Activity: Waves, Waves, Everywhere

Objectives

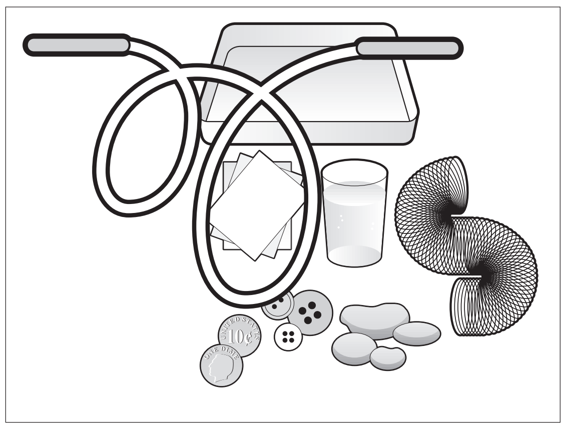
- Identify the components of a radio wave
- Identify the ranges of frequencies of the electromagnetic spectrum
- Observe water waves
- Create waves in different frequencies

Activity Overview

This activity will allow students to understand the relationship between water waves and air waves by learning about their parts. Students will also learn about frequencies of the electromagnetic spectrum. They will work individually and in teams. Younger students will observe and draw waves in the water and with a Slinky. Older students will be able to see the relationship of radio waves to other waves in the electromagnetic spectrum and will be able to identify these parts. They will work in pairs to observe and create a visual representation of waves in varying frequencies.

Materials

- Glass or metal pan
- Water
- White paper
- Eye dropper
- 1 Slinky per group of 4; or
- 1 short rope or jump rope
- Data Collection Sheet



Science Standards

- Science as Inquiry
- Physical Science
- Transfer of Energy
- Science and Technology
- Understanding About Science and Technology

Technology Standards

- Technological Knowledge
  – Technological Concepts and Principals

Mathematics Standards

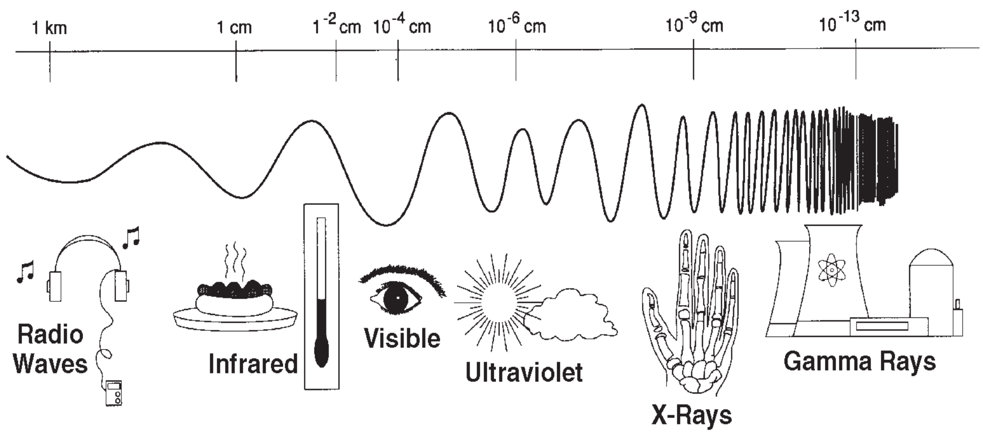
- Problem Solving
- Patterns
- Relationships

Timeframe: 30–45 minutes

Background Information

All around the world every minute of every day people are talking, and they are all talking at the same time. Think of places that you have been where everyone is talking at once—between classes at school, football games, shopping malls. Was it hard to hear just one particular conversation?

When you turn on a radio, you hear people talking or you hear music. As you change the tuner to successive stations, you find that there is some form of audio on all the stations. You may wonder how they can all talk at once, but you can only hear one station at a time. This is due, in part, to **electromagnetic waves—** waves that are partly electric and partly magnetic and carry energy emitted by vibrating electric charges in atoms. All waves are on an electromagnetic spectrum.



