We wish to thank all the teachers who participated in the pilot of this project, especially George Rublein of the College of William and Mary, Pat Robertson of the Arlington County Public Schools, William B. William of the Williamsburg-James City County Schools, and Anne Stowe if the Clarke County Public Schools.

Partially funded under the federal Dwight D. Eisenhower Professional Development Program through the State Council of Higher Education for Virginia

Donna R. Sterling, George Mason University
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Background
International Comparison

Measurement is the lowest scoring area for U.S. students on the Third International Mathematics and Science Study (U.S. Department of Education (1996, 1997, 1998). Most people can’t recall when they learned measuring skills. These are not skills that are emphasized in curricula throughout the United States. This resource guide was created to help break this cycle. In the resource guide are several assessment activities for determining your students’ level of understanding. The questions on these assessments were drawn from the Standards of Learning for Virginia Public Schools assessments, the National Assessment for Education Progress assessments, and the Third International Math and Science Study.

Standards

The activities in this resource guide were developed to conform to state and national standards including the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics, 2000) and the National Science Education Standards (National Resource Council, 1996). Included at the beginning of this resource guide are the measurement skills and data analysis standards from the Standards of Learning for Virginia Public Schools. There is a chart showing which Virginia standards each activity targets.
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Virginia Standards of Learning

Science

4.1 The student will plan and conduct investigations in which
* distinctions are made among observations, conclusions (inferences), and predictions;
* data are classified to create frequency distributions;
* appropriate metric measures are used to collect, record, and report data;
* appropriate instruments are selected to measure linear distance, volume, mass, and
  temperature;
* predictions are made based on data from picture graphs, bar graphs, and basic line graphs;
* hypotheses are formulated based on cause and effect relationships;
* variables that must be held constant in an experimental situation are defined; and
* numerical data that are contradictory or unusual in experimental results are recognized.

4.6 The student will investigate and understand how weather
conditions and phenomena occur and can be predicted. Key
concepts include
* weather factors (temperature, air pressure, fronts,
  formation and type of clouds, and storms); and
* meteorological tools (barometer, hygrometer, anemometer,
  rain gauge, and thermometer).

5.1 The student will plan and conduct investigations in which
* appropriate instruments are selected and used for making quantitative observations of
  length, mass, volume, and elapsed time;
* rocks, minerals, and organisms are identified using a classification key;
* data are collected, recorded, and reported using the appropriate graphical representation
  (graphs, charts, diagrams);
* accurate measurements are made using basic tools (thermometer, meter stick, balance,
  graduated cylinder);
* predictions are made using patterns, and simple graphical data are extrapolated; and
  estimations of length, mass, and volume are made.

5.4 The student will investigate and understand that matter is
anything that has mass; takes up space; and occurs as a solid,
liquid, or gas. Key concepts include
* atoms, molecules, elements, and compounds;
* mixtures and solutions; and
* effect of temperature on the states of matter.

6.1 The student will plan and conduct investigations in which
* observations are made involving fine discrimination between similar objects and organisms;
* a classification system is developed based on multiple attributes;
* differences in descriptions and working definitions are made;
* precise and approximate measures are recorded;
scale models are used to estimate distance, volume, and quantity;
*hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
*a method is devised to test the validity of predictions and inferences;
*one variable is manipulated over time with many repeated trials;
*data are collected, recorded, analyzed, and reported using appropriate metric measurement;
*data are organized and communicated through graphical representation (graphs, charts, and diagrams); and
*models are designed to explain a sequence.

6.2 The student will demonstrate scientific reasoning and logic.
Key concepts include
* ideas are investigated by asking for and actively seeking information;
* multiple tests of ideas are performed before accepting or rejecting them;
* alternative scientific explanations are analyzed; and
* conclusions are based on scientific evidence obtained from a variety of sources.

6.7 The student will investigate and understand that matter has physical and chemical properties and can undergo change.
Key concepts include
* physical changes; and
* changes in chemical composition, including oxidation reactions (rusting and burning), photosynthesis, and acid-base neutralization reactions.

LS.1 The student will plan and conduct investigations in which
* data are organized into tables showing repeated trials and means;
* variables are defined;
* SI (metric) units are used;
* criteria are established for evaluating a prediction;
* models are constructed to illustrate and explain phenomena;
* sources of experimental error are identified;
* dependent variables, independent variables, and constants are identified;
* variables are controlled to test hypotheses and trials are repeated;
* continuous line graphs are constructed, interpreted, and used to make predictions; and
* interpretations from the same set of data are evaluated and defended.

LS.12 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include
* food production and harvest;
* change in habitat size, quality, and structure;
* change in species competition;
* population disturbances and factors that threaten and enhance species survival; and
* environmental issues (water supply, air quality, energy production, and waste management).

PS.1 The student will plan and conduct investigations in which
* length, mass, volume, density, temperature, weight, and force are accurately measured and reported using the International System of Units (SI - metric);
* triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and spring scales are used to gather data;
* data from experiments are recorded and interpreted from bar, line, and circle graphs;
* research skills are utilized using a variety of resources;
* independent and dependent variables, constants, controls, and repeated trials are identified;
* valid conclusions are made after analyzing data;
* research methods are used to investigate practical problems and questions; and
* experimental results are presented in appropriate written form.

PS.2 The student will investigate and understand the basic nature of matter. Key concepts include
* the particle theory of matter;
* elements, compounds, mixtures, acids, bases, salts, organic, inorganic, solids, liquids, and gases;
* characteristics of types of matter based on physical and chemical properties;
* physical properties (shape, density, solubility, odor, melting point, boiling point, color);
* chemical properties (acidity, basicity, combustibility, reactivity).

PS.4 The student will investigate and understand how to use the periodic table of elements to obtain information. Key concepts include
* symbols, atomic numbers, atomic mass, chemical families, periods, valence numbers, metals, metalloids, and nonmetals; and
* binary compounds (chemical activity, physical properties, formulas, and nature of bonding).

PS.5 The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include
* physical changes (effect of temperature on state, particle size on solubility, and temperature on solubility);
* nuclear reactions (products of fusion and fission and their effects on human beings and the environment); and
* chemical changes (types of reactions, reactants and products, and balanced equations).

PS.7 The student will investigate and understand temperature scales, heat, and heat transfer. Key concepts include
* absolute zero, phase change, freezing point, melting point, boiling point, conduction,
convection,
radiation, vaporization, and condensation; and
* applications of heat transfer (heat engines, thermostats, and refrigeration).

PS.10 The student will investigate and understand scientific principles and technological applications of work, force, and motion. Key concepts include
* work, force, mechanical advantage, efficiency, power,
  • horsepower, gravitational force, speed/velocity,
* mass/weight, Newton's three laws of motion, acceleration; and
* applications (simple machines, compound machines, powered vehicles, rockets, restraining devices, projectiles).
Virginia Standards of Learning

Mathematics

4.10 The student will
a) estimate and measure weight/mass, using actual measuring devices, and describe the results in U.S. Customary/metric units as appropriate, including ounces, pounds, grams, and kilograms;
b) identify equivalent measurements between units within the U.S. Customary system (ounces and pounds) and between units within the metric system (grams and kilograms); and
c) estimate the conversion of ounces and grams and pounds and kilograms, using approximate comparisons (1 ounce is about 28 grams, or 1 gram is about the weight of a paper clip; 1 kilogram is a little more than 2 pounds). * 

* The intent of this standard is for students to make ballpark comparisons and not to memorize conversion factors between U.S. Customary and metric units.

4.11 The student will
a) estimate and measure length, using actual measuring devices, and describe the results in both metric and U.S. Customary units, including part of an inch (1/2, 1/4, and 1/8), inches, feet, yards, millimeters, centimeters, and meters;
b) identify equivalent measurements between units within the U.S. Customary system (inches and feet; feet and yards; inches and yards) and between units within the metric system (millimeters and centimeters; centimeters and meters; and millimeters and meters); and
c) estimate the conversion of inches and centimeters, yards and meters, and miles and kilometers, using approximate comparisons (1 inch is about 2.5 centimeters, 1 meter is a little longer than 1 yard, 1 mile is slightly farther than 1.5 kilometers, or 1 kilometer is slightly farther than half a mile). *

* The intent of this standard is for students to make ballpark comparisons and not to memorize conversion factors between U.S. Customary and metric units.

4.12 The student will
a) estimate and measure liquid volume, using actual measuring devices and using metric and U.S. Customary units, including cups, pints, quarts, gallons, milliliters, and liters;
b) identify equivalent measurements between units within the U.S. Customary system (cups, pints, quarts, and gallons) and between units within the metric system (milliliters and liters); and
c) estimate the conversion of quarts and liters, using approximate comparisons (1 quart is a little less than 1 liter, 1 liter is a little more than 1 quart).*

* The intent of this standard is for students to make ballpark comparisons and not to memorize conversion factors between U.S. Customary and metric units.
4.20 The student will collect, organize, and display data in line and bar graphs with scale increments of one or greater than one and use the display to interpret the results, draw conclusions, and make predictions.

5.11 The student will choose an appropriate measuring device and unit of measure to solve problems involving measurement of:
   a) length–part of an inch (1/2, 1/4, and 1/8), inches, feet, yards, miles, millimeters, centimeters, meters, and kilometers;
   b) weight/mass–ounces, pounds, tons, grams, and kilograms;
   c) liquid volume–cups, pints, quarts, gallons, milliliters, and liters;
   d) area–square units; and
   e) temperature–Celsius and Fahrenheit units.
Problems also will include estimating the conversion of Celsius and Fahrenheit units relative to familiar situations (water freezes at 0°C and 32°F, water boils at 100°C and 212°F, normal body temperature is about 37°C and 98.6°F).

5.18 The student will, given a problem situation, collect, organize, and display a set of numerical data in a variety of forms, using bar graphs, stem-and-leaf plots, and line graphs, to draw conclusions and make predictions.

5.19 The student will find the mean, median, mode, and range of a set of data.

6.8 The student will solve multistep consumer-application problems involving fractions and decimals and present data and conclusions in paragraphs, tables, or graphs. Planning a budget will be included.

6.9 The student will compare and convert units of measure for length, area, weight/mass, and volume within the U.S. Customary system and the metric system and estimate conversions between units in each system:
   a) length–part of an inch (1/2, 1/4, and 1/8), inches, feet, yards, miles, millimeters, centimeters, meters, and kilometers;
   b) weight/mass–ounces, pounds, tons, grams, and kilograms;
   c) liquid volume–cups, pints, quarts, gallons, milliliters, and liters; and
   d) area–square units.

* The intent of this standard is for students to make ballpark comparisons and not to memorize conversion factors between U.S. Customary and metric units.

6.18 The student, given a problem situation, will collect, analyze, display, and interpret data in a variety of graphical methods, including:
   a) line, bar, and circle graphs;
   b) stem-and-leaf plots; and
a) box-and-whisker plots.
Circle graphs will be limited to halves, fourths, and eighths.

6.19 The student will describe the mean, median, and mode as measures of central tendency, describe the range, and determine their meaning for a set of data.

