Space Technology
Pre and Post

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Included are activities for you to do with the class—before and after the workshop—to reinforce the concepts and terms in the lesson. There is also a section on activity extensions, books, vocabulary, and a Space Technology pop quiz related to the topic.

BEFORE THE WORKSHOP

To maximize the workshop's impact and educational value, we recommend introducing the students to space and technology prior to the workshop. Here are several fun, easy, educational activities that will prepare the class for the workshop. These experiments will also help the students become familiar with the concept of observation, hypothesis, experimentation, and the scientific method.

Space Technology Spin-offs

Students learn how some technology developed for use in space works on Earth.

Note: Replace the following materials with pictures as an alternative.

Materials

- Metal baseball bat
- Pair of running shoes
- Computer mouse
- Ear thermometer
- Cordless telephone headset
- Emergency reflective blanket
- Cordless drill
- Bicycle helmet

- Edible toothpaste
- Index cards (10)

Procedure

1. Before class begins, use the index cards to write the object's name on one side and its origin (see table below) on the other side. Place the materials or pictures at the front, or around the room. Place the accompanying cards beside the materials with the names facing up.
2. Inform the students that these objects were initially created for use in space. Companies found a use for these objects on Earth and marketed them to the public.
3. Group the class into teams and have each team pick a card. Challenge the team members to determine the object's technology, use in space and on Earth. Have the teams spend 5-10 minutes on each card.
4. Invite the students to read the explanation after guessing (making a hypothesis) the object's technology and uses.

Explanation

NASA's technology designed for use in space—now commercialized for use on Earth—is a spin-off. NASA created the Technology Transfer Program in 1962 to promote the transfer of aerospace technology to the public sector. The idea of commercializing space technology was to offset the high costs involved with space research. You can look on NASA's website in the *NASAlife* section to find out more about space spin-offs. The following table defines the spin-offs (origins) used for this activity.

Metal golf clubs & other metal sports equipment	The metals used to build space shuttles and satellites need to be strong enough to withstand the stresses of space. Scientists developed a new metal called vitrified metal that is strong, elastic, and durable. Vitrified metal can replace titanium to make airplanes, medical tools, golf clubs, baseball bats, bicycle frames, and cellular phones.
Running shoes Nike Air	NASA used a special method to create space suits to walk on the Moon. The process is "blow rubber molding," and it fills the space inside a mold with shock-absorbing materials. A NASA engineer had an idea to use the same technology to create shock-absorbing running shoes!
Computer mouse	An engineer working on an early version of computers had an idea for a device that could make computers more useful. He proposed his idea to NASA headquarters and received enough money to develop this device. At first, the engineer called his device a *bug*. Now, we call it the mouse!
Ear thermometer	NASA scientists developed a technology using infrared to measure the temperature of stars and planets. Infrared is the set of wavelengths found just past the color red on the light spectrum, in the range of wavelengths that we cannot see. Any heat source emits infrared, even your body! A company

	transformed this space technology into an infrared thermometer that measures your body temperature through your ear.
Cordless telephone headset	Astronauts in space need to communicate with their fellow team members and with scientists on Earth. NASA worked with a company to create hands-free radio headsets for their astronauts. Police, fire, taxicab, and other radio dispatch centers now use this technology. The company continued to develop new products such as the Bluetooth headsets for phones and laptop computers.
Emergency reflective blanket	The thin metal insulation found on NASA spacecrafts reflects thermal radiation from the Sun, protecting its passengers. This metal transforms into sheets of film, fabric, paper, or foam. A company used this technology to create thin, lightweight emergency blankets that reflect body heat back towards its user. These blankets help keep a person wrapped warm for hours in the cold outdoors.
Cordless drill Black & Decker	Astronauts need to gather samples from the Moon for analysis on Earth. NASA worked with a company to create small, lightweight, battery-powered drills to bore into the lunar rock. These portable drills became popular for use in construction work and in medical offices for surgery.
Bicycle helmet	NASA's Ames Research Center developed shock-absorbing material called temper foam for aircraft seats. This foam now lines the inside of bicycle helmets. The aerodynamic shape of the bicycle helmet evolved from airfoil research. Airfoil is the shape of a wing that improves an aircraft's aerodynamics.
Edible toothpaste	Foaming toothpaste is messy in space, especially since you cannot spit! A dental consultant for NASA developed edible toothpaste that doesn't foam when you brush, so you don't have to spit.