The **electromagnetic spectrum** is a continuous range of waves—radio waves, infrared, visible, ultraviolet, x-rays, and gamma rays. It is a means of classifying electromagnetic waves according to their frequency. Waves all move, or vibrate, at the same speed ("c" for constant), but differ in their frequency. The **frequency** is how often a vibration occurs. This unit of frequency is called a **hertz** (Hz). When Heinrich Hertz first demonstrated radio waves in 1886, he found that the source of all waves was something that vibrates. Radio and television stations often announce that they are operating on a frequency of "x-number" of Megahertz. This is the frequency range assigned to them by the International Telecommunication Union (ITU). This organization divides the entire range of communications frequencies among those who use them. This includes commercial radio, television, and Amateur Radio. Radio waves vibrate at the lowest frequency and have the longest wavelengths on the electromagnetic spectrum.

Visible light is just a small part of this vast spectrum. Light waves and radio waves are both electromagnetic waves that originate from the vibration of electrons. Sound waves are not electromagnetic waves, but a mechanical vibration of matter. So even though we hear a radio by means of sound waves, radio waves and sound waves are not the same.

A specific radio frequency is assigned to Amateur Radio operators when they are transmitting to space. All Amateur Radio operators, this includes those who operate for Space Amateur Radio Experiments (SAREX) missions, use a small portion of the frequency bands on the electromagnetic spectrum. Any amateur station that is located more than 50km above Earth's surface is defined by the Federal Communications Commission (FCC) as a space station. Amateur satellites, the Space Shuttle orbiters, the Russian MIR Space Station, and the International Space Station all fall under this category.

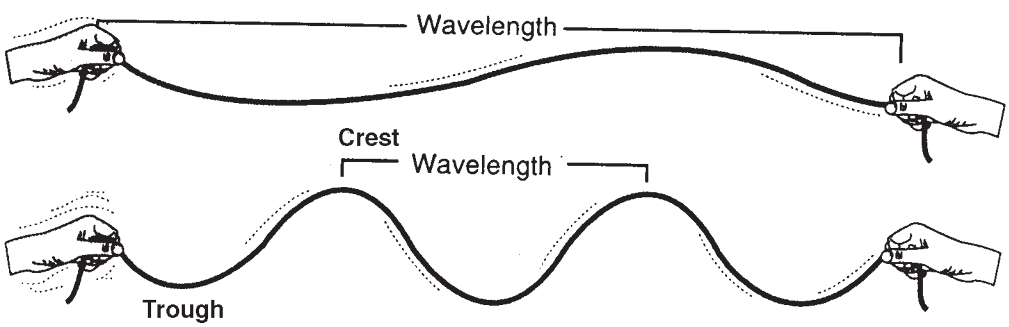
If you drop a pebble into a pond circular waves will emanate from the drop source. The human eye can follow these waves as they progress outward from the drop point. These waves like all other waves have **amplitude, wavelength,** and **frequency.** These three characteristics are present in all waves that make up the electromagnetic spectrum.

The **frequency** of a wave is measured in hertz, the wavelength in meters. Thus, the speed of a given wave is measured in meters per second. This relationship is the same for all kinds of waves, such as sound waves, light waves, or water waves.

A **wavelength** is the distance a wave travels through space in a single cycle. It can be measured from any point along the wave as long as it is consistently measured from the same point. The speed of the wave is equal to the frequency times the wave length. The **amplitude** of a wave is the maximum displacement on either side of the midpoint of a wave. The **midpoint** is the point at which the wave is at rest.

