STEAMCITY CURRICULUM

DECIBEL DETECTIVES

Noise and learning abilities

thematic: environment, well-being and public health

Introduction

This protocol explores **the impact of noise on learning and well-being in school environments**. Following the steps of the **scientific method**, students will conduct an experiment to collect, analyze, and present quantitative and qualitative data to address their research question. 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

They will familiarize themselves with noise-related issues, design their own study protocol, program sound level meter sensors, and analyze the collected data. This approach develops various skills and deepens their understanding of how the sound environment influences their daily school life.

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

Interdisciplinarity

biology
social and health sciences
technology and engineering
mathematics

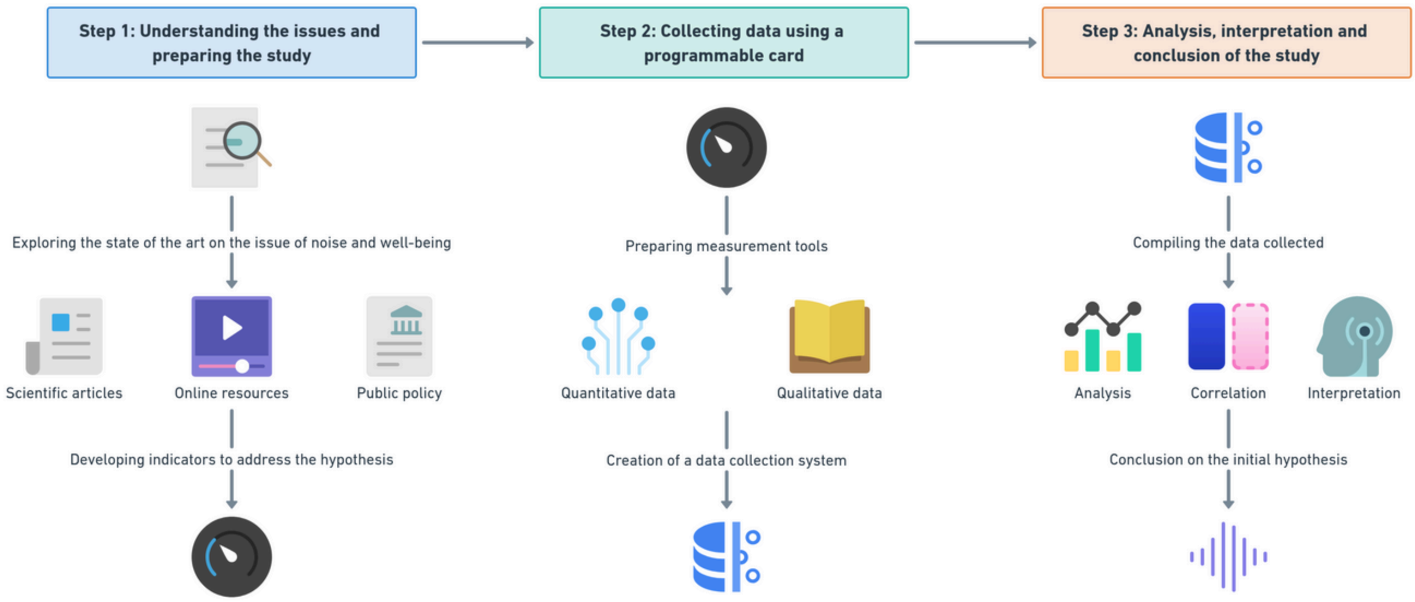
Sustainable Development Goals

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Overview

Protocol Structure



Step 1: Understanding the issue and preparing the study

Students will begin with a documentary study on the relationship between noise and cognitive abilities. They will explore scientific articles, study reports, and online resources to understand the effects of noise on learning and well-being. This research will allow them to become familiar with key concepts and existing evaluation methods. Following this study, they will collectively develop **indicators** to assess their well-being and cognitive performance, such as fatigue level, concentration ability, quality of class participation, perceived stress level, and performance in specific cognitive tasks. These indicators will form the basis of a structured analytical framework for the rest of the activity.

Step 2: Data Collection

During step 2, students will implement their protocol. They will start by preparing the measurement tools. They will program decibel sensors to take automatic readings according to the established protocol. They will learn the basics of programming and using sensors. They will develop a structured logbook to record daily assessments of well-being and cognitive performance, as well as potentially influential external factors (physical activity, weather, type of classroom activities, sleep quality). The sensors will be positioned in the classroom to take automatic sound level readings according to the established protocol, for one week. Each day of the study week, students will complete their logbook, evaluating their well-being and cognitive performance indicators, and noting external factors. Students will also note in their journal any particular events that may influence the noise level or their well-being (for example, construction work near the school, important evaluations).

Step 3: Analysis, interpretation, and conclusion of the study

Once the collection week is over, students will compile and analyze the data according to the methods defined in their experimental protocol. Based on these analyses, students will create graphs and visualizations to represent the correlations between noise levels and the various indicators of well-being and cognitive performance. They will also examine the influence of external factors on these relationships. Students will interpret the results of their analysis and reflect on their implications. Several questions will guide their reflection: what correlations did you observe between noise level and your well-being/cognitive performance indicators, how did other factors (physical activity, weather, type of classroom activity) influence these relationships, what recommendations could you make to improve the sound environment of the classroom and optimize learning conditions, what were the main difficulties encountered during this study, and how could the protocol be improved for future investigations... Students will synthesize their results and conclusions in a visual presentation (for example, a scientific poster or a presentation).

