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Educational Product

Educators | **Grades 6-8**

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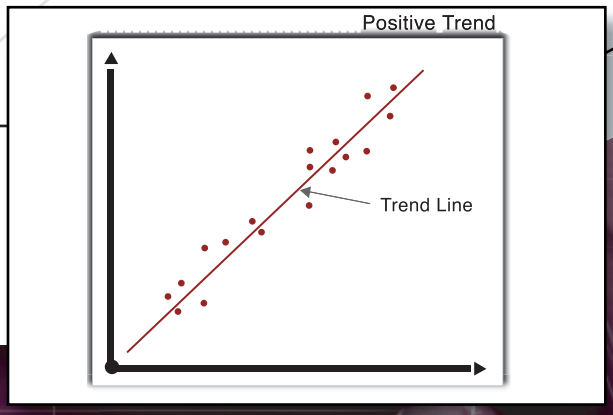
NASA CONNECT™

good STRESS:

Building Better Muscles and Bones

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



NASA CONNECT™: *Good Stress: Building Better Muscles and Bones* is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. You may access this publication and other educational products at the following address: **http://spacelink.nasa.gov/products**

Find a PDF version of the educator guide for NASA CONNECT™ at the NASA CONNECT™ web site: **http://connect.larc.nasa.gov**

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www.aiaa.org

www.cnu.edu

www.iteawww.org

www.nasa.gov

www.nsbri.org

www.nctm.org

www.nsta.org

www.nec.com

http://knowitall.org

NASA CONNECT™

good STRESS:

Building Better Muscles and Bones

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

Program Overview

Hands-On Activity

AIAA FOUNDATION Registered users of NASA CONNECT™ may request an American Institute of Aeronautics and Astronautics (AIAA) classroom mentor. For more information or to request a mentor, e-mail **nasaconnect@aiaa.org**.

Acknowledgments: Special thanks to Summer 2004 Educators in Residence, Chris Giersch, and the National Council of Teachers of Mathematics (NCTM).

The hands-on activities used in this educator guide appear in *From Outer Space to Inner Space/Muscles and Bones: Activities Guide for Teachers* created by Baylor College of Medicine for the National Space Biomedical Research Institute under NASA Cooperative Agreement NCC 9-58. The activities are used with permission of Baylor. All rights reserved.

program overview

educator guides

SUMMARY & OBJECTIVES

In NASA CONNECT™, *Good Stress: Building Better Muscles and Bones*, students will learn about the importance of building and maintaining better muscles and bones. They will learn that all stresses in life are not "bad." In fact, the body needs "good" stresses, like exercise, to be healthy. Students will see how scientists and researchers collect and analyze physiological data to understand how muscle and bones are constantly changing, especially in a microgravity environment. By conducting inquiry-based and web activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classrooms.

STUDENT INVOLVEMENT

Inquiry-Based Questions

Host, Jennifer Pulley, and NASA engineers and scientists will pose inquiry-based questions throughout the program. These questions allow the students to investigate, discover, and critically think about the concepts being presented. When viewing a videotape or DVD version of NASA CONNECT™, educators should pause the program at the designated segments so students can answer and discuss the inquiry-based questions. During the program, Jennifer Pulley and NASA engineers and scientists will indicate the appropriate time to pause the tape or DVD. For more information about inquiry-based learning, visit the NASA CONNECT™ web site, **http://connect.larc.nasa.gov**.

Teacher note: Please preview the program before introducing it to your students so that you will know where the pauses occur.

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 (NSES) Standards, and the National Health Education Standards. The activity, *Good Stress*, appears in the Muscles and Bones: Activities Guide for Teachers developed by Baylor College of Medicine for NASA's National Space Biomedical Research Institute (NSBRI). In *Good Stress*, students will collect, analyze, and visually represent data to explore the effects of stress on the muscles in their hands.

Teacher note: Students should already have experience with scatter plots, box-and-whisker plots, and stem-and-leaf plots.

Squeak Norbesaur Challenge

The web activity is teacher created and is aligned with the National Council of Teachers of Mathematics (NCTM) Standards, the National Science (NSES) Standards, and the International Technology Education Association (ITEA) Standards. In the NASA CONNECT™ Norbesaur Challenge, students will study biomechanics with an engaging and fun Squeak activity. They will also become involved in measuring speed and distance; use ratios to normalize data; and plot data using a scatter plot. To access the NASA CONNECT™ Norbesaur Challenge, go to the NASA CONNECT™ web site **http://connect.larc.nasa.gov**.