Let's Begin

1. Gather students around a pan of water on the floor. If the pan is glass, place a white piece of paper under the pan. Have students observe that the surface of the water is flat. Ask them to predict what will happen when a drop of water is dropped into the pan of water. Write predications on the Data Collection Sheet. Discuss predictions.
2. Have a student drop water from an eyedropper into the center of the pan. Ask for observations on what has happened. Guide students to observe the wave that has been created as it moves outward along the surface of the water in expanding circles. The image of the wave should be reflected on the paper under the glass pan.
3. Draw observations on the Data Collection Sheet. What shapes were the waves that were created? How did the waves move? Were the circles evenly spaced? Students should record observations on the Data Collection Sheet.



4. Show the picture of the wave. Identify the different parts of the wave—crest, trough, amplitude, midpoint, wavelength. Explain that the highest parts are **crests,** and that the lowest parts are **troughs.** The distance between the crests of two waves side by side is called **wavelength.** The height of the crests above the midpoint is called the **amplitude.** The troughs are usually the same distance below the midpoint as the crests are above. Students should record these vocabulary definitions on the Data Collection Sheet.
5. Drop water again. Observe waves again. Have students look for the crest, trough, amplitude, and wavelengths. Ask students to name the different parts of the waves they just observed. Do they see a difference in patterns of the waves?

Introduce the Slinky. (**HINT:** A short rope or jump rope may be substituted.) Ask for students observations of the properties. Explain that the Slinky represents waves and how they might look at different frequencies.

1. Ask two students to demonstrate how a wave is created. Stretch the Slinky to about 1 meter on the floor (not carpet) or table top. (Do not overstretch.) Ask one student to hold one end of the Slinky still. The second student will move the other end slowly back and forth. They should observe that a wave has been created.
2. Have students do the procedure in groups of four. Ask them to draw on the Data Collection Sheet the wave they see. Tell them to increase the rate at which they move the Slinky back and forth. Explain to

students that they are changing the frequency of the wave. Ask them to explain the relationship between the rate at which the Slinky is moved back and forth and the frequency. How is the wavelength changed? Guide them to understand that faster movement corresponds to higher frequency and shorter wavelengths.

3. Show the chart of the electromagnetic spectrum contained in the Background Information. (Teachers may wish to make a transparency of this chart. Students may also wish to refer to the Data Collection Sheet to view the chart.) Explain that each mark on the frequency scale represents a frequency ten times higher than the mark to its right. The small numbers after the 10s tell how many zeros are in the number. For example, 10^6 is 1 followed by 6 zeros (1,000,000). Discuss the different forms of waves contained in the spectrum and where they are placed. Have students label on the Data Collection Sheet the radio waves, microwaves, infrared, visible light, ultraviolet, x–rays, and Gamma rays. Ask them to move the Slinky again and tell which waves they are showing.

Extensions

1. Find out more about the Electromagnetic Spectrum. Write a report and present it to the class on three ways frequencies in the spectrum affect our daily lives.
2. Understanding the Electromagnetic Spectrum helps to understand radio waves in a more global way. Ask students to find examples in a magazine, newspaper, on television, or on the Internet of items contained in the spectrum frequencies. Bring pictures or write names of objects on paper and place on a large drawing of the Electromagnetic Spectrum on the board.

Data Collection Sheet

Name ____

Group Names ______________________________________

Date ________________

What will happen when a pebble is dropped into the water? ____________

____

____

Draw observations of water after pebble is dropped:

Vocabulary

Electromagnetic Spectrum ______________________________

____

Frequency ____

____

Hertz ____

____

Wavelength ______________________________________

____

Crest ____

____

Trough ____

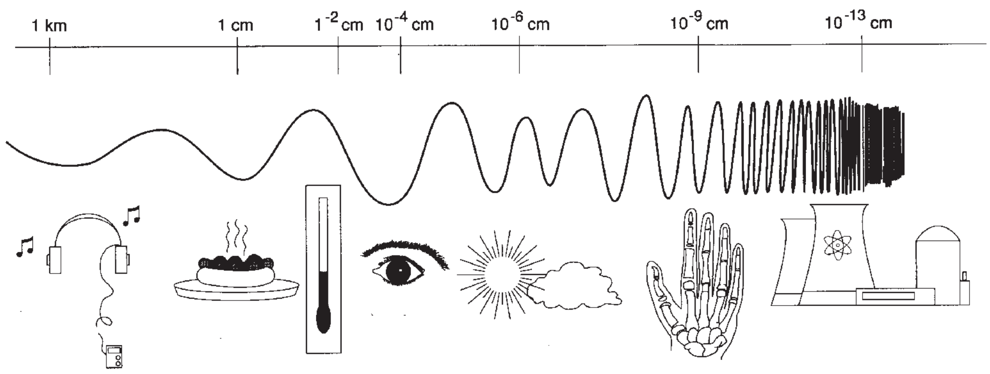
____

Amplitude _______________________________________

____

Midpoint ____

____



Label the Parts of the Electromagnetic Spectrum

Observations of Slinky (written here or drawn below)

What did you learn?

Activity: Can I Hear You?

Objective

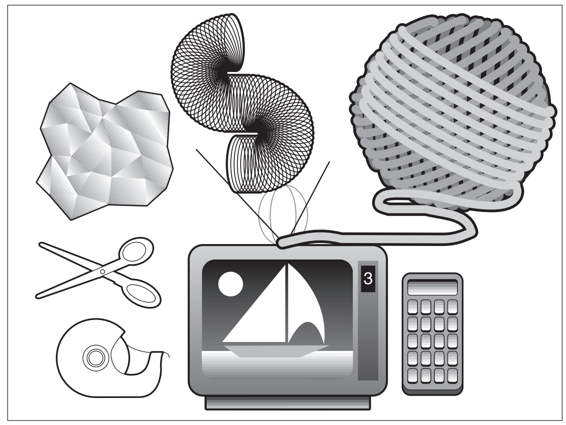
- Demonstrate radio waves cannot pass through certain metals

Activity Overview

Students will work as a class to discover that energy waves must be present in order for the remote control to change the channel on the television.They will make oral and written observations and predict what they think will happen when the remote control is pointed at the television.They will compare the results when the receiving eye on the television is uncovered and when it is covered with aluminum foil.Then the class will discuss what has happened, and be guided by the teacher to draw conclusions.

Materials

- Television
- Tape
- Scissors
- Remote control
- Aluminum foil
- 6' yarn (any color)
- 1 slinky per group of 4
- Data Collection Sheet



Science Standards

- Science as Inquiry
- Physical Science
- Transfer of Energy
- Science and Technology
- Science as Human Endeavor

Technology Standards

- Technological Knowledge
  – Technological Concepts and Principles
- Technological Processes
  – Utilizing and Managing Technological Systems
- Technological Contexts
  – Informational Technology

Timeframe 30–45 minutes

Background Information

The Space Amateur Radio Experiment (SAREX) has been included on many Shuttle flights and will be on the International Space Station. In order for SAREX to be operational, a signal must connect a radio on Earth to the Shuttle orbiter or International Space Station.The signal cannot be seen by the human eye, but must be present for an astronaut or a student to talk or be heard.This signal is called a radio wave. Radio waves are a form of energy. They go from the radio on Earth to a land-based antenna. The signal is then transmitted to an antenna located in the window of the orbiter, then to the SAREX system inside the orbiter. This process is reversed as the signal is sent back to Earth. Many school children over the years have been able to participate in or listen to conversations to and from space using this system.

This activity involves the entire class. A television has been used since it is an item readily accessible in most schools. Most television remote controls use infrared signals. In this activity, the signal will be blocked by aluminum foil, a very light, man-made metal.