Getting started

Steps	Duration	Difficulty	Material
Step 1 **Preparing**	30 minutes	★☆☆☆☆	• Internet access for documentary research • Whiteboard or large paper for protocol creation • Markers of different colors • Post-its for brainstorming
Step 2 **Collecting**	30 minutes for programming + 1 week of data collection	★★★☆☆	• 1 programming board e.g. Micro:bit integrating a noise level sensor • Computer to program the board and collect data • A power supply solution (PC or external battery) • Printed or digital logbooks for each student
Step 3 **Analysing**	1 hour	★★★☆☆	• Computers with data processing software (e.g., Excel, Google Sheets, Libre Office) • Software for creating graphs and visualizations (e.g., Canva Education, Genially) • Materials for creating scientific posters or presentations (paper, markers, presentation software) • Projector or screen for final presentations

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 preparing the study

Background and description of the problem to be solved in this step: The main objective of the first sequence of this protocol on noise is to **prepare a study protocol around the issues of noise on learning and well-being in school environments**. This initial phase allows students to familiarize themselves with key concepts and existing evaluation methods in the field of noise. The goal is to lead them to measure and collectively develop relevant indicators to assess well-being and cognitive performance in the school context. These indicators, such as fatigue level, concentration ability, quality of class participation, perceived stress level, and performance in specific cognitive tasks, 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 complex relationship between noise and cognitive abilities, which will help them better grasp the importance of a balanced sound environment for their learning. They will also develop skills in documentary research, essential for deepening their understanding of the subject. Additionally, students will learn to design measurement indicators, a crucial skill for any scientific approach. Finally, they will be led to prepare a scientifically valid study protocol, which will allow them to develop their methodological rigor and critical thinking.

Conceptualisation

The central hypothesis to explore in this phase is that **the noise level in the classroom has a significant impact on students' well-being and cognitive performance**. This hypothesis falls directly 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 noise in school environments and its effects. This research work will allow them to understand the importance of this issue and argue for the relevance of a study on the health status and well-being of students in relation to their sound environment. By exploring the concepts of **well-being** and **cognitive performance**, students will be led to reflect on appropriate indicators to assess the health status and well-being of a population, in this case, the school community. They will need to consider indicators such as stress level, concentration ability, or sleep quality, all of which can be affected by prolonged exposure to noise.

The complementarity of indicators will be a crucial aspect to examine. Students will need to understand how different types of measurements (subjective and objective) can complement each other to give a more complete picture of the impact of noise. For example, they could consider combining measurements of sound levels in decibels with subjective assessments of acoustic comfort. Finally, to test this hypothesis rigorously, students will need to argue for the choice of method and data collection tools.

Students Investigation

__Documentary study and pollution identification__

To start the activity, students will conduct documentary research on the relationship between noise and cognitive abilities. They will analyze articles, study reports, and relevant resources to understand the effects of noise on learning and well-being. This step will allow them to acquire a knowledge base and familiarize themselves with key concepts and existing evaluation methods.

Protocol Design

Once the documentary corpus is compiled and studied, students will draw lessons from it to develop a simple but rigorous protocol to evaluate the impacts of noise on their cognitive abilities within the classroom. The protocol will follow the scientific approach, including several key steps: **formulating a clear research question, developing a testable hypothesis, designing and conducting controlled experiments, systematically analyzing collected data, interpreting results and evaluating the initial hypothesis, and finally sharing results and conclusions with the class**. This methodical approach will allow students to rigorously explore the impact of noise on their concentration and cognitive performance in class, using measurement tools, systematic data collection procedures, and appropriate analysis methods. They will learn to identify trends, correlations, and significant relationships between the studied variables, and to formulate conclusions based on empirical evidence.