7.16 The student will create and solve problems involving the measures of central tendency (mean, median, mode) and the range of a set of data.

7.17 The student, given a problem situation, will collect, analyze, display, and interpret data, using a variety of graphical methods, including
   a) frequency distributions;
   b) line plots;
   c) histograms;
   d) stem-and-leaf plots;
   e) box-and-whisker plots; and
   f) scattergrams.

7.18 The student will make inferences, conjectures, and predictions based on analysis of a set of data.

8.12 The student will make comparisons, predictions, and inferences, using information displayed in frequency distributions; box-and-whisker plots; scattergrams; line, bar, circle, and picture graphs; and histograms.

A.17 The student will compare and contrast multiple one-variable data sets, using statistical techniques that include measures of central tendency, range, and box-and-whisker graphs.
Part 2

Measurement Skills
Chapter 2
Length, Volume, and Mass

Topic
Measurement Skills

Key Questions
1. How do we measure length, volume, and mass?
2. Where did our measurement system come from?
3. How do we measure?
4. What are some real world applications of length measurements?

Guiding Documents
Virginia Standards of Learning
• Science 4.1, 4.6, 5.1, 5.4, 6.1, 6.7, LS.1, LS. 12, PS.1, PS.2, PS.4, PS.5, PS.7, PS.10
• Mathematics 4.10, 4.11, 4.12, 5.11, 6.9

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry. (NSES, 143)

NCTM Standard
In grades 3–5 all students should understand measurable attributes of objects and the units, systems, and processes of measurement
• understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;
• understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems;
• carry out simple unit conversions, such as from centimeters to meters, within a system of measurement;
• understand that measurements are approximations and how differences in units affect precision. (NCTM, 171).

Science
Measurement

Mathematics
Measurement

Integrated Methods
Comparing and contrasting
Collecting data
Applying
Generalizing
Inferring

Background Information
Physical and Mathematical Scientists use the metric system exclusively in data collection, analysis, and reporting. All of the national science standards recommend the exclusive use of metric units in all academic instruction. The National Council of Teachers of Mathematics recommends that the metric system be used as the primary measurement system in mathematics instruction.

Measurement is one foundation upon which scientific inquiry rests. Before things can be analyzed and investigated they must first be measured. The concept of measurement and the skills associated with accurate measurement, engages students in mathematical content. Using this mathematical thinking, students construct relationships among numbers and the
scientific principles they are investigating. With measurement, students build upon their knowledge to increase their understanding of real-life applications. Students develop a good sense of measurement units by measuring length, volume, and mass using metric tools that enable future productive work in mathematics, science, and society.

References
Activity 1- Pre-Assessment

Materials
• Paper strips to record measurements on
• container in which to place completed measurement strips

Length Station  --
• meter stick
• object to measure such as a plastic straw that retains its length when being handled

Volume Station –
• graduated cylinder
• water
• plastic wrap or tin foil to cover the top of graduated cylinder to reduce evaporation

Mass Station --
• balance
• object to measure

Management
1. Supply each station with materials.

   Station 1- Length. Place a meter stick and an object to measure, such as a plastic straw, at the first station. (Note: Be sure the item to be measured has square ends. Irregular shaped ends can introduce error that is not part of this activity.)

   Station 2 – Volume. Pour water into graduated cylinder making sure that the curved part of the water surface (the meniscus) falls between two lines of measurement. Cover the cylinder with plastic wrap or foil to avoid evaporation.

   Station 3 – Mass. Place a triple-beam balance and an object to be measured at this station.

2. For pre-assessment students must work individually.
3. Rotate students through the stations.
4. Remind the students to make their measurements as accurately as the instruments will allow and to record the units.
5. Select objects or amounts that provide measurement values that fall between the graduations of the measurement device.
6. Adding a little food coloring to the water will make the meniscus easier to see.
7. Check student analysis results for the five most common errors. Students will often eliminate the final one or two digits on some measuring devices.
8. Since only three students at a time are going through the stations, the rest of the class will be taking a written pre-assessment test, reading the History of Measurement, and completing the history worksheet.

Procedure
1. Pre-assess students measuring skills by having them complete the activities at the three stations. Depending upon their previous instruction, they are likely to encounter some difficulty using the instruments provided. That is an expected component of this exercise.
2. Give a brief introduction to each station without using metric vocabulary or measurement terms.
3. The teacher should record the correct measurement at each station both before and after the students have
1. Students have gone through the stations. This will let the teacher know if there have been any problems with the stations.
2. Rotate students through the stations.
3. Students record their measurement at each station on a strip of paper. When all measurements have been completed, they place the strip into a container before leaving the stations.
4. After all of the students have completed the measurements, list their measurements on the board along with the correct answers.
5. Divide the students into groups to analyze the data for each measuring device.
6. Remind students to check for errors in the numbers measured.
7. Discuss their analysis of the data.
8. Review the errors observed in the data.
9. Compare their errors with the Five Common Mistakes Made When Measuring (transparency 1).
10. Show students how to read the numbers off a measuring device using the transparency 2 of the ruler. Place an object to measure on the transparency and ask students to read the length. Using the overhead projector is extremely helpful in teaching measurement because all children can see exactly what you are demonstrating. Talk the students through how to read the numbers from the digit with the largest place value to the smallest. This will make sure that students do not drop either the initial or final digit in the answer.
11. Have the students record the length of the object. Explain to the students that correct answers can be within two units of in the estimated digit. Therefore if the measured answer is 9.36, then 9.34, 9.35, 9.36, 9.37, and 9.38 are all considered correct. Show students that scientists write the measurement with a plus or minus two in the estimated digit 9.36 ± 0.02. When an instrument is not labeled with its accuracy, 2 in ± 0.02 in the estimated digit is the convention for accuracy. It is not necessary for students to learn how to write plus and minus numbers, though it would make a good extension for gifted and talented students.
12. Ask the students: Why are the units of measurement not recorded for transparency measurements? Discuss that the length is not a standard unit and varies with the distance of the overhead projector to the screen.
13. Use transparencies of different sections of a meter stick so that students can practice measurements with different numbers of significant digits such as between 1-9 cm and 10-20 cm.
14. After students are proficient with length measurement, rotate the ruler transparency 90º and turn it into a graduated cylinder by drawing the base on the small number end of the ruler and spout on the large number end of the ruler.
15. Ask the students if the surface of a liquid is flat. Share that most liquid surfaces are concave such as water. Oil and mercury are the two most common convex surfaces. Draw a meniscus (curve of a liquid surface) on the graduated cylinder.
transparency you created and ask the
students where you read the
measurement. The meniscus is
always read at the center of the
curve. Discuss how to avoid parallax
by placing your eyes at the same
level as the curved surface and not
being above or below the surface.

19. Repeat the measurement process
with different surface levels until the
students are proficient.

20. Make sure that students make the
connection that the numbers on all
measuring devices are read the same
way.

Follow-up discussion
1. What does the class pre-assessment
data suggest?
2. Compare data to give students the
opportunity to detect their errors.
3. Have students brainstorm the criteria
that are used to determine if a
measurement is accurate.
4. Why have scientists standardized the
process of making measurements?
5. How are the numbers on a measuring
device all read the same way?

Extensions
1. Have students practice by measuring
other objects. Use objects that hold their
shape and have clearly defined edges.
Label the objects with the correct
measurement so that the students can
check their measurements.

2. Students can add their own items to
the collection of classroom objects to be
measured by finding items and labeling
them with the measurements. On one
side of the label the students should the
name of the object and the quantity to be
measured (mass, length, or volume) and
write the correct measurement on the
reverse side. Have the students sign their
name to the objects they wish to add to
the collection and have two other
students verify the measurement and
sign their names also. Before adding the
student donated objects to the classroom
collection, verify that the measurements
on the labels are correct.

3. Have students record measurements
with a plus or minus two in the estimated
digit $9.26 \pm 0.02$.

References
Commonwealth of Virginia Department of
Education (2000). Standards of Learning for
Virginia Public Schools. Retrieved from
http://www.pen.k12.va.us/VDOE/Instruc
tion/sol.html.

National Center for Educational Statistics.
(2001). National Assessment of Educational
Progress. Retrieved from

National Center for Educational Statistics.
(2001). The Third International
Mathematics and Science Study. Retrieved from
Name:___________________

Measurement Skills Pre-Assessment

1a. What is the length of this caterpillar?

A 6.0 cm  
B 6.5 cm  
C 7.0 cm  
D 7.5 cm

1b. Explain how you determined your answer.

2a. Use your inch ruler to help you answer this question. Which is the closest to the length of this mailing label?

AB&C Company  
322 Elm Street  
Anycity, USA 00012

A. 2 in.  
B. 2½ in.  
C. 3 in.  
D. 3½ in

2b. Explain how you determined your answer.

Source: Assessment items taken from the Standards of Learning for Virginia Public Schools Assessment, the Third International Math and Science Study [TIMSS] and the National Assessment of Educational Progress [NAEP]
3a. Which is the closest to the weight of a pear?

A. 4 ounces
B. 4 pounds
C. 40 pounds
D. 40 tons

3b. Explain how you determined your answer.

4a. Keith used 1 quart of milk to make pudding. Which is closest to this amount?

A. 1 milliliter
B. 1 liter
C. 1 gallon
D. 1 cup

4b. Explain how you determined your answer.
5a. Which of the boxes X, Y, or Z has the LEAST mass?

A. X  
B. Y  
C. Z  
D. All three boxes have the same mass.

5b. Explain how you determined your answer.

6a. What is the difference between the water level in the cylinder before and after the rock was added?

A. 3 mL  
B. 11 mL  
C. 14 mL  
D. 25 mL

6b. Explain how you determined your answer.
7a. Mrs. Thomas made 4 quarts of strawberry jelly. This amount is the same as —

A. 1 cup  
B. 1 pint  
C. 1 gallon  
D. 1 milliliter

7b. Explain how you determined your answer.

8a.

Amanda studied the mass gain in chickens for her science project. Which of these is the mass of this chicken?

A. 2 kg  
B. 3 kg  
C. 5 kg  
D. 7 kg

8b. Explain how you determined your answer.
9a.

What is the weight (mass) shown on the scale?

A. 153 g
B. 160 g
C. 165 g
D. 180 g

9b. Explain how you determined your answer.

10a.

Which of these is closest to the length of the pencil in the figure?

A. 9 cm
B. 10.5 cm
C. 12 cm
D. 13.5 cm

10b. Explain how you determined your answer.
11a. Of the following, which is the best unit to use when measuring the growth of a plant every other day during a 2-week period?

A) Centimeter
B) Meter
C) Kilometer
D) Foot
E) Yard

11b. Explain how you determined your answer.

12a. This table shows temperatures at various times during the week.

