STEAMCITY CURRICULUM

LIGHT VS. ZZZ
The Great Sleep Battle

thematic: environment, well-being and public health

Introduction

This protocol explores the **impact of urban pollution on sleep quality**. Sleep plays a crucial role in mental, physical, and cognitive health. In urban environments, various environmental factors can disrupt its quality, particularly artificial light, ambient noise, and screen use habits.

Following the **scientific method**, students will conduct a study to collect and analyze quantitative and qualitative data about their sleep and environmental pollution. They will program sensors to track this data, then interpret the results to identify possible solutions. To conduct this study, students will need to **identify urban nuisances** affecting sleep, and analyze their effects on circadian rhythm, sleep phases, and nocturnal interruptions:

- The **light pollution**, caused by artificial night lighting such as street lamps or illuminated signs, inhibits the production of melatonin (the sleep hormone). This inhibition delays falling asleep and disrupts circadian cycles, which are the body's natural biological rhythms over a 24-hour period.
- The **noise pollution**, particularly constant traffic, neighborhood, or construction noise, causes micro-awakenings that prevent restorative sleep. These noise disturbances particularly affect deep sleep phases, which are essential for recovery.
- **Temperature** and **humidity** also play important roles, particularly in urban areas where construction and insulation practices influence these factors. A room that is too hot or too humid, often due to poor insulation or the urban heat island effect, can affect sleep cycles, increasing nocturnal movements and fatigue upon waking.
- Finally, **technological habits**, such as intensive screen use before bedtime, stimulate the brain. This delays falling asleep and increases sleep fragmentation. The **blue light** emitted by screens is particularly harmful to melatonin production and specifically impacts the time needed to fall asleep.

The **circadian rhythms** are our internal biological clock that controls wake-sleep cycles over a 24-hour period. These rhythms are essential for regulating many physiological and behavioral functions in our body. They are particularly sensitive to external environmental signals, especially light and noise. A disruption of these signals can have significant consequences on our health and well-being, leading particularly to sleep cycle disruption, and negative cognitive effects, impacting attention, concentration, memory, and reasoning abilities. Students will seek to **explore correlations between disrupted sleep and cognitive performance**, focusing particularly on their perceptions of their attention level and memory. ***Learn more:*** *Explore the* ***Going Further Section***.

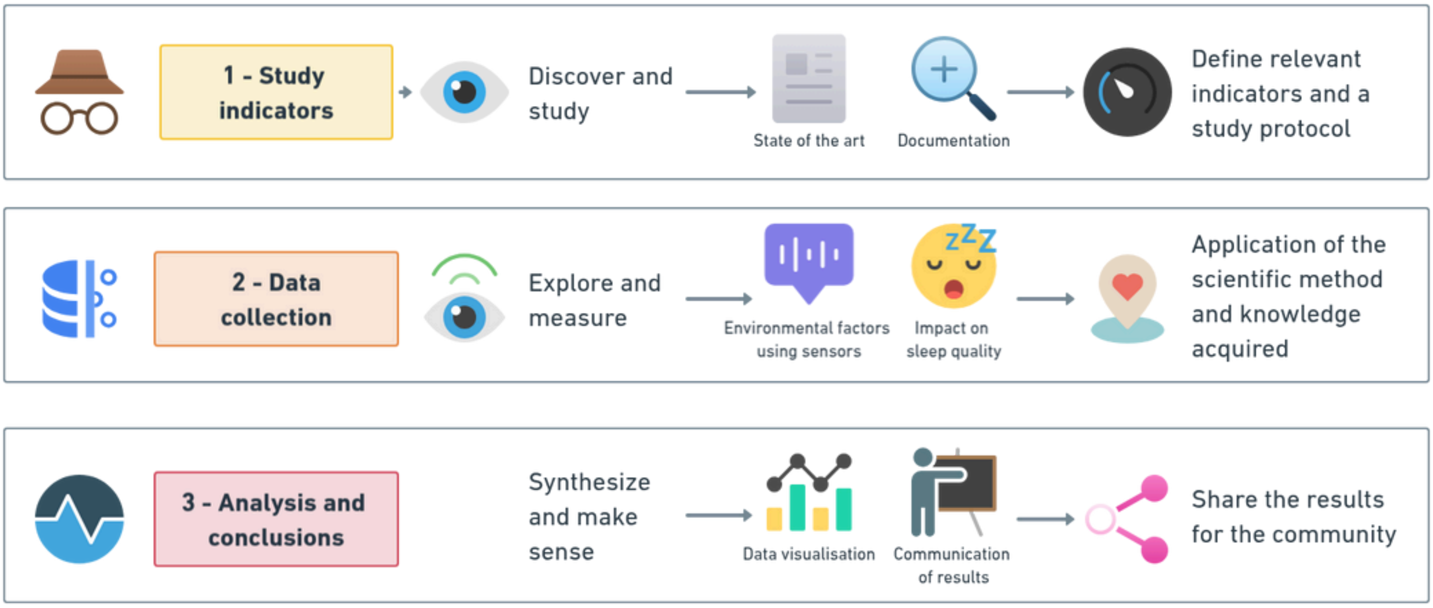
Interdisciplinarity

biology
social and health sciences
technology and engineering
mathematics

Sustainable Development Goals

Overview

Protocol Structure



Step 1: Understanding the Problem and Defining Indicators

This first phase of the protocol allows students to establish the theoretical and methodological foundations of their study on sleep in urban environments. Through documentary research and protocol design, they develop a deep understanding of issues related to sleep disorders and their impact on public health. Students acquire essential skills in scientific research, particularly the ability to evaluate sources, synthesize complex information, and design rigorous methodology. The formulation of testable hypotheses and detailed planning of data collection prepare them for the practical phase of the study. This first step also helps develop their critical thinking through the identification of potential biases and reflection on methodological limitations. Class discussions enrich their understanding and raise awareness of the importance of a structured scientific approach.

Step 2: Data Collection

This analysis and interpretation phase represents the culmination of the scientific protocol, where students develop their skills in statistical analysis and data visualization. They learn to combine quantitative data (from sensors) and qualitative data (logbooks) to study the impact of urban pollution on sleep quality. Through this process, they gain practical experience in scientific methodology, develop their critical thinking, and their ability to identify correlations between environmental variables and health. This phase is essential as it allows students to understand how to transform raw data into meaningful conclusions and concrete recommendations for improving sleep in urban environments. The skills developed - statistical analysis, data visualization, critical interpretation, and scientific communication - are fundamental for their future academic and professional careers.

Step 3: Analysis, Interpretation, and Conclusion

This final phase concludes the protocol by allowing students to synthesize and make sense of their sleep research. During this phase, they develop skills in statistical analysis and scientific data visualization, combining environmental sensor data with logbooks. Students learn to identify correlations between urban environmental variables and sleep quality, while developing their critical thinking about potential biases and study limitations. This final phase not only allows them to verify their initial hypotheses about the impact of urban pollution on sleep but also to propose concrete solutions based on empirical evidence. It is a comprehensive learning opportunity that strengthens their scientific communication skills and their understanding of how research can inform public health policies.