Protocol Example

1. **Study objective**: To examine how noise levels in the classroom influence our ability to concentrate, memorize, and solve problems, as well as our sense of well-being at the end of a school day.
2. **Hypothesis**: The higher the noise level within the classroom, the more likely students are to experience fatigue, have difficulty concentrating, and see their performance decrease.
3. **Study duration**: A full school week (5 days).
4. **Data collection method**:
    - Quantitative measurements: Use of decibel sensors placed in the classroom, recording sound levels every 5 minutes during the day, for a week of classes.
    - Qualitative measurements: Well-being perception rating grid after each class, daily questionnaire on fatigue level, stress, and perceived quality of the day.
    - Analysis of external factors: Evaluation of particular events that may influence noise level or students' well-being (for example, construction work near the school, important evaluations, weather conditions, special activities - field trips, sports activities...).
5. **Data usage**:
    - Data storage
        - The **quantitative data** from decibel sensors will be stored in a CSV file incorporating date, time, and recorded decibel level information.
        - The **qualitative data** will be entered daily in a personal study journal for each student.
    - Data analysis
        - We will calculate **daily average sound levels** and identify **noise peaks** (moments when the sound level exceeds a predefined threshold). Graphs will be created to **show the evolution of sound level over time**, with **highlighting of peaks**.
        - We will aggregate **well-being and cognitive performance data from all students**. If significant differences are noted in personal journals, additional questionnaires will be considered to integrate new information into our study.
        - We will **visually compare noise levels with each well-being/performance indicator**. We will create **simple graphs showing general trends between noise and our indicators**. We will identify and discuss cases that seem to deviate from these general trends.
        - To deepen our analysis, we will calculate the **correlation coefficients between noise levels and each of our well-being and cognitive performance indicators**. Interpreting these coefficients will help us determine which aspects of well-being and performance are most sensitive to noise variations 👉 *See section "Going further - Understanding correlation coefficients" in phase 3.*
        - We will **categorize the noted external factors** (e.g., weather, type of activity, particular events). We will analyze the impact of these factors on sound levels and well-being/performance indicators. Comparative graphs will be created to show variations according to different contexts.
6. **Presentation of results**: Creation of graphs showing the correlation between noise level and cognitive performance and documentation of the protocol on an infographic that can be shared with the class, the school, or on social networks.

Advice for Teachers: In an active learning approach, it is interesting to let students carry out this protocol design exercise by themselves. However, the teacher will play a crucial role as a guide, adopting a semi-directed approach to ensure that the final protocol incorporates the essential components of the study: **the use of a noise sensor (sound level meter) for objective measurements, and the creation of a survey journal including qualitative analysis of school days over at least a full week**. This approach will ensure scientific rigor while promoting students' autonomy and creativity in their investigative process.

Conclusion & Further Reflexion

At the end of this phase, students will have gained an in-depth understanding of the relationship between noise and cognitive abilities, developed skills in documentary research, and collectively created a structured study protocol. To conclude the sequence, several questions can be opened for discussion:

- **How has your understanding of the relationship between noise and cognitive abilities evolved during this phase?**
- **Which information sources proved to be the most relevant during your documentary study on noise and cognitive performance? Why?**
- **How does the process of creating indicators help you better structure your approach to studying noise in the classroom?**
- **What challenges do you anticipate in implementing the measurement protocol you have designed? How do you plan to overcome them?**
- **How do the indicators we have developed allow for a more nuanced analysis of the impact of noise on well-being and cognitive performance in the classroom?**
- **What aspects of the influence of noise on learning still seem difficult to capture with the protocol we have created?**

Step 2: Data Collection

Background and description of the problem to be solved in this step: This phase focuses on implementing the study protocol previously developed to assess the impact of noise in school environments. Students will apply the scientific methods they have developed to collect concrete data on the effects of noise on well-being and cognitive performance in their school environment. This practical step will allow students to confront their hypotheses with real-world conditions, while developing their skills in data collection and analysis.

Learning Objectives: Through this phase, students will develop essential technical and methodological skills. They will learn to program and use decibel sensors, thus strengthening their technology skills. The structured data collection will allow them to understand the importance of scientific rigor. By practicing daily observation and self-assessment, they will develop critical analysis and personal reflection skills, crucial for their academic and personal development.

This step can be done in partnership with technology discipline.

Conceptualisation

In this phase, students continue to work around the central hypothesis of this protocol, i.e., **the noise level in the classroom has a significant impact on students' well-being and cognitive performance.**

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.

Through this exploration, students will address the challenges of **collecting and processing a set of data to characterize a population in terms of its health**. This approach is fundamental in the scientific method:

- **Data Collection:** This step is the starting point of any scientific investigation. Students will use decibel sensors to measure sound levels in different school spaces, while collecting data on their well-being and cognitive performance. The importance of this step lies in the quality and reliability of the data collected, which will determine the validity of the entire study.

- **Data Processing:** This phase is essential for transforming raw data into usable information. Students will learn to organize and structure the collected data, using digital tools to create tables and graphs. This process is crucial as it allows for highlighting trends and patterns that would not be immediately visible in the raw data.

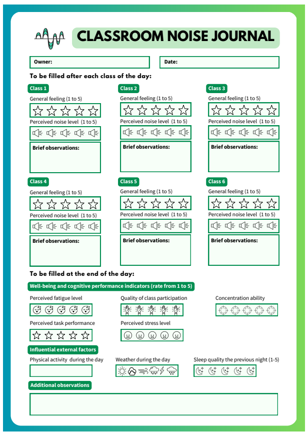
Students Investigation

<u>Preparation and positioning of measurement tools</u>
Students will begin by programming the decibel sensors to perform automatic readings according to the established protocol. This step will allow them to acquire basic skills in programming and sensor use. To do this, they will use a simple visual programming environment suitable for beginners such as MakeCode. They will create a program allowing the sensor to take a measurement every 5 minutes and store this data in a CSV file (Comma-Separated Values, a text file format where data is separated by commas). The detailed code will be provided later to facilitate this task and ensure that programming is not an obstacle to the study. This approach will allow students to understand how data is collected and stored for later analysis, while familiarizing themselves with the basics of programming. The sensors will be positioned in the classroom to perform automatic sound level readings according to the established protocol, for a week.