Let's Begin

1. Share with students the Background Information. Draw attention to the television. Have students list observations of the television on the Data Collection Sheets. Discuss the observations and make a group list on the board.
2. Show the remote control and ask the students what function it has. Students list individual observations of the properties of the remote control on the Data Collection Sheets and then on the board.
3. Ask a student to turn on the television. List individual predictions on Data Collection Sheets and on the board as to what will happen when another student points the remote control at the television and pushes the channel button. Let a student demonstrate by changing channels.
4. Ask what the students think caused the remote control to turn on the television. Guide them to understand the television receiving eye received the signal that caused the channel to change. Ask two students to take the yarn and show the path the signals took. Have them hold the yarn in place. (Guide them to the receiving eye on the television, not the screen.) Ask the class for the definition of a receiving eye. Check the list of observations made on the Data Collection Sheets and the board. If the term receiving eye is not there, add it to the list.
5. Ask a student to take a piece of aluminum foil and tape it over the receiving eye on the television. Have students write predictions on the Data Collection Sheet as to what will happen when a student tries to change the channel again. Elicit responses. **NOTE:** Aluminum is a very light weight, non-magnetic metal.The signal sent out from the remote control device is reflected by this metal.
6. Have a student try to change channels. Discuss what has happened. Ask the two students with the yarn if they can show the path the signal took this time. Lead them to stretch the yarn from the remote to the receiving eye and back out again showing the signal did not get through but was reflected instead. Write on the Data Collection

Sheet their observations of what has happened. Ask for volunteers to read to the class. Discuss the observations. Repeat the activity as many times as necessary. Collect Data Collection Sheets for assessment.

Extensions

1. Have students choose other materials to try to block the signal from changing the channel. Wax paper, notebook paper, cardboard, wood, rubber, etc. Make observations and predict what will happen.
2. Have the students use remote-controlled cars or walkie-talkies to show the presence of radio waves. Experiment with the different variables such as the distance the waves travel. How far away can the car be controlled? How far away can you hear another person?
3. Have students try pointing the remote control at different angles from the television. Does the control need to be pointed at the television? What happens when it is pointed in another direction?

Data Collection Sheet

Name ____

Group Names ____

Date ____________________

List observations of television	List observations of remote control

Predictions

Predictions for aluminum foil	What have you learned?

Activity: "Hello Over There"

Objectives

- Demonstrate with light beams how Amateur Radio satellite and repeaters send and receive signals
- Problem solve how a beam of light can be directed around a barrier

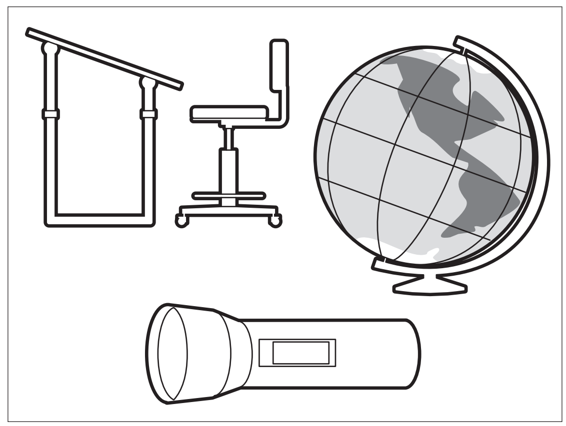
Activity Overview

This activity will allow students to simulate radio waves being transmitted and received using repeaters. Earth will be observed so students will understand why this method of communication is needed. In teams of four, students will problem solve to send a beam of light from one side of a barrier to the other. They will learn the path that light follows and how it reacts when a smooth, shiny surface (mirror) is placed in its path. Amateur Radio vocabulary will be introduced. Students will complete a Data Collection Sheet detailing methods used to solve a problem. Older students will predict where the light waves will be positioned on the other side of the barrier.

