Engineering Challenge: Speakers and Insulators

Description:

This lesson will apply students' knowledge of sound and amplitude to an engineering problem. Students will design and build both a speaker and an insulator using household materials in order to amplify and absorb the sound, respectively, from a stereo or phone. Students will discuss how design (materials, shape, size, etc.) contributes to sound levels.

Objectives:

- Understand how design and materials impact sound levels
- Design and engineer a speaker and insulator using common household materials
- Apply science and math concepts to design solutions for technical problems
- Apply the principles of engineering to determine which household materials will be most effective at either amplifying or absorbing sound waves

Vocabulary:

Absorption, amplitude, decibel, design, diffusion, engineer, insulator, reflection, sound waves, vibration

Materials:

- Stereo speaker or phone
- Sound meter or smartphone applications (i.e., Arduino Science Journal, CDC NIOSH Sound Level Meter)
- Miscellaneous household materials (i.e., toilet paper rolls, plastic cups, coffee filters, and cardboard)
- Tape
- Scissors
- Computer access

Background Information:

Engineers are professionals that design, build, and maintain various things. Engineers are often tasked with solving problems in our everyday lives through design. Design is a step-by-step process that engineers use to create tools. Everything from cellular phones to shopping carts are all designed and engineered.

Sound travels in waves. Sound waves can either be amplified, reflected, absorbed, or diffused. Diffusion occurs when sound hits an irregular surface and breaks up the sound wave into smaller paths. Sound is reflected when it bounces off a flat surface, like an echo. The opposite of sound reflection is absorption. A sound is absorbed when it does not bounce back and is therefore taken in by the material.

Engineering a Speaker:

When thinking about engineering our own speakers, we must first apply the principles of design to our creations. Using design methods is crucial to determine if the speaker will amplify or dampen the sound level. One design aspect to consider is the shape of the speaker. For example, megaphones with a funnel shape can help to amplify sound because sound is directed out from one particular area, or the source. Another design aspect to consider is the type of materials used since this can influence the sound level. For example, metal can be used to increase or amplify the sound level. Shape and materials are only two of the many design aspects to consider when engineering a speaker. By experimenting with design, students can apply their knowledge of amplitude and vibration to construct the loudest speaker.

Engineering an Insulator:

When considering how to create an insulator that can absorb the most noise, it is also

important to think about how it is designed. This includes the materials used to create the sound insulator. For example, foam soundproofing panels can be effective at absorbing noise whereas metal can be effective at reflecting noise. Another design aspect to consider is the shape of the insulator. For example, irregular shapes can better absorb sound waves than flat, smooth shapes. Through experimentation and engineering, students can understand how different materials and shapes can impact an insulator's ability to absorb noise and apply these ideas to their own lives.

Method:

Part I: Engineering a Speaker

- Introduce students to the terms sound, vibration, and amplitude.
- Discuss how sound is measured on the dB scale. Explain that decibels are measured on a logarithmic scale; therefore, every increase of 10 dB doubles the intensity of the sound.
- Discuss how design (i.e., shape, materials, size, etc.) factors into the sound level of an object. Play videos, look at images, or demonstrate sound from different musical instruments as examples to explain how design can influence sound levels.
- Split students into small groups. In groups, students should collaborate to first draw an object they believe will best amplify sound from a phone speaker or small stereo.
- Using their drawings as a guide, have groups physically engineer the speaker. Provide each group with basic materials such as tape, scissors, and paper. To offer a greater challenge, allow groups only ten additional items from the available materials.
- Before testing your students' speakers, make sure to know the sound level of your test sound without any amplification. To get a consistent test sound, try using a video of a tuning note. To calibrate the sound meters to this sound level with the least amount of interference, test the test sound in a quiet hallway or empty room. Use this measurement as a baseline or control for the experiment.
- When speakers are completed, test each group's speaker one at a time using a phone or stereo speaker. Students should be silent in order to reduce any interferences that will skew the data.
    - While testing each speaker, remind students that sound is measured on the dB scale. Decibels are measured on a logarithmic scale; therefore, every increase of 10 dB is an increase of 10x the sound intensity, which creates a perceived doubling of sound loudness.
- Discuss results with students using the following discussion questions.

Part II: Engineering an Insulator

- Explain to students that sound travels in waves. Introduce the concepts of reflection, diffusion, and absorption. Using the online wave interference simulation, show students how different materials interact with sound waves. Connect these concepts to 'real-world' examples such as sound-proof rooms and echoes.
- Students should rejoin their groups. The goal of this activity is for students to design a sound insulator that absorbs the most amount of sound or measures the lowest sound level.
- Allow students time to draw, design, and determine problems and solutions for their sound insulator on paper first.
- Then, provide time for students to engineer their sound insulators. Have students collect only ten objects from the materials you provide to build their insulator. All students will be given basic materials such as scissors, paper, and tape.
- Before testing the insulators, take a sound reading of the test-sound. To get a consistent test-sound, try using a video of a tuning note. To calibrate the sound meters to this sound level with the least amount of

interference, measure the test-sound in a quiet hallway or empty room. Use this measurement as a baseline or control for the experiment.

- When the insulators are completed, test each group's insulator one at a time using a phone or stereo speaker. Test each insulator one at a time. Students should be silent in order to reduce any interferences that will skew the data.
    - While testing each insulator, remind students that sound is measured on the decibel scale. This is a logarithmic scale; therefore, every decrease in 10 dB is a decrease of 10x the sound intensity, which creates a perceived halving of sound loudness.
- Discuss results with students using the following discussion questions.

Discussion:

Part I: Engineering a Speaker

- Which speaker amplified the sound level the most? What design features made this speaker the loudest?
- Which materials did you choose and why?
- If you were to repeat this activity, how would you improve your design?
- How did the design of the speaker contribute to the sound level?

Part II: Engineering an Insulator

- In this activity, was sound being reflected, absorbed or diffused?
- Which insulator absorbed the sound level the most? Which materials were most effective in insulating noise?
- How does the design of an object affect the effectiveness of absorbing a noise?
- How does the reflection, absorption, or diffusion of sound affect our environment?

Extension:

- Have students repeat the activity to improve upon their original designs.
    - What are some things you did differently the second time and why?
    - What effect did your changes have on the outcome of the experiment?
- Have students record each group's data for the speaker and insulator in a table and then have students visualize the data as a bar graph. Group number should be on the X-axis and decibel level should be on the Y-axis.
- Learn more about making a speaker from household materials by following the New York Hall of Science's lesson Make a Better Speaker.
- Get creative! Allow students to use 3D modelling software to design their speaker tools.
- Have students think about how design of their environment (i.e., classroom, school, neighborhood, and city) contributes to sound level.
    - What are some design features you would change to alter the sound levels?
- Use Science Buddies' lesson to create a new sound insulator. Have students collect their own data by using the Arduino Science Journal application.

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