Getting started

Steps	Duration	Difficulty	Material
Understanding the Problem and Defining Indicators	1 classroom sequence	★☆☆☆☆	• Computers or tablets with Internet access for documentary research and/or pre-selected documentation on sleep • Paper, pens for note-taking • Mind mapping software (Freemind, Miro, Whimsical etc.) or paper/foam board in A3 format (recommended format)
Data Collection	1 classroom sequence + homework	★★★★☆	• Micro:bit programmable boards (6 recommended but can work with 1 or 2) • Logbook for recording observations (example in annex) • Solutions for the armband (see useful links provided below)
Analysis, Interpretation, and Conclusion	1 classroom sequence	★★★☆☆	• Computers with data processing software • Presentation tools (PowerPoint, Canva, etc.) • Templates for scientific report writing

Glossary

Keywords & Concepts	Definitions
Sleep quality	Measure of sleep efficiency, including ease of falling asleep, duration, nocturnal awakenings, and feeling of restfulness upon waking.
Sleep phases	Different stages of sleep, including light, deep, and REM sleep, each having specific recovery functions.
Sleep hygiene	Set of practices and habits promoting quality and restorative sleep.
Circadian rhythms	Biological cycles of approximately 24 hours that regulate physiological functions, particularly sleep-wake cycles.
Melatonin	Hormone produced by the pineal gland, regulating the sleep-wake cycle and synchronizing the biological clock.
Chronotype	Natural tendency of a person to sleep at certain hours, influencing their sleep and wake preferences.
Light pollution	Excess artificial night lighting, disrupting ecosystems and biological rhythms of living beings.
Blue light	Part of the light spectrum emitted by screens, known to suppress melatonin production and disrupt sleep.
Noise pollution	Excessive exposure to noise, which can disturb sleep, cause stress, and affect health.
Light sensor	Device measuring environmental light intensity, used to evaluate light pollution.
Sound sensor	Device measuring ambient noise levels, used to quantify noise pollution.
Motion sensor	Device detecting physical movements, which can be used to track agitation during sleep.

Protocol

Step 1: Understanding the Problem and Defining Indicators

Background and description of the problem to be solved in this step: This phase introduces students to the concepts of circadian rhythms, light, sound, and thermal pollution, as well as their impacts on sleep. The main objective is to prepare a scientific protocol to study the main external sleep disruptors, by developing **relevant indicators** to measure sleep quality and urban nuisances. This initial phase allows students to become familiar with key concepts and their impact on quality of life, leading them to explore different aspects of urban pollution and collectively develop indicators to evaluate them. Students will be led to understand and explain how sleep disorders constitute a major public health problem, affecting individual well-being and health on a large scale.

Learning Objectives: Through this activity, students will develop several key competencies. They will learn to understand the complexity of circadian rhythms and the impact of urban pollution on sleep, which will help them better grasp the importance of a balanced nocturnal environment. They will develop a scientific understanding of sleep cycles and environmental nuisances. Additionally, students will learn to design indicators to evaluate sleep quality and urban pollution, a crucial skill for any scientific approach. Finally, they will be led to prepare a structured and rigorous study protocol, which will allow them to develop their analytical capacity and scientific rigor.

Conceptualisation

The main hypothesis that will guide this entire protocol is that **sound, visual, and thermal pollution can disturb sleep cycles, particularly by extending the time it takes to fall asleep and increasing nocturnal interruptions.** Students will study how lack of sleep impairs cognitive performance. This activity directly addresses public health and urban quality of life concerns.

To explore this question in depth, students will need to compile and structure a **documentary corpus** on the subject of urban and technological pollution, as well as their effects on sleep. 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 the impact of urban pollution on sleep. The importance of this research work lies in its ability to provide a theoretical framework and justify the relevance of studying the effects of light and sound pollution on sleep quality in urban contexts.

By exploring the concepts of **sleep cycles**, **light, sound, and technological pollution**, as well as **cognitive performance**, students will identify in the literature **methods for evaluating and analyzing impacts**. **Indicators**, such as time to fall asleep, frequency of nocturnal interruptions, movement amplitude during the night, duration of different sleep phases, or levels of fatigue and concentration upon waking, are **essential for quantifying and qualifying sleep quality**. The diversity of these indicators allows for a nuanced understanding of urban pollution effects on sleep, taking into account their variations in intensity and duration. Students will need to understand how these different types of indicators can complement each other to paint a picture of pollution's impact on sleep. For example, combining objective measurements of light and noise levels with subjective evaluations of sleep quality and cognitive performance offers a richer and more detailed perspective.

The choice of method and data collection tools is fundamental to ensure the study's validity and reliability. Students will need to justify their methodological choices by considering the complexity of interactions between urban pollution and sleep, as well as individual variability in sensitivity to these factors. The importance of the method lies in its ability to produce consistent and comparable data, essential for drawing meaningful conclusions about the impact of urban pollution on sleep quality and cognitive performance.

Students Investigation

Documentary study and pollution identification

To begin the activity, students will conduct **documentary research** on different types of pollution affecting sleep quality. They will analyze **scientific articles, research reports, educational videos, or public health reports and campaigns** to identify and understand the effects of these pollutions on sleep cycles, circadian rhythms, and general well-being. This step will allow them to build a solid knowledge base and become familiar with key concepts such as melatonin, sleep phases, and existing evaluation methods for measuring sleep quality in urban environments.

> **Advice for Teachers:** If Internet access is limited in the classroom, documentary research can be conducted outside of class. The teacher can provide a pre-selected corpus of texts that students will analyze in groups. Students can also compile the corpus at home, then collectively study the documents in class. This approach allows for combining individual and collaborative work.

Students will be encouraged to **identify and classify the different types of pollution identified**, focusing particularly on those that are measurable. The teacher will ensure that the four main types of pollution (light, sound, temperature/humidity, and technological) are properly identified, while allowing students to explore other responses if they find them relevant and documented in their research. This approach will allow students to develop their **critical thinking** and ability to select relevant information, while preparing them for the next phase of study protocol design.

At the end of this documentary research phase, students will present their findings, for example in the form of a **mind map**. This visual representation will show the connections between the different concepts studied: types of urban pollution (light, sound, thermal), effects on sleep (disruption of circadian rhythms, time to fall asleep, sleep quality, nocturnal interruptions), evaluation methods (objective measurements and subjective assessments), impacts on health and well-being (short and long term), and potential solutions (pollution reduction and individual adaptation). Additionally, it will be interesting for students to categorize their information sources by type of resource, such as scientific articles, case studies, government reports, or public health publications. This will allow methodological studies to emerge according to the different stakeholders who have addressed the sleep issue. The mind map will also serve as a support for class discussion and facilitate the transition to the study protocol design phase.

Protocol Design

After compiling and studying the documentary corpus, students will develop a simple and rigorous protocol to evaluate the impact of identified pollutants on their sleep quality. The protocol will follow the scientific method, 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 identified pollutants on their sleep, 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 formulate conclusions based on empirical evidence.

> **Advice for Teachers:** In an active learning approach, it is beneficial to let students carry out this protocol design exercise by themselves. However, the teacher's crucial role as a guide involves adopting a semi-directed approach to ensure that the final protocol incorporates the essential components of the study. This includes using light, noise, and temperature sensors for objective measurements, as well as maintaining a sleep journal comprising qualitative analysis of nights over at least a complete week and using motion sensors to analyze sleep quality. This approach will ensure scientific rigor while promoting student autonomy and creativity in their investigative process.

Protocol Example

1. **Study Objective**: Study how light, sound, thermal, and technological pollution influence sleep quality and well-being upon waking.
2. **Hypothesis**: The higher the pollution levels, the more sleep quality will be affected, leading to decreased well-being and cognitive performance upon waking.
3. **Study Duration**: One complete week (7 nights).
4. **Sample**: The study will be conducted in groups of 3 students over one week, with each student having 2 programmable boards (one for pollution measurements and one for movement measurements) with the necessary sensors. Groups will rotate over a 2-month period, or 8 weeks. In total, the study will involve 24 students.
5. **Data Collection Method**:
   - Quantitative Measurements: Use of light, decibel, temperature, and humidity sensors placed in the bedroom, recording levels every 15 minutes during the night.
   - Qualitative Measurements: Daily sleep journal including bedtime, estimated time to fall asleep, perceived sleep quality, number of nighttime awakenings, movement amplitude - which can be measured using a motion sensor - and assessment of well-being and alertness upon waking.
   - Analysis of External Factors: Recording of specific events that may influence sleep (for example, stress, intense physical activity, screen use before bedtime, time between last meal and bedtime, type of food consumed in the evening, exposure to natural light during the day, reading time before falling asleep...).
6. **Data Usage**:
   - Data Storage
     - The **quantitative data** from sensor use will be stored in a **.csv** file incorporating date, time, and levels of light, noise, temperature, humidity, movement.
     - The **qualitative data** will be entered daily in each student's personal sleep journal.
   - Data Analysis
     - We will calculate **nightly averages of pollution levels** and identify **peaks** (times when levels exceed predefined thresholds). Graphs will be created to **show the evolution of pollution levels throughout the night**, with **peak highlighting**.
     - We will aggregate **sleep quality and wake-up well-being data from all students**. Additional questionnaires will be considered.
     - We will **visually compare pollution levels with each indicator of sleep quality and well-being**. We will create **simple graphs showing general trends**. We will identify and discuss cases that appear to deviate from these general trends.
     - To deepen our analysis, we will calculate **correlation coefficients between each of our indicators**. Interpreting these coefficients will help us determine which aspects of sleep are most sensitive to pollution variations.
     - We will **categorize the noted external factors** and analyze their impact on pollution levels and sleep quality. Comparative graphs will be created to show variations according to different contexts.
7. **Results Presentation**: Creation of graphs showing the correlation between pollution levels and sleep quality, and documentation of the protocol on an infographic that can be shared with the class, school, or on social networks.