<table>
<thead>
<tr>
<th></th>
<th>6 a.m.</th>
<th>9 a.m.</th>
<th>Noon</th>
<th>3 p.m.</th>
<th>8 p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>15°</td>
<td>17°</td>
<td>20°</td>
<td>21°</td>
<td>19°</td>
</tr>
<tr>
<td>Tuesday</td>
<td>15°</td>
<td>15°</td>
<td>15°</td>
<td>10°</td>
<td>9°</td>
</tr>
<tr>
<td>Wednesday</td>
<td>8°</td>
<td>10°</td>
<td>14°</td>
<td>13°</td>
<td>15°</td>
</tr>
<tr>
<td>Thursday</td>
<td>8°</td>
<td>11°</td>
<td>14°</td>
<td>17°</td>
<td>20°</td>
</tr>
</tbody>
</table>

Which thermometer shows the temperature at 8 p.m. on Monday?

A.  
B.  
C.  
D.  

12b. Explain how you determined your answer.
13a. In the figure above, the tube was filled to the 0 mark at the start. How much liquid has been let out?

A) 10 milliliters  
B) 15 milliliters  
C) 25 milliliters  
D) 40 milliliters  
E) 50 milliliters

13b. Explain how you determined your answer.
14a.

The beakers shown above contain different amounts of water. Which beaker has about 200 milliliters of water in it?

A) A  
B) B  
C) C

14b. Explain how you determined your answer.

15a. The weight of an object on the Moon is 1/6 the weight of that object on the Earth. An object that weighs 30 pounds on Earth would weigh how many pounds on the Moon?

Answer: ______________________

15b. Explain how you determined your answer.
16a. An experiment was set up to measure the distance a snail would travel in 5 minutes. Which of these rulers should be used to give the most precise measurement?

Answer:____________________

16b. Explain how you determined your answer.

17a. The length of a trail that Pat hiked in one day could have been

A) 5 milliliters  
B) 5 centimeters  
C) 5 meters  
D) 5 kilometers

17b. Explain how you determined your answer.
Common Measuring Mistakes

• reading the numbers
  o premature rounding off of numbers
  o creating extra numbers

• units
  o knowing what the unit is
  o correct unit abbreviations

• fractions in metric measurements

• multiple units

• missing initial digit
Pre-Assessment  Transparency 3
Student Data Recording Strips for Pre-assessment

Cut into strips so that each student has one strip.

A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C
A     B     C

*Pre-Assessment* Student Worksheet 1
Pre-assessment Data Analysis
Record your class data in the table.

<table>
<thead>
<tr>
<th>Station 1 -- Length</th>
<th>Station 2 --Volume</th>
<th>Station 3 –Mass</th>
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</thead>
<tbody>
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</table>

Analysis

Pre-Assessment Student Worksheet 2
Measuring Practice

Record your data in the table.

<table>
<thead>
<tr>
<th>Station 1 -- Length</th>
<th>Station 2 -- Volume</th>
<th>Station 3 -- Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object:</td>
<td>Object:</td>
<td>Object:</td>
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<tr>
<td>Measurement:</td>
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<td>Measurement:</td>
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<td>Measurement:</td>
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<td>Measurement:</td>
</tr>
</tbody>
</table>

Pre-Assessment Student Worksheet 3
Activity 2 - The History of Measurement and the Metric System

Early Measurement Systems

Measurement has been important since the early days of human communication when people traded with one another. Having standard units of measure enabled people to trade more equitably. Roughly 7,000 years ago, the Egyptians came up with a very simple balance. A rod would hang by cording tied in the center. Additionally, there would be cording tied at each end where objects could be hung. If the objects were equal the rod would be level with the ground but if one object was heavier, the rod would tilt down at the heavier end. Many civilizations, including the Romans made improvements on this balance. The Roman balance had a center rod with two trays hanging from both ends. However, the balance also had a pointer that showed when the trays were balanced. In addition to refining the balance, the Romans established a standardized unit of mass. The first known standard was a grain of wheat and the grain is still used today when measuring some medicines. The conquests of the Roman Army spread the Roman measuring system in Europe, Western Asia, England, and Africa.

The Babylonians first standardized a unit for measuring capacity by using a hollow cube filled with water. By selecting specific linear measurements, the first unit of capacity was established. A cube filled with water is still used today as a standard unit of capacity.

England created a system of measurement units by using body measurements of the reigning monarch. The ‘foot’ was the length of the King's or Queen's foot and when a new monarch took over, the length of the 'foot' changed too. This system of measurement was not standardized until the Magna Charta sealed by King John of England in 1215 when the importance of common unit standards was recognized.

Metric System

Origins of the modern metric system of units and standards of measure are traceable back to both the 17th and 18th century. The basic concept behind the modern metric system was to form a straightforward, easily understood, and a universally acceptable system of weights and measures. As early as 1670, the first proposal to closely approximate what eventually became the metric system was presented by Gabriel Mouton. Mouton, a vicar with St. Paul’s Church of Lyon, France, boldly suggested that a standardized unit of length could be based on the arc of one minute of longitude to be subdivided decimally. Hence, three major characteristics of the metric system were described: decimalization, rational prefixes, and using a measure of natural phenomena about the earth as the basis for a definition. Mouton’s proposal was revolutionary, misunderstood, heavily criticized, and amended. The French Academy of Sciences, in 1790, studied Mouton’s revised proposal, deciding to recommend that the length of the meridian passing through Paris be determined from the North Pole to the Equator. This distance, 1/10,000,000, determined the metre and was the basis of a new decimal-based linear system of measurement.
This revolutionary proposal of a metric system was met with resistance, and in 1812, Napoleon I, then emperor of France, reinstated the old units of measure. In 1840, a mandate to use the metric system in France, took effect and the use of the system eventually spread throughout other European countries as well as the United States. It is important to note that even though the United States legalized the use of the metric system, it was not mandatory. In 1975, the Diplomatic Conference of the Meter met producing the Treaty of the Meter, signed and supported by delegates of 17 countries including the United States. This treaty served as the institutional channel necessary to promote refinement, diffusion, as well as the use of the metric system. Today only the United States, Burma and Liberia use a system of measure other than the metric system.

**Adopting the Metric System in the U.S.**

Presidents George Washington, Thomas Jefferson, and John Quincy Adams are credited for the driving forces behind the use of the metric system in the United States. Two important events in 1866 helped shape the future of the history of measurements. First, the National Academy of Sciences conducted and released a special study of the metric system in January 1866. Secondly, Congress enacted legislation that authorized the use of the metric system, but stopped short of a mandate. The law assisted in harmonizing the United States measurement system with other nations. The legislation also paved the way for calculation of values of customary units of measurement utilized in the United States from the corresponding metric units. The secretary of state was granted authority and direction to provide each state with one set of standard metric weights and measures.

In order to facilitate trade and commerce in the 18th century the metric system was built on the definitions of two units: the meter (length) and the kilogram (mass). From these two definitions, other units such as area and volume were derived. Interestingly, the primary goal of a complete system of measurements, derived logically, from the definition of a single unit has never been realized. However, the basic idea prevailed with a modern metric system developed on six base units and designated by the 11th International Committee for Weights and Measures, widely known as CIPM (Comité International des Poids et Mesures) as the International System of Units.

The use of the metric system in various segments of both commerce and industry steadily increased throughout the 20th century. The scientific and medical community uses the metric system as a universally accepted means for measurement. Other industries such as automobile, electronics, chemical and electric power have adopted the metric system, with other fields such as optometry and photography using parts of the metric system. Pressure from the international business community may be the catalyst for successful adoption of the metric system in the U.S. Pressure is being exerted by international competition and trade from many organizations such as the European Economic Community that are threatening to restrict United States imports that lack conformity to metric standards. Therefore, many United States firms have chosen to go metric, rather than maintaining dual inventories.
History of Measurement and the Metric System

Directions: After reading the article, answer the following questions.

1. Why did early man need a measurement system?

2. What are the problems with a measurement system based on body parts?

3. Why was the metric system created?

4. What countries in the world do not use the metric system?

5. Why do you think the United States will or will not adopt the metric system?
Activity 3 - Homework

Materials
3 placards (1 gram, 1 meter, 1 liter)
3 tables

Management
1. Assign step 1 in procedure as homework.
2. Place one sign on each of the three different tables for students to display their examples.
3. On each table place the appropriate metric instrument so that students can check their objects.

Procedure
1. The night before explain to the students that they are to bring in objects (a total of 3) that are 1 gram, 1 meter, and 1 liter.
2. When the students arrive have them check the measurements of their objects.
3. Have students place their objects on the appropriate table.

Follow-up Discussion
1. Ask each student to examine and compare the objects on each table.
2. Ask students to share their objects that are 1 gram, 1 meter, and 1 liter.

Extension
1. If space permits, leave the collection for comparison throughout the unit.
Activity 4 - Length Stations

Materials
Hall and Garden Station–
• 2 bicycle tires on rims
• 2 meter sticks taped to wall
• 2 yardsticks taped to wall
Floor Molding Station–
• small rulers
Car tire Station –
• 2 different tires for comparison

Management
1. Adapt this activity to your situation.
2. Students should work in small groups.
3. A room covered with carpet or sheet vinyl works well for this activity. Find a curved surface for the students to measure such as the border of a garden.
4. In the floor molding station, students can measure the actual floor molding in the room.
5. Obtain two car tires. Ones without the metal rims are lighter.

Procedure
1. Assign students to small groups.
2. Review with student the Five Common Mistakes Made When Measuring and measuring techniques if necessary.
3. Give a brief introduction to each station.
4. At the car tire station, the students try to solve the puzzle of what measurement the numbers represent.
5. Rotate student groups through the stations.
6. After all of the groups have completed the measurements, have students analyze the data for each measuring device.

Follow-up discussion
1. Who needs to use this means of measurement and why?
2. What level of accuracy is needed for a consumer to purchase the appropriate amount of materials for these situations?
3. What are ways to measure the circumference of an object?
4. When might someone need this measurement?
5. What careers might use this type of measurement?
6. What does the numerical data on the tire mean?
7. Why do you think that metric and U.S. standard measurements were both used in the same code for tires?
8. Why do we need to know what the numbers on a tire mean?

Extension
1. Have students compare prices of carpet from various stores and write a proposal for re-carpeting the classroom.
2. Have students determine how much carpet needs to be purchased to cover the classroom.
3. Bring in samples of different moldings of various quality and prices from a home improvement store. Using the price per foot or per yard, have the students determine the replacement cost for the floor molding in the classroom. Discuss with students the advantages and disadvantages of using a material of higher/lower quality.
4. Have students look at tires at home and determine the information it tells them about the car.
Name _____________________

Length Stations
(Adapt to your situation.)