Satellite Status

Students learn about the different tasks accomplished by satellites orbiting the Earth.

Materials

- Transparent tape
- Colored tape (3 colors)
- Pencils (1 per pair)
- Large city road maps (1 per group)
- Smaller road map versions (photocopy 1 per pair)
- Cotton balls (3 per group)
- Toy cars (or stickers) (3 per group)
- Small dollhouse dishes (3 per group)

Procedure

1. Before class begins, tape the road maps to the floor of the classroom. Stretch the cotton balls to look like clouds. Tape three cars, three dollhouse dishes, and three clouds to each map. Tape an oval around a map with one of the colored tapes. Mark a circle around the same map with a different colored tape, and a line along one side of the same map with the third colored tape.
2. Tell the students that they will act out the tasks of satellites orbiting the Earth. Explain the cotton balls represent clouds, cars represent vehicles with GPS navigation devices, and small dollhouse dishes represent television satellite dishes.
3. Divide the class into groups of six. Have group members pair up to form *satellites*. Assign one satellite member the *driver* role and the other the *viewer* role. Give each viewer a smaller version of the road map and a pencil.
4. Instruct the first pair in each group to locate the cotton ball clouds. The driver holds the viewer by the shoulders and counts to five to move the viewer one-step to the right around the oval path, while the viewer notes where the materials are located on the smaller map. The pair will continue moving in this manner until the end of the activity.
5. Instruct the second pair to locate the cars on the map. Repeat the driver instructions in step 4. The viewer kneels after moving. The satellite pair follows the circle path around the map.
6. Instruct the third pair to locate the plastic satellite dishes. Repeat the driver instructions in step 4. The satellite pair follows the line path.
7. After 15-20 minutes, discuss the differences in the tasks assigned to each satellite pair. Discuss how the satellite's altitude (standing or kneeling) and the satellite's orbit (circle, oval, and line) affect the viewer's perception of the objects on the map. Explain that satellites move in around the Earth based on their designed task. See the explanation below for more details.

Extension Activity: Assign each group of students a different type of satellite and have them research their locations and orbits around the Earth.

Explanation

An orbit is the path an object, such as a satellite, follows as it circles around another object such as a planet. The moon is a natural satellite that orbits the Earth. Artificial satellite orbits depend on three factors: the shape of its orbit (circular or elliptical), the altitude or distance from the Earth (low, medium, or high), and the angle the orbit makes with the equator (large angle if it moves near the poles and small angle if it moves near the equator). We use satellites for communication, spying, search and rescue, scientific research, meteorology, navigation, and space exploration. A satellite with a circular geostationary orbit moves so that it always views the same location on the Earth. Satellites with geostationary orbits provide information for communications such as satellite TV. The GPS technology uses navigation satellites with medium altitude orbits. The largest angle for a satellite's orbit is 90°, called a polar orbit. Polar orbits bring satellites over both north and south poles, allowing them to cover the entire Earth's surface. These satellites are helpful in observing the Earth for weather patterns, Earth mapping, or for scientific research.

AFTER THE WORKSHOP

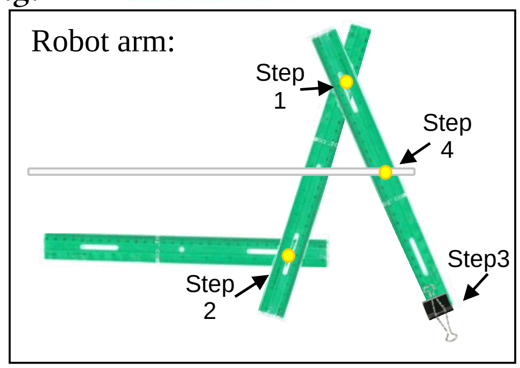
Here are some activities you may wish to do with the class after the workshop to reinforce and expand the science concepts.

CanadArm Models

Students build and manipulate a robot arm.

