Measuring Sound in Our Environment

Description:

In Part I, students will learn how to measure sound levels in the environment using sound level meters. In Part II, students will identify the differences in analyzing the data in a log scale versus an arithmetic scale to understand how each scale provides a different way to visualize their information. Students will discuss design elements and other aspects that account for the patterns seen in their data and graphs.

Objectives:

- Understand the difference between sound and noise by quantitative measurements.
- Measure and analyze sound data according to the scientific method.
- Explain in real numbers the definition of harmful sound and its relation to mental and physical health effects.

Vocabulary:

Ambient, analyze, decibel, exposure, intensity, noise pollution, quantitative

Materials:

- Paper
- Pencils
- Sound meter (free applications such as Arduino Science Journal or CDC NIOSH Sound Level Meter on smartphones can be used as a substitute)
- DEP Loudness Chart
- "Graphing Sound Data" worksheet
- Graph paper

Background Information:

Part I:

Sounds are caused by vibrations and are measured in units called decibels (dB). Most sound is measured in dBA, which is the decibel level that follows the frequency sensitivity of the human ear at low levels. dBA is good for measuring damage to ears. Measurements of 85 dBA and higher are defined as harmful sound. Extended exposure to levels over 85 decibels can cause hearing damage as well as mental and emotional stress.

To better understand this, it is important to collect real-world data. When collecting sound data, data must be collected from a variety of sources. Having multiple data points is important because sound intensity is not uniform, especially in schools. For example, gymnasiums and cafeterias are typically louder than libraries and classrooms. The reason for this lies in the design of the spaces. Design can be the arrangement or organization of a tool, object, process, or environment. Some design features that can contribute to the sound intensity include lighting, ceiling height, layout of furniture, and size of the room. Observing the sound intensity in different spaces can give better insights into why indoor noise pollution is important to study in school environments.

Please note that sound meters and apps range in their sensitivity and accuracy. These devices will not be as accurate as the sound meters that DEP noise experts use when they take measurements in response to a noise complaint.

Part II:

It is also important to observe sound intensity. Sound intensity is often considered the loudness of a sound. Intensity is measured in decibels (dB) which is on a logarithmic scale; therefore, a sound recorded at 40 dB is ten times more intense than a sound recorded at 30 dB.

It is often hard to conceptualize the logarithmic scale if it is a new concept. Data can be transformed from a logarithmic scale to an arithmetic scale to better understand the magnitude of difference between two or more intensities. To convert data from a logarithmic scale to arithmetic scale the value X should become 10^X. For example, if the mean subway volume was measured to be 85 dB then in an arithmetic scale it would be 10^{85}. If the mean volume for a library is 35 dB then in an arithmetic scale it would be 10^{35}. These numbers are huge and almost impossible to represent as a bar graph but can still be used to help students understand how log scale and magnitude are important when thinking about how we measure sound.

Method:

Part I:

- Ask students to define sound. Then ask them to define noise. Write down their responses.
- Explain how the volume of a sound is measured in decibels. Decibel readings of 85 dB and higher are defined as physically harmful sounds.
- Generate two lists with the students: one side will include examples of sound and the other list will include examples of noise, in your classroom or community environment. Organize both lists in order from quietest to loudest. Have students explain the differing characteristics between the two lists.
- Tell students that they will be measuring sound levels; thus, they will be seeing a quantitative determination of sounds and noise.
- Demonstrate how to use the sound level meters or sound level meter apps in the classroom before they conduct the investigation.
    - If using the Arduino Science Journal app, press the plus button to create a new experiment. Then, press the edit button and select “Sensors.” Scroll to the end and select the “Sound Intensity” option. Press “record” to record sound and “stop” to end the recording. Press the back arrow to see a snapshot of the recording.
    - If using the CDC NIOSH app, press the play button to start recording sound. Write down the LAeq (Equivalent) which is the average of the sound every second. Make sure to save the recording by pressing the download button. Students should take note of the Lmax in the observation notes section of their worksheet.
        - *While both applications can be used, the Arduino Science Journal is more student friendly, while the NIOSH application provides the most accurate data.
- Break students into small groups. Each group should create a hypothesis about the noise levels in different school locations for their investigation.
- Have students discuss how the design, arrangement, and social norms for a given space impact the amount of sound and noise in that space.
- Select places to measure sound such a hallway, library, cafeteria, gym, or schoolyard.
- Have students share, either in their notebooks or together as a class discussion, what they hypothesize sound measurements will be in each of the selected areas where sound will be measured (which areas they think will be the loudest, quietest, etc.).