Hall and Garden

Scenario – You need to replace the carpet in the hall.
Use the bicycle tire to determine the length of the hall in metric and English measurements.
_____________   ____________

Who needs to use this means of measurement and why?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Scenario – You need to replace the border of the garden.
Use the bicycle tire to determine the length of the curved line (border on the garden outside of the room) in metric and English measurements.
_____________   ____________

What are ways to measure the circumference of an object?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Floor Molding

Scenario – You need to replace the floor molding.
Using the tools provided, what is the length of the floor molding needed to replace the floor molding in the room? _________________

When might someone need this measurement?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Car Tires

What does the numerical data on the tire mean? P###/#R##
TIRE MARKINGS

Tire Size and Shape
Typically, the tire size looks something like P225/50 R 16. The "P" means a passenger-car. The next three digits tell you the width of the tire in millimeters (here 225 mm). Large and high-performance cars tend to have wide tires, greater than 200 mm. The two digits after the slash is the ratio of the sidewall height to the tire width. Here, the height of the sidewall is 50 percent of the tire width. High performance tires tend to have a low ratio – usually below 60. The "R" means radial ply. This is used for most tires. The next two digits reflect the diameter of the metal wheel rim (inner diameter of the tire) in inches.
Activity 5 – Mass and Volume of Sand

Materials
- Sand
- 6 Containers of different sizes to hold sand
- 6 Foil baking pans
- Assortment of measuring instruments – length, volume, and mass

Management
1. Place empty containers inside of a foil pans to catch any sand that spills.
2. Inexpensive foil baking pans are available at most local grocery stores.
3. Buckets and plastic ware of various sizes work as containers for holding the sand.
4. Students will be using successive small measurements to determine the amount of sand that they have been given. Therefore the container of sand that they are to be given should be larger than the measuring devices can hold at one time.
5. Students work in small groups.

Procedure
1. Set up stations.
2. Place a foil pans to catch spills at each station.
3. Give each group a container of sand to measure.
4. Have students select whatever measuring devices they want to use to measure the sand in their container. With enough time the students will naturally measure the sand by volume and mass. Only after they have completed a measurement on one way should they be prompted to measure in another way.
5. Multiple ways of measuring will be part of the follow-up discussion.
6. Have groups record their findings.
7. Have students complete student worksheet.

Follow-up discussion
1. What measurements did you make and why?
2. What kind of decisions did you have to make in measuring?
3. How many different ways could you measure the sand?
4. How is sand measured that is sold in stores?
5. Who would need to measure sand and why?
How much sand is there?

After measuring the amount of sand using the measuring devices provided, answer the following questions.

1. Describe which measurements you made and why?

2. What kind of decisions did you have to make in measuring?

3. Who would need to measure sand and why?
Activity 6- Estimated Measurements Scavenger Hunt

**Topic**
Measurement Skills

**Key Questions**
1. How precise does an estimated answer need to be?
2. What makes a measurement a good measurement?
3. What is the difference between estimation and approximation?

**Guiding Documents**

*Virginia Standards of Learning*
- Science 4.1, 4.6, 5.1 5.4, 6.1, LS.1, PS.1, PS.2, PS.4, PS.5, PS.7
- Mathematics 4.10, 4.11, 4.12, 5.11, 6.9

*NSES Standards*

    Content Standard A: As a result of activities in grades 5-8, all students should develop
    - Abilities necessary to do scientific inquiry
    - Understandings about scientific inquiry. (NSES, 143)

*NCTM Standard*

    In grades 3–5 all students should understand measurable attributes of objects and the units, systems, and processes of measurement
    - understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;
    - understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems;
    - carry out simple unit conversions, such as from centimeters to meters, within a system of measurement;
    - understand that measurements are approximations and how differences in units affect precision;
    - explore what happens to measurements of a two-dimensional shape such as its perimeter and area when the shape is changed in some way. (NCTM, 171).

**Science**
Measurement

**Mathematics**
Estimation
Measurement

**Integrated Methods**
Comparing and contrasting
Collecting data

**Background Information**
The accuracy of numbers are affected by several things. Counted numbers are exact. When we count how many people are in a room, we know the exact number. On the other hand, measured numbers are always an approximation. When using a measuring device, all of the digits are read directly except the last digit which is an estimate in tenths of the distance between the lines.
What makes a measurement a good measurement? Precision and accuracy. These terms define how scientists look at measurements and calculations. Precision is how repeatable the measurement is. If you measured an object and obtained the same answer 10 times in a row, that measurement is precise. Accuracy is how correct an answer is. Accuracy measures the correctness of an answer. For example, if you measured the mass of a pencil with a malfunctioning balance, you could get a precise measurement (if all of your attempts gave the same answer), but the accuracy would be poor because the scale was not working properly.

References

Materials
- Measurement cards
- Thermometer
- Meter stick
- Yardstick
- balance
- Objects to measure
- Scissors

Management
1. Students should work in pairs.
2. Have students separate measurement cards before distributing the scavenger hunt worksheet.
3. Remind students to check measurements for reasonableness.
4. If the measurement cards are not used, all predictions should be recorded before any measuring devices are obtained and any measurements are taken.

Procedure
1. Discuss the importance of good estimation skills.
2. Explain to the students that they are to look around the classroom and find the objects that they predict are close approximations of the measurements given on the measurement cards and worksheet.
3. Explain the directions for the activity.
   1. Distribute Scavenger Hunt worksheet and measurement cards.
   2. Have students cut out the measurement cards and place them face down in a stack.
   3. The first student draw a card and tries to find an object in the classroom with the same measurement.
   4. Each student lists the object in the prediction column on the Scavenger Hunt worksheet that next to the measurement that corresponds to the
measurement given on the measurement card.
5. His or her partner measures the object and each student records the actual measurement on the worksheet.
6. After recording the measurements on the Scavenger Hunt worksheet, the second student draws a card and repeats the process.
7. The activity continues until all cards have been drawn.

4. If the measurement cards are not used explain that all predictions are to be recorded before any objects are measured.

Follow-up Discussion
1. What are the student results?
2. What is the purpose of estimating a measurement?
3. When is it alright to estimate and when do you need an exact answer?

Extensions
Have students estimate answers to the following questions:
1. What is the volume of a swimming pool?
2. How high is a typical tree?
3. How long is an unsharpened pencil?
4. How cold is your freezer?
5. What is the mass of a paperclip?
6. What is the area of a piece of notebook paper?
7. What is the volume of a coffee cup?
8. How long does it take light to travel from the sun to the earth?
9. What is the volume of a bathtub?
10. How fast can a passenger car go?
<table>
<thead>
<tr>
<th>Measurement Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find an object with a length of 1 centimeter.</td>
</tr>
<tr>
<td>Find an object with a length of 1 inch.</td>
</tr>
<tr>
<td>Find an object with a length of 1 yard.</td>
</tr>
<tr>
<td>Find an object with a length of 5 centimeters.</td>
</tr>
<tr>
<td>Find an object with a length of 50 millimeters.</td>
</tr>
<tr>
<td>Find an object with a mass of 0.5 kilograms.</td>
</tr>
<tr>
<td>Find an object with a mass of 5 grams.</td>
</tr>
<tr>
<td>Find an object with a volume of 50 cubic centimeters.</td>
</tr>
<tr>
<td>Find an object of your choice with a mass of _______ grams.</td>
</tr>
</tbody>
</table>
## Estimated Measurement Scavenger Hunt

Name: __________________________________________

What is the classroom temperature in Celsius? __________

Look around the classroom and find objects that you predict are close approximations of the given measurements. After you have made your predictions, measure the objects you choose.

<table>
<thead>
<tr>
<th>Given Measurement</th>
<th>Prediction</th>
<th>Actual Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 centimeter</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>1 inch</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>1 yard</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>5 centimeters</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>50 milliliters</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>0.5 kilograms</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>5 grams</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>50 cubic centimeters</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

Your choice: ________ grams __________

What object prediction surprised you the most? __________
Explain why.
Activity 7- Plan a Volksmarch

Topic
Measurement

Key Questions

Guiding Documents
Virginia Standards of Learning
Science PS.1
• The student will be able to plan and conduct investigations in which length, mass, volume, density, temperature, weight, and force are accurately measured and reported using the International Systems of Units (SI-metric).
Math 5.11
• The students will choose an appropriate measuring device and unit of measure to solve problems involving measurement of weight/mass and volume.

NCTM Standard
• Make and use measurements in problems and everyday situations

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry.

Science
Measurement

Mathematics
Measurement

Background
A Volksmarch is a walking event that is also called volkswalking. In Germany, these events were originally termed Volkswandern - "volkswandering." Reportedly this was difficult for American military stationed in Germany to understand and so they started using the term Volksmarsch. It evolved into Volksmarch in the United States. Those feeling that the term was too foreign, coined the word - Volkswalk. Today, a volksmarch is a non-competitive 6 mile (10 kilometer) walk. It's not a pledge walk or a race. It is a fun activity you do with a club, with your family, with your pet, or all by yourself.

Materials
Plan a Volksmarch Worksheet

Management
1. Students should work in small groups to complete this activity. But the worksheet can be completed individually.

Procedure
1. Distribute the Plan a Volksmarch student worksheet.
2. Explain the background of a Volksmarch and tell students that they will be planning a Volksmarch at their school that will last approximately one hour.
3. Have students work in small groups to plan their Volksmarch.

Follow-up Discussion
1. Have students share their plan for their Volksmarch.
Plan a Volksmarch!

Plan a Volksmarch at your school that will last approximately one-hour. A Volksmarch (people’s walk) is a German tradition where families and friends walk through the countryside or a town. At the completion of a Volksmarch, medals are often given which people collect and wear on a vest or hat.

1. What will be the distance of your one-hour Volksmarch?

2. Explain how you determined that the total distance of your Volksmarch would take about one hour to complete?

3. Draw a map of your planned Volksmarch, and give the approximate measurements for each segment.

4. How would you measure this distance?
Activity 8- How Do Mass and Weight Compare?

**Topic**
- Mass
- Weight
- Metric Measurement
- U.S. Standard Measurement

**Key Questions**
1. What is the basic difference between mass and weight?
2. What instrument do you use to measure mass?
3. What instrument do you use to measure mass?

**Guiding Documents**
**Virginia Standards of Learning**
- Science
  - 4.1, 5.1, 5.4, 6.1, LS.1, PS.1, PS.10
- Mathematics
  - 4.10, 4.11, 4.12, 5.11, 6.9

**NSES Standards**
Content Standard A: As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry.

**NCTM Standards**
In grades 3–5 all students should understand measurable attributes of objects and the units, systems, and processes of measurement
- understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;
- understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems;
- carry out simple unit conversions, such as from centimeters to meters, within a system of measurement;
- understand that measurements are approximations and how differences in units affect precision. (NCTM, 171).

**Science**
- Mass
- Weight
- Measurement
- Data collection

**Mathematics**
- Measurement
- Data collection

**Integrated Methods**
- Observing
- Predicting
- Collecting and recording data
- Comparing and contrasting
- Applying
- Generalizing
- Inferring

**Background**
Weight is the measurement of the force of gravity on an object as it is pulled towards the center of the Earth. Mass is the actual quantity of matter in that object or the amount of material that is in an object. Weight and mass are often used interchangeably but they are different. However, because weight is the measurement of gravitational force on an object, the farther the object is away from the center of the Earth the
less it weighs. This is why astronauts appear "weightless" in outer space. The mass of an object remains constant regardless of the object's location and weight varies depending on an objects location. Mass and not weight is almost always the quantity we are interested in measuring.

References

Materials
Mass and Weight Student Worksheet
Mass and Weight Transparency 1

Management
1. Students should work individually during the presentation comparing mass to weight but can work in pairs to complete the quantities table.