Materials

- Dowels 1cm (3/16") diameter, 40cm (16") length (e.g. balloon sticks) (1 per student)
- Binder clips 2.5cm (1") width (1 per student)
- Brass paper fasteners 3.8cm (1-1/2") shank (3 per student)
- Flat plastic 30cm (12") rulers with holes in the middle (3 per student)
- Pipe cleaners (3 per student)
- Adhesive labels (3 per student)



Safety Warning: Do not allow the children to play with the rulers or sticks.

Procedure

1. Before class, label three stickers per student: forearm, upper arm, and hand. Create a robotic arm as described in steps 2-5.
2. Hand each student two rulers, one fastener, and forearm and upper arm labels. Instruct the students to label one ruler forearm and the other upper arm. Instruct the students to thread a brass paper fastener through the hole near the ends of the rulers to attach the forearm and upper arm rulers.
3. Hand each student another ruler, fastener, and hand label. Have the students stick the hand label on the ruler. Instruct the students to use the fastener to attach the hand ruler to the end of the forearm ruler.
4. Hand each student a binder clip. Instruct them to clip the end of the hand ruler to form “fingers” for their robotic arms.
5. Hand each student a dowel and fastener. Tell the students that the dowel controls the robotic arm. Instruct the students to squeeze the fastener around the dowel, thread the remainder through the middle hole of the hand ruler, and then spread the shanks apart.
6. Hold the upper arm ruler steady in one hand while moving the hand ruler with the attached dowel.
7. Mold the pipe cleaners in shapes that stand on their own with a hook at the top. You should be able to use the clip on your robot arm to pick up the pipe cleaners.
8. Manipulate the hand ruler with the dowel to pick up the pipe cleaners with the binder clip (the robot’s fingers). Demonstrate this to the class, and then challenge them to pick up and move the pipe cleaners.

9. Compare the children's robotic arms to their own arms. Discuss the function of the upper arm, forearm, shoulder, elbow, and wrist joints in both types of arms. Explain how the fasteners act like wrist and elbow joints between the hand, forearm, and upper arm; in addition, the students' hands and wrists that hold the upper arm rulers act like their robot arm's shoulder joints.

Explanation

The students create robotic arms modeled after the Canadarm on the Space Shuttle Discovery. The Canadarm is a Shuttle Remote Manipulator System (SRMS). This technology helps astronauts manipulate objects in space located close to the space shuttle. The computer on the shuttle controls Canadarm's shoulder, elbow, and wrist joints. This SRMS can set satellites into orbit, or capture them for repairs. It supports astronauts during spacewalks and has cameras at the elbow and wrist joints, which provide visual inspection of the shuttle and its payload. It can knock ice off the shuttle's wastewater dumping vents and loosen a jammed solar panel! The Canadarm2 is a newer version of the SRMS with more joints and two grasping "hands" on either end of the arm. The Canadarm2 is outside the International Space Station (ISS). It grasps an anchor point on the station with one hand to either work with the other, or flip itself to move around the ISS.

Satellite Sight

Students draw the image according to the information relayed by a satellite to ground stations.

Materials

- Graph paper (1 per student)
- Pencils (1 per student)
- Simple photographs (e.g., house or animal against a plain background) (1 per pair)

Procedure

1. Before class, find pictures of objects with a sharp, contrasting background. There should be one picture for each pair of students in your class. Draw a 10x10 square grid over each picture. The squares on the image can be a different size than the squares on the graph paper.
2. Ask students to predict how satellites collect information about Earth. Explain that the students will model how satellites transmit their data to the computers on earth.
3. Have the students pair up with a partner and assign one child the *sender* role and the other the *receiver* role. Give out the pencils. Give the sender the image with the 10x10 grid and the receiver one sheet of graph paper. Advise the senders to hide the image from their receivers!
4. Instruct the students to label the columns of their graphs (paper or picture) from left to right with the letters A to J. Instruct the students to number the rows on the far left column from top to bottom with the numbers 1 to 10.

Explain how grid locations work (e.g., A1 is the square located in column A and row 1).

5. Explain how a satellite relays information to a computer with binary code: When receivers call out a square location on the grid such as A1, the senders locate it on their image grid and say "zero" if the square is just the background or "one" if the square contains part of the object in the image.
6. Instruct the pairs to receive and send all the squares in their grid. Challenge the receivers to determine what object the senders see, and then compare the sent and received data.
7. Have the pairs switch roles, and instruct the new senders to switch images with another pair's sender. Advise them to hide the picture from their partners. Give the receiver a new sheet of graph paper, and repeat steps 4-6 for the new image.

