FUNCTIONS AND STATISTICS: Dressed for Space is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**

A PDF version of the lesson guide for NASA CONNECT can be found at the NASA CONNECT web site: **http://connect.larc.nasa.gov**

NASA CONNECT

Functions and Statistics: Dressed for Space

An Educator Guide with Activities in Mathematics, Science, and Technology

Acknowledgments: Special thanks to Summer 2001 Educators in Residence, Chris Giersch, Bill Williams, and National Council of Teachers of Mathematics (NCTM).

Program Overview

SUMMARY AND OBJECTIVES

In *Functions and Statistics: Dressed for Space,* students will learn about the past, present, and future space suits that astronauts wear. They will learn how the Mercury, Gemini, and Apollo space suits were developed. Students will also learn why sizing a space suit is critical for astronauts working in space. They will also be introduced to three advanced space suit prototypes: the H-Suit, I-Suit, and D-Suit. Students will observe NASA researchers using functions and statistics to determine sizing and performance characteristics. By conducting hands-on and web activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classrooms.

STUDENT INVOLVEMENT

Cue Card Questions

Norbert, NASA CONNECT's animated cohost, poses questions throughout the broadcast. These questions direct the instruction and encourage students to think about the concepts being presented. When viewing a videotaped version of NASA CONNECT, educators have the option to use Norbert's Pause, which gives students an opportunity to reflect and record their answers on the Cue Cards (p. 13). Norbert appears with a remote to indicate an appropriate time to pause the videotape and discuss the answers to the questions.

Hands-On Activity

The hands-on activity is teacher-created and is aligned with the National Council of Teachers of Mathematics (NCTM) standards, the National Science Education (NSE) standards, the International Technology Education Association (ITEA) standards, and the National Education Technology (NET) standards. Students will investigate how different colors, refective surfaces, and different materials are affected by radiant heat abosorption and heat radiation. They will plot, analyze, and summarize data to determine the validity of student predictions.

Instructional Technology Activity

The Materials Science Challenge project is aligned with the National Council of Teachers of Mathematics (NCTM) standards, the National Science Education (NSE) standards, and the International Technology Education Association (ITEA) standards. This project, developed by the NASA Classroom of the Future, provides middle and high school students with an opportunity to integrate hands-on experiments, web-based research, and interactive simulations as they develop effective solutions to space-based problems. To access the Materials Science Challenge project, go to Dan's Domain on NASA CONNECT's web site at **http://connect.larc.nasa.gov/dansdomain.html**.

RESOURCES

Teacher and student resources (p. 17) support, enhance, and extend the NASA CONNECT program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this lesson guide, the NASA CONNECT web site, http://connect.larc.nasa.gov, offers online resources for teachers, students, and parents. Teachers who would like to get the most from the NASA CONNECT web site can visit "Dan's Domain," located at **http://connect.larc.nasa.gov/dansdomain.html.**

Hands-On Activity

BACKGROUND

To explore and work in space, human beings must take their environment with them because there is no atmospheric pressure and no oxygen to sustain life. Inside the spacecraft, the atmosphere can be controlled so that special clothing is not necessary, but when outside, people need the protection of space suits.

The Extravehicular Mobility Unit (EMU) comprises the space suit assembly, the primary life support system, the display and control module, and several other crew items designed for space walks and emergency life support. The EMU accommodates a variety of interchangeable systems that interconnect easily and securely in single-handed operation for either normal or emergency use. It provides the astronaut with oxygen for breathing and maintains a pressure around the body to keep body fluids in the liquid state. At an altitude above 19,000 m (19 km), the air pressure is no longer sufficient to keep body fluids from boiling. Furthermore, the sudden absence of external pressure that balances the internal pressure of body fluids and gases would rupture fragile tissues such as eardrums and capillaries. The net effect on the body would be swelling, tissue damage, and a deprivation of oxygen to the brain that would result in unconsciousness in less than 15 seconds.