Procedure
1. Display student worksheet as a transparency.
2. Distribute Mass and Weight Student Worksheet to facilitate their note taking process.
3. Explain that weight and mass are different although the terms are often used interchangeably.
4. Weight is the measurement of the force of gravity on an object as it is pulled towards the center of the Earth.
5. Explain that the farther the object is away from the center of the Earth the less it weighs.
6. Mass is the amount of material that is in an object.
7. The mass of an object remains constant regardless of the object's location and weight varies depending on an objects location.
8. Have students work in pairs to discuss for the metric/U.S. Standard table on the worksheet.

Follow-up Discussion
1. Which instrument is used to measure mass?
2. Which instrument is used to measure weight?
3. Compare the information on the tables to give students the opportunity to detect their errors.
4. Using Mass and Weight Transparency, discuss each quantity with it’s associated unit of measurement, the symbol for the unit of measure, the U.S. Standard approximation and the instrument used for measurement.

Extension
1. Have students determine their mass and weight on another plant.
2. Writing Prompt: When astronauts are ‘weightless’ in outer space, are they also ‘mass(less)’.
Name________________________

How do mass and weight compare?

Mass and weight are different.

Mass ________________________________

Location ______________________________

Instrument __________________________

Weight _______________________________

Location ______________________________

Instrument __________________________

Metric System or International System (SI)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
<th>U.S. Standard Approximation</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Mass and Weight Student Worksheet & Transparency
How do mass and weight compare?

Mass and weight are different.

Mass ___the quantity of matter in an object

Location ___same every where

Instrument ______ balance ______

Weight ___measure of the pull of gravity

Location ___varies with the distance from the center of gravity

Instrument ___spring scale

Metric System or International System (SI)
___________ a decimal system of measurement

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
<th>U.S. Standard Approximation</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>meter</td>
<td>m</td>
<td>1 yard</td>
<td>ruler</td>
</tr>
<tr>
<td>Volume</td>
<td>liter</td>
<td>l or L</td>
<td>1 quart</td>
<td>glassware - beaker graduated cylinder</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram</td>
<td>kg</td>
<td>1kg = 2.2 pounds</td>
<td>balance</td>
</tr>
<tr>
<td>Temperature</td>
<td>Kelvin (Celsius)</td>
<td>K (C)</td>
<td>water freezing = 0°C boiling = 100°C</td>
<td>thermometer</td>
</tr>
<tr>
<td>Time</td>
<td>second</td>
<td>s</td>
<td>same</td>
<td>clock</td>
</tr>
</tbody>
</table>
Activity 9- Comparing Metric and U.S. Standard Measurements

**Topic**
Metric Measurement  
U.S. Standard Measurement

**Key Questions**
1. What is the basic difference between the U.S. Standard Measure and the Metric system?
2. How do you estimate the approximate equivalent measurements between the metric and U.S. Standard system?
3. To go from one unit to another in the metric system, what do you do?

**Guiding Documents**
*Virginia Standards of Learning*
- Science  
  4.1, 5.1, 6.1, LS.1, PS.1  
- Mathematics  
  4.10, 4.11, 4.12, 5.11, 6.9

*NSES Standards*
*Content Standard A: As a result of activities in grades 5-8, all students should develop*
- Abilities necessary to do scientific inquiry  
- Understandings about scientific inquiry.

*NCTM Standards*
- Make and use measurements in problems and everyday situations.

**Science**
- Measurement  
- Data collection

**Mathematics**
- Measurement  
- Data collection

**Integrated Methods**
- Observing

**Background**
Weight and mass are often used interchangeably but they are different. Food packaging labels often refer to the ‘weight’ of the product. The description should indicate the ‘mass’ of the product within the container.

**References**

**Materials**
- Provide a collection of grocery items with label values for mass and volume given in both U.S. Standard and Metric measures. Your collection might include soup, crackers, beans, rice, cookies, soft drinks, and juice in containers of various sizes.
- Student Information Gathering Sheet

**Management**
1. Students will gather information about package contents and compare
quantities of mass and volume in two systems.

2. Students should determine an approximate equivalent unit for measure in U.S. Standard Measure and Metric system for mass and for volume.

3. Students will examine labels of grocery items to locate measurements of package contents in U.S. Standard Measure and Metric system.

4. The Student Information Gathering Sheet table will be used to compare measurements of each item in two systems.

**Procedure**

1. Arrange students in pairs.
2. Give each group a set of food labels or actual products.
3. Ask students to identify quantities on labels. Do not specify whether they are Metric or U.S. standard measures.
4. Have students list items and quantities on the Student Information Gathering Sheet.
5. Talk about the base 10 system the metric system uses using the Fact Sheet.
6. Have students make comparisons between the two systems of measuring, using Compare It’s Pretty Much the Same handout.
7. Using the fact sheets, have students convert units of measurement for the food items listed on Student Information Gathering Sheet.
8. Have students answer questions at the bottom of the Student Information Gathering Sheet.
9. As students finish, have them read the History of Measurement and the Metric System.

**Follow-up discussion**

1. What are the student results of this investigation?
2. Using Compare It’s Pretty Much the Same transparency, what are the differences between the metric system and the U.S. Standard system?
3. Why do we need to know metrics?
4. Will the United States ever convert to the metric system?

**Extension**

1. Visit World Wide Calculators at http://www.worldwidemetric.com/metric.htm. This site provides four graphics of calculators that provide metric/U.S. Standard conversions for: length, mass, pressure, and volume. Students can use the calculators to explore conversions.
2. Discuss reasons to convert to the metric system. i.e. Eliminate double measuring system, the metric system is easier to use, less chance of error.
3. Calculate calories found in a pound of pure fat; in a pound of pure carbohydrate; and in a pound of pure protein. (Note: 1 gram fat equals 9 calories; one gram of carbohydrate or a gram of protein equals 4 calories.)
4. Invite the manager of a grocery store to visit your classroom and teach students about unit pricing. Following the instruction, request they evaluate student understanding of the concept through examples such as: a 12 ounce can of tomatoes priced $0.89 (with a unit price at $2.38 per quart) is a better buy than a 6 ounce can priced $0.64 (with a unit price at $3.42 per quart). Request the manager bring products that come in two or three sizes and/or brands. Have students compare items, prices and unit prices.
5. Discuss why the U.S. is resistant to changing to the metric system.
6. Ask students if they feel we should join other countries in using the metric system. Have them explain their views in writing.
Compare:
It’s Pretty Much the Same

<table>
<thead>
<tr>
<th>U.S. Standard</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 teaspoon</td>
<td>~ 5 mL</td>
</tr>
<tr>
<td>1 cup + 1 tablespoon</td>
<td>= 250 mL</td>
</tr>
<tr>
<td>8 oz.</td>
<td>0.25 liter</td>
</tr>
<tr>
<td></td>
<td>2.5 deciliter</td>
</tr>
</tbody>
</table>

So:
1 cup is approximately equal to 250 milliliters.
8 ounces is equal to ¼ quart or is approximately equal to 0.25 liter.

<table>
<thead>
<tr>
<th>2 cups + 2 tablespoons</th>
<th>= 500 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 oz. + 2 tablespoons</td>
<td>= 0.5 liter</td>
</tr>
<tr>
<td>1 pint</td>
<td>= 5 deciliters</td>
</tr>
</tbody>
</table>

So:
2 cups is approximately equal to 500 mL.
16 ounces is approximately equal to ½ quart or 0.5 liter.
1 pint is approximately equal to 5 deciliters.

<table>
<thead>
<tr>
<th>4 cups + 4 tablespoons</th>
<th>= 1 liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 oz. + 4 tablespoons</td>
<td>= 1000 mL</td>
</tr>
<tr>
<td>1 qt.</td>
<td>= 10 dL</td>
</tr>
</tbody>
</table>

| 1 quart                | ~ 1 liter |

So:
4 ¼ cups is approximately equal to 1 liter or 1 quart is approximately equal to 1 liter.

Comparing Metric to U.S. Standard Transparency 1
Comparing Metric and U. S. Standard Measure Units on Grocery Items

Fact Sheet

Comparing Mass Measurements in Two Systems

<table>
<thead>
<tr>
<th>Metric Measure</th>
<th>U. S. Standard Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>grams (g)</td>
<td>ounces (oz)</td>
</tr>
<tr>
<td>kilograms (kg)</td>
<td>pounds (lbs)</td>
</tr>
<tr>
<td>1,000g = 1 kg</td>
<td>16 oz = 1 lb</td>
</tr>
<tr>
<td>454 grams = 1 pound</td>
<td>1 pound = 454 grams</td>
</tr>
</tbody>
</table>

Comparing Volume Measurements in Two Systems

<table>
<thead>
<tr>
<th>Metric Measure</th>
<th>U. S. Standard Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mL = 1 cc</td>
<td>1 cup = 8 fl. oz.</td>
</tr>
<tr>
<td>1000 mL = 1 liter</td>
<td>16 fl. oz. = 1 pint</td>
</tr>
<tr>
<td></td>
<td>32 fl. oz. = 2 cups = 1 quart</td>
</tr>
<tr>
<td></td>
<td>4 quarts = 1 gallon</td>
</tr>
<tr>
<td>1 liter ~ 1 quart</td>
<td>1 quart ~ 1 liter</td>
</tr>
</tbody>
</table>

Comparing Metric to U.S. Standard Transparency 2
# Student Information Gathering Sheet

## I. Comparing Package Content Measures by **Mass**

<table>
<thead>
<tr>
<th>Item</th>
<th>U. S. Measure</th>
<th>Metric Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16 oz. = 1 lb</td>
<td>1,000g = 1 kg</td>
</tr>
</tbody>
</table>

## II. Comparing Package Content Measures by **Volume**

<table>
<thead>
<tr>
<th>Item</th>
<th>U. S. Measure</th>
<th>Metric Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 cup = 8 fl. oz.</td>
<td>1 mL = 1 cc</td>
</tr>
<tr>
<td></td>
<td>2 cups = 16 fl. oz = 1 pint</td>
<td>1,000 mL = 1 liter</td>
</tr>
<tr>
<td></td>
<td>2 pints = 1 quart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 quarts = 1 gallon</td>
<td></td>
</tr>
</tbody>
</table>

4. Approximately, how many grams are in one pound?

5. Approximately, how many mL are in one fluid ounce?

Comparing Metric to U.S. Standard Student Worksheet 1
Chapter 3
Exploring Density

Topic
Density

Key Questions
1. What is density?
2. What is the numerical value for the density of water?
3. How are 1 mL, 1 g, and 1 cm of water related?
4. How does the density of an object affect whether it sinks or floats in water?