Materials

For each team of 4:

- 1 flashlight
- 1 mirror
- 1 chair or desk to act as barrier
- 1 piece of white paper
- Globe or map of Earth
- Data Collection Sheet



Science Standards

- Science as Inquiry
- Science and Technology
- Abilities of Technological Design

Technology Standards

- Technological Knowledge
  – Technological Concepts and Principles
- Technological Processes
  – Utilizing and Managing Technological Systems
- Technological Contexts
  – Informational Technology

Mathematics Standards

- Problem Solving
- Communication
- Geometric and Spatial Relations

Timeframe: 30–45 minutes

Background Information

When looking at a relief map of the Earth, one cannot help but notice that Earth is not a flat plain. There are many valleys and mountain ranges. When standing on an ocean shoreline, Earth appears flat. But we know that Earth is round. Pictures sent from satellites and orbiting spacecraft have allowed us to see our round Earth. Since radio waves travel in a straight line, how then can we send a signal to the other side of a barrier and beyond? Some radio signals, called **direct waves,** travel in a straight direction or line-of-sight. These signals cannot bend or "jump" over a barrier such as a hill or mountain range. They are also unable to curve around Earth. The signal from a radio on one side of the hill is transmitted to the other side by a repeater positioned on the top of the barrier. A **repeater** receives a signal on one frequency and simultaneously sends, or re-transmits (repeats) it on another frequency to a radio on the other side of the barrier thereby extending the range of the re-transmitted signals. The frequency it receives on is the **input frequency,** and the frequency it transmits on is the **output frequency.** Often located atop a tall building or high mountain, VHF and UHF repeaters greatly extend the operating range of Amateur Radio operators using mobile and hand-held transceivers. When a transmitter and receiver are combined into one box, it becomes a transceiver and can send and receive signals. If a repeater serves an area, it's not necessary for everyone to live on a hilltop. But you have to be able to hear the repeater's transmitter and reach the repeater's receiver with your transmitted signal.

Let's Begin

1. Share background information with students. Show globe or relief map of Earth. Have students write or draw their observations of Earth on the Data Sheet. Discuss these observations orally.
2. Gather students together around a barrier (chair, desk, etc.) Explain to students that the barrier represents a very tall hill or mountain range.
3. Show flashlight, mirror, and piece of paper. Discuss the properties of each, how they are used in our daily lives, and any prior knowledge students may have about light beams and how they travel. The flashlight beam represents radio waves, the mirror represents the repeater on top of a hill, and the piece of paper represents the radio on the other side.

HINT: Cover the flashlight with a piece of paper that has a small, vertical slit cut in the middle. This will create a narrower light beam.

Discuss vocabulary words and have students write definitions to those words on the Data Collection Sheet.

4. Tell students they will work in teams of four. The problem they must solve is **to devise a way to send a beam of light to the other side of the barrier going over the top of the barrier.** The light must travel from the flashlight held touching the floor on one side of the barrier to the piece of paper placed on the floor on the other side of the barrier. Remind them that they must go over the barrier. They will need to document the steps they take in the Data Collection Sheet. After a group discussion, make sure students understand the task. Give ample time for students to work in their groups to write the problem to be solved, discuss and predict what they think will

happen, solve the problem, and write down the information on the Data Collection Sheet. Have each group share their procedure with the class. Allow the class to ask questions and make suggestions.

5. As a follow up to the initial activity, each group can take what they have learned from watching the other groups and the suggestions they have been given and improve their procedure.

For Younger Students

For younger students, the teacher might show the globe or map and discuss them. Make a class list of the students' observations. Show them the materials. Let them shine the flashlight and observe how the light travels. Position one student on the floor holding the flashlight, another standing at the end of the barrier holding the mirror pointing toward the ground high above the student's head as if it were a repeater on a hill, and a third student sitting on the other side of the barrier holding the piece of white paper to simulate receiving the signal. Guide the students to discover that if they shine the light onto the mirror, it will reflect over the barrier and onto the other side.

Help the student holding the paper to position himself or herself to where the light will shine on the paper. Allow all students to take part while the group helps direct what is happening.