The space suit also shields the astronaut from deadly hazards. One of these hazards is the presence of high-speed particles. These particles are called micrometeoroids and usually are smaller than a grain of sand, have a mass that is only a fraction of a gram, and travel at speeds ranging from a few kilometers to as many as 80 kilometers per second. An astronaut struck by one of these can be severely injured. The near-Earth environment has the additional problem of space debris such as paint chips and metal fragments from old rocket boosters and satellites. Being struck by these particles can be equally dangerous; therefore, space suits must be constructed to withstand impacts.

Besides providing protection from bombardment by micrometeoroids, radiation of electrically charged particles from the Sun, and ultraviolet radiation, the space suit insulates the wearer from the temperature extremes of space. Without the Earth's atmosphere to filter the sunlight, the side of the space suit facing the Sun may reach temperatures as high as 121 C; the other side, exposed to darkness, may be as cold as –157 C. The most difficult problems the designers of the EMU face are restricting the radiation of the suit to minimize heat loss through radiation, thus making it insensitive to the temperatures encountered in space..

Space suits of the future will incorporate new materials and technology created for the purpose of solving the problems faced by astronauts in space. They will attempt to sustain, insulate, protect, and provide for maximum mobility to allow the astronauts to perform their tasks, accomplish their missions, and remain safe.

NATIONAL STANDARDS

Mathematics (NCTM) Standards

- Understand patterns, relations, and functions
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Select and use appropriate statistical methods to analyze data
- Develop and evaluate inferences and predictions that are based on data
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others

Science (NSE) Standards

- Abilities necessary to do scientific inquiry
- Understanding scientific inquiry
- Science and Technology
- Understanding science and technology
- History and Nature of Science
- Science as a human endeavor

Technology (ITEA) Standards

Design

- Develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities of a Technological World

- Develop abilities to assess the impact of products and systems.

Technology (NET) Standards

- Select and use appropriate tools and technology resources to accomplish a variety of tasks and solve problems.

INSTRUCTIONAL OBJECTIVES

The students will

- investigate the effect of different colors, reflective surfaces, and different materials on radiant heat absorption and heat radiation.
- use prior knowledge to predict the material/color which has the optimum thermal properties.
- use a Celsius scaled thermometer to measure and record temperature.
- plot, analyze, and summarize data to determine the validity of student predictions.
- use a combination of known materials to design, test, and present an improved solution.
- incorporate collaborative problem-solving strategies in a real-life application.

VOCABULARY

absorption – interception of radiant energy

mean – the statistic that is the sum of the values in a data set divided by the number of values in the set

radiation – emission and transmission of radiant energy through space or through a material

range – the statistic that is the difference between the greatest and least values in a set of data

statistics – the study of information or data

temperature – degree of hotness or coldness measured on a definite scale

PREPARING FOR THE ACTIVITY

Student Materials (per 4-student group)

Group 1 (Colored cans – heating)

2 identical metal cans (ex. coffee cans)
3 thermometers
white construction paper
black construction paper
cardboard
stopwatch or timer
temperature data chart (p. 11)
heat lamp (optional)
clear tape
red pencil
purple pencil
red erasable overhead pen
purple erasable overhead pen
transparency grid (p. 12)
grid pattern (heating)
Sun (optional)

Group 2 (Colored cans – freezing)

2 identical metal cans
3 thermometers
white construction paper
black construction paper
cardboard
stopwatch or timer

temperature data chart (p. 11)
heat lamp (optional)
trash bag
red pencil
purple pencil
clear tape
red erasable overhead pen
purple erasable overhead pen
transparency grid (p. 12)
grid pattern (cooling)

Group 3 (Material cans – heating)

2 identical metal cans (ex. coffee cans)
3 thermometers
cardboard
stopwatch or timer
temperature data chart (p. 11)
heat lamp (optional)
clear tape
cotton balls (enough to cover can)
aluminum foil (enough to cover can)
glue stick
orange pencil
brown pencil
orange erasable overhead pen
brown erasable overhead pen
transparency grid (p. 12)
grid pattern (heating)
Sun (optional)