Extension Activity: Instruct the senders to use a ruler to draw an extra line down the middle of each column and across each row to make 20 columns and 20 rows to split each cell in half. Have the pairs switch images with one another. Instruct the students to label the columns from left to right A to T and the rows from top to bottom 1 to 20. Challenge the pairs to receive and send the new data, and then to compare the resulting image with the previous 10x10 grid images.

Explanation

Radio signals relay space technology data to the Earth. The ground stations receive and relay these signals in a numbered computer code called the binary code. The word binary means two numbers, and the code consists of two values, *one* and *zero*. One code value is a *bit*. Eight linked bits is a *byte*. A bit is on if its code value is *one*. A bit is off if its code value is *zero*. When a satellite sends binary coded images, the resulting image reflects gray shades ranging from white to black. Each pixel in the image uses one byte of information. This means all eight bits in the byte can be on or off, and this determines the pixel's gray shade. Each pixel can be one of 256 possible gray shades! In our experiment, each pixel or square uses only one bit. This means that each pixel could only be black if the bit is on, or white if the bit is off. Increasing the pixels and bits per pixel improves the detail of an image sent from space.

MORE TO DO

Language Arts

- Have students research and write a report about one of NASA's fact-finding missions to other planets. These can include the Mariners, Pioneers, Vikings, and Voyagers. Have students present their reports in chronological order.
- Describe what a space technology tool does, and how it helps space exploration.
- Have students write a procedure for how scientists receive information from satellites.

Art

- Have students recreate towns or landscapes based on satellite images with various materials such as modeling clay, paper, or recycled materials.
- Challenge students to change remote-control cars into space rovers. They could attach Styrofoam balls cut in half to represent radar, aluminum squares to represent solar panels, etc.

Math

- Measure and recreate a small-scale model of a NASA planetary space rover using materials such as craft sticks, building blocks, or modeling clay.
- Create a timeline of major space technological inventions such as the first telescope, satellites, and Canadarm.
- Have students draw an image in a graph and convert it into binary code: zeros and ones. The student would start the conversion at the top left corner and move along each row from left to right. The student writes 0 if a square is empty, or writes 1 if it is filled or partially filled. Separate rows with a slash. E.g., the top three rows would look as follows: 0001101101 / 0011000101 / 0101101011 /. Refer to the Satellite Sight experiment in the After the Workshop section for more information.
- Once complete have students exchange binary codes, redraw the images, and compare the coded image with the initial image.

Social Studies

- Research the terrain of another moon or planet. Create a general list of landforms such as mountains, craters, cliffs, crevasses. Encourage students to clip relevant articles in magazines and newspapers to find examples of how satellites aid in communications, weather forecasting, business, and science. Start a satellite bulletin board.
- Have students compare the five senses (sight, taste, hearing, smell, and touch) to the instruments found on space probes and rovers (cameras, radar, collecting tubes, etc.).
- Download a program that creates a satellite ground station in your computer. Ground stations receive data transmissions from weather satellites. Have your students analyze the data to predict when the next satellite will be overhead.

Challenge the class to create a schedule for when they can expect to receive an image. Learn how to loop together several images of cloud conditions and movements from different passes of the satellites to make reliable weather predictions. Create a weather chart based on the data received from your classroom computer ground station.

Field Trip Suggestions

- Visit a planetarium.
- Visit a space museum.
- Visit a weather station.

BOOKS

Title: Zathura: a space adventure
Author: Van Allsburg, Chris
Publisher: Houghton Mifflin
ISBN#: 0618253963
Description: Two brothers play a board game and find themselves launched into outer space. The story is fast-paced and full of action, and readers will enjoy the realistic brotherly banter between the two boys as much as the description of their adventures. By the end of the story, the boys learn that working together is the way to solve problems. This book is suitable for students in kindergarten to 3rd grade.