RESOURCES

Teacher and student resources enhance and extend the NASA CONNECT™ program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions.

hands-on activity

BACKGROUND

Generally, when we think of stress, we think of being overworked, mentally tired, or overwhelmed by our daily lives. While too much stress can be detrimental to the body, too little of some kinds of stress can be harmful. Activities such as walking, carrying packages, and mopping the floor are physical stresses. Activities such as doing crossword puzzles, balancing the checkbook, and reading are mental stresses. There also are emotional stresses, like receiving a bad grade on a test or walking into a surprise birthday party. Our bodies, including muscles and bones, require some physical and mental stresses to be healthy and grow.

Physical stress occurs when bones and muscles must work against a force. It occurs when we pick up something heavy, like a 20-pound bag of cat litter. Gravity pulls down on the bag, and we have to work to overcome that force to lift the bag. Swimming also causes stress because muscles and bones have to work against the resistance of the water to move the body. Gravity pulls on our bodies, and our muscles and bones constantly work to counteract that force and keep us balanced.

Stress from physical activity is necessary for bone growth and maintenance. The body builds bone based on its needs. The need for any particular bone is dictated by the amount of stress placed on it. During the years a person's bones are growing (from birth to about age 25), physical stress on bones causes builder cells to work more, which makes bones grow. Builder cells produce collagen fibers that form the framework of bones. The framework is then filled in with minerals, producing strong, thick bones. Even after they stop growing, bones still need physical stress to maintain thickness and strength.

Muscles also rebuild and grow as a result of physical stress. Stress can lead to change in either muscle strength or muscle stamina (the ability to perform an activity for a long time without becoming tired). High-intensity, short-duration exercises (or stresses), like weight lifting, cause the muscles to increase in strength. Low-intensity, long-duration activities, such as running and swimming, cause muscles to increase in stamina.

INSTRUCTIONAL OBJECTIVES

The students will

- explore the effects of stress on the muscles in their hands.
- gain experience in collecting, analyzing, and displaying relevant data.

NATIONAL STANDARDS

NCTM Mathematics Standards

Data Analysis and Probability

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.

- Formulate questions, design studies, and collect data about a characteristic shared by two populations of different characteristics within one population.
- Select, create, and use appropriate graphical representations of data, including box plots, scatter plots, and stem-and-leaf plots.

Select and use appropriate statistical methods to analyze data.

- Find, use, and interpret measures of center and spread, including mean and interquartile range.
- Discuss and understand the correspondence between data sets and their graphical representation, especially stem-and-leaf plots, box plots, and scatter plots.

Develop and evaluate inferences and predictions that are based on data.

- Make conjectures about possible relationships between two characteristics of a sample on the basis of scatter plots of the data and approximate lines of fit.

NSES Science Standards

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

- Structure and function of living systems

Science in Personal and Social Perspectives

- Personal Health

National Health Education Standards

Health Education Standard 1:

Students will comprehend concepts related to health promotion and disease prevention.

- Explain how health is influenced by the interaction of body systems.

NASA RELEVANCE

The current major countermeasures for bone and muscle deterioration during long duration space flight include nutrition and exercise. Without adequate nutrition, problems can arise for every system in the body. Ensuring that astronauts have the right nutrients in the food they eat in space is critical for their health during and after flight. It is important that astronauts receive sufficient calories and adequate nutrition to maintain their energy level and good health. Crewmembers must also have a variety of foods so they do not become tired of the "same old thing" and, therefore, not eat enough. At the same time, performing daily exercise consisting of leg cycle ergometry, treadmill walking and running, and resistance strength training also helps astronauts decrease bone and muscle losses. Astronauts who faithfully perform their exercise programs return to Earth in better physical condition and recover faster. In contrast, those that do not exercise regularly are at greater risk for bone fractures, and thus, must complete a longer rehabilitation program.