Guiding Documents
Virginia Standards of Learning
Science 4.1, 5.1, 6.1, LS.1, PS.1, PS.2,
Mathematics 4.10, 4.12, 5.11, 6.9
NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry.
NCTM Standards
In grades 6-8 all students should understand measurable attributes of objects and the units, systems, and processes of measurement
• understand both metric and customary systems of measurement;
• understand relationships among units and convert from one unit to another within the same system. (NCTM, 241)

Science
Physical Science - Density
Data collection
Measurement

Mathematics
Measurement

Data collection

Integrated Methods
Observing
Predicting
Collecting and recording data
Applying
Generalizing

Background Information
Density is the ratio of mass to volume. It is determined by dividing the mass of an object by its volume. Water has the density of 1 gram per cubic centimeter (1g/cm³). If we measure one cubic centimeter of water, it will have the mass of one gram. One cubic centimeter is equivalent to one milliliter (1 mL). In creating the metric system, water was defined as the standard of comparison for volume and mass. The numerical values were set at 1 g = 1 mL = 1 cm³ for water at 4°C at sea level. Scientists do not adjust density for temperature and altitude unless extreme accuracy is needed.

References
Activity 10- Exploring Density

Materials
Station 1 – Equal volume and unequal mass
- Balance
- Meter stick
- 2 objects of identical volume and unequal mass – cover items with foil to conceal identity. For example: two identical sized cans (from kitchen) with different masses or two identical sized rectangular solids (a brick and a piece of Styrofoam).
- Exploring Density Student Worksheet

Station 2 - Equal mass and unequal volume
- Balance
- Meter stick
- 2 objects of identical mass and very different volumes. For example: salt and Styrofoam packing peanuts in sealed plastic bags.

Station 3 – 1 cubic centimeter equals 1 milliliter
- Lots (at least 15) of 1 centimeter cubes (ones that sink in water work best)
- Graduated cylinder at least one centimeter in diameter and marked in 1 milliliter divisions
- Water

Management
1. Arrange the stations in different areas of the room to provide sufficient workspace for each group.
2. Students should work in small groups.
3. Prepare the foil wrapped objects.
4. Station 3 will require paper towels or sponges to absorb spills.

Procedure
1. Explain that because density is a composite quantity (a ratio), it requires two measurements to produce a single number. Show students the bricks and ask: What two things do we have to measure to compute the density of an object?
2. Distribute students Exploring Density—Day 1 worksheet and have student groups rotate through stations.
3. Remind students that it is important to make their predictions at each station before using any of the objects located at the station.
4. Students should answer the worksheet questions at each station. Remind the students that they will need a pen/pencil.

Follow-up discussion
Station 1 - Unwrap the items and discuss the mass and volume for each.
Station 2 - Discuss which weighs more a pound of feathers or a pound of nails. (neither) Discuss the mass and volume for the two items at this station.
Station 3 - Discuss that in the metric system the unit of length is the basis for other measurements. The system was established with 1 cm³ = 1 mL.

Extensions
1. Have students prove that 1 mL of water had the mass of 1 g. Most student balances can not accurately measure a mass that is as small as 1
g. However, they can easily measure 10 g or 100 g. Therefore the students can measure 10 mL or 100 mL of water.
Exploring Density

Station 1
Without touching, observe the two objects. How are they the same? How are they different?

Pick up the objects. How are they the same? How are they different?

Station 2
Without touching, observe the two objects. How are they the same? How are they different?

Pick up the objects. How are they the same? How are they different?

Station 3
Prediction: What is the relationship between the volume of a 1 centimeter cube and its volume in milliliters?

What is the volume in milliliters of a 1 centimeter cube?

Exploring Density Student Worksheet 1
Activity 11- Density of a Liquid

Materials
- Graduated cylinder
- Balance
- Water (The density of water is 1 g/mL.)
- Density of a Liquid Student Worksheet

Management
1. Students should work in small groups.
2. This activity will require paper towels or sponges to absorb spills.

Procedure
1. Ask students how to determine the density of water.
2. Distribute students Density of a Liquid worksheet and have student groups rotate through the station.
3. Students should answer the worksheet questions at each station. Remind the students that they will need a pen/pencil.

Follow-up Discussion
Compare student data for the density of water. Discuss that the metric system was defined so that for water at 4°C 1 cm³ = 1 mL = 1 g. Discuss how the students determined the density of water. Ask if the process would be the same or different for another liquid such as oil.

Extension
1. Use geometry to measure the density of a regular block of wood. Two problems have to be solved: Volume and mass. The volume can be computed from linear measurements.
2. The mass has to be measured directly on a balance.
Density of a Liquid

1. What is the density of water?

2. List the steps of the procedure you used to determine the density of a rock?

Density of a Liquid Student Worksheet
Activity 12- Density of a Solid

Materials
- Graduated cylinder
- Balance
- Water
- Small rock that fit in the graduated cylinder
- Density of a Solid Student Worksheet

Management
1. Students should work in small groups.
2. This activity will require paper towels or sponges to absorb spills.

Procedure
1. Ask how you would determine the density of a rock.
2. Discuss the relationship between density and the ability of things to float, for instance in water. Point out that floating (in water) is a way to determine whether the object is made of material that is less (floating) or more (sinking) dense than water.
3. Distribute students Density of a Solid worksheet and have student groups rotate through the station.
4. Students should answer the worksheet questions at each station. Remind the students that they will need a pen/pencil.

Follow-up Discussion
1. Compare student data. Ask the students how the density of a rock compares to the density of water. (The number is greater than 1 for any item that sinks.) Ask the students to predict the density for an item that floats. (The number is less than 1 but greater than zero.) Ask why the density must be greater than zero.

Extension
1. Have the students determine the density of an object that floats in water.
2. Discuss why aircraft carriers, made largely of steel, can float.
Density of a Solid

1. What is the density of a rock?

2. List the steps of the procedure you used to determine the density of water?

*Exploring Density* Student Worksheet 3
Activity 13- Soft Drink Density

Materials
- 1 can of regular coke (Coca-Cola work best for demonstration purposes)
- 1 can of diet coke
- 1 plastic container
- water
- Soft Drink Density Student Worksheets

Management
1. When performing this investigation it is important that the same brand of soda be used for the cans of regular and diet soda. If Brand A is used for the regular soda, Brand A should also be used for the diet soda.
2. This activity can be done as a demonstration.
3. The Predictions worksheet is designed to be cut horizontally into two pieces providing a worksheet for two students.
4. A sponge or paper towel should be available to absorb spills.

Procedure
1. Pour water into a container that is larger than the soft drink can.
2. Share scenario about cans falling into a stream. (See Soft Drink Density worksheet)
3. Using the Predictions worksheet, have students make predictions about what will happen when unopened cans of diet and regular soda are placed in containers of water.
4. Have students draw their predictions.
5. Place unopened cans of regular soda into water and then remove.
6. Place unopened can of diet soda into water and remove.
7. Have students record the results on the reverse side of their Predictions worksheet.
8. Have students complete Soft Drink Density worksheet.

Follow-up Discussion
1. Ask students to explain why the regular can of soda sank and the diet soda did not sink.
2. Have students compare the ingredients in each can.
3. Lead students to the conclusion that table sugar (sucrose) has more mass than artificial sweetener and it is the sugar that made the can of regular soda sink.

Extension
1. A variety of objects makes this investigation even more interesting. If possible, use an assortment of soda such as regular, diet, caffeine free as well as different brands if they are available. Large grocery stores are good sources for diversity.
Predictions

On the diagrams below, draw the location and position of an unopened can of regular and an unopened can of diet soft drink when they are placed in containers of water.
Regular       Diet

Exploring Density Student Worksheet 4

Name _____________________

Soft Drink Density

Situation: You are boating on a shallow stream. The boat tips over and your cooler filled with soft drinks falls into the water and the cans tumble out.

Predict what will happen when the unopened cans of diet and regular soda fall into the water. Draw a picture showing where the cans will end up.

After recording your prediction, place the unopened cans in water and observe what happens.

As a group, determine a scientific explanation to explain what you observed.

Exploring Density Student Worksheet 5
Activity 14- Measurement Skills Post-Assessment

Materials

Post-Assessment worksheets

Management

Students work individually.

Procedure

1. Distribute the post-assessment worksheets to students.
2. Assess student worksheets for common mistakes.

References


Name:___________________

Measurement Skills Post-Assessment

1a. What is the length of this caterpillar?

A  6.0 cm  
B  6.5 cm  
C  7.0 cm  
D  7.5 cm

1b. Explain how you determined your answer.

2a. Use your inch ruler to help you answer this question. Which is the closest to the length of this mailing label?

AB&C Company  
322 Elm Street  
Anycity, USA 00012

A. 2 in.  
B. 2 ½ in.  
C. 3 in.  
D. 3 ½ in

2b. Explain how you determined your answer.

Source: Assessment items taken from the Standards of Learning for Virginia Public Schools Assessment, the Third International Math and Science Study [TIMSS] and the National Assessment of Educational Progress [NAEP]
3a. Which is the closest to the weight of a pear?

A. 4 ounces
B. 4 pounds
C. 40 pounds
D. 40 tons

3b. Explain how you determined your answer.

4a. Keith used 1 quart of milk to make pudding. Which is closest to this amount?

A. 1 milliliter
B. 1 liter
C. 1 gallon
D. 1 cup

4b. Explain how you determined your answer.
5a. Which of the boxes X, Y, or Z has the LEAST mass?

A. X  
B. Y  
C. Z  
D. All three boxes have the same mass.

5b. Explain how you determined your answer.

6a. What is the difference between the water level in the cylinder before and after the rock was added?

A. 3 mL  
B. 11 mL  
C. 14 mL  
D. 25 mL

6b. Explain how you determined your answer.
7a. Mrs. Thomas made 4 quarts of strawberry jelly. This amount is the same as —

A. 1 cup  
B. 1 pint  
C. 1 gallon  
D. 1 milliliter

7b. Explain how you determined your answer.

8a.

Amanda studied the mass gain in chickens for her science project. Which of these is the mass of this chicken?

A. 2 kg  
B. 3 kg  
C. 5 kg  
D. 7 kg

8b. Explain how you determined your answer.
9a.
What is the weight (mass) shown on the scale?

A. 153 g
B. 160 g
C. 165 g
D. 180 g

9b. Explain how you determined your answer.

10a.

Which of these is closest to the length of the pencil in the figure?

A. 9 cm
B. 10.5 cm
C. 12 cm
D. 13.5 cm

10b. Explain how you determined your answer.
11a. Of the following, which is the best unit to use when measuring the growth of a plant every other day during a 2-week period?

A) Centimeter  
B) Meter  
C) Kilometer  
D) Foot  
E) Yard  

11b. Explain how you determined your answer.

12a. This table shows temperatures at various times during the week.

<table>
<thead>
<tr>
<th></th>
<th>6 a.m.</th>
<th>9 a.m.</th>
<th>Noon</th>
<th>3 p.m.</th>
<th>8 p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>15°</td>
<td>17°</td>
<td>20°</td>
<td>21°</td>
<td>19°</td>
</tr>
<tr>
<td>Tuesday</td>
<td>15°</td>
<td>15°</td>
<td>15°</td>
<td>10°</td>
<td>9°</td>
</tr>
<tr>
<td>Wednesday</td>
<td>8°</td>
<td>10°</td>
<td>14°</td>
<td>13°</td>
<td>15°</td>
</tr>
<tr>
<td>Thursday</td>
<td>8°</td>
<td>11°</td>
<td>14°</td>
<td>17°</td>
<td>20°</td>
</tr>
</tbody>
</table>

12b. Explain how you determined your answer.