Conclusion & Further Reflexion

At the end of this first phase, students will have gained a **deeper understanding of sleep disorders as a public health issue**. This awareness will enable them to better comprehend the societal challenges related to sleep quality in urban environments. Students will have also refined their skills in **documentary research** and **critical analysis**. They will be able to **navigate scientific literature effectively**, **evaluate the relevance and reliability of sources**, and **synthesize complex information** coherently.

A particularly important aspect of their learning will be the **design of a rigorous study protocol and the development of appropriate data collection tools**. This practical experience will give them a concrete overview of scientific methodology and strengthen their ability to plan and conduct structured investigations.

It is essential to emphasize that the main objective of this approach is to **familiarize students with the scientific method and help them understand its different stages**. Although the study may have limitations in terms of sample size or duration, it offers students a valuable opportunity to grasp key concepts of scientific research. This includes hypothesis formulation, data collection, analysis and interpretation of results, and critical reflection on the methodology used. This practical experience will allow them to develop scientific thinking and a deep understanding of the challenges and opportunities inherent in public health and urban environment research.

To deepen reflection, teachers can use the following opening questions to stimulate discussions:

- **"How could we improve the reliability of our study? What factors could influence our results?"** This question encourages students to think critically about their methodology and identify potentially confounding variables.
- **"What is the importance of sample size in our study? How does it affect the validity of our conclusions?"** This question addresses concepts of representativeness and generalization of results.
- **"What other potential biases can we identify in our protocol? How could we mitigate them?"** This reflection encourages students to adopt a critical approach and consider methodological improvements.

Step 2: Data Collection

Background and description of the problem to be solved in this step: This stage combines the use of sensors to measure environmental pollution and tools to evaluate sleep quality. Students will use **light, temperature, humidity, and noise sensors** to obtain **quantitative data on pollution**, as well as **motion sensors** to **track their nocturnal activity**. In parallel, they will maintain a **logbook** to collect **qualitative data** about their sleep. This approach, combining technology and personal observation, will allow students to gain a deep understanding of the connections between pollution and sleep quality, while developing skills in collecting and analyzing various types of data. Students will explore how data collection can contribute to raising awareness about the impact of blue light and noise on sleep, thus engaging in primary prevention in public health.

Learning Objectives: Through this phase, students will develop technical and analytical skills. They will learn to program and use sensors, thereby strengthening their technology and data collection competencies. In parallel, maintaining a logbook will allow them to document their observations and develop their self-assessment and analysis capabilities. This combination of objective and subjective measurements will help them better understand the multifaceted impacts of environmental nuisances on their sleep and overall well-being.

Conceptualisation

In this phase, students develop the hypothesis formulated in phase 1, namely that **light, sound, and thermal pollution can disrupt sleep cycles, particularly by extending the time to fall asleep and increasing nocturnal interruptions, which can impair cognitive performance**.

This phase allows for more detailed and personal exploration of this hypothesis, combining objective measurements and subjective perceptions.

The use of sensors and a logbook provides a structured approach to explore this hypothesis:

- **Quantitative measurements:** Light, noise, temperature, and humidity sensors provide objective data on environmental pollution, allowing correlations to be established with sleep quality. The motion sensor measures agitation during sleep, offering complementary information about rest quality.
- **Subjective exploration:** The logbook allows collection of qualitative data on sleep perception and well-being, thus enriching understanding of pollution's effects on sleep.

Through this exploration, students address key concepts and crucial issues in scientific methodology:

- **Mixed data collection and analysis:** Students learn to combine and interpret quantitative (sensors) and qualitative (logbook) data, developing a holistic understanding of the studied phenomenon.
- **Circadian cycles and sleep:** By studying sleep disturbances, students deepen their understanding of biological rhythms and the importance of an environment conducive to rest.
- **Impact of urban pollution on health:** This phase allows students to connect environmental pollution with concrete effects on health and cognitive performance, thus contributing to resolving the initial hypothesis.
- **Scientific methodology and experimental rigor:** By following a structured protocol over several nights, students develop a practical understanding of the importance of consistency and repetition in scientific research.

Students Investigation

To carry out the data collection process, students must first understand and build their measurement tools. This includes several technological and sociological tools according to the indicators being measured:

Indicators	Measurement Tools
Ambient Light Level	Light sensor
Sound Level	Noise sensor
Ambient Temperature	Temperature sensor
Humidity	Humidity sensor
Nocturnal Movements	Motion sensor
Time to Fall Asleep	Sleep journal
Screen Exposure	Sleep journal
Subjective Sleep Quality	Sleep journal
Sleep Interruptions	Sleep journal
Perceived Fatigue Upon Waking	Sleep journal

Advice for Teachers: The indicators listed are non-exhaustive and can be adjusted based on the documentary research conducted in phase 1. However, in this protocol, we provide all the instructions needed to create measurement tools associated with these specific indicators.

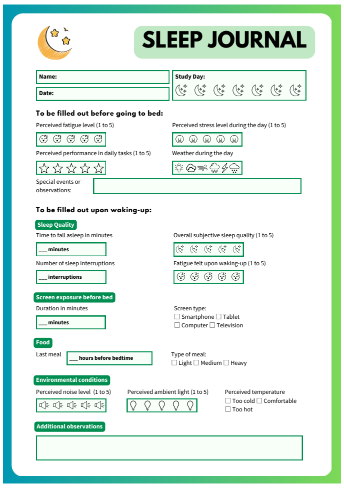
Preparation of technological measurement tools - Using the Micro:bit board and additional sensors: To perform quantitative measurements of indicators such as light level, noise, temperature, humidity, and movement, students will need to program an electronic board and associated sensors to automate data collection. This step will allow them to acquire basic programming and electronics skills. To do this, we recommend using a simple visual programming environment suitable for beginners such as **MakeCode**. They will create a program that allows sensors to take measurements at regular intervals (for example every 5 seconds, minutes, hours...) and store this data in a.csvfile (Comma-Separated Values, a text file format where data is separated by commas). The sensors will be positioned for one week in the rooms of the students conducting the measurements to perform automatic readings according to the established protocol.

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. **Two practical activity sheets are available: 1. Programming the board measuring environmental data: light, noise, temperature and 2. Programming the board measuring movement amplitude during the night (including adding a wristband).**

Preparation of qualitative measurement tools - Creating a personal logbook

Collectively, students will create a personal journal template including fields for each identified qualitative indicator, such as time to fall asleep, screen exposure, subjective sleep quality, sleep interruptions, and perceived fatigue upon waking. For each indicator, they will need to establish consistent rating scales (for example, from 1 to 10). A dedicated section for additional notes or remarks will allow recording complementary observations that could be relevant to the study. This journal must be filled out by students during the study each morning (7 times total), in paper or digital format, depending on what is most practical for them.

Here aside is an example of personal Sleep Journal to be filled in over 7 days of study available for printing in annex.



Data collection: Once all tools have been prepared in class, tested (particularly the sensors) and validated by the teacher, students will set up their system for one week with 3 students, rotating over one or two months (to obtain a coherent study sample). They will place the programmed sensors in their bedroom and complete their logbook daily. This step will allow them to concretely apply the scientific protocol they have developed and build rigor in regular data collection. They will become aware of the importance of consistency in a scientific study and will be able to observe in real-time the variations in environmental parameters and their own perception of sleep.

