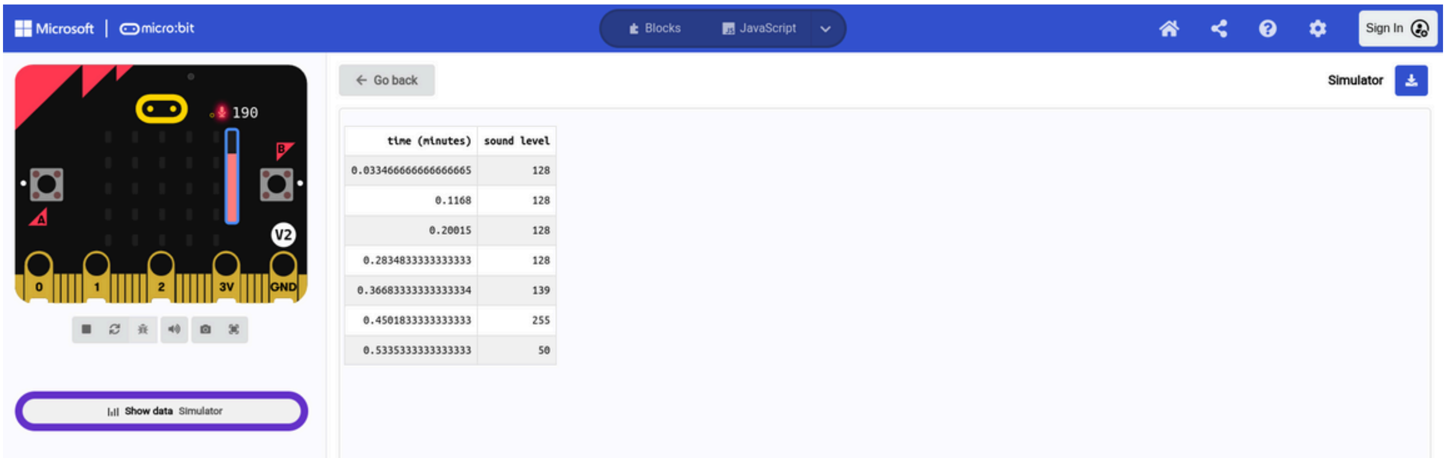
Then, you can start arranging your block following the code provided below (add an infinty loop, record data in the datalogger ...).



You can also copy paste the code in the Javascript editor available.



Test the program using the simulator in MakeCode.



Once your program is working properly on the simulator, transfer it to your Micro:bit: click **"Download"** in MakeCode to generate a .hex file. This file contains the compiled program that will allow the board to function. Copy the .hex file from your download folder to the "**MICROBIT**" removable drive. Once the file is copied, the board automatically restarts and executes the code.

<u>Step 2: Placing the Micro:bit and start recording data</u>
Once programmed, place the micro:bit for collecting the data you need i.e. in one student backyard, in the park next to the school, in the town hall ... depending on your location selection. Use an external battery pack to ensure that your board will collect data over the week for instance.

When positionned, press button "A" on the MicroBit to start data recording via the program.

<u>Step 3: Retrieving data and cleaning up the board for the next recording session</u>
Once the collection period is done, you can retrieve your data from the datalog file **called "MY_DATA.HTM, available on the micro:bit drive**. Copy it on your computer and rename it with the current date (e.g., LOCATIONNAME.HTM).

After copying and renaming the file, delete the **MY_DATA.HTM** file from the MicroBit board to free up space and allow for new data recording.

Once opened, the data log pages will be accessible in HTML format. They will provide all collected data and allow you to download it in .csv format.

Code

Here is the Javascript code used to program a micro:bit board in order to regularly collect data on light, noise and temperature:

```
input.onButtonPressed(Button.A, function () {
    basic.showIcon(IconNames.Yes)
    basic.pause(200)
    basic.clearScreen()
    while (true) {
        datalogger.log(
        datalogger.createCV("sound level", input.soundLevel())
        )
        basic.pause(5000)
    }
})
basic.showIcon(IconNames.No)
    datalogger.includeTimestamp(FlashLogTimeStampFormat.Minutes)
```

<u>How does the code work?</u> This program measures the ambient sound level (in decibels) every 5 seconds (the interval can be modified to correspond to 1 minute, 5 minutes, twice per hour...) and compiles the information in a "**datalogger**" from which we can download a .csv file.

A **.csv** file (Comma-Separated Values) is a text file format used to store tabular data (like in a table or spreadsheet). Each line of the file represents a row of data, and each value in a line is separated by a delimiter (often a comma, but sometimes a semicolon or tab). It is possible to retrieve data from a .csv file in spreadsheet software like Excel or LibreOffice Calc. In Excel, open the software, click on **File > Open**, select the .csv file, and configure the delimiters if necessary via the import tool. In LibreOffice Calc, follow a similar process: click on **File > Open**, select the file, and use the import wizard to choose the delimiter (for example, comma or semicolon). In both cases, the data appears in table form, ready to be analyzed.