To facilitate the implementation of this step, you will find in the section “**Practical Implementation**” all the instructions for programming a Micro:bit board and associated sensors to perform these measurements. The code for each measurement is provided, ready to use, if needed.

<u>Creation of the logbook</u>

Students will develop a structured logbook to record daily assessments of their well-being and cognitive performance, as well as potentially influential external factors (physical activity, weather, type of classroom activities, sleep quality) presented here aside and available for print in annex:



CLASSROOM NOISE JOURNAL

Owner:

Date:

To be filled after each class of the day:

Class 1
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

Class 2
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

Class 3
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

Class 4
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

Class 5
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

Class 6
General feeling (1 to 5)
Perceived noise level (1 to 5)
Brief observations:

To be filled at the end of the day:

Well-being and cognitive performance indicators (rate from 1 to 5)

Perceived fatigue level

Quality of class participation

Concentration ability

Perceived task performance

Perceived stress level

Influential external factors

Physical activity during the day

Weather during the day

Sleep quality the previous night (1-5)

Additional observations

<u>Daily data collection</u>

Each day of the study week, students will complete their logbook, assessing their well-being and cognitive performance indicators, and noting external factors. Students will also record in their journal any special events that may influence noise levels or their well-being (for example, construction work near the school, important evaluations).

Advice for Teachers: In an interdisciplinary approach, it could be interesting to present the protocol to other teachers in the class. Those who wish could participate in the study, thus creating a collective dynamic around the project. Volunteer teachers could remind students to fill in their logbook and possibly integrate reflections on noise into their lessons. This collaborative approach, if adopted, would allow students to perceive the importance of the study in different learning contexts and could promote a more global awareness of the impact of noise on their school environment.

Conclusion & Further Reflexion

At the end of this data collection phase, students will have acquired practical skills in scientific data collection and self-assessment. To conclude this sequence, several reflection questions can be asked:

- **What challenges did you encounter when programming and using the decibel sensors? How did you overcome them?**
- **How did you find the experience of keeping a daily logbook? Which aspects were the easiest or most difficult?**
- **Did you notice any interesting trends or patterns in your data over the course of the week?**
- **How has this experience influenced your perception of noise in your learning environment?**
- **What improvements would you suggest for the data collection process if we were to repeat this study?**

Step 3 - Analysis, interpretation, and conclusion of the study

Background and description of the problem to be solved in this step: This phase focuses on the in-depth analysis of the collected data, the interpretation of results, and the development of recommendations based on the study's conclusions. Students will compile, analyze, and visualize the collected data, using statistical methods and visualization tools to identify correlations between noise levels and indicators of well-being and cognitive performance. This crucial step will allow students to draw meaningful conclusions from their study and develop concrete recommendations for improving the school's sound environment.

Learning Objectives: Through this phase, students will develop essential skills in data analysis and visualization, learning to critically interpret scientific results. They will improve their ability to solve complex problems by proposing solutions based on empirical evidence. Additionally, by preparing a presentation of their results, students will strengthen their scientific communication skills, learning to synthesize and present complex information in a clear and convincing manner.

This step can be done in partnership with mathematics discipline.

Conceptualisation

In this phase, students continue to explore the central hypothesis: **the noise level in the classroom has a significant impact on students' well-being and cognitive performance.** The focus is on in-depth analysis of the collected data and its interpretation.

This step is crucial for transforming raw data into actionable information and drawing meaningful conclusions. It will allow students to develop essential skills in data analysis, critical thinking, and scientific communication, while deepening their understanding of the impact of noise on health and well-being in the school environment. Students will address several key concepts and tools:

- **Analyze a dataset to characterize a population in terms of its health:** Students will learn to use statistical methods to analyze the data collected on noise levels and well-being/performance indicators. They will develop skills in quantitative and qualitative analysis to paint a picture of the impact of noise on the health of the studied population.
- **Analyze the interactions between different determinants of a population's health status:** Students will explore potential correlations between noise levels, well-being, and cognitive performance. They will learn to identify and interpret complex interactions between these different factors.
- **Process quantitative data to produce information within the framework of a study:** Students will use data visualization tools (graphs, diagrams) to represent their results in a clear and understandable manner. They will learn to choose the most appropriate representations to highlight identified trends and patterns.
- **Explain the importance of presenting a study and its dissemination:** Students will understand the importance of effectively communicating the results of their study. They will learn to synthesize their findings, formulate evidence-based conclusions, and prepare a convincing presentation of their results.

Students Investigation

Data compilation and analysis

Students will begin by compiling all the data collected during the study week. They will use digital tools such as spreadsheets to organize and analyze this data according to the methods defined in their experimental protocol. This step will allow them to develop skills in data management and processing. Depending on their specific protocol established in phase 1, this analysis could include calculating daily average noise levels, identifying noise peaks, aggregating well-being and cognitive performance data, creating comparative graphs, calculating correlation coefficients if planned, and analyzing the impact of identified external factors. This comprehensive approach will allow students to develop a complete understanding of their data while adhering to the methodology they themselves established.