Group 4 (Material cans – freezing)

2 identical metal cans (ex. coffee cans)
3 thermometers
cardboard
stopwatch or timer
temperature data chart (p. 11)
cardboard box or cooler (optional)
trash bag
cotton balls (enough to cover can)
aluminum foil (enough to cover can)
clear tape
glue stick
orange pencil
brown pencil
orange erasable overhead pen
brown erasable overhead pen
transparency grid (p. 12)
grid pattern (cooling)

Group 5 (Material cans – heating)

2 identical metal cans (ex. coffee cans)
3 thermometers
cardboard
stopwatch or timer
temperature data card (p. 11)
heat lamp (optional)
clear tape
3 meat trays (enough to cover can)
insulation tape (enough to cover can)
green pencil
blue pencil
green erasable overhead pen
blue erasable overhead pen
transparency grid (p. 12)
grid pattern (heating)
Sun (optional)

Group 6 (Material cans – freezing)

2 identical metal cans (ex. coffee cans)
3 thermometers
cardboard
stopwatch or timer
temperature data chart (p. 11)
cardboard box or cooler (optional)
trash bag
3 meat trays (enough to cover can)
insulation tape (enough to cover can)
green pencil
blue pencil
clear tape
green erasable overhead pen
blue erasable overhead pen
transparency grid (p. 12)
grid pattern (cooling)

Teacher Materials

large cooler
ice (30 lbs)

Time

Discussing the activity ....10 min
Preparing the activity ....15 min
Conducting the activity ....65 min

Focus Questions

1. What are the basic functions of a space suit?

2. Why is it important to look at thermal properties in a space suit design?
3. What are some materials that comprise a space suit?
4. How do NASA engineers use math to design a space suit?

Advance Preparation

1. The teacher should make six transparency copies of the grid pattern (p. 12).
2. The teacher should fill the large cooler with ice. The cafeteria is a great place to obtain ice.

THE ACTIVITY

Step 1: Introducing the Activity

A. Announce to the class: "Today you will become a Thermal Property Investigator (TPI). Your job is to investigate thermal properties of various materials and colors, graph and analyze results, and develop your own combination of materials to be considered for future space suits."

B. Organize students into six groups. Each group has four students.

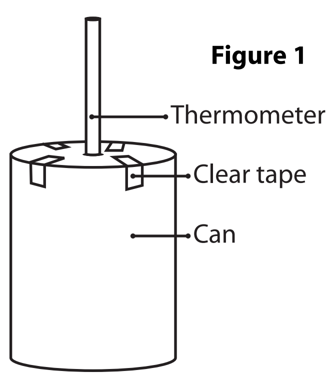
C. Assign each group a number (1-6). In each group, one student should be designated as the timekeeper, one student as the data recorder, one student as the thermometer reader, and one student as the data analyzer.

D. Distribute all materials.

E. Using the temperature data card, have each group record its initial information. Information includes: group number, materials used, and the experimental process (heating /cooling).

F. Have students cut out cardboard lids to fit the cans by tracing the circumference of the cans. A small puncture should be made in the center of the lid to hold the thermometer. This hole needs to be smaller than the diameter of the thermometer so that it can hold it firmly in place. Attach the lid to each can using clear tape. See Figure 1.

Figure 1



G. Have each group cover the cans with the materials provided. Each material should be applied in a single layer.

Groups 1 & 2	Groups 3 & 4	Groups 5 & 6
white can	cotton ball can	meat tray can
black can	aluminum foil can	insulated tape can

Note: The meat tray (foam) needs to be slowly molded around the can and held in place by rubber bands. The top and bottom can be glued or taped. The cotton balls should be glued to the can by using the glue stick. Make sure the can is completely covered with cotton balls that are applied in a single layer.

H. Have students carefully insert the thermometers into the cans through the holes in the lid. Make sure the bulb of the thermometer is in the center of the can, not touching the sides or bottom.