Advice for Teachers: This protocol suggests using several electronic boards to conduct the study, with an ideal number of six. This number can be reduced depending on available equipment. The main objective of this experiment is to enable students to develop a rigorous scientific approach. This approach aims to introduce them to the scientific method, careful data interpretation, and develop their critical thinking regarding the subtleties of research. Although the use of electronic sensors is an attractive aspect of the experiment, it is not essential to achieving the main pedagogical objectives. The emphasis is on the scientific process itself: formulating hypotheses, designing a protocol, systematic data collection (whether electronic or manual), and critical analysis of results. This approach allows students to understand that the value of a scientific study lies more in the rigor of the method than in the sophistication of the tools used. If your access to electronic tools is limited, we recommend:

- Using a single Micro:bit board rotating between students over 3-day periods
- Focusing on quantitative indicators directly measurable with the Micro:bit board, prioritizing built-in sensors, particularly brightness, noise, or temperature
- Emphasizing qualitative logbooks and using the Micro:bit board to measure light, noise, temperature without movement measurement (which would necessarily require using a second board)
- Using smartphone applications to complement measurements if necessary, such as **Arduino Science Journal** (a free application for measuring sound, light, and movement) or **Decibel X** (for measuring sound levels).

These adaptations also offer a pedagogical opportunity. We recommend encouraging students to conduct critical reflection on the methodology used. This reflection can include a discussion of potential biases related to a limited sample or short observation period, thus allowing students to understand the limitations and challenges inherent in scientific research.

Conclusion & Further Reflexion

At the end of this phase, students will have gained **practical and in-depth experience with the scientific method applied to a public health issue**. This immersion in a research protocol will allow them to better understand the challenges related to data collection and analysis in real-world settings. They will be able to use sensors and collect data rigorously, providing them with a solid foundation for future scientific investigations. Their understanding of the connections between the urban nighttime environment and sleep quality will be deepened, allowing them to better grasp the complex interactions between health and environment. It is important to emphasize that the main objective of this phase is to **familiarize students with real data collection and its associated challenges**. Although the study may have limitations in terms of scale, it offers a valuable opportunity to understand the nuances of applied scientific research.

To deepen reflection, teachers can use the following opening questions:

- "**What challenges did you encounter during data collection? How could you improve the process?**" This question encourages students to think critically about their practical experience.
- "**How do different data sources (sensors and logbooks) complement each other? What are the advantages and limitations of each method?**" This question addresses the complementarity of quantitative and qualitative data.
- "**What unexpected factors did you observe that could influence sleep quality? How could you incorporate them into a future study?**" This reflection encourages students to think holistically and consider improvements for future research.

Step 3 - Analysis, interpretation and conclusion

Background and description of the problem to be solved in this step: To conclude the study, students will combine in this final step the analysis of collected data on environmental pollution and sleep quality. They will use statistical and visualization tools to identify correlations between urban disturbances and sleep. They will interpret the results from light, noise, temperature, and humidity sensors, as well as nocturnal activity data and logbooks. This approach, combining quantitative and qualitative analysis, will allow students to develop skills in analyzing various types of data. Students will explore how data interpretation can contribute to developing concrete solutions for improving sleep in urban environments, thus engaging in a public health approach.

Learning Objectives: Through this phase, students will develop skills in statistical analysis and scientific data visualization. They will learn to identify and interpret correlations between urban environmental variables and their impacts on sleep quality. This experience will enable them to formulate evidence-based recommendations for improving sleep conditions in urban environments. Additionally, they will gain a deep understanding of the complex interactions between the urban nighttime environment and sleep health. Finally, students will strengthen their scientific communication skills, learning to effectively present results and propose concrete solutions.

Conceptualisation

In this final phase, students will analyze and interpret the collected data to verify their main hypothesis: light, noise, and thermal pollution have a significant impact on sleep quality and cognitive performance.

This crucial step of the scientific approach involves several important aspects:

- **Statistical analysis:** In collaboration with the mathematics course, students will apply statistical methods to process their data. They will calculate means, standard deviations, and correlation coefficients to quantify relationships between environmental variables and sleep quality. They will learn to use statistical tools to evaluate the significance of their results. This approach will help them understand the importance of mathematical rigor in interpreting scientific data.
- **Data visualization:** Students will create graphs, diagrams, and infographics to visually represent their results. They will use tools to generate clear and informative visualizations. This step will show them the importance of visual communication in presenting scientific results.
- **Bias identification:** An important part of the analysis will involve identifying and discussing potential biases in the study. Students will reflect on their sample size, study duration, and external factors that could influence their results. This critical reflection will help them understand the limitations of their study and the importance of caution in interpreting scientific results.
- **Exploration of preventive measures:** Based on their analyses, students will explore the potential effectiveness of primary prevention measures to improve sleep health in urban environments. They will propose solutions based on collected evidence, such as reducing blue light exposure or improving sound insulation. This step will help them understand how scientific research can inform public health policies.

By following this methodical approach, students will develop a deep understanding of the scientific method, the importance of rigorous data analysis, and the need for careful interpretation of results.

Students Investigation

Data preparation and consolidation: To prepare for the analysis phase, students will need to consolidate all data collected during the recording phase in a structured and traceable manner. They can create a shared folder (for example on Google Drive) with individual subfolders for each study participant where the recording files from micro:bit cards and logbooks will be stored. This centralized storage system will ensure study traceability and reliability by preserving all raw data in its original format. This crucial step of structured export and aggregation will prevent data loss and facilitate subsequent analysis.

Retrieving data from Micro:bit cards: Students will need to retrieve data from Micro:bit electronic cards at the end of each collection period. Using a "**datalogger**" tool, an automatic data recording device, will allow storage of information collected by sensors in the Micro:bit cards. The student will export this data in .csv format, obtaining two separate files (one per card): one containing environmental information and the other movement measurements. For efficient organization, each file will be named according to a standardized format like "student_name_collection_week_collection_type.csv" (for example emiliedubois_week1_movement.csv). This method will allow structured management of data collected by each student during the study period.

Advice for Teachers: Once all data is consolidated, verify the integrity and consistency of information, particularly measurement units and date/time formats.

Collaborative data analysis: After consolidating individual data in an organized and structured folder, allowing students to easily locate the collected data, students will proceed to the analysis, processing, and interpretation phase of the results. Form groups of 3 to 4 students, ensuring that group members were not themselves subjects of the study they will analyze to reduce potential bias. Assign an equal number of studies to analyze to each group, based on the total number of studies conducted and the number of groups formed.

- **Initial data processing:** Each group creates a single table for each participant studied, gathering all measured variables (environmental and sleep-related). Standardize data formats (units of measurement, rating scales) to ensure consistency across different studies. It will be easier to process data if it is all available (when possible) in digital format. For example, for qualitative assessments, we can use rating scales between 1 and 5 or 1 and 10 to more easily create correlations using mathematical and statistical tools.
- **Sample table to complete:** Here is an improved table model that students could use to consolidate their data:

Date	Time	Noise Level	Light	Temperature	Humidity
Unit	*HH:MM*	*dB*	*Lux*	*°C*	*%*
2024-11-16	22:00	45	10	20	60
2024-11-17	22:00	50	5	19	65
2024-11-18	22:00	40	8	21	55
Average	**-**	**45**	**7.67**	**20**	**60**
Median	**-**	**45**	**8**	**20**	**60**
Standard Deviation	**-**	**5**	**2.52**	**1**	**5**

Nocturnal Movements	Screen Exposure	Time to Fall Asleep	Number of Interruptions	Sleep Quality	Fatigue Level
Amplitude	*Minutes*	*Minutes*	*Number*	*Scale 1-10*	*Scale 1-10*
0.8	120	25	2	7	3
1.2	90	35	3	6	4
0.5	60	20	1	8	2
0.83	**90**	**26.67**	**2**	**7**	**3**
0.8	**90**	**25**	**2**	**7**	**3**
0.35	**30**	**7.64**	**1**	**1**	**1**

Statistical analysis: Through the consolidation of data in a single digital spreadsheet, students will be able to calculate simple descriptive statistics for each variable:

- **Mean:** The central value of a dataset, calculated by adding all values and dividing by the total number of values.
- **Median:** The value that lies in the middle of a dataset sorted in ascending or descending order.
- **Standard deviation:** A measure of the dispersion of values around the mean, indicating the variability of the data.

