Listening Devices

Design Challenge Learning

The Tech
Museum of Innovation

201 S. Market St.
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thetech.org

Students design a listening device that will allow them to listen to the sound generated by an object inside a box. As they iterate through this design challenge, they gain firsthand experience in the design process.

Grades 3-8
Estimated time: 30 minutes

Student Outcomes:

1. Students will be able to design and build a device that will trap and reflect sound waves.
2. Students will be able to discuss design considerations based on their knowledge of sound waves.
3. Students will be able to utilize the three step design process to meet an engineering challenge.

Next Generation Science Standards
Grade 3-5: *Engineering Design* 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3
Grade 4: *Physical Science* 4-PS3-2, 4-PS4-3
Grade 6-8: *Engineering Design* MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4
Grade 8: *Physical Science* MS-PS4-2

Common Core Language Arts-Speaking and Listening
Grade 3: SL.3.1b-d, SL.3.3, SL.3.4a
Grade 4: SL.4.1b-d, SL.4.4a
Grade 5: SL.5.1b-d, SL.5.4
Grade 6: SL.6.1b-d
Grade 7: SL.7.1b-d
Grade 8: SL.8.1b-d

Vocabulary:

Familiarity with these terms and concepts will enhance students' experience in the activity

- Acoustic: The ability of an enclosed space to reflect sound waves; the total effect of sound.
- Compressional Wave: A wave that carries sound energy.
- Echo: The repeating of a sound caused by reflection of sound waves.
- Energy: The ability to perform work. Appears in many forms, all of which are either kinetic or potential.
- Medium: A material through which a wave travels (solid, liquid, or gas).
- Sound: Energy traveling away from a vibrating object.
- Vibrate: To move rapidly back and forth.
- Wave: A transfer of energy as it travels away from the energy source.

Resources:

- Sound Waves: An article in "Bitesize" produced by the BBC on the science of sound. The article includes images and animations of waves, the inner ear, and sound-producing devices. www.bbc.co.uk/education/guides/z8d2mp3/revision/1
- How Stethoscopes Work: This "How Stuff Works" article covers the science behind stethoscopes. http://science.howstuffworks.com/everyday-tech/stethoscopes.htm
- NeoK12: A website that provides a collection of educational videos, lessons, and games for K-12. Their collection on sound includes quizzes, activities, images for presentations, and videos. www.neo12.com/Sound.htm

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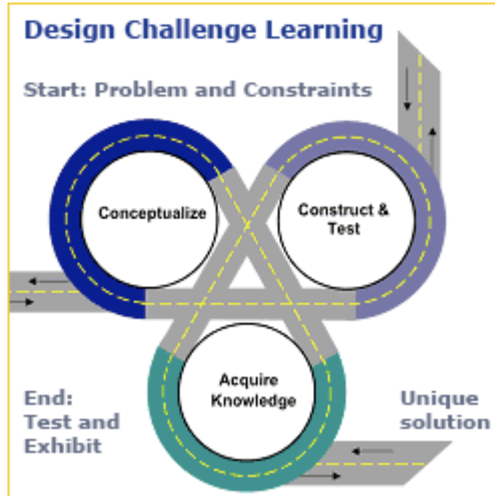
Design Challenge Process:

The Design Challenge Process is designed so students reinforce their science, mathematics, social studies, and language arts content knowledge, through an open-ended process that results in an original, team-driven solution. Students are expected to take responsibility for assessing their own progress and incorporate peer feedback as they conceptualize and redesign their projects.



The process consists of three interconnected steps:

Conceptualize
- Identify problem, materials, and constraints
- Brainstorm ideas and possible solutions

Construct and Test
- Select a solution
- Design and construct
- Prototype
- Redesign or modify
- Retest

Acquire Knowledge
- Research
- Share solutions
- Reflect and discuss

Through the try, fail, learn approach, students develop the skills and habits of mind of Silicon Valley innovators: creativity, problem solving, design, collaboration, leadership, risk-taking, perseverance, and learning from failure.

Materials:

Materials can be limiting or inspirational to students! Have a wide variety of materials to promote a diversity of solutions. "Recycled items" are really useful: old mouse pads, wood scraps, boxes, cardboard tubes, strawberry baskets, etc.

Class Supplies to Share:
- Plastic soda bottles
- Paper towel rolls
- Stiff paper
- Straws
- Plastic tubing (varying sizes)
- Masking tape
- Aluminum foil
- Plastic wrap
- Rubber bands
- Rubber balloons
- Clay
- Scissors
- Plastic or paper cups
- String

Testing Supplies:
- Metronome
- Box to fit metronome
- Padding (bubble wrap, foam, packing peanuts)

NOTE: To build the test rig place the metronome inside the box and pack the box with padding so the metronome is almost inaudible once the box is sealed. You may use other adjustable sound making devices instead of a metronome. Consider using a fan or other noisy devices inside the testing area to obscure any sounds that are audible without a device.

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Lesson Plan:

Introduction (2 minutes)

You have been given the task of designing a listening device that will help a detective hear sounds through objects. For one of the detective's current cases, a box has been discovered that is believed to contain a secret recorded clue. Unfortunately, the box is stuck and cannot be opened or moved from its current location. Can you design a device that will allow the detective hear the clue?

Listening Device Challenge (18 minutes)

1. Introduce the Challenge: Design and build a device to listen to a device that is inside a box.
2. Introduce the Constraints:
    - Your device needs to allow the detective's ear to remain at least a foot away from the box.
    - You may only use the materials provided.
    - You will need to accurately repeat/represent the sound that is heard within the box.
    - You may only test twice during the building period and prior to your demonstration.
    - There is a time limit of 15 minutes.
3. Build: Give students about 15 minutes to build and test. The instructor should ask open-ended questions to help guide students through the design process, but should also allow students space to tinker.
4. Test: The test rig (a padded and sealed box with a noise making device inside) should be placed inside a taped-off square whose edges are at least one foot away from the test rig. Consider placing a fan or other noise canceling device nearby to obscure any sounds that may be audible without a student-designed device. Students should stand outside the taped off square in order to attempt to hear what is inside the box. Make sure to watch the test rig during the build time – students are only allowed two tests prior to their demonstration.

Demonstration and Reflection (10 minutes)

1. Demonstration: Have students demonstrate their devices one team at a time. At the end of all of the demonstrations have the teams share what they believe what the clue was.
2. Reflection: Have each group of students explain their design strategy. The instructor should ask leading questions to get at the science behind the designs.
    - Teaching Points:
        - Sound is created when an object vibrates matter.
        - Sound travels from one place to another in waves.
        - When sound waves are confined to a tube, they are trapped and reflected back and forth until they reach the other side.
    - Questions:
        - What is the best shape and size for the part that goes against the box?
        - Is it better to cover the object against the box with a membrane?
        - How would your design work if you held it farther away from the box? Why?
        - How would different types of materials work as the membrane and why?
        - What type of tube is best for connecting to your ear (big/small and thick/thin)?
3. Discussion: Discuss the process each of the engineering teams went through and how it is the same process that engineers go through in order to solve a variety of challenges. Discuss other purposes the devices built in the class might serve, or other problems it might have. Guide students to consider stethoscopes how they work, why we use them, and the history of their development.