Step 2: Conducting the Activity

Groups 1, 3, and 5

A. Have each group measure the initial temperature in the room. Record the value on the temperature data card.

Suggestion: The teacher should remind students how to read a Celsius thermometer.

B. Have each group place its cans in front of a heat lamp. Make sure the cans are exposed equally to the light.

Note: If doing the experiment outside, place the cans in the sunlight so that all are exposed equally. Avoid casting shadows on the cans.

C. Have each group measure the temperature of the cans after 1 minute has expired. Record the value on the temperature data card.

D. Have each group repeat step C for twelve additional readings taken in 1-minute increments.

Groups 2, 4, and 6

A. Have each group place a garbage bag inside the cardboard box to serve as a liner.

B. Have each group place its cans inside the box. Fill the box with enough ice to reach the tops of the cans.

C. Have each group insert a thermometer in the ice.

D. Have each group measure the temperature of the cans after 1 minute has expired. Record the value on the temperature data card.

Suggestion: The teacher should remind students how to read a Celsius thermometer.

E. Have each group repeat step C for twelve additional readings taken in 1-minute increments.

F. Have each group measure the temperature of the ice. Record the value on the temperature data card.

Step 3: Data Analysis

A. Have students use colored pencils to graph their data on the grid (p. 12). Use the following color code:

Material	**Color**
aluminum foil	brown
cotton balls	orange
insulating tape	green
black construction paper	purple
white construction paper	red
foam meat tray	blue

The teacher should discuss with the class the range of the data to determine the maximum, minimum, and scale to be used for the Y-axis for both experimental processes, heating and cooling. (Scales will be different for the heating process and cooling process). The X-axis is defined by time in minutes.

Note: All heating groups should use the selected heating scale, and all cooling groups should use the selected cooling scale.

B. Have students note five observations that are substantiated by the data collected. Observations include trends, patterns, or comparisons. Have students write the observations at the bottom of the temperature data card in the observation section.

C. Using the same color code and erasable pens, have the data analyst for each group graph the group's data on the transparency grid provided by the teacher.

D. Have each group hand in their transparency to the teacher.

E. The teacher should overlay the transparencies presented by the heating groups on the overhead projector. The teacher should then analyze the data with the students by asking the heating groups for their observations.

F. The teacher should overlay the transparencies presented by the cooling groups on the overhead projector. The teacher should then analyze the data with the students by asking the cooling groups for their observations.

G. Have the students compare and contrast the graphs and data.

Step 4: Discussion

A. Which material/color had the greatest overall variation? Which material/color had the least variation?

B. What inferences can be made about color, materials, and temperature variation?

C. What relationships exist between time and temperature variation?

D. Based on analysis and discussion of data, select two of the tested materials to layer into a covering to produce improved thermal results. Support this recommendation in a paragraph that summarizes your analysis of the data.

Extensions

A. Have students test their recommended layers to see if improved thermal results are achieved.

B. Have the students use the graphing calculator to input data, display, and analyze results.

C. Compute and compare the line of best fit for the linear section of the graph.

D. Have students design a space suit with material combinations they would like. This assignment could be a poster project or an actual suit. Use guidelines appropriate for the group (i.e., number of layers, types of material, cost, size).

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

Temperature Data Chart

Group Number:________

Material:________________

Experimental Process:
❑ Heating ❑ Cooling

Initial Temperature:____

Time	Temp.
1 min	
2 min	
3 min	
4 min	
5 min	
6 min	
7 min	
8 min	
9 min	
10 min	
11 min	
12 min	