A better understanding of bone and muscle changes in space flight will lead to improved treatments for both astronauts and Earth-bound patients alike. The information gained from research on astronauts in space may benefit the many people here on Earth whose daily activities are affected by metabolic deficiencies, weakened muscles, or loss of bone mass.

PREPARING FOR THE ACTIVITY

Teacher note: *Students should already have experience with scatter plots, box-and-whisker plots, and stem-and-leaf plots. See teacher handout for a review of the three plots.*

Student Materials *(groups of 2)*

- 2 transparent plastic knives
- stopwatch
- spring-hinge clothespin
- Stress This! (Student Handout)
- colored pencils (optional)

Teacher Materials

- overhead projector and screen

Time

Setup	10 minutes
Activity	50 minutes on Day 1
	5 minutes every other day for two weeks
Discussion	30 minutes on last day of activity

THE ACTIVITY

Lesson Description

Teacher note: *Pass out all student materials to each group.*

ENGAGE

Introduce the topic of stress by asking questions such as these:

- What is stress?
- How can stress be a good thing?
- What are some good stresses?

Explain that there are "good" stresses and "bad" stresses and that the body needs good stresses, such as exercise, to be healthy.

Students will investigate how physical stress can affect bone — a hard material. Have students compare the two plastic knives to determine whether they are the same or different. Instruct students to bend one plastic knife back and forth several times without breaking it. Again, have students compare the two knives. Ask them if anything is different between them. Request a volunteer to bring up his or her group's plastic knives and place them on the overhead projector. Have students observe the knives and ask again if there is anything different between them. The students will be able to observe that very thin opaque lines have developed only in the knife that was bent. Often, the lines are observable even without using an overhead projector; however, the projector will make the lines easier to see.

Discuss the students' observations. Explain that when they bent the plastic knives, they applied physical stress and changed the appearance of the objects. Ask the following questions:

- If we wanted to break this knife, would it be easier to do so where we bent it before or at another point?
- Why do you think it would be easier to break where we've already bent it?

The changes in the knives may look minor, but they are important to the object's structure. This concept is true for bones, too. Gravity and movement cause invisible stress patterns in bones. These patterns are very small. If we could see them, they would look very unimportant, but they tell the "bone construction crews" where to work to make bone thicker and stronger.

EXPLORE

Stress and Muscles

Explain to students that they will be exploring the effects of stress on the muscles in their hands.

The first trial will test each student's initial muscle strength and stamina. Explain the exercise to students. Ask all students to predict how many times they will be able to click a clothespin with their nondominant hand (thumb and index finger) during each of three, one-minute trials, and to record their predictions in a data table. See figure 1.

Figure 1

Note: *Organizing data is an important skill students need to practice. Have each group construct its own data table for the activity.*

Technology Insertion Point: *If technology is available, students are encouraged to record their results electronically using a graphing calculator, a computer, or personal digital assistant (PDA, i.e., PALM Pilot).*

Have all students count the actual number of times in one minute each one of them can click a clothespin when using his or her nondominant hand and record the results. Have students rest for one minute and then repeat the trials two more times. Have one student complete the trial while the other measures the time. Then have students switch roles. After students have completed all trials, ask the following questions:

- Did you feel your hand muscles burn?
- Were you more tired after each minute of clicking?
- Why do you think that happened?

Every other day for the next two weeks, have students repeat the exercise described previously. This repetition is the conditioning period. The stress induced by the clothespin on the muscles of the hand will cause the muscles to become stronger and gain stamina. Students should predict and report their results each day.

The test of how well the stress conditioning worked comes on the last day of the two-week period. Again, have each student predict how many times he or she will be able to click the clothespin during the timed periods and record his or her prediction. Have each student repeat the clicking-resting experiment and record the results.