Title: Midnight on the Moon
Author: Osborne, Mary Pope
Publisher: Random House
ISBN#: 0679863745
Description: The Magic Tree House series' characters open a book into space. Their explorations are out of this world! Look for Space, a non-fiction accompanying book in the Reference Book section. This book is suitable for students in kindergarten to 3rd grade.

Title: Tom Swift and his megascope space prober
Author: Appleton, Victor
Publisher: Simon Pulse
ISBN#: NA
Description: Tom Swift is a young scientist inventor whose inventions propel him into battles against sinister enemies. In this story, Tom works to complete his megascope space prober, designed to "keep an eye on the universe." His megascope space prober is a radio telescope that sends a special kind of radio wave to scan the surface of different objects and thus create a picture. This book is suitable for students in 3rd to 6th grade.

Title: The technology book for girls and other advanced beings
Author: Romanek, Trudee
Publisher: Kids Can Press
ISBN#: 0439358728
Description: This book follows a girl's research for her science fair project. The girl's curiosity engages readers to discover the science of how everyday gadgets work. Quick facts and short, easy experiments support the abstract concepts of modern-day technology. This book is suitable for students in 3rd to 6th grade.

Reference Books

Title: Space
Author: Osborne, Will and Mary Pope Osborne
Publisher: Random House
ISBN#: 037581356X
Description: This is a Magic Tree House series Research Guide to the Magic Tree House book, Space. Discover facts about stars, planets, space travel, life on other planets, and much more! This book is suitable for students in 1st to 3rd grade.

Title: Artificial intelligence: robotics and machine evolution
Author: Jefferis, David
Publisher: Crabtree
ISBN#: 0778700461
Description: This book introduces readers to the past, present, and future of artificial intelligence. Early science-fiction stories explaining the use of these machines today in factories and for space exploration provide the history and evolution of robotics. This book is suitable for students in kindergarten to 3rd grade.

Title: Comets, asteroids and meteorites
Author: Nicolson, Cynthia Pratt
Publisher: Kids Can Press
ISBN#: NA
Description: This book provides experiments, facts, and explanations about comets, meteors, and asteroids. This book is suitable for students in 2nd to 4th grade.

Title: Mapping the planets and space
Author: Deboo, Ana
Publisher: Heinemann Library
ISBN#: 1403467919
Description: Explore the technology used to map the solar system, and examine the images these instruments produce. Get an up-close view of the planets in our solar system. Learn about the universe beyond the Milky Way. This book is suitable for students in 2nd to 4th grade.

Title: Hubble Space Telescope: exploring the Universe
Author: Cole, D. Michael
Publisher: Enslow Publishers
ISBN#: 0766011208
Description: Learn about the history of the Hubble Space Telescope. Find out how astronauts fixed the faulty lens on the Hubble Space Telescope, and view the images it now provides scientists on Earth. This book is suitable for students in 3rd to 5th grade.

VOCABULARY

Binary numbers: A system of counting numbers with a “base-two,” which means it has only two values, 0 and 1. Computers use the binary number system for coding data. The system we typically use to count is a base-ten system. Base-ten systems use 10 numbers, from 0 to 9.

Geostationary satellite: A satellite’s orbit that lies above the Earth’s equator with the same speed as the Earth’s rotation. Geostationary satellites always appear at the same spot in the sky and are useful for telecommunications such as satellite television.

Geosynchronous satellite: A satellite whose orbit around the Earth matches the Earth's (sidereal) rotation period. Geosynchronous satellites appear at the same spot in the sky at the same time everyday.

Ground station: A radio station located on or near the Earth’s surface that can transmit or receive information to or from a spacecraft.

Orbit: The path that an object such as a satellite follows as it moves around a planet or other large body in space.

Pixels: The smallest component of a picture that one technology can transmit to another.

Polar satellite: A satellite’s orbit that passes over both poles of the Earth. Most polar satellites can observe the entire Earth’s surface over a period of fourteen days. Polar satellites are useful for observing the weather.

Program: A set of instructions fed into a computer to make it work.

Satellite: An object in space that orbits a larger object. The Moon is a natural satellite that orbits the Earth.

Spin-off: The creation and use of a product inspired by something existing and used in a different manner.

Technology: A product or process developed and applied for practical purposes.