Extensions

1. Have students experiment with different surfaces other than a mirror, such as aluminum foil, smooth, wrinkled, pleated. What happens to the beam of light on each of these surfaces? Why does this occur?
2. Have students experiment with variables. Keep the position of the flashlight and the mirror constant. Change the direction of the mirror. Note the changes in angles in which the light strikes the mirror. Predict where the light will strike. Move the paper to that position. Turn on the light. Were students correct? Why?
3. Have older students predict where they think the light beam will fall and place a piece of paper on the floor where they think the beam of light will hit. What reasons can they give for their prediction?
4. Discuss the angle of incidence and the angle of reflection. Have students measure angles of the light as they approach the mirror and as they leave the mirror. Use a laser beam if possible for a finer line. Have students arrange mirrors on a table top in a circle, and send a beam of light from one mirror to another. Use as many as 10 mirrors. Students should problem solve to come to the conclusion that the entrance and exit angles are the same. (Reference: *Conceptual Physics,* Seventh Edition, Paul G. Hewitt, ISBN 0-673-52185-0)
5. Research in the library and on the Internet to find out more about radio waves and how they act and react in different situation.

Data Collection Sheet

Name ____

Group Names ____

Date ____________________

Observations of Earth	Problem to Solve

Repeater ____

____

Input Frequency ______________________________________

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Output Frequency _____________________________________

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Vocabulary

Data Collection Sheet

What Materials Did You Use? ______________________________

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What Did You Do? ______________________________

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What Did You Observe? ______________________________

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What Did You Learn? ______________________________

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Activity: Say It With Space Talk

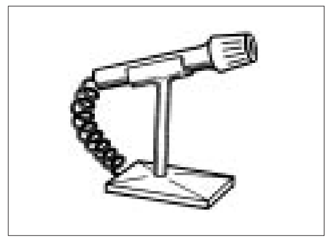
Objectives

- State oral directions clearly and correctly
- Construct a structure using oral directions

Activity Overview

Students will work in pairs to discover the importance of correct communication. They will construct a simulated microphone and learn how to use it correctly. They will work as a NASA astronaut and the Capsule Communicator (CAPCOM) to explain how to correctly build a structure with pattern blocks. The microphone will be used correctly each time they speak. The class will discuss and assess the importance of correct communication as it pertains to space travel.

Materials (For each pair of students)



- Pattern blocks
- 1 manila folder (or hard bound book)
- 2 popsicle sticks or tongue depressors, or two cardboard centers from paper towel rolls
- Aluminum foil pieces
- Books or short stories about space (1 for each group)
- Optional: 2.5 cm styrofoam ball for top of microphone
- Data Collection Sheet

Science Standards

- Science as Inquiry
- Science and Technology
- Science as a Human Endeavor

Technology Standards

- Technological Knowledge
  – Linkages
- Technological Processes
  – Utilizing and Managing Technological Systems
- Technological Contexts
  – Informational Technology

Mathematics Standards

- Problem Solving
- Communication
- Geometric and Spatial Sense
- Patterns and Relationships

Timeframe: 30–45 minutes

Background Information

Communication is an important, vital, and necessary part of all spaceflights. The members of each Shuttle and International Space Station crew must talk with each other and with workers on the ground to carry out the many functions needed to fly the spacecraft and rendezvous with other objects in space. Mission Control must keep in constant contact with other personnel at sites around the world to monitor the progress of the spacecraft as it orbits Earth. Teachers and students in schools communicate with each other to learn more about space travel and how it is changing our lives each and every day.

The astronauts use a radio on board the Shuttle on frequencies used by Amateur (or "ham") Radio operators to communicate directly with large groups of students. For all operations, Earth stations listen to the input or receiving frequency and transmit only when the Shuttle is in range of the ground station and the astronauts are using the radio. Students listen for any instructions from the astronauts as to the output or transmitting frequency before transmitting to avoid interfering with other radio users. They practice using a microphone correctly just as the astronauts must do during their training for the mission.