EXPLAIN

Teacher note: *Students should already have experience with scatter plots, box-and-whisker plots, and stem-and-leaf plots.*

Journal Write (Students): Instruct students to write a paragraph about the results of the experiment. They should explain what happened and why they think things turned out the way they did. Discuss results from the initial and final experiments. Students will discover that they were able to click the clothespin more times (and with less muscle soreness) in the first one-minute period after the conditioning period. This result shows that their muscles have grown stronger. Students also will discover that they are able to click more times in the second and third one-minute periods after the conditioning has taken place. This result shows that the muscles have increased in stamina. Students should answer and discuss the following questions:

Analyzing Muscle Strength

1. How did the muscle strength in your hand change over the conditioning period?
   Answer: The muscle strength should increase over the conditioning period.
2. What data points did you analyze to determine your answer in question 1?
   Answer: Students should use Trial 1 actual data from the first day and the last day.
3. What type of graph *(scatter plot, box-and-whiskers plot, or stem-and-leaf plot)* is most appropriate to visually verify your answer to question 1?
   Answer: Scatter plot
4. Using the appropriate data, construct a graph to visually verify your answer to question 1. *(Colored pencils may be helpful if technology is not available.)*
   Answer: Graphs may vary

Analyzing Muscle Stamina

5. How did the muscle stamina in your hand change over the conditioning period?
   Answer: Muscle stamina should increase over the conditioning period.
6. What data points did you analyze to determine your answer in question 5?
   Answer: Students should use Trial 1 actual data from the first day and Trial 3 actual data from the last day.
7. What type of graph (scatter plot, box-and-whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 5?
   Answer: Scatter plot
8. Using the appropriate data, construct a graph to visually verify your answer to question 5.
   (Colored pencils may be helpful if technology is not available.)
   Answer: Graphs may vary.

Analyzing Muscle Strength Between Boys and Girls

9. You will need to collect the last day's Trial 1 actual data from every boy and girl in the class. Arrange the data in an organized chart, one column for boys and another column for girls. Based on the data you collected, which group of students, boys or girls, had greater muscle strength in their hands?
   Answer: Answers may vary.
10. Verify your answer graphically. What type of graph (scatter plot, box-and-whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 9? Construct your graph.
    Answer: Box-and-whiskers plot or stem-and-leaf plot

Comparing Predicted Versus Actual Results

11. Compare your predicted results and actual results in Trials 1–3 on the first day to those in Trials 1–3 on the last day. Did your predicted results improve over the course of the experiment?
    Answer: Predicted results should improve over time.
12. What type of graph (scatter plot, box-and whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 11? Explain why.
    Answer: Scatter plot
13. Using the appropriate data, construct a graph to visually verify your answer to question 11. (Colored pencils may be helpful if technology is not available.)
    Answer: Graphs may vary.

Additional Critical Thinking Questions

14. What are some recommendations to improve this activity?
    Answer: Graphs may vary.
15. You have analyzed muscle strength, muscle stamina, muscle strength between boys and girls, and you also compared predicted versus actual results. What are some other ways you can analyze the data?
    Answer: Graphs may vary.

Technology Insertion Point: *If technology is available, encourage students to graph their results electronically by using a graphing calculator, a computer, or a personal digital assistant (PDA, i.e., PALM Pilot).*

EXTENSION

Have students present their findings to their peers. Presentations may be in the form of a PowerPoint presentation, a poster board, a web page, a piece of artwork, music, or other delivery system.

EVALUATE

As a class, students should create their own rubric or method of assessment for the presentations. Students can work in their groups to brainstorm some initial ideas. After the teacher presents all the ideas to the class, the students can decide, as a class, the final rubric or scoring method.

Student Handout

Stress This!

Directions:

1. Predict the number of times you will be able to click the clothespin between your thumb and index finger in your nondominant hand for a one-minute period. Record your prediction in an organized chart. Organizing data is an important skill you need to practice.
2. Hold the clothespin in your nondominant hand between your thumb and index finger. While your partner is watching the timer, count the number of times in a one-minute period you are able to click the clothespin. Record the result.
3. Rest for one minute, then predict again and repeat step 2. Rest for another minute. Repeat prediction and step 2 again for a third trial. Be sure to hold the clothespin the same way in every time trial.
4. Switch roles with your partner and have him or her conduct the same experiment, steps 1–3, with his or her nondominant hand and record the results.
5. After completing the three trials, your teacher will ask you some critical thinking questions.
6. Repeat steps 1–4 every other day for two weeks, for a total of seven days. Record your predictions and results in your organized chart.
7. After the experiment is completed, write a paragraph about the results of your experiment. You should explain what happened and why you think things turned out the way they did. Discuss results from the initial and final experiments. You should answer and discuss the following questions:

Student Handout

Stress This!