<u>What is the correlation coefficient?</u> The correlation coefficient is the specific measure that quantifies the strength of the linear relationship between two variables in a correlation analysis.

The coefficient is denoted as *r* in a correlation report. For two variables, the formula compares **the distance of each data point from the variable mean and uses it to indicate how much the relationship between the variables follows an imaginary line drawn through the data**.

This is what is meant by "correlations concern linear relationships." Correlation only includes two variables and provides no information about possible relationships containing more data. This analysis will not detect (and will therefore be biased by) outliers present in the data and cannot detect important external factors to consider in your study.

<u>Formula</u>: The sample correlation coefficient can be represented by a formula:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

<u>Illustrated example (from the protocol, with a limited number of data)</u>

Step 1 - Calculate sample means

Day	Noise level (dB)	Average stress level (1-5)
Monday morning	70	5
Monday afternoon	50	2
Tuesday morning	70	5
Tuesday afternoon	55	3
Wednesday morning	50	2
Thursday morning	55	3
Thursday afternoon	60	4
Friday morning	75	5
Friday afternoon	70	5
Mean	**61.67**	**3.78**

Step 2 - Calculate the distance of each data point from its mean

Day	Noise level (dB)	Distance noise level - mean	Average stress level (1-5)	Distance stress level - mean
Monday morning	70	**Example: 70 - 61.67 = 8.33**	5	**Example: 5 - 3.78 = 1.22**
Monday afternoon	50	**-11.67**	2	**-1.78**
Tuesday morning	70	**8.33**	5	**1.22**
Tuesday afternoon	55	**-6.67**	3	**-0.78**
Wednesday morning	50	**-11.67**	2	**-1.78**
Thursday morning	55	**-6.67**	3	**-0.78**
Thursday afternoon	60	**-1.67**	4	**0.22**
Friday morning	75	**13.33**	5	**1.22**
Friday afternoon	70	**8.33**	5	**1.22**

Step 3 - Calculate the top of the coefficient equation

$$\sum[(xi - \overline{}x)(yi - \overline{}y)] \sum[(xi - x^{-})(yi - y^{-})]$$

Day	Distance noise level - mean	Distance stress level - mean	Distance noise * Distance stress
Monday morning	8.33	1.22	**Example: 8.33 * 1.22 = 10.19**
Monday afternoon	-11.67	-1.78	**20.74**
Tuesday morning	8.33	1.22	**10.19**
Tuesday afternoon	-6.67	-0.78	**5.19**
Wednesday morning	-11.67	-1.78	**20.74**
Thursday morning	-6.67	-0.78	**5.19**
Thursday afternoon	-1.67	0.22	**-0.37**
Friday morning	13.33	1.22	**16.30**
Friday afternoon	8.33	1.22	**10.19**
Sum			**98.33**

Step 4 - Calculate the bottom of the coefficient equation

Day	Distance noise level - mean	Distance noise squared	Distance stress level - mean	Distance stress squared
Monday morning	8.33	**Example: 8.33² = 69.44**	1.22	**Example: 1.22² = 1.49**
Monday afternoon	-11.67	**136.11**	-1.78	**3.16**
Tuesday morning	8.33	**69.44**	1.22	**1.49**
Tuesday afternoon	-6.67	**44.44**	-0.78	**0.60**
Wednesday morning	-11.67	**136.11**	-1.78	**3.16**
Thursday morning	-6.67	**44.44**	-0.78	**0.60**
Thursday afternoon	-1.67	**2.78**	0.22	**0.05**
Friday morning	13.33	**177.78**	1.22	**1.49**
Friday afternoon	8.33	**69.44**	1.22	**1.49**
Sum		**750.00**		**13.56**

When multiplying the results of the two expressions, we get: $$750x13.56 = 10,166.67$$

The bottom of the equation is therefore: $$\sqrt{10,166.67} = 100.83$$

Step 5 - Finish the calculation and conclude

The closer *r* is to zero, the weaker the linear relationship. Positive values of *r* indicate a positive correlation when the values of both variables tend to increase together. Negative values of *r* indicate a negative correlation when the values of one variable tend to increase and the values of the other variable decrease. **The values 1 and -1 each represent "perfect" correlations, positive and negative respectively**. Here, the correlation is proven.

$$r = \frac{98.33}{100.83} = 0.98$$

Data visualization and interpretation of results

Based on their analyses, students will create graphs and visualizations to represent the correlations between noise levels and various indicators of well-being and cognitive performance. They will also examine the influence of external factors on these relationships, integrating these variables into their visualizations in a coherent manner.

Interpretation of results

Students will interpret the results of their analysis and reflect on their implications in depth. They will carefully examine the observed correlations between noise level and their indicators of well-being and cognitive performance, taking into account the complexity of the relationships identified. Their reflection will extend to the influence of external factors such as physical activity, weather conditions, and the type of classroom activity (for example, exam phases, during which the noise level is very low, the feeling of stress is high, and the concentration level is high), in order to understand the broader context of their study. Based on their observations, they will formulate concrete and feasible recommendations to improve the sound environment of the classroom and optimize learning conditions.