Which thermometer shows the temperature at 8 p.m. on Monday?

A.  
B.  
C.  
D.  

12b. Explain how you determined your answer.
13a. In the figure above, the tube was filled to the 0 mark at the start. How much liquid has been let out?

A) 10 milliliters  
B) 15 milliliters  
C) 25 milliliters  
D) 40 milliliters  
E) 50 milliliters

13b. Explain how you determined your answer.
14a. The beakers shown above contain different amounts of water. Which beaker has about 200 milliliters of water in it?

A) A  
B) B  
C) C

14b. Explain how you determined your answer.

15a. The weight of an object on the Moon is 1/6 the weight of that object on the Earth. An object that weighs 30 pounds on Earth would weigh how many pounds on the Moon?

Answer: _______________________

15b. Explain how you determined your answer.
16a. An experiment was set up to measure the distance a snail would travel in 5 minutes. Which of these rulers should be used to give the most precise measurement?

Answer:____________________

16b. Explain how you determined your answer.

17a. The length of a trail that Pat hiked in one day could have been

A) 5 milliliters
B) 5 centimeters
C) 5 meters
D) 5 kilometers

17b. Explain how you determined your answer.
Part 3
Data Analysis
&
Experimental Design
Chapter 4
Experimental Design

Topic

Experimental Vocabulary
The Scientific Method

Key Questions

How do you design a scientific experiment?

Guiding Documents

Virginia Standards of Learning
Science 4.1, 6.1, 6.2, LS.1, PS.1
Mathematics 6.18

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry.

NCTM Standards
In grades 6–8 all students should Select and use appropriate statistical methods to analyze data. (NCTM, 249).

Science
Measurement
Data collection

Mathematics
Measurement
Data collection

Integrated Methods

Observing
Predicting
Collecting and recording data
Comparing and contrasting
Applying
Generalizing
Inferring

Background

The Experimental Design process is a procedure to help students design an experiment and report their findings. It is an effective method for teaching students that designing an experiment begins with specific questions about events that will enable them to alter variables and observes the effects.

References


Activity 15- Data Analysis Pre-Assessment

Materials
Pre-Assessment worksheets

Management
Students work individually.

Procedure
3. Distribute the pre-assessment worksheets to students.
4. Assess student worksheets for common mistakes.

References


1a. The graph shows the amount of money earned per week by 5 students in their summer jobs.

1a. Tanya earned $80 per week more than Silas. Which could be her weekly salary?
   A) $115
   B) $250
   C) $275
   D) $290

1b. Explain how you determined your answer.

Source: Assessment items taken from the Standards of Learning for Virginia Public Schools Assessment, the Third International Math and Science Study [TIMSS] and the National Assessment of Educational Progress [NAEP].
On which day were more boxes of lemons picked than either boxes of oranges or boxes of grapefruit?

A) Monday  
B) Tuesday  
C) Wednesday  
D) Thursday  
E) Friday  
F) No Day  
G) I don’t know

2b. Explain how you determined your answer.
The table above shows the results of a survey of hair color. On the circle below, make a circle graph to illustrate the data in the table. Label each part of the circle graph with the correct hair color.

3b. Explain how you determined your answer.
4a.

The picture shows the growth curve of a bacterial population. According to this information, the bacterial population doubles every-

A. 5 minutes  
B. 20 minutes  
C. 30 minutes  
D. 60 minutes

4b. Explain how you determined your answer.
5a. The graph shows the number of books checked out at the public library each day last week.

<table>
<thead>
<tr>
<th>Books Checked Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
<tr>
<td>Saturday</td>
</tr>
</tbody>
</table>

Each box represents 10 Books

On which day were there 3 times as many books checked out as on Tuesday?

A  Wednesday  
B  Thursday  
C  Friday    
D  Saturday

5b. Explain how you determined your answer.
6a. Rhea took a survey of the students in her class to find out about their career interests. The results are shown in the graph.

The mode of the data is associated with which career?

A. Health Related  
B. Engineering / Science  
C. Education  
D. Computers

6b. Explain how you determined your answer.
7a. Hypothesis: If the amount of nitrogen fertilizer is increased, then the height of the corn increases. Which of these is the independent (manipulated) variable for an experiment testing this hypothesis?

A  The height of the corn in each experimental group
B  The number of corn plants in the experimental groups
C  The size of the experimental groups
D  The amount of fertilizer added to each experimental group

7b. Explain how you determined your answer.
8a. This is a list of Beth’s English homework scores for the grading period.

93, 83, 64, 84, 76, 83, 78, 76, 60, 81

Which stem-and-leaf plot correctly displays the information?

A

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

B

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

C

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6, 6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 3, 4</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

D

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0, 4</td>
</tr>
<tr>
<td>7</td>
<td>6, 6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 3, 4</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

8b. Explain how you determined your answer.
9a. The list shows the scores made by each member of Jaime’s discussion group on the last test.

69, 79, 62, 93, 73, 81, 73, 78

Which box and whiskers plot correctly displays the information?

9b. Explain how you determined your answer.
10a. An adult toad lays 6,000 eggs at a time in a pond. Which graph shows the number of tadpoles and toads that will most likely result in the pond from these eggs?

A)  

B)  

C)  

D)  

10 b. Explain how you determined your answer.
Activity 16- Experimental Design

Materials

- Student Worksheet 1-4
- Transparencies 1-7

Management

1. This lesson works well as a class presentation to help students understand the key aspects of a valid scientific experiment.
2. When students complete *Experimental Design Vocabulary* Student Worksheet 4, they could work in small groups and compare answers.

Procedure

1. Distribute *Experimental Design Vocabulary* Student Worksheet 1. This will aid in the student note-taking process.
2. Using Transparency 1-2, define experimental design vocabulary.
   a. Hypothesis is a specific statement of a prediction that describes what you expect will happen in your study.
   b. Independent Variable: The variable that the experimenter purposefully changes. (The “I” variable – “I’ set it.)
   c. Dependent Variable: the variable that responds to the changes made by the experimenter.
   d. Constants variables that are kept the same throughout the study.
   e. Control: A standard situation that provides a basis for comparison, often a no treatment situation.
   f. Repeated Trials - The number of times the experiment is repeated.
3. Define an experiment using transparency 3.
5. Explain the *Experimental Design Diagram* using transparencies 4 and 5.
9. Using the data table on transparency 6 and student worksheet 4, have students complete the Experimental Design Diagram.

Follow-up Discussion

1. Why are there only one independent variable and one dependent variable for an experiment?
2. Why is everything else kept constant?
3. Why is an experiment repeated?
Experimental Design Vocabulary

**Hypothesis:** a specific statement of a prediction that describes what you expect will happen in your study.

**Independent Variable:** The variable that the experimenter purposefully changes. (The “I” variable – “I” set it.)

**Dependent Variable:** the variable that responds to the changes made by the experimenter.

**Constants:** variables that are kept the same throughout the study.
Experimental Design Vocabulary

**Control:** A standard situation that provides a basis for comparison, often a no treatment situation.

**Repeated Trials:** The number of times the experiment is repeated.
What is an experiment?

An experiment is a test of a hypothesis (prediction). Conditions are created under which the hypothesis is tested and results are recorded. Observations are made and recorded and then they are compared conditions in order to determine the relationship of the variables being tested.
### Experimental Design Diagram

| Title: The effect of ________________________ on ______________ |
| Hypothesis: If ________________________________ is ________, |
| then ________________________________ will ________. |

| Independent Variable: |
| Levels: |
| Trials: |

| Dependent Variable: |
| Constants: |

Adapted from Students and Research by Cothron, Giese, and Rezba
**Experimental Design Diagram**

| Title: The effect of __________(IV)____________ on ______(DV)_______ |
| Hypothesis: |
| If ______(IV)_________ is ___(increased, decreased or remains the same___, then _____(DV)_______ will ___(increased, decreased or remains the same ___. |
| Independent Variable: |
| Levels: |
| Trials: |
| Dependent Variable: |
| Constants: |

Adapted from Students and Research by Cothron, Giese, and Rezba

*Experimental Design  Transparency 5*
## Experimental Design Diagram

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td></td>
</tr>
<tr>
<td>Hypothesis:</td>
<td></td>
</tr>
<tr>
<td>IV:</td>
<td></td>
</tr>
<tr>
<td>Levels:</td>
<td></td>
</tr>
<tr>
<td>Trials:</td>
<td></td>
</tr>
<tr>
<td>DV:</td>
<td></td>
</tr>
<tr>
<td>C:</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Students and Research by Cothron, Giese, and Rezba
Experimental Design Diagram

Title: The Effect of Concentration of Antifreeze on Time for Water to Freeze

Hypothesis: If the concentration of antifreeze increases, then the time it takes water to freeze will increase.

<table>
<thead>
<tr>
<th>IV: Amount of Antifreeze (%)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials:</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

DV: Time to Freeze (minutes)

C: Temperature
   Size of container
   Shape of container

Adapted from Science Experiments by the Hundreds (1996) by Cothron, Giese, and Rezba
**Experimental Design Vocabulary**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis</td>
<td></td>
</tr>
<tr>
<td>Independent Variable</td>
<td></td>
</tr>
<tr>
<td>Dependent Variable</td>
<td></td>
</tr>
<tr>
<td>Constants</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
</tr>
<tr>
<td>Repeated Trials</td>
<td></td>
</tr>
</tbody>
</table>
# Experimental Design Diagram

**Title:** The effect of ______________________ on ______________

**Hypothesis:** If _________________________________ is _________,
then ______________________________ will ________.

**Independent Variable:**

<table>
<thead>
<tr>
<th>Levels:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Trials:</th>
</tr>
</thead>
</table>

**Dependent Variable:**

**Constants:**

---

Adapted from Students and Research by Cothron, Giese, and Rezba

*Experimental Design Student Worksheet 2*
<table>
<thead>
<tr>
<th><strong>Title:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypothesis:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>IV:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Levels:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Trials:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DV:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>C:</strong></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Students and Research by Cothron, Giese, and Rezba
The Effect of Concentration of Antifreeze on Time for water to freeze.

<table>
<thead>
<tr>
<th>Levels:</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials:</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Using the *Experimental Design Diagram*:

1. What is the dependent variable? (What is the variable that is being investigated?)

2. What is the independent variable? (What is the variable that will be purposefully altered or set during the experiment? What will cause a change in the dependent variable?)

3. Name three constants. (Name three things that will not change during this experiment.)

4. Write your hypothesis in the if/then form on your Experimental design Diagram.
Chapter 5

Statistics
Activity 17- Introduction to Data and Graphs

Topic
Statistics

Key Questions
1. What are statistics?
2. When would you use a bar or circle graph?
3. When would you use a box plot, stem and leaf plot or a line graph?

Guiding Documents
Virginia Standards of Learning
- Science 4.1, 5.1, 6.1, LS.1, PS.1
- Mathematics 4.20, 5.18, 5.19, 6.18, 6.19, 7.17, 7.18

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry.