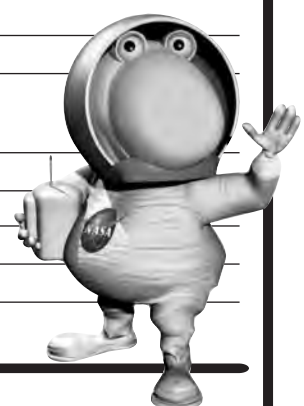
Cue Cards

Phil West, Engineer, NASA Johnson Space Center

1 What is an EMU?

2 Why is sizing a space suit critical to astronauts?

3 Why can't space suits be individually tailored for each astronaut?



Amy Ross, Space Suit Engineer, NASA Johnson Space Center

1 What will the future space suit be used for?

2 How do you evaluate advanced space suits?

3 Analyzing the data, which suit has the best elbow performance?

Teacher Materials

Cue Cards

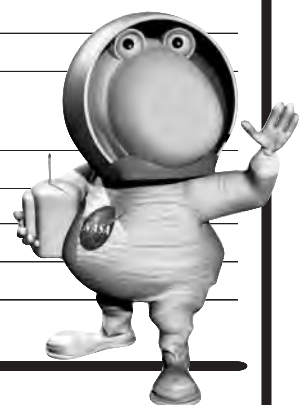
Phil West, Engineer, NASA Johnson Space Center

1 What is an EMU?

Possible Answers: The EMU or Extravehicular Mobility Unit is the current space suit that astronauts use in space. It has a combination of soft and hard components to provide support, mobility, and comfort.

2 Why is sizing a space suit critical to astronauts?

Possible Answers: It is important for an astronauts' space suits to fit just right so that they can achieve the best range of motion possible when working in space.



3 Why can't space suits be individually tailored for each astronaut?

Possible Answers: With over 100 astronauts working at NASA, it would be too expensive to individually tailor a space suit for each astronaut. Instead, NASA builds components of varying sizes to piece together a space suit.

Amy Ross, Space Suit Engineer, NASA Johnson Space Center

1 What will future space suit be used for?

Possible Answers: The future space suit will be used for exploring nearby planets such as Mars.

2 How do you evaluate advanced space suits?

Possible Answers: Each suit is evaluated based on several categories like sizing, comfort, weight, stowage volume, and isolated joint range of motion. For the category of isolated joint range of motion, there are thirteen different types of motion; for example, waist, shoulder, ankle, hip, and elbow flexion and extension.

3 Analyzing the data, which suit has the best elbow performance?

Possible Answers: According to the chart, the I-Suit has the best elbow performance; however, if you factor in comfort and elbow performance, the H-Suit exhibits superior overall performance.

Instructional Technology Activity

DESCRIPTION

The complex environment of space has presented scientists and engineers with dynamic challenges. Many of the issues encountered in this unique environment demand a fresh approach to problem solving – one that requires a synthesis of disciplines and talents. The Material Science Challenge Web site, developed by the NASA Classroom of the Future, provides middle and high school students with an opportunity to integrate hands-on experiments, web-based research, and interactive simulations as they develop effective solutions to space-based problems.

NATIONAL STANDARDS

Technology (ITEA) Standards

The Attributes of Design

- Design is a creative planning process that leads to useful products and systems.
- There is no perfect design.
- Requirements for a design are made up of criteria and constraints.

Engineering Design

- Design involves a set of steps, that can be performed in different sequences and repeated as needed.
- Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.
- Modeling, testing, evaluation, and modifying are used to transform ideas into practical solutions.

Apply the Design Process

- Specify criteria and constraints for the design.
- Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints and refine as needed.
- Make a product or system and document the solution.

Use and Maintain Technological Products and Systems

- Use computers and calculators in various applications.

Information and Communication Technologies

- Information and communication systems allow information to be transferred from human being to human being, from human being to machine, and from machine to machine.
- The design of a message is influenced by such factors as intended audience, medium, purpose, and nature of the message.
- The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.

Science (NSE) Standards

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding scientific inquiry

Physical Science

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Science and Technology

- Abilities of technological design
- Understanding science and technology

History and Nature of Science

- Science as a human endeavor
- Nature of science

Mathematics (NCTM) Standards

- Understand patterns, relations, and functions.
- Use mathematical models to represent and understand quantitative relationships.
- Analyze change in various contexts.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.
- Create and use representation to organize, record, and communicate mathematical ideas.
- Use representations to model and interpret physical, social, and mathematical phenomena.