Synthesis and presentation

Students will synthesize their findings and conclusions in a visual presentation (for example, a scientific poster or a presentation on Canva or any other tool used). This step will allow them to develop skills in scientific communication and presentation of research results. Students will apply the principles of effective scientific communication in their visualizations. They will choose accessible and contrasting color palettes for better readability, include clear and concise legends for each graph, and create infographics summarizing the main results in an attractive and understandable way.

To help you, a presentation of some graphical tools that could allow students to create an attractive presentation with reduced effort is available in the going further section of this protocol.

Conclusion & Further Reflexion

At the end of this comprehensive activity analyzing the impact of noise on learning, students have acquired valuable skills in scientific data collection, statistical analysis, and interpretation of results. To conclude this protocol and encourage in-depth reflection on the entire process, the following questions can serve as a framework:

- **How has your understanding of the impact of noise on learning evolved through this experimentation?**
- **Which aspects of data analysis did you find most challenging? Most revealing?**
- **How do you think the results of this study could be used to improve the learning environment in your school?**
- **What skills have you developed during this project that could be useful in other areas of your academic or personal life?**
- **If you were to do this study again, what would you do differently? Why?**

Practical Implementation

Programming your Micro:bit for measuring ambient sound level

Material and tools needed

To program a micro:bit board to measure ambient sound level in your classroom, you will need:

- **1 Micro:bit V2 Board 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 Cable**: For powering and programming the micro:bit
- **Battery Pack** (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

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

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

Instructions for wiring and using the micro:bit board

Follow these steps to program, place, record, and retrieve environmental data using the micro:bit.

Step 1: Programming the Micro:bit

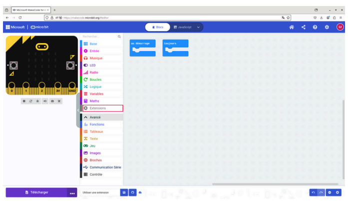
Connect the Micro:bit board: With your USB Cable, connect the board to your computer by using the **micro-USB connector**. Once connected, the micro:bit board will appear on the computer as a removable drive (e.g., "MICROBIT").

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

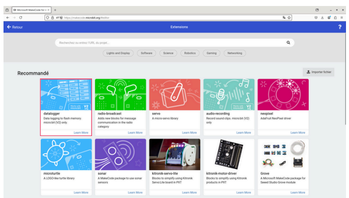
Once on the editor, and after creating your new project, you will get the default "ready to go" screen shown here and will need to install an **extension**.

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.

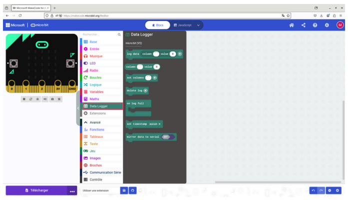
In the block display columns, click on the **EXTENSIONS** button. In the list of extensions available, search for the **Datalogger extension** that will be used for this activity. Click on the extension you want to use and a new block group will appear on the main screen.



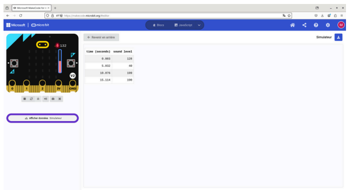
1 Open the extensions menu from the MakeCode editor for micro:bit.