ASSESSMENT QUIZ

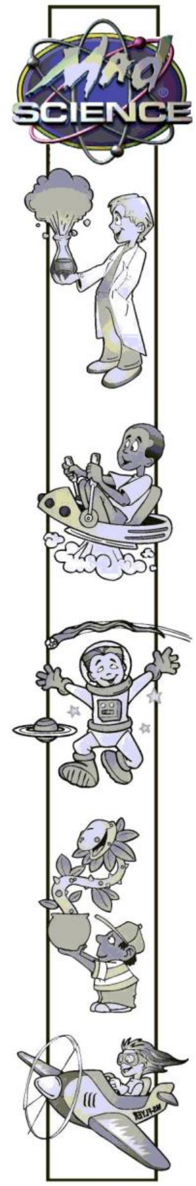
The next page contains a series of questions designed to help assess students' understanding of the concepts in the workshop. It is in a pop quiz format to photocopy and give to children to complete after the workshop.

Answer Key to Space Technology Quiz:

1. B
2. A
3. C
4. A
5. B
6. A

Space Technology Quiz

Circle the correct answer for each question.



1. The names of the joints on the Canadarm are:
    a) the axis, vortex, and compass joints
    b) the wrist, elbow, and shoulder joints
    c) the ankle, knee, and hip joints

2. An example of a NASA spin-off is:
    a) using an infrared thermometer to measure a fever
    b) a picture of a Space Shuttle on a spinning top
    c) using the word technology to describe an object used in space

3. A satellite is:
    a) a hovercraft that carries an astronaut
    b) a space shuttle launching pad
    c) an object that orbits a larger object

4. In binary code, the values 1 and 0 represent:
    a) on and off
    b) the score
    c) up and higher up

5. The orbit of a satellite is based on:
    a) the name given to the satellite
    b) the task that the satellite needs to perform
    c) the magnetic field of the Sun

6. A satellite image is made up of:
    a) pixels
    b) stars
    c) astronauts

PAPER ACTIVITIES

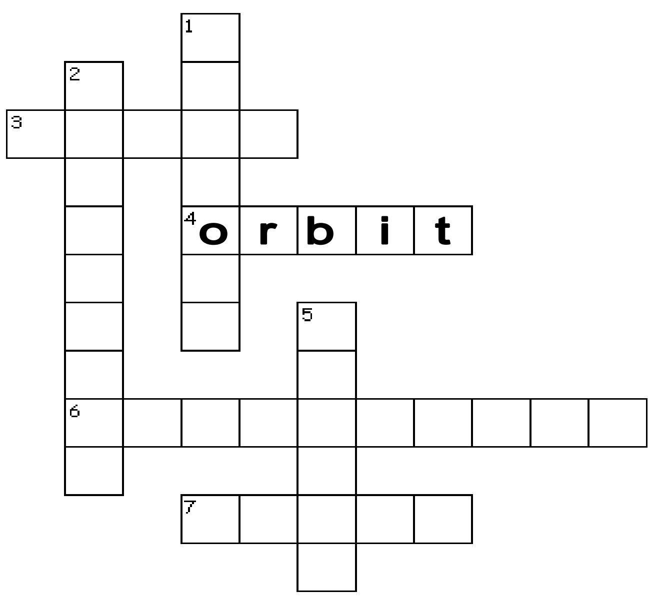
Letter Tiles
Unscramble the sentence: Use trial-and-error to place the tiles into the spaces below. There is one example done for you.
Clue: What do astronauts do when they want to take a space walk?

R S	T L E	ME	E A V	AT	R !	TH	H E I
H U T	T H E	E P	T E O	E T	Y L	A R K	I N G

			E A V				

Answer:
They leave their shuttle at the parking meteor!

Criss-Cross Words
Place the words from the list in the grid. There is one example done for you.



Word List
binary
orbit
satellite
technology
Earth
radio
spinoff

Clues
Across
3. A machine that catches and sends sound waves from far away.
4. The path a satellite follows around a planet.
6. An object used to help us work.
7. The name of our planet.

Down
1. Finding another use for a technology.
2. An object that orbits a planet.
5. A counting system that uses only 1's and 0's.

Criss-Cross Word solution
Across: 3.radio 4.orbit 6.technology 7.earth
Down: 1.spinoff 2. satellite 5. binary