Initialization of button "A" press event: When the user presses **button "A"** on the MicroBit, the function `input.onButtonPressed(Button.A, function () {...})` is triggered.

Display of "Yes" icon during execution: Before starting data recording, the program displays the **"Yes"** icon (`basic.showIcon(IconNames.Yes)`) for **200 milliseconds** (0.2 seconds) to indicate that the recording process has started.

200 millisecond pause: After displaying the "Yes" icon, the program waits **200 milliseconds** using `basic.pause(200)`.

Screen clearing: After the 200 millisecond pause, the screen is cleared with `basic.clearScreen()`, which prepares the screen for what follows without being cluttered with images.

Infinite data collection loop: The program enters an infinite loop `while (true)`. This means that data will be collected and recorded endlessly until the MicroBit is turned off or restarted.

Recording data in the datalogger: At each loop iteration, the program records the values from the MicroBit sensors regarding **sound level** using `input.soundLevel()`, which captures the ambient sound level.

The **sound level** measures a **relative** value and do not have standard units like decibels (**dB**). Specifically, the sensor measures perceived intensity. This value is a numerical estimate (from 0 to 255), where 0 represents the minimum value (complete silence/complete darkness) and 255 the maximum value (a very loud noise/intense light).

These values are recorded in the **datalogger** as variables with name "sound level". This is done via the `datalogger.log()` function:

```
datalogger.log(
    datalogger.createCV("sound level", input.soundLevel())
)
```

The `createCV` function allows creation of a "CV" (context value) for each sensor, and the `datalogger.log` function allows recording these values in a file on the MicroBit.

5 000 millisecond pause before next reading: After each recording, the program waits **5 000 milliseconds** (5 seconds) before reading the sensor values again. This is achieved with `basic.pause(5000)`. You can change the duration of the pause to capture more or less data (for instance, every minute).

Data timestamping (included via `datalogger.includeTimestamp`): Outside the button-linked function, the command `datalogger.includeTimestamp(FlashLogTimeStampFormat.Minutes)` is used to include a timestamp with each data recording. The timestamp format is in **minutes**, meaning each recording will have a time indicator based on minutes elapsed since program start.

Display of "No" icon before execution: Before the user presses button "A", the program displays a **"No"** icon (basic.showIcon(IconNames.No)) to indicate that the MicroBit is waiting for user action.

Exploring the theme of noise

What is noise?

Noise, defined as an unpleasant or disturbing auditory sensation, is omnipresent in our daily lives and constitutes a significant source of environmental pollution. According to the European Environmental Agency, about **95 million people** are exposed to harmful levels of road traffic noise. At least **20% of the urban population** is exposed to levels considered harmful to health. In many cities, this percentage can reach 50% of the urban population. It is estimated that at least **18 million people** are highly annoyed and 5 million are highly sleep disturbed by long-term exposure to noise from transport in the EU. In addition, it is estimated that long-term exposure to transport noise causes about 11,000 premature deaths and 40,000 new cases of ischaemic heart disease.

https://www.eea.europa.eu/en/topics/in-depth/noise?activeTab=fa515f0c-9ab0-493c-b4cd-58a32dfaae0a

Noise is a **sound vibration** perceived by the human ear. Although some sounds are perceived as pleasant or neutral, noise becomes harmful when it is felt to be **unpleasant**, **unpredictable** or **uncontrollable**. These characteristics can transform noise into a factor of **stress** and **dissatisfaction** in living or working environments.

It is measured in **decibels (dB)**, a unit that indicates the intensity of sound, and this varies according to situations:

- **30 dB**: quiet place (bedroom, rest area).
- **65 dB**: busy street or classroom.
- **85 dB**: danger threshold for the ear (barking, crying baby).
- **100 dB and above**: concerts, jackhammer, ambulance siren.

An **acceptable sound level for work requiring sustained attention** is between **45 and 55 dB**.

Effects of noise on health

Noise, particularly when **chronic**, can have many adverse effects on health:

- **Stress, irritability and anxiety**, sometimes leading to **aggression** or **depression**.
- Impairment of **concentration**, **memorization** and **comprehension** of spoken or written language.
- Hindrance to **communication** and disruption of **cognitive tasks**, especially those involving **short-term memory**.

These impacts are particularly notable in learning and work environments, where noise can **compromise the quality of education** and **reduce employee productivity**.

Excessive and prolonged noise negatively affects physical and mental health. It can cause **sleep disorders**, **chronic discomfort**, and **cardiovascular problems**. According to the European Environment Agency (EEA), **ambient noise due to road traffic** is one of the main sources of noise pollution. About 20% of the European population — over 100 million people — is exposed to noise levels deemed dangerous to health. The EEA estimates that each year, prolonged exposure to noise contributes to approximately **48,000 new cases of heart disease** and **12,000 premature deaths**. Additionally, **22 million people** experience significant chronic discomfort, and **6.5 million** suffer from severe sleep disorders.

Noise also affects cognitive health, especially in children. For example, aircraft noise has been associated with **reading disorders in about 12,500 schoolchildren**. Although air pollution causes more deaths, noise has a more immediate impact on **quality of life** and **mental well-being**, according to WHO studies.