2 Select the datalogger extension from the list (you can also use the search tool).

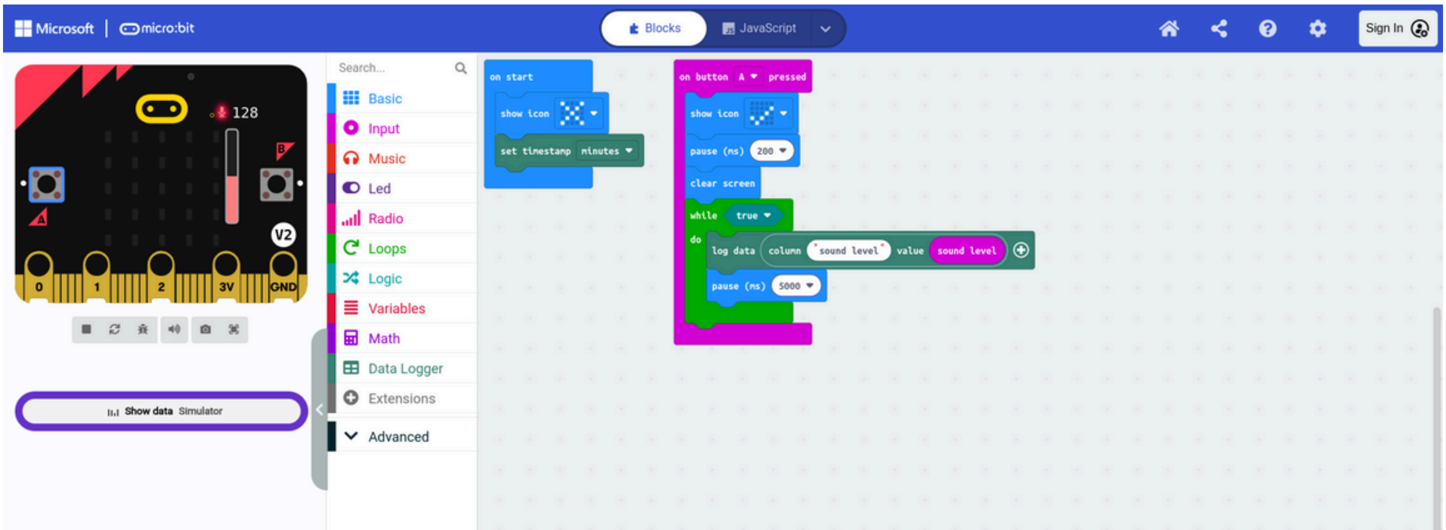


3 The datalogger extension appears in the list of available blocks from your editor.

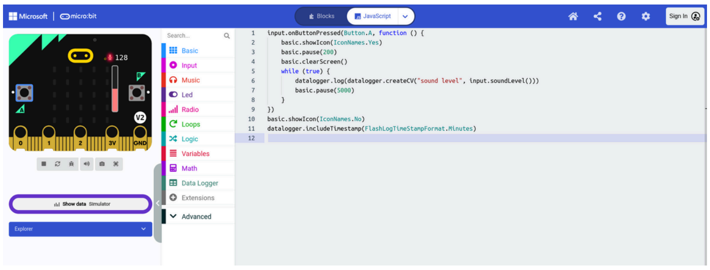


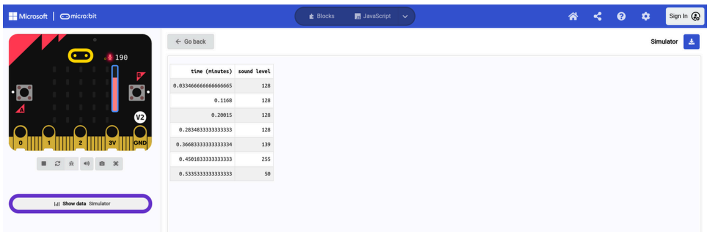
4 The datalogger allows you to access a data recording simulator.

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.

Step 2: Placing the Micro:bit and start recording data

Once programmed, place the micro:bit for collecting the data you need i.e. in your classroom, if possible in a neutral space (not near a specific student to avoid collecting specific noises, but for instance around the door, in a high area ...). **If feasible, use an external battery pack to power the micro:bit continuously during the recording.** Ensure that each day, the board is placed again in the exact same position to record comparable data.

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

Step 3: Retrieving data and cleaning up the board for the next recording session

We recommend using the board for the entire classroom day, then retrieving the data each evening before leaving school, and reconnecting it each morning of study. **It will be necessary to copy the .hex to your "MICROBIT" removable drive each morning and retrieve the data log each evening to avoid data loss.**

This file from the datalog **will be called "MY_DATA.HTM, available on the micro:bit drive)**. Copy it every evening on your computer and rename it with the current date (e.g., CLASSROOMDAYX_YYYY-MM-DD.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.

Repeat the process for the next session i.e. the next day before starting the classes.

At the end of the collection period, you can retrieve all the filed collected from the different micro:bit boards. Once opened, the data log pages will be accessible. 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 sound level:

```
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)
```

How does the code work?

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).

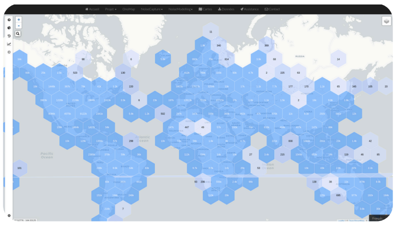
The directive has been revised to improve noise calculation methods and to better take into account the **effects of noise on health**, based on the latest studies from the World Health Organization (WHO). In 2023, a report shows that progress has been made, but more efforts are needed to reduce by 30%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

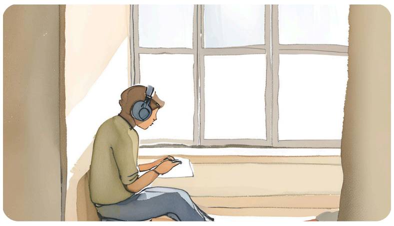
Ideas of Complementary Projects

Create a sound map of the school using multiple Micro:bits



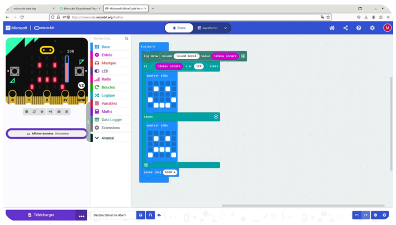
Sound mapping is a common practice in urban planning and public health to analyze and manage noise pollution. Tools like **NoiseCapture** already allow citizens to contribute to interactive noise maps in cities. Applying this approach to the school offers an opportunity to raise students' awareness of the issues in their sound environment, while introducing concepts of scientific measurement, geography, and data analysis. The goal is to empower students while allowing them to experience a project at the intersection of science and new technologies. Students could analyze noise variations by area and time, and propose solutions to improve the sound environment.

Add the use of cognitive tests to the analysis activity



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.