NCTM Standards
In grades 6–8 all students should 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 representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots.

Science
Scientific Method

Mathematics
Statistics

Background Information
Statistics is the science of collecting, organizing, and interpreting data and statistics uses this data to gain a better understanding of our world. Statistics is interesting and valuable because it provides strategies and tools for using data to gain insight into real life problems.

References

Materials
Introduction to Statistics Student Worksheet 1
Introduction to Statistics Transparency 1-7

Management
1. This is an introduction to statistics.
2. This information lends itself to direct presentation.
3. Have students fill out worksheet as either a note taking process or during the follow-up discussion.
Procedure
1. Explain the tools of statistics
2. Talk about the methods of statistics.
3. Explain discrete versus continuous data.
4. Explain distribution.
5. Talk about the different types of graphs.
6. When to use each type of graph.
7. Explain that each graph has a specific use and what that use is.
8. Explain that they are not interchangeable.
9. That there are conventions for the use of each type of graph.

Follow-up Discussion
1. What types of data are there?
2. When would you use each type of graph?
The Science of Statistics

1. The tools of statistics help us to:
   1. ________________________________
   2. ________________________________
   3. ________________________________
   4. ________________________________

2. The methods of statistics help us to:
   1. ________________________________
   2. ________________________________
   3. ________________________________
   4. ________________________________
   5. ________________________________

3. Discrete data is:
   __________________________________________________________.

4. Continuous data is:
   __________________________________________________________.

5. The distribution of a variable tells us:
   __________________________________________________________.
6. The types of graphs used for discrete variables are:
   1. _____________________
   2. _____________________

7. The types of graphs used for continuous variables are:
   1. _____________________
   2. _____________________
   3. _____________________

8. I would use a bar graph to: ________________________________
   ____________________________________________________________________________.

9. I would use a circle graph to: _____________________________
   ____________________________________________________________________________.

10. I would use a box plot to: _____________________________
    ____________________________________________________________________________.

11. I would use a stem and leaf plot to: _____________________
    ____________________________________________________________________________.

12. I would use a line graph to: _____________________________
    ____________________________________________________________________________.

*Introduction to Statistics* Student Worksheet
The Tools of Statistics Help Us To:

- Organize Data
- Display Data
- Summarize Data
- Interpret Data
- Visualize relationships
Statistical methods help us to:

- Designing studies
- Collecting data
- Analyze the data
- Interpreting the results
- Present the results
Discrete versus Continuous Data

Discrete data takes only a finite number of different values.

Continuous data can take on any value within a range of values.
Distribution

The Distribution of a variable tells us how often it takes on each of its possible values. The description of a distribution should include its shape, center and numeric range.
Graphs are statistical devices that are used to examine data and describe their main features.

Graphs for discrete variables:
- Bar Graphs
- Circle Graphs

Graphs for continuous variables:
- Box Plots
- Stem and Leaf Plots
- Line Graphs
When do you use a bar or a circle graph?

**Bar graphs** are used to show the amount of data that falls into each category. They show only the categories you choose.

**Circle Graphs** require that all the categories that make up a whole be included in the chart.
When do you use Box Plots, Stem and Leaf Plots, or a Line Graph?

A box plot is a diagram along one axis that uses the five number summary as a graphical representation of the data. It is used to illustrate the distribution of a set of data. Box plots are a fast way to provide information about the set of data as a whole and identify situations that require further study.

A Stem and leaf plots is diagram that cab be used as a fast way to get visual representation of the shape of a distribution while including the actual numerical values in the graph. Stem plots are used for small numbers of data that have values that are all greater than zero.

Line graphs are used to show the change in data over time.
Activity 18- Mean and Range

**Topic**
- Mean
- Range

**Key Questions**
1. What is meant by the term ‘mean’?
2. How do you find the mean for a data set?
3. What is meant by the term ‘range’?
4. How do you compute the range in a data set?

**Guiding Documents**

*Virginia Standards of Learning*
- *Science* 4.1, 5.1, 6.1, LS.1, LS.12, PS.1
- *Mathematics* 5.19, 6.19, 7.16

*NSES Standards*

Content Standard A: As a result of Activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry. (NSES, 143)

*NCTM Standards*

In grades 6–8 all students should 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 representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots.

**Science**
- Data Analysis

**Mathematics**
- Mean
- Range

**Integrated Methods**

Collecting and recording data
Comparing and contrasting
Applying

**Background**

Mean and range are two of the descriptive statistics. Mean is the process many think of as ‘average’. There are three types of ‘averages’ that describe the center of a data set; mean, median, and mode. The mean is the arithmetic average of the dataset or the sum of the numbers in the dataset divided by number of numbers in the dataset. The median is the middle number. The mode is the number that appears most often. The range is the difference between the highest and lowest numbers in a dataset. The mathematical development of these statistics has been motivated by its real world application.

**References**

Materials
- Student Worksheets 1-2
- Transparencies 1-5

Management
1. Students should work individually during the presentation of definitions but can work in pairs when analyzing data.

Procedure
1. Distribute student worksheet 1 to aid students in their note taking process.
2. Using *Mean and Range* Transparency 1 to define ‘mean’. Explain that the mean is usually what we think of as the average.
4. Using *Mean and Range* Transparency 3, explain how to compute the mean.
5. Use the *Mean and Range* Transparency 4 to explain how to compute the range of a data set.
6. Distribute *Mean and Range* Student Worksheet 2. Explain to the students that this is the data from an investigation that studied the effects of the amount of fertilizer on the height of plants. There were three trials for each independent variable. The students are to compute the mean and the range for each trial.
7. Discuss results using *Mean and Range* Transparency 5.

Follow-up Discussion
1. Have students compare results.
2. Discuss the means and range of the plant height data.

Extension
1. Make a list of ten numbers whose:
   1. (List 1) mean is 10.
   2. (List 2) mean is the same as the mean for List 1, but whose range is bigger than the range of the numbers in List 1.
3. (List 3) whose mean is 11 and whose range is 18. [2, 4, 6, 8, 10, 12, 14, 16, 18, 20]
Mean

The sum of the data entries divided by the number of data entries.

Range

The difference between the highest and lowest data values.

Mean and Range Transparency 1
Test Scores for a Class of Fifteen Students
(Sample Data Set)

26, 60, 54, 35, 96,
78, 90, 52, 85, 24,
64, 65, 57, 77, 82

Mean and Range Transparency 2
Mean

• Compute the sum of the data entries.

\[ 24 + 26 + 35 + 52 + 54 + 57 + 60 + 64 + 65 + 77 + 78 + 82 + 85 + 90 + 96 = 945 \]

• *Divide the sum by the number of data entries.*

\[ 945 \div 15 = 63 \]

• The mean is 63.
Range

• Compute the range by finding the difference between the highest and lowest value in the data set.

24 26 35 52 54 57 60 64 65 77 78 82 85 90 96

highest value       lowest value
96 - 24 = 72

• The range of the data is 72.
The Effect of Amount of Fertilizer on the Height of Plants

<table>
<thead>
<tr>
<th>Amount of Fertilizer (mg)</th>
<th>Mass of Algae (g)</th>
<th>Mean (g)</th>
<th>Range (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0 (control)</td>
<td>25</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>10</td>
<td>82</td>
<td>74</td>
<td>78</td>
</tr>
<tr>
<td>15</td>
<td>102</td>
<td>110</td>
<td>118</td>
</tr>
<tr>
<td>20</td>
<td>135</td>
<td>128</td>
<td>148</td>
</tr>
<tr>
<td>25</td>
<td>176</td>
<td>159</td>
<td>163</td>
</tr>
<tr>
<td>30</td>
<td>202</td>
<td>211</td>
<td>196</td>
</tr>
</tbody>
</table>

Adapted from Science Experiments by the Hundreds (1996) by Cothron, Giese, and Rezba

*Mean and Range Transparency 5*
<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Derived Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial</td>
<td>Trial</td>
<td>Trial</td>
</tr>
</tbody>
</table>

Adapted from Science Experiments by the Hundreds (1996) by Cothron, Giese, and Rezba

*Mean and Range* Transparency 6
Mean and Range

Test Scores for a Class of Fifteen Students
(Sample Data Set)

| 26, 60, 54, 35, 96, |
| 78, 90, 52, 85, 24, |
| 64, 65, 57, 77, 82 |

1. Define the following terms:

   Mean - __________________________________________________
   __________________________________________________________

   Range-__________________________________________________
   __________________________________________________________

2. Compute the mean of the sample data set. (Make sure to show your calculation.)

3. Compute the range of the sample data set. (Make sure to show your calculation.)
Directions: Compute the Mean and the range for each of the three trials in the data table below. Put your final answers in the appropriate column.

### The Effect of Amount of Fertilizer on the Height of Plants

<table>
<thead>
<tr>
<th>Amount of Fertilizer (mg)</th>
<th>Mass of Algae (g)</th>
<th>Mean (g)</th>
<th>Range (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0 (control)</td>
<td>25</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>50</td>
<td>49</td>
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<tr>
<td>10</td>
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<td>74</td>
<td>78</td>
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<td>15</td>
<td>102</td>
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<td>20</td>
<td>135</td>
<td>128</td>
<td>148</td>
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</tr>
<tr>
<td>30</td>
<td>202</td>
<td>211</td>
<td>196</td>
</tr>
</tbody>
</table>

Adapted from Science Experiments by the Hundreds (1996) by Cothron, Giese, and Rezba
Chapter 6

Graphing
Activity 19- Introducing a Bar Graph

Topic
Graphing

Key Questions
1. What types of data are there?
2. When would you use a bar line or circle graph?
3. What is the use of each type of graph?
4. What are the standard conventions for a graph?

Guiding Documents
Virginia Standards of Learning
- Science 4.1, 5.1, 6.1, 6.2, LS.1, PS.1
- Mathematics 4.20, 5.18, 6.18, 7.18, 8.13,

NCTM Standards
In grades 3–5 all students should—
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- design investigations to address a question and consider how data-collection methods affect the nature of the data set;
- collect data using observations, surveys, and experiments;
- represent data using tables and graphs such as line plots, bar graphs, and line graphs;
- recognize the differences in representing categorical and numerical data. (NCTM, 178)

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry. (NSES, 143)

Science
Data collection
Graphing

Mathematics
Data collection
Graphing

Integrated Methods
Observing
Predicting
Sorting
Classifying
Collecting and recording data
Comparing and contrasting
Applying
Generalizing
Inferring

Background Information
Archaeologists use artifacts (objects made by humans) and sites to help tell the stories of ancient peoples. After examining the artifacts, they make inferences about the lives and beliefs of a people. But sometimes the artifacts have been altered by the elements or their meanings and uses have become obscured.

Fossils are plant and animal remains or traces found in the earth from past geological time periods that have hardened into rocks.
Graphing in science and mathematics are similar but there are some differences in terminology. Both science and mathematics use variables to reflect known and derived information. The variable representing the known information is called the "X" axis in mathematics and the independent variable in science. The variable representing the derived information is called the “