Directive 2002/49/EC

Noise, particularly when **chronic**, can have many adverse effects on health:

Directive 2002/49/EC, also known as the **Environmental Noise Directive**, is a European law that aims to measure and manage noise levels in the environment to protect citizens' health. Noise affects at least 1 in 5 Europeans, causing problems such as cardiovascular diseases, sleep disorders, and annoyance.

https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32002L0049

It establishes a common approach in the European Union to identify and act on noise pollution levels. It pursues the following objectives:

1. **Assess noise exposure**: Measure noise levels in residential areas and evaluate their health effects, particularly through **noise maps**.
2. **Inform the public**: Ensure that citizens are informed about noise levels in their environment and their effects.
3. **Prevent and reduce noise**: Protect citizens by reducing noise levels in areas where they are too high.
4. **Preserve quiet areas**: Maintain sound quality in areas where noise is still low.

The directive does not set specific noise levels not to be exceeded; this is left to national authorities. Common methods are used to calculate noise exposure (indicators **Lden** for daily noise and **Lnight** for night noise).

The directive has been revised to improve noise calculation methods and to better take into account the **effects of noise on health**, based on the latest studies from the World Health Organization (WHO). In 2023, a report shows that progress has been made, but more efforts are needed to reduce by 30% the number of people affected by noise by 2030, in line with the **Zero Pollution Action Plan**.

The implementation of the European Noise Directive has not achieved all objectives, particularly due to a lack of data and insufficient production of **noise maps** and **action plans** in some regions. Nevertheless, various strategies are being implemented, such as the use of **noise-reducing road surfaces**, the development of **electric vehicles**, and the creation of **quiet zones** in cities. A combined approach aimed at reducing both noise and air pollution could optimize public health outcomes.

https://www.eea.europa.eu/publications/environmental-noise-in-europe

Ideas of Complementary Projects

Oases of silence: Creating and mapping quiet zones in the city

Oases of silence are urban spaces designed to offer respite from ambient noise, to improve urban quality of life. This approach is illustrated by existing projects such as the Tranquil City initiative in the United Kingdom or the NGO Quiet Parks International. Students could draw inspiration from these initiatives to imagine and design their own oases of silence adapted to the local context. Students could identify locations in their neighborhood, measure sound levels, and propose improvements to create oases. They could use applications like **Hush City** to get inspired and share their discoveries. This activity would allow for the exploration of urban planning concepts, urban ecology, and public health, encouraging reflection on sustainable urban space development.

Explore further:

- Quiet Parks International
- Are quiet places going extinct? Meet the volunteers who are trying to change that.
- Manifesto - Tranquil City
- HUSH CITY APP

Urban Symphony: Composing a Musical Work from City Sounds

Cognitive tests are commonly used in psychology and neuroscience to evaluate the effects of various environmental factors on mental performance and well-being. They go beyond simple memorization exercises and allow for exploring dimensions such as sustained attention, processing speed, or the perception of subjective well-being. In a school setting, their use in practical activities helps students better understand the impact of noise on their mental efficiency and feelings. Students could program the Micro:bit to display sequences of numbers to memorize and compare performances according to noise levels.

Explore further:

- R. Murray Schafer
- The Sonic City with Tod Machover of MIT Media Labs
- Audacity, le logiciel libre pour enregistrer et éditer vos fichiers audio

Link with biodiversity: Impact of urban noises on local fauna

In public and professional spaces, audio or visual alert systems are often used to monitor and limit sound levels. For example, some libraries or daycare centers use devices that signal when sound thresholds are exceeded. In schools, such a system can raise students' awareness of the importance of their own behavior in creating a calming environment. Designing such a device with Micro:bits introduces students to engineering and electronics concepts while offering them an immediate and practical awareness of noise issues. This could raise students' awareness of their sound environment in real-time.

Explore further:

- Sons et biodiversité en ville: favoriser des paysages sonores de qualité pour les êtres vivants | Cerema
- Home
- iNaturalist

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   The European directive establishing a framework for assessing and managing environmental noise.
4. **Sons et biodiversité en ville: favoriser des paysages sonores de qualité pour les êtres vivants | Cerema**
   Discusses urban noise pollution and strategies to enhance soundscapes for biodiversity and human well-being.

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   Offers resources and project ideas for using micro:bit in educational settings, including environmental monitoring.
2. **NoiseCapture Interactive Community Map**
   A citizen science project mapping global noise pollution through user-recorded data.
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   A mobile app enabling users to identify and map quiet urban areas, supporting soundscape preservation.
4. **Audacity: Free Audio Recording and Editing Software**
   An open-source tool for recording, analyzing, and editing sound, ideal for noise monitoring and analysis.

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   Highlights efforts to identify and protect quiet spaces amid increasing noise pollution.
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   A video on using technology to design interactive soundscapes for urban environments.
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   A platform that engages citizen scientists to document biodiversity, including sound-based observations.
4. **Home - Utopia Lille 3000**
   A creative platform exploring urban challenges, including soundscapes and environmental issues.