Let's Begin

1. When students, astronauts, and ham radio operators use the Amateur Radio to talk with people next door, all over the world, or orbiting in space, they use a microphone. Explain to students that they are going to make a "pretend" microphone that will be used when practicing how to talk correctly over the radio. Give each student one popsicle stick, tongue depressor, or cardboard center from a paper roll, and a large piece of aluminum foil. Demonstrate how to wrap the foil around the top of the stick in a ball so it looks like the top of a microphone. A 2.5 cm styrofoam ball may be placed on top of the stick and covered with one layer of foil instead.
2. Model for students how to hold the microphone in one hand, not too close to the mouth. Say the names of the nine planets to demonstrate how to speak slowly and distinctly. Be sure to tell the students each time they have finished speaking that they are to say "Over." This is the word used by Amateur Radio operators to signify they have finished their transmission and others may now talk. Allow time for students to make a microphone and to practice speaking with their teammate. Circulate among the students and make sure they are holding the microphone correctly and speaking correctly. Have one student say the nine planets, stopping wherever they wish and saying "Over." The teammate must begin speaking into the microphone saying the next planet, and when finished, saying, "over."

   Example: "Mercury, over." "Venus, Earth, Mars, over." "Jupiter, Saturn, over."

   After the initial practice time, tell students they are going to read to their teammates. Each student in the team will read a paragraph or page from a book or story while holding the microphone correctly. Each time they have finished reading, they must say "over" before the next person can begin. Teammates are not to begin until they hear the word "over."

   When the class has had sufficient practice time, have them put down the microphones and show them the pattern blocks. Ask students to tell you what they know about each shape. Have students draw each shape or write the names of each block on the Data Collection Sheet as you display them to the class. (Square, triangle, two parallelograms, hexagon, trapezoid)

HINT: For older students, use one block of each shape. For younger students, pick only two or three.

Explain to students that when astronauts are in space, they talk to the ground through a Capsule Communicator (CAPCOM). This is another astronaut located in the Mission Control Center (MCC) at Johnson Space Center (JSC) in Houston. All information and directions are relayed to the astronauts on orbit through the CAPCOM.

3. Tell students that one member of each team will be taking the role of astronaut and the other member will be CAPCOM. Show students the blocks you are going to use and ask them to get those blocks from their pile.
4. Model the activity by taking the role of CAPCOM and having all students become astronauts. Build a structure behind a manila folder so students cannot see the structure. Make sure students understand spatial perspective and orientation of left and right.

After you have built a structure, use your microphone to give detailed instructions so the students will be able to replicate what you have built. Remember to say “over” after each set of instructions.

5. After the students have completed building, compare the structures. Discuss which words you used that were helpful to them in building. Have students make a list of these words on the Data Collection Sheet.
6. Students will now be given time to build with their partners. They will build many times, switching roles each time, and using the microphone each time. Circulate among the class to monitor and assist.
7. When building has been accomplished many times, have students write directions on the Data Collection Sheets. These sheets can be taken up for assessments. They can also be used as written instructions for other students to build structures.
8. Discuss the importance communication played in building the structure. How would this be important in spaceflight? How will this be important in building the International Space Station?

Extensions

1. Have students use two-way radios. Each student should be in a different room or location. Build the structures by communicating the directions correctly over the radio.
2. Have students write their own script for a play describing a problem on the Shuttle or International Space Station. The problem would necessitate the building or repairing of some piece of equipment used by astronauts during a mission. Students could perform the play. If video equipment is available, students could set up their own production as a news cast and show the production to other classes.
3. Have students use the microphones each time they talk for an entire day.

Data Collection Sheet

Name ______________________________

Group Names ______________________________

Date ____________________

Names/Shapes of Pattern Blocks

Directions for building my structure:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

Communications are important in spaceflight because: ____________________

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What have you learned? ______________________________

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