Create an alert for loud learning environments



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 design and creative digital tools

Canva

Creation of graphics, videos, infographics... with real-time collaboration

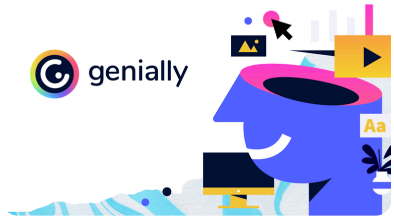
Resources provided: Images, graphics, videos, audio elements

Accessibility: Very accessible

Free features: Access to thousands of templates, basic graphic elements, limited cloud storage

Education Plan available freely for teachers

Genially



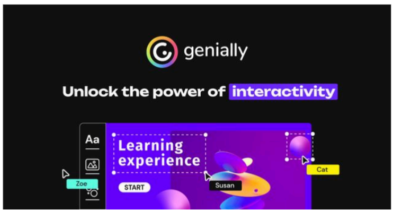
Creation of interactive presentations, infographics, games, animated content

Resources provided: Images, graphics, animations

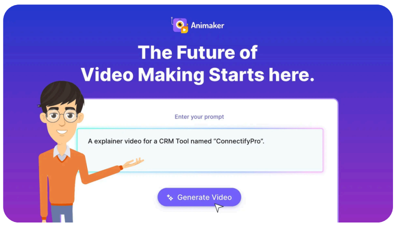
Accessibility: Accessible

Free features: Access to basic templates, limited interactive features, public publications

Reduce fee for professional account access for educators



Animaker



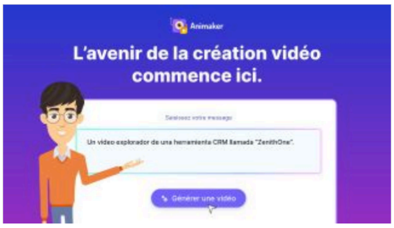
Creation of animated videos, video infographics, video presentations, animated GIFs

Resources provided: Images, graphics, audio elements, animations

Accessibility: Moderately accessible

Free features: SD video export, limited access to resources, watermark on videos

No plan for education



Powtoon

Creation of graphics, presentations, videos, infographics, real-time collaboration

Resources provided: Images, graphics, audio elements, animations

Accessibility: Accessible

Free features: SD video export, limited access to resources, watermark on videos

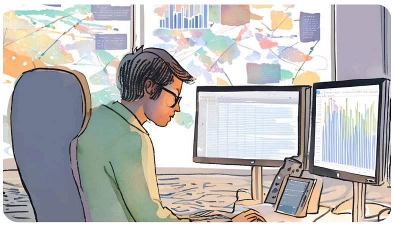
Reduce fee for professional account access for educators

Video Maker | Make Videos and Animations Online

Make videos in minutes with...

powtoon.com

Piktochart



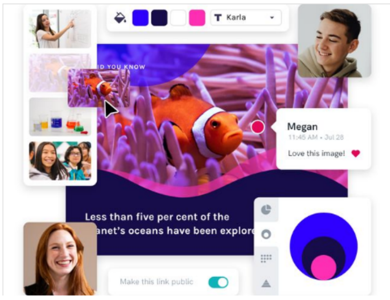
Creation of infographics, presentations, reports, posters

Resources provided: Images, graphics, icons

Accessibility: Very accessible

Free features: Access to basic templates, limited export to certain formats, limited storage

Reduce fee for professional account access for educators



Freepik & Flaticon

Access to free and premium design resources, icons, and illustrations

Resources provided: Images, icons, illustrations

Accessibility: Very accessible

Free features: Free access to basic resources with attribution

No plan for education

https://www.freepik.com

https://www.flaticon.com

Bibliography

Environmental Noise and Its Impact:

- **Environmental Noise in Europe — 2020**
  A comprehensive report by the European Environment Agency on noise pollution trends, sources, and impacts across Europe.
- **Noise**
  Explores noise as an environmental issue, its effects on health, and strategies for mitigation.
- **NoiseCapture Interactive Community Map**
  A citizen science initiative allowing users to contribute to a global noise pollution map by recording local noise levels.
- **EUR-Lex - Directive 2002/49/EC on Environmental Noise**
  The European directive establishing a framework for assessing and managing environmental noise.

Technology and Tools for Learning:

- **Micro:bit Educational Foundation**
  Provides resources and project ideas for using micro:bit in educational settings, including environmental monitoring projects.
- **NoiseCapture App and Tools**
  A mobile app designed to measure and map noise levels, empowering communities to analyze environmental noise data.

Scientific Concepts and Analysis:

- **Correlation - Wikipedia**
  An explanation of the concept of correlation, its significance in data analysis, and its applications in scientific research.

CLASSROOM NOISE JOURNAL

Owner:

Date:

To be filled after each class of the day:

Class 1

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

Class 2

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

Class 3

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

Class 4

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

Class 5

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

Class 6

General feeling (1 to 5)

Perceived noise level (1 to 5)

Brief observations:

To be filled at the end of the day:

Well-being and cognitive performance indicators (rate from 1 to 5)

Perceived fatigue level

Quality of class participation

Concentration ability

Perceived task performance

Perceived stress level

Influential external factors

Physical activity during the day

Weather during the day

Sleep quality the previous night (1-5)

Additional observations