In a second phase, students will proceed to analyze correlations between the measured variables. Based on their preliminary analyses and working hypotheses, students will choose the most relevant variable pairs to study. For example: nighttime noise level and sleep quality, screen exposure and time to fall asleep or ambient temperature and number of sleep interruptions. For each selected pair of variables, students will calculate the correlation coefficient using the method described below. Students will analyze the strength and direction of the obtained correlations, keeping in mind that correlation does not necessarily imply causation. Based on these analyses, students will draw their initial conclusions regarding the relationships between the studied variables and their potential impact on sleep quality.

What is the correlation coefficient? 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. **The sample correlation coefficient can be represented by a formula**:

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

Illustrated example (applied to the protocol, with a limited number of measurements)

Step 1 - Calculate sample means

Night	Night average - Noise level (dB)	Sleep interruptions
Monday	45	2
Tuesday	40	1
Wednesday	55	4
Thursday	50	3
Friday	60	5
Saturday	35	0
Sunday	30	0
Mean	**45**	**2.14**

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

Night	Night average - Noise level (dB)	Distance noise level - mean	Sleep interruptions	Distance interruptions - mean
Monday	45	**0**	2	**-0.14**
Tuesday	40	**-5**	1	**-1.14**
Wednesday	55	**10**	4	**1.86**
Thursday	50	**5**	3	**0.86**
Friday	60	**15**	5	**2.86**
Saturday	35	**-10**	0	**-2.14**
Sunday	30	**-15**	0	**-2.14**

Step 3 - Calculate the top of the coefficient equation

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

Night	Distance noise level - mean	Distance interruptions - mean	Distance noise * Distance interruptions
Monday	0	-0.14	**0**
Tuesday	-5	-1.14	**5.7**
Wednesday	10	1.86	**18.6**
Thursday	5	0.86	**4.3**
Friday	15	2.86	**42.9**
Saturday	-10	-2.14	**21.4**
Sunday	-15	-2.14	**32.1**
Sum			**125**

Step 4 - Calculate the bottom of the coefficient equation

Night	Distance noise level - mean	Distance noise squared	Distance interruptions - mean	Distance interruptions squared
Monday	0	**0**	-0.14	**0.0196**
Tuesday	-5	**25**	-1.14	**1.2996**
Wednesday	10	**100**	1.86	**3.4596**
Thursday	5	**25**	0.86	**0.7396**
Friday	15	**225**	2.86	**8.1796**
Saturday	-10	**100**	-2.14	**4.5796**
Sunday	-15	**225**	-2.14	**4.5796**
Sum		**700**		**22.86**

When multiplying the results of the two expressions, we get: **700 x 22.86 = 16 002.** The bottom of the equation is therefore:

$$\sqrt{16,002} = 126.5$$

Step 5 - Complete the calculation and conclude

$$r = \frac{125}{126.5} = 0.99$$

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 while the values of the other variable decrease. **The values 1 and -1 each represent "perfect" correlations, positive and negative respectively**. Here, with a correlation coefficient of 0.99, we can conclude that there is a very strong positive correlation between noise level and number of sleep interruptions.

Optional Step - Calculating the Confidence Interval: To enhance the scientific rigor of the analysis, it is recommended to add an optional step focusing on the use of the confidence interval. This statistical method allows for evaluating the precision and reliability of observed correlations, thus offering a more nuanced perspective on the obtained results. The confidence interval helps determine whether correlations are statistically significant and to what extent they can be generalized to a larger population. It helps understand the potential magnitude of the relationship between variables in the studied population. The confidence interval is also a valuable tool for determining the statistical significance of observed correlations, particularly when it does not contain zero. It guides decisions regarding the need to collect more data or to further investigate certain relationships. It offers the possibility to present results in a more nuanced and rigorous manner, thus improving the quality of scientific communication. By applying this method, students will be able not only to identify important correlations but also to evaluate their reliability and relevance in the broader context of their study on the impact of urban pollution on sleep quality. This additional approach will help strengthen the validity of the study's conclusions and develop students' critical thinking regarding the interpretation of statistical data.

Methodology and Calculation of the Confidence Interval: Calculate the correlation coefficient (r) between two variables (for example, noise level and number of sleep interruptions). Apply the simplified formula for the 95% confidence interval where:

- **r**: The calculated correlation coefficient
- **n:** The number of observations in the study
- **1.96**: The critical value for a 95% confidence level

$$IC_{95\%} = r \pm \frac{1.96}{\sqrt{n}}$$

This formula allows us to estimate the range in which the true population correlation lies, with 95% confidence. **For example, using our study data where r = 0.99 and n = 7 (for the 7 days of the week), the confidence interval would be approximately [0.96, 1.00]. This means we are 95% confident that the true correlation between noise level and sleep interruptions lies between 0.96 and 1.00, indicating a very strong to almost perfect correlation.**

Data Visualization: To visually represent the study results, students will use simple and accessible tools. They will create graphs using software like Excel or Google Sheets, which offer basic functionalities to generate bar charts, line graphs, and scatter plots. These tools will allow students to easily produce clear visual representations of their data, such as the evolution of noise levels over time or the relationship between noise and sleep interruptions. For more specific visualizations, they can also use free online applications like Canva, which offer pre-designed templates to create attractive infographics. These simplified approaches will allow students to focus on data interpretation rather than mastering complex tools. They can, for example, create scatter plots, box plots, and line graphs to visualize relationships between variables and their temporal evolution.

Summary and Presentation of Results: Based on their analyses, students will identify the **environmental factors having the greatest impact on sleep**. They will research **existing studies on effective interventions** for these factors and propose solutions adapted to the local context, such as recommendations for nighttime lighting or improving sound insulation. They will also evaluate the **feasibility and potential impact of these solutions.** An important part of the analysis will consist of **identifying and discussing potential study biases**. Students will examine sample size, study duration, and uncontrolled external factors that could influence the results. This critical reflection will help them understand the limitations of their study and the importance of caution in interpreting scientific results. To showcase their work and the complex scientific approach used, students may prepare (optional final step) a **visual presentation summarizing the key points of the study**. This presentation will highlight the use of multiple variables and tools, thus emphasizing the rigor of their approach. A results presentation session will be organized, potentially open to the school or local community, allowing students to develop their scientific communication skills.

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 in-depth study on the impact of urban pollution on sleep quality, it is crucial to step back and evaluate the entire process and results obtained. This conclusion and reflection phase allows not only to synthesize the discoveries made but also to examine the skills acquired and the perspectives opened by our research.

This protocol, based on a rigorous scientific approach, has led students to explore the scientific method in practice. From the initial formulation of hypotheses to the final data analysis, including the design and implementation of measurement tools, each step has contributed to developing essential skills for future scientists and informed citizens.

Students have learned to plan a scientific study, identify relevant variables, choose appropriate data collection methods, and implement a reliable measurement system. Through the use of statistical and visualization tools, students have developed their ability to process multivariate data, identify correlations, and draw conclusions based on empirical evidence.

The preparation and presentation of results have allowed students to develop their communication skills, learning to synthesize complex information and present it clearly and convincingly to different audiences.

To deepen the reflection, teachers can use the following opening questions:

- "**How could the results of this study be used to influence local urban planning and public health policies?**" This question encourages students to reflect on the practical application of their discoveries.
- "**What ethical challenges did we encounter during the collection and analysis of personal sleep data, and how could we improve our approach in the future?**" This question addresses the ethical issues of scientific research.
- "**To what extent do you think the results of our local study can be generalized to other urban contexts? What adaptations would be necessary to replicate this study on a larger scale?**" This reflection encourages students to consider the scope and limitations of their study.
- "**How has this experience changed your perception of the relationship between urban environment and health? What personal actions do you plan to take following these discoveries?**" This question encourages students to reflect on the personal impact of their research and the concrete actions that result from it.