Analyzing Muscle Strength

1. How did the muscle strength in your hand change over the conditioning period?
2. What data points did you analyze to determine your answer in question 1?
3. What type of graph (scatter plot, box-and-whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 1?
4. Using the appropriate data, construct a graph to visually verify your answer to question 1.

Analyzing Muscle Stamina

5. How did the muscle stamina in your hand change over the conditioning period?
6. What data points did you analyze to determine your answer in question 5?
7. What type of graph (scatter plot, box-and-whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 5?
8. Using the appropriate data, construct a graph to visually verify your answer to question 5.

Analyzing Muscle Strength Between Boys and Girls

9. You will need to collect the last day's Trial 1 actual data from every boy and girl in the class. Arrange the data in an organized chart, one column for boys and another column for girls. Based on the data you collected, which group of students, boys or girls, had greater muscle strength in their hands?
10. Verify your answer graphically. What type of graph (scatter plot, box-and-whiskers plot, or stem-and leaf plot) is most appropriate to visually verify your answer to question 12? Construct your graph.

Comparing Predicted Versus Actual Results

11. Compare your predicted results and actual results in Trials 1–3 on the first day to those in Trials 1–3 on the last day. Did your predicted results improve over the course of the experiment?
12. What type of graph (scatter plot, box-and whiskers plot, or stem-and-leaf plot) is most appropriate to visually verify your answer to question 11?
13. Using the appropriate data, construct a graph to visually verify your answer to question 11.

Additional Critical Thinking Questions

14. What are some recommendations to improve this activity?
15. You have analyzed muscle strength, muscle stamina, muscle strength between boys and girls, and you have also compared predicted versus actual results. What are some other ways you can analyze the data?

Teacher Handout

Review of scatter plots, box-and-whisker plots, and stem-and-leaf plots

Scatter plots

A scatter plot is a graph that displays two sets of data as ordered pairs. When a scatter plot shows a positive trend, one set of values increases as the other set tends to increase. When a scatter plot shows a negative trend, one set of values increases as the other tends to decrease. When the points in a scatter plot do not cluster along a trend line, the points show no relationship and no trend. A trend line is a line you draw on a graph to approximate the relationship between the two sets of data. See Figure 2.