INSTRUCTIONAL OBJECTIVES

Students will

- gain a solid foundation in the basic principles of the Materials Science Discipline.
- foster an understanding of basic scientific, mathematical, and technological principles relating to materials science through traditional print, hands-on activities, and computer simulations.
- enhance their problem-solving skills.
- learn the ability to critically analyze real world problems.
- increase their capacity for applying knowledge to novel situations.

Resources

BOOKS, PAMPHLETS, AND PERIODICALS

Barton, Byrom. *I Want to Be an Astronaut*, Harpercollins Juvenile Books, 1992.

Heinlein, Robert A. *Have Spacesuit, Will Travel,* Ballentine Books, 1995.

Kozloski, Lillian D. *U.S. Space Gear: Outfitting the American Astronaut,* Smithsonian Institute Press, 2000.

Mullane, Mike R. *Do Your Ears Pop in Space? And 500 Other Surprising Questions About Space Travel*, John Wiley and Sons, 1987.

Nye, Jody Lynn. *Don't Forget Your Spacesuit, Dear,* Baen Books, 1996.

Thompson, Kim; Paskiet, Mark *I'd Like to be an Astronaut: Learning About Gravity, Space Travel and Famous Astronauts*, Twin Sisters Productions, 1996.

Zubrin, Robert. *Entering Space: Creating a Spacefaring Civilization*, J P Tarcher, 2000.

WEB SITES

Space Suits/General Information
http://www.hq.nasa.gov/office/pao/History/SP-4026/noord47.html
http://www.jsc.nasa.gov/pao/factsheets/nasapubs/wardrobe.html
http://www.dfrc.nasa.gov/airsci/er-2/pshis.html#Why
http://www.howstuffworks.com/space-suit.htm

Aerospace/Interactive Activities and General Info
http://observe.arc.nasa.gov/nasa/spacefly/spacefly_index.shtml.html
http://www.jsc.nasa.gov/Bios/more.html
http://quest.arc.nasa.gov/space/team/index.html
http://www.spaceflight.nasa.gov/outreach/jobsinfo/astronaut.html
http://spaceflight.nasa.gov/
http://starchild.gsfc.nasa.gov/docs/StarChild/
http://kids.msfc.nasa.gov/
http://www.jsc.nasa.gov/er/seh/seh.html
http://lsda.jsc.nasa.gov/kids/L&W/livework.htm
http://spaceflight.nasa.gov/gallery/video/station/mmats/index.html

Aerospace Related Lesson Plans and Sites for Educators
http://spacelink.nasa.gov/products/Suited.For.Spacewalking/
http://learningoutpost.jsc.nasa.gov/expeditions.html
http://spacelink.nasa.gov/NASA.Projects/Human.Exploration.and.Development.of.Space/Living.and.Working.In.Space/
http://kids.msfc.nasa.gov/Teachers/

Figure This!
Offers Mathematics Challenges that middle school students can do at home with their families to emphasize the importance of a high-quality mathematics education for all.
http://www.figurethis.org

Engineer Girl
Part of the National Academy of Engineering's Celebration of Women in the Engineering project. The project brings national attention to the opportunity that engineering represents to people of all ages, particularly to women and girls.
http://www.engineergirl.org

GetTech
Through its web site and collateral materials, GetTech helps prepare students in fun ways for tomorrow's great jobs.
http://gettech.org

Event-Based Science
Event-Based Science is a new way to teach science at the middle school level. Newsworthy events establish the relevance of science topics; authentic tasks create the need-to-know more about those topics; and lively interviews, photographs, web pages, and inquiry-based science activities create a desire to know more about those topics. http://www.mcps.k12.md.us/departments/eventscience

7 Steps for Teachers Using Television in the Classroom

TV programs can add a new dimension to your classroom and promote active learning among your students. The following steps can guide you in preparing a lesson using instructional television: http://www.qued.org/erc/teachers/mediatips.html