Practical Implementation 1.

Measuring environmental data: light, noise, temperature

Material and tools needed

To program a micro:bit board to collect light, noise, and temperature levels, you will need the following materials:

- **Micro:bit V2 Board and its built-in sensors**: The main programmable board including a built-in light sensor through its LED display, a built-in sound level sensor and a built-in temperature 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) or 177 EUR for 10 kits (check here)

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

We recommend for this step to program at least 3 to 6 micro:bit boards for sharing them among students and gather more information and data. You can do it with only 1 board, but you will need either to expand the overal duration of the collection period or reduce the duration of the collection period per student from 7 to 3 days.

Instructions for wiring and using the micro:bit board

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

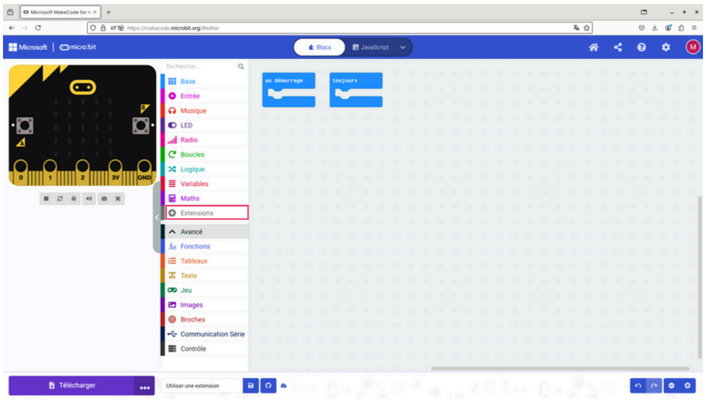
Step 1: Programming the Micro:bit

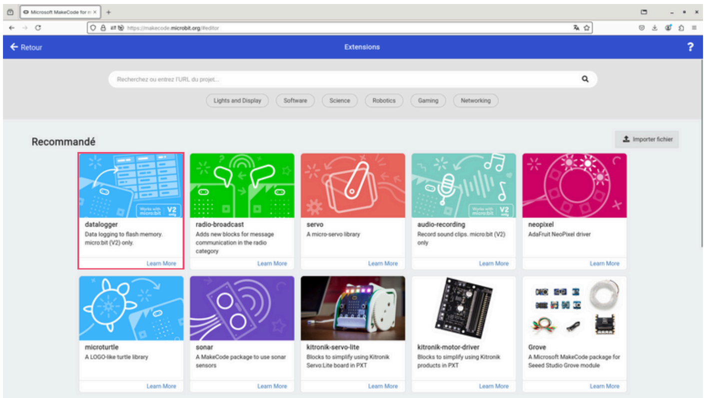
Connect the Micro:bit board: With your USB Cable, connect the board to your computer by using the **micro-USB connector**. Once connected, the micro:bit board will appear on the computer as a removable drive (e.g., "MICROBIT").

Write the Program: Open the MakeCode editor to create a program that collects 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**.

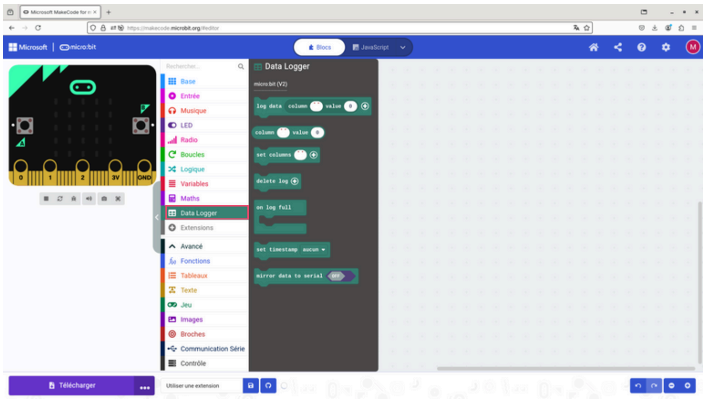
Extensions in MakeCode are groups of code blocks that are not directly included in the basic code blocks found in MakeCode. Extensions, like the name implies, add blocks for specific functionalities. There are extensions for a wide array of very useful features, adding gamepad, keyboard, mouse, servo 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.

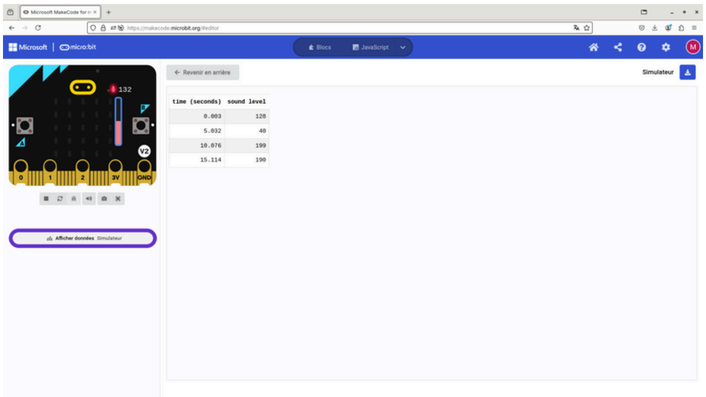




1 Open the extensions menu from the MakeCode editor for micro:bit.

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

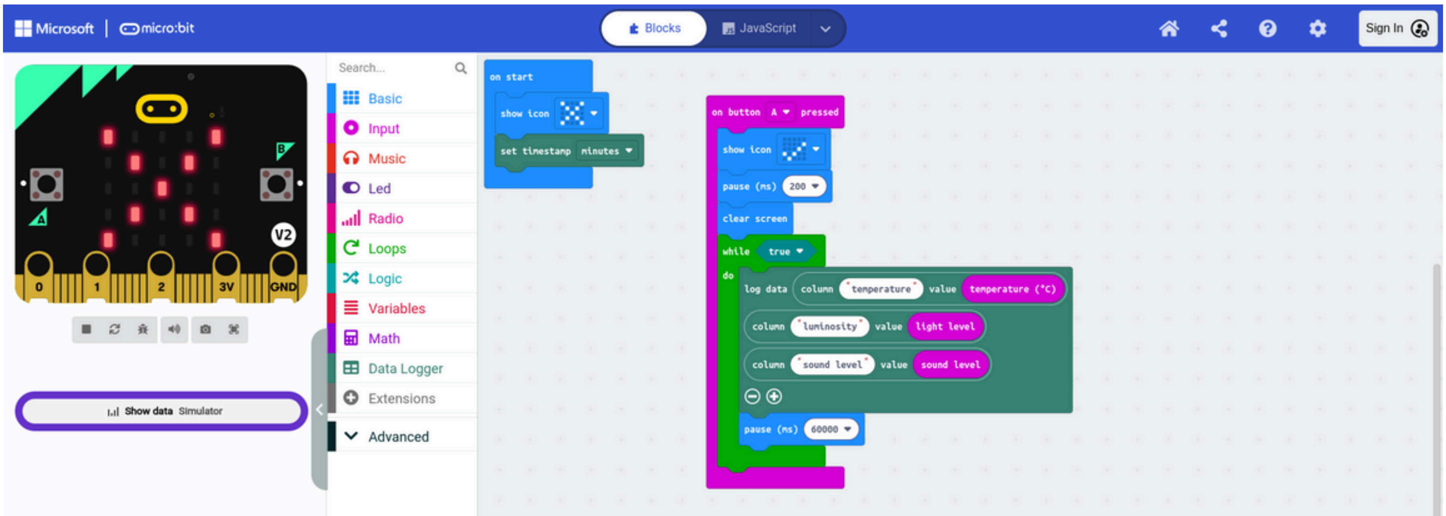




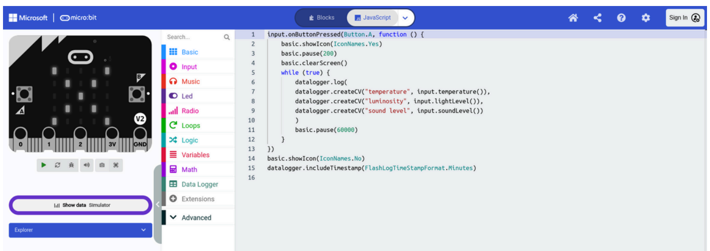
3 The datalogger extension appears in the list of available blocks from your editor.

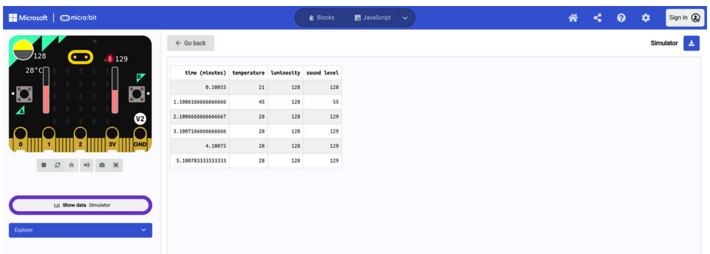
4 The datalogger allows you to access a data recording simulator.

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.

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

Once programmed, place the micro:bit for collecting the data you need i.e. near your bed in an area where it can accurately record light, noise, and temperature without obstruction. **Use a computer or external battery pack to power the micro:bit continuously during the recording.** Ensure that each night, the board is placed again in the exact same position to record comparable data.

Before going to bed, 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

Each morning, to avoid data loss, we recommend to disconnect the micro:bit from its power source to stop data recording and **connect the micro:bit to your computer to access the file compiled over the night by the datalogger (which will be called "MY_DATA.HTM, available on the micro:bit drive)**.

Copy this file to your computer and rename it with the current date (e.g., BOARD1_NAME_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 evening before going to bed.

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 light, noise and temperature:

```
input.onButtonPressed(Button.A, function () {
    basic.showIcon(IconNames.Yes)
    basic.pause(200)
    basic.clearScreen()
    while (true) {
        datalogger.log(
        datalogger.createCV("temperature", input.temperature()),
        datalogger.createCV("luminosity", input.lightLevel()),
        datalogger.createCV("sound level", input.soundLevel())
        )
        basic.pause(60000)
    }
})
```

```
})
basic.showIcon(IconNames.No)
    datalogger.includeTimestamp(FlashLogTimeStampFormat.Minutes)
```

How does the code work?

This program measures the ambient sound level, temperature and luminosity. Every minute (the interval can be modified to correspond to 10 seconds, 5 minutes, twice per hour...) the program 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:

- **Temperature**: `input.temperature()`, which retrieves the current temperature in degrees Celsius.
- **Light level**: `input.lightLevel()`, which measures the ambient light level.
- **Sound level**: `input.soundLevel()`, which captures the ambient sound level.

The **sound level** and **light level** measure a **relative** value and do not have standard units like decibels (**dB**) for sound level or lux (**lx**) for brightness. 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).

The temperature is measured in degrees Celsius (**°C**).

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

```
datalogger.log(
    datalogger.createCV("temperature", input.temperature()),
    datalogger.createCV("luminosity", input.lightLevel()),
    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.

60,000 millisecond pause before next reading: After each recording, the program waits 60,000 **milliseconds** (1 minute) before reading the sensor values again. This is achieved with `basic.pause(60000)`.

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.

Practical Implementation 2.

Measuring movement amplitude during the night

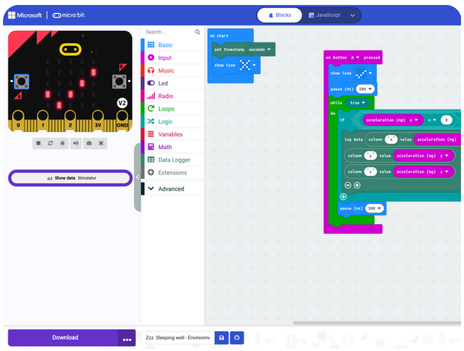
Material and tools needed

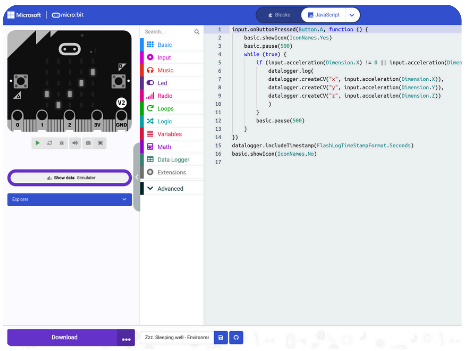
To program a micro:bit board to collect information about your movement aplitude over the night, you will need the same material as for the measurement of environmental data and you can refer to the Practical Implementation Activity Sheet 1 for wiring, programming and using the Micro:bit board. You can follow the same steps for this stage, only updating the program with the right piece of code available hereunder.

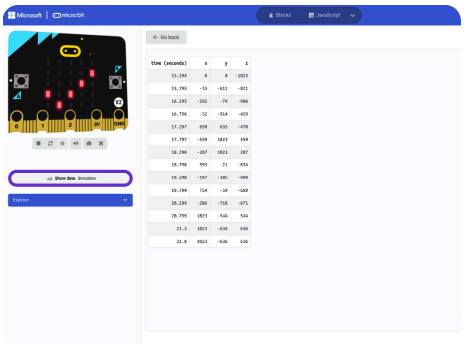
Code

Here is the Javascript code used to program a micro:bit board in order to regularly collect data on movement:

```
input.onButtonPressed(Button.A, function () {
    basic.showIcon(IconNames.Yes)
    basic.pause(500)
    while (true) {
        if (input.acceleration(Dimension.X) != 0 || input.acceleration(Dimension.Y) != 0 ||input.acceleration(Dimension.Z) != 0) {
            datalogger.log(
            datalogger.createCV("x", input.acceleration(Dimension.X)),
            datalogger.createCV("y", input.acceleration(Dimension.Y)),
            datalogger.createCV("z", input.acceleration(Dimension.Z))
            )
        }
        basic.pause(500)
    }
})
datalogger.includeTimestamp(FlashLogTimeStampFormat.Seconds)
basic.showIcon(IconNames.No)
```







How does the code work?

This program measures acceleration values captured by the accelerometer. Every 500 milliseconds (the interval can be modified to correspond to 10 seconds, 5 minutes, twice per hour...) the program checks if the board is in motion and if it is, it compiles the data 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.

This program is designed to record accelerometer data on a MicroBit when button "A" is pressed, and store it in a **datalogger** with values for the **X**, **Y**, and **Z** axes.

Initialization of button "A" press event: When the user presses **button "A"** on the MicroBit, the function `input.onButtonPressed(Button.A, function () {...})` is triggered. This prevents data recording as soon as the board is connected.

Display of "Yes" icon during recording: Before starting recording, the program displays a "Yes" icon (`basic.showIcon(IconNames.Yes)`) on the MicroBit screen for **500 milliseconds** (0.5 seconds), to indicate that data recording will begin.

500 millisecond pause: The program waits **500 milliseconds** using `basic.pause(500)`.

Infinite data collection loop: The program enters an **infinite** loop (`while (true)`), which means it will continue running until the MicroBit is turned off or restarted.

Checking accelerometer data: At each loop iteration, it checks if any of the acceleration values (on X, Y, or Z axes) is different from zero. This is done with the condition:

```
if (input.acceleration(Dimension.X) != 0 || input.acceleration(Dimension.Y) != 0 ||
input.acceleration(Dimension.Z) != 0)
```

If any of these values is different from zero (meaning movement has been detected), the program records this data in the **datalogger**.

Data recording: The acceleration values for X, Y, and Z axes are recorded using the `datalogger.log()` function: This function creates a record of acceleration values whenever the values are different from zero, with a timestamp for each recording. The timestamp is automatically added thanks to the following line (explained later).

```
datalogger.log(
    datalogger.createCV("x", input.acceleration(Dimension.X)),
    datalogger.createCV("y", input.acceleration(Dimension.Y)),
    datalogger.createCV("z", input.acceleration(Dimension.Z))
)
```

500 millisecond pause before next reading: After recording the data, the program pauses for **500 milliseconds** (`basic.pause(500)`) before resuming accelerometer value readings.

Data timestamping (included via datalogger.includeTimestamp): Outside the button-linked function, the command `datalogger.includeTimestamp(FlashLogTimeStampFormat.Seconds)` is used to include a timestamp in seconds format for each recording in the datalogger. This means each recording will be accompanied by the time elapsed since the program started.

Display of "No" icon after program execution: When the program is executed (before the infinite loop begins), the "No" icon (`basic.showIcon(IconNames.No)`) is displayed, to indicate that the MicroBit is in waiting mode before button "A" activation.

The data: The accelerometer returns values in **milli-g** for each axis (X, Y, Z). This means that if the accelerometer detects an acceleration of **1000 milli-g**, this corresponds to an acceleration of 1G (or 9.81 m/s^2) on that axis.

Wristband for wearing the Micro:bit board during the night

Several resources can help you attach the Micro:bit board to a wristband which will allow students to wear it during the night. Here are some relevant tutorials and accessories that can help you complete this step:

- Smart Coding Watch Kit - micro:bit
- Duct Tape Watch
- BBC micro:bit wrist holder | mattoppenheim
- Yahboom Wrist:bit wearable watch kit based on BBC Micro:bit V2/V1.5 board
- CHARGE for micro:bit

Explore design and creative digital tools

Canva

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

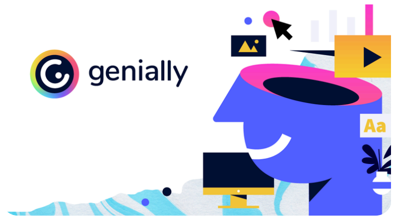
Resources provided: Images, graphics, videos, audio elements

Accessibility: Very accessible

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

Education Plan available freely for teachers

Genially



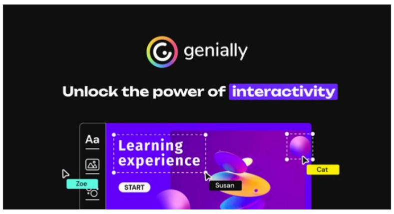
Creation of interactive presentations, infographics, games, animated content

Resources provided: Images, graphics, animations

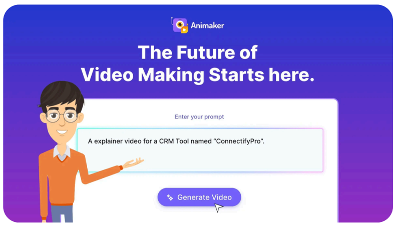
Accessibility: Accessible

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

Reduce fee for professional account access for educators



Animaker



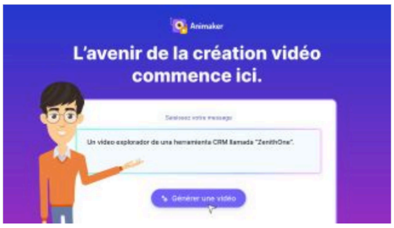
Creation of animated videos, video infographics, video presentations, animated GIFs

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

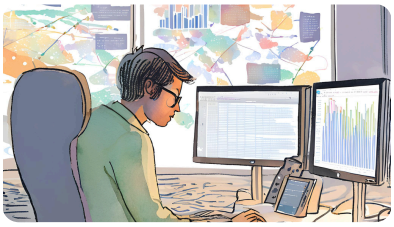
Resources provided: Images, graphics, audio elements, animations

Accessibility: Accessible

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

Reduce fee for professional account access for educators

Piktochart



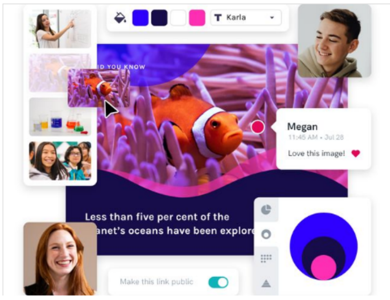
Creation of infographics, presentations, reports, posters

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

Sleep Research and Public Health:

1. European Sleep Research Society (ESRS)
   Focuses on advancing knowledge of sleep and its disorders through research and education.
2. Sleep Europe Foundation
   Promotes sleep science and health initiatives across Europe.
3. National Sleep Foundation
   Offers science-based advice and resources for better sleep health.
4. World Sleep Society
   A global organization dedicated to advancing sleep health and science.
5. Sleep: A Neglected Public Health Issue
   Explores the global public health challenges posed by insufficient sleep.
6. The Global Problem of Insufficient Sleep and Its Serious Public Health Implications
   Reviews the worldwide implications of inadequate sleep on public health.
7. Sleep and Cognition
   An in-depth look at how sleep affects memory, decision-making, and overall cognitive performance.
8. How Lack of Sleep Impacts Cognitive Performance and Focus
   Explains the effects of sleep deprivation on cognitive abilities.
9. How Noise Can Affect Your Sleep Satisfaction
   Discusses the impact of environmental noise on sleep quality.

Circadian Rhythm and Related Topics:

1. Circadian Rhythm - Wikipedia
   A comprehensive overview of circadian rhythms and their role in regulating sleep and other bodily functions.
2. Circadian Rhythms - National Institute of General Medical Sciences
   An educational overview of circadian rhythms, their impact on health, and the consequences of disruptions.
3. Sleep and Circadian Rhythms - Annenberg Learner
   This module covers natural rhythms and sleep stages, illustrating the brain's electrical activity during a typical night's sleep.
4. The Complete Guide to Circadian Rhythm - Sleepopolis
   A comprehensive guide explaining the sleep-wake cycle and its influence on physiological functions.
5. Sleep and Circadian Health Curriculum - World Sleep Society
   A curriculum developed to guide educational programs on sleep and circadian health.
6. Sleep and Daily Rhythms - BioEd Online
   Lessons and activities focusing on sleep, circadian rhythms, and factors affecting sleep quality.

Citizen Science Projects:

1. Cities at Night
   A citizen science project analyzing light pollution to understand its effects on the environment and human sleep.
2. iTechExplorers – Citizen Science Project
   A project exploring bedtime technology use, sleep patterns, and circadian rhythms, inviting public participation.
3. Sleep: One Third of Life - European Citizen Science Platform
   A project inviting students to explore their sleeping habits and identify their chronotypes.
4. Sleep Tracking: The Brain and Circadian Rhythm's Role in Sleep - Science Buddies
   A science project that allows students to experiment and explore factors influencing sleep schedules.
5. Learn About Human Circadian Cycles - Science Buddies
   A project to investigate human circadian cycles by tracking body temperature variations.

Wearable Technology and Sleep:

1. Smart Coding Watch Kit - micro:bit
   A wearable coding kit that can be adapted for sleep monitoring projects.

2. **Duct Tape Watch**
   A DIY project using micro:bit to create wearable tech.
3. **BBC micro:bit Wrist Holder**
   A 3D-printed holder for the micro:bit, enabling wearable applications.
4. **Yahboom Wrist:bit Wearable Watch Kit**
   A wearable kit for micro:bit projects, useful for sleep or activity tracking.
5. **CHARGE for micro:bit**
   A charging and expansion kit for wearable micro:bit devices.

SLEEP JOURNAL

Name:

Date:

Study Day:

To be filled out before going to bed:

Perceived fatigue level (1 to 5)

Perceived stress level during the day (1 to 5)

Perceived performance in daily tasks (1 to 5)

Weather during the day

Special events or observations:

To be filled out upon waking-up:

Sleep Quality

Time to fall asleep in minutes

___ minutes

Overall subjective sleep quality (1 to 5)

Number of sleep interruptions

___ interruptions

Fatigue felt upon waking-up (1 to 5)

Screen exposure before bed

Duration in minutes

___ minutes

Screen type:
☐ Smartphone ☐ Tablet
☐ Computer ☐ Television

Food

Last meal **___ hours before bedtime**

Type of meal:
☐ Light ☐ Medium ☐ Heavy

Environmental conditions

Perceived noise level (1 to 5)

Perceived ambient light (1 to 5)

Perceived temperature
☐ Too cold ☐ Comfortable
☐ Too hot

Additional observations