- While in the field, each group should record their data in the "Graphing Sound Data" worksheet included at the end of this lesson. Remember that there is always a certain level of ambient, or background noise.
- Have students take a reading for one minute, and record the minimum, maximum, and average sound level readings from each of the locations your students selected.

Chart Example:

Location	Sound Measurement (dBA)
Hallway during class time	60
Library	30
…	…

- Compile student data (on blackboard), and have students complete their worksheets including data collected by other groups.
- Create a list of the collected sounds and dBA measurements from the different locations on the board from quietest to loudest.
- Pass out DEP's loudness scale as a reference. Students can create a similar scale for their school, based on the data that they collected.

Part II:

- Introduce sound and intensity as vocabulary terms. Discuss how sound intensity is measured using decibels.
- Using their data and observations recorded in the "Graphing Sound Data" worksheet, students will now visualize the data in a bar graph. Have students convert the logarithmic scale to arithmetic before graphing the data points. Room location should be on the X-axis and average decibel level should be on the Y-axis.
- Make sure to point out that decibels are measured on a logarithmic scale. For example, a sound measured at 40 dBA is twice as loud as a sound measured at 30 dBA.

Discussion:

- Does a noise have to be loud? What makes something a noise?
- How did listening to certain sounds make you feel? What sounds correlated with which emotions?
- How can we reduce indoor noise pollution in our schools?
- How does design connect to sound and noise?

Extension:

- Consider environments that we frequently come across outside of school. Measure and analyze the sound levels at these locations, for example while commuting to school.
- Think about how noise pollution can affect young people. Look at the Listen Up! Protect Your Hearing tool from the Centers for Disease Control and Prevention (CDC) on why it's important for young people to protect their hearing. Have students look at the various sounds and discuss afterwards. Did the level of noise from any sounds surprise you?
    - After this, read tips in the article "How Do I Prevent Hearing Loss from Loud Noise?" from the CDC to teach students ways in which they can protect their hearing. from the CDC to teach students ways in which they can protect their hearing.
- Use DEP's Engineering a Speaker and Insulator lesson to design a tool to reduce sound. Students will discuss how design (materials, shape, size, etc.) contributes to the ability of an insulator to decrease sound levels.

NYC Department of Environmental Protection
educationoffice@dep.nyc.gov
For more information visit www.nyc.gov/dep

Name: _____ Date: _____

Graphing Sound Data

Directions: With your sound meter or smartphone app, record sound intensity for your location in the table. Record three readings at each location for one minute, ensuring you record the minimum, maximum, and average sound level readings from each of your locations. Make sure to write down observations about the design of the location and any ambient sounds you hear.

The sound meter used to collect data is _____

Location	Measurements			Notes/Observation
	Minimum	Maximum	Average	

Name: _____ Date: _____

Questions:

1. Was your hypothesis correct?

   _____

   _____

   _____

2. Were you surprised by some of your sound level readings? Give an example and explain.

   _____

   _____

   _____

3. Which parts of your school were the quietest or loudest?

   _____

   _____

   _____

4. How did listening to certain sound levels make you feel? Explain which location made you feel this way.

   _____

   _____

   _____

5. What are some ways we can all help reduce the noise in our school?

   _____

   _____

   _____