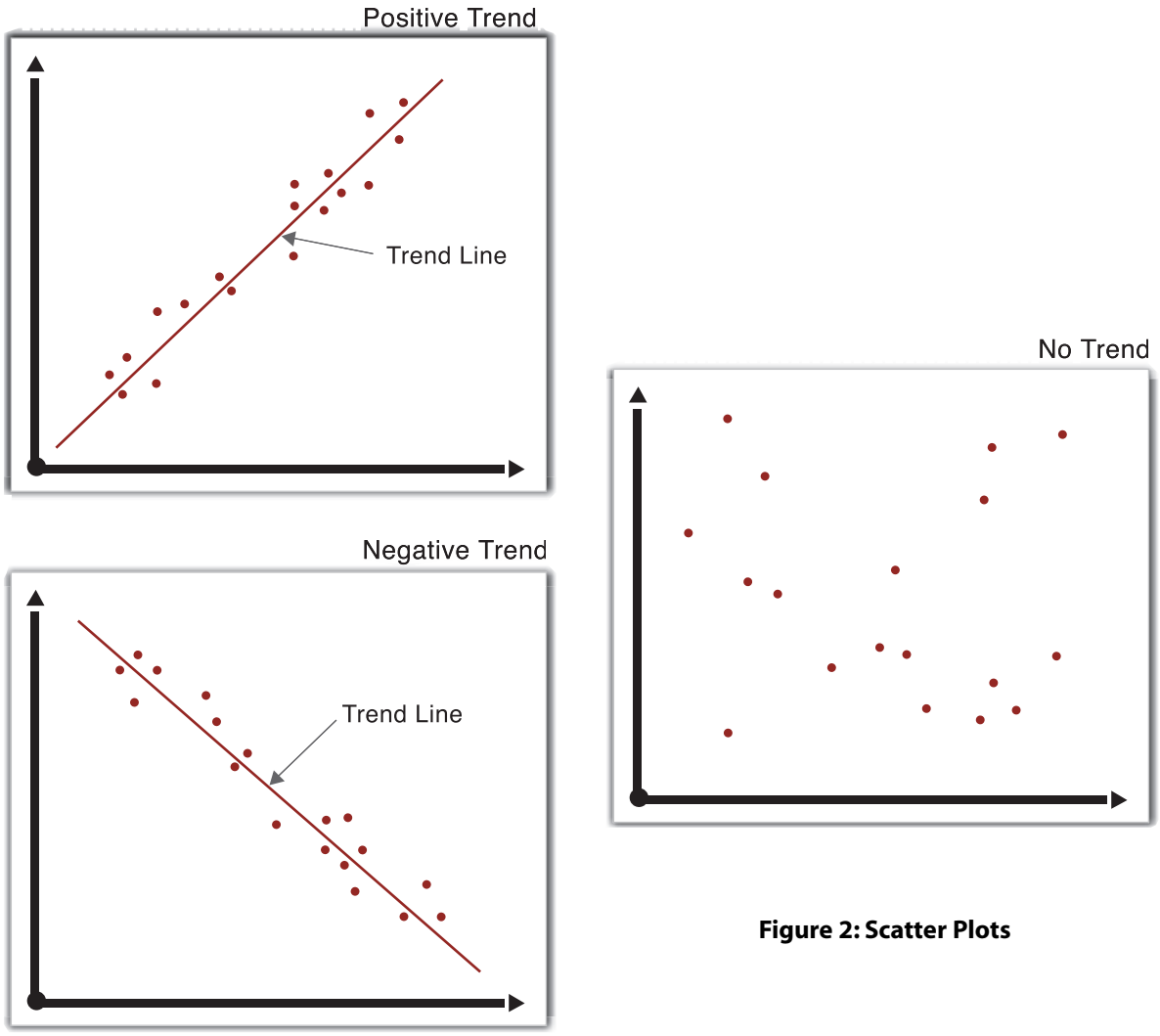

Figure 2: Scatter Plots

Teacher Handout

Review of scatter plots, box-and-whisker plots, and stem-and-leaf plots

Box-and-whisker plots

Box-and-whisker plots

A box-and-whisker plot is a graph that describes a data set along a number line. It shows the greatest value, the least value, and quartiles. Quartiles divide the data into four equal parts. The middle quartile is the median of the data. The lower quartile is the median of the lower half of the data. The upper quartile is the median of the upper half of the data. Box-and-whisker plots are useful with very large data sets or for making comparisons between data sets. See Figure 3.

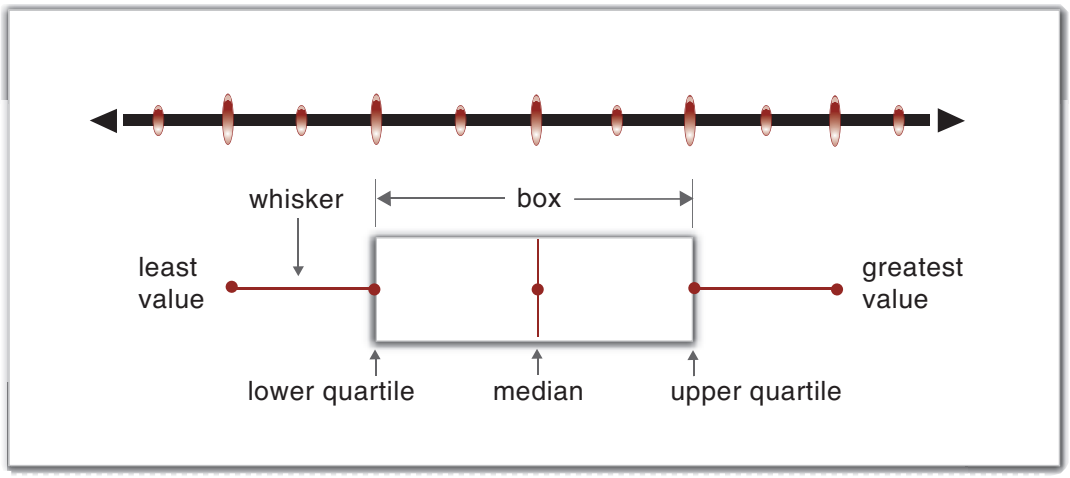

Figure 3: Box-and-whisker Plots

Teacher Handout

Review of scatter plots, box-and-whisker plots, and stem-and-leaf plots

Stem-and-leaf plots

Stem-and-leaf plots

A stem-and-leaf plot is a graph that uses the digits of each number to show the shape of the data. Each data value is broken into a "stem" on the left and a single digit "leaf" on the right. To read the data, combine the stem with each leaf in the same row. See Figure 4. A stem-and-leaf plot can quickly show the distribution of a data set and retains each data value.

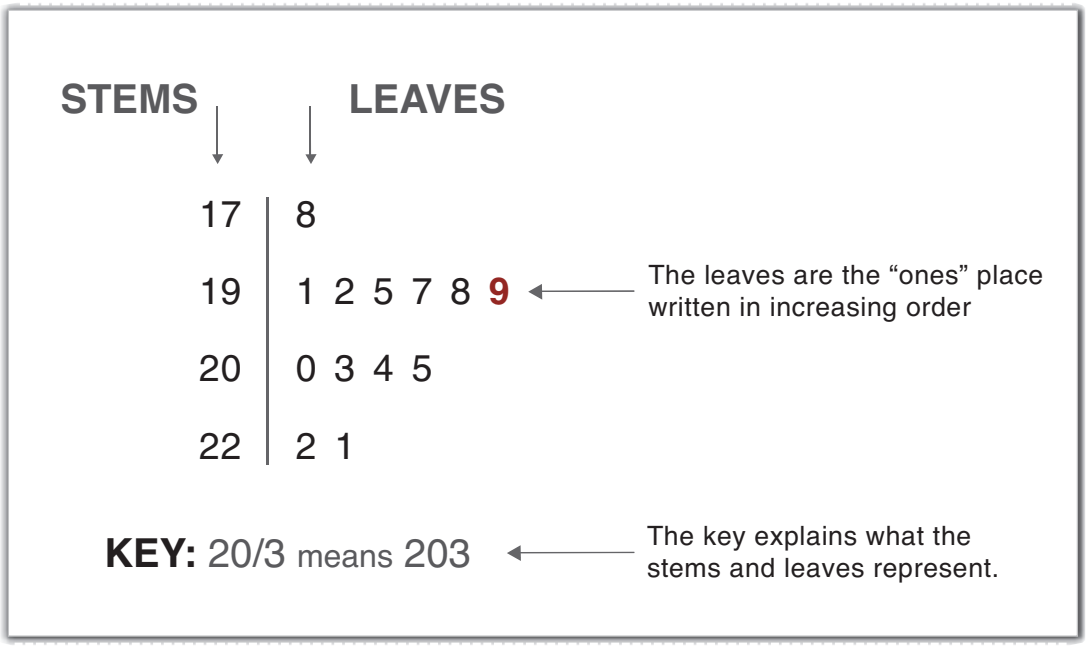

Figure 4: Stem-and-leaf Plots

RESOURCES

BOOKS

Ganeri, Anita: *Your Muscles and Bones (How Your Body Works)*: Gareth Stevens Audio, 2003.

Treays, Rebecca: *Understanding Your Muscles & Bones*: Usborne Books, 1997.

Zonta, Pat: *Jessica's X-Ray*: Firefly Books, LTD., 2002.

WEB SITES

NASA's Office of Physical and Biological Research
http://spaceresearch.nasa.gov

NASA Office of Bioastronautics
http://slsd.jsc.nasa.gov/bioastronautics/

Science@NASA
http://science.nasa.gov/headlines/y2001/ast01oct_1.htm
http://science.nasa.gov/headlines/y2001/ast02aug_1.htm

National Space Biomedical Research Institute
http://www.nsbri.org

National Space Biomedical Research Institute Materials for Middle School Teachers
http://www.nsbri.org/Education/Mid_Act.html

Muscles and Bones – Educator's Guide
http://nsbri.org/Education/TG/TG_Muscles.pdf

Vanderbilt Center for Space Physiology and Medicine
http://www.mc.vanderbilt.edu/gcrc/space/

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 the Women in Engineering project. The project brings national attention to the opportunity that engineering represents to people of all ages, but particularly to women and girls.
http://www.engineergirl.org

NCTM – National Council of Teachers of Mathematics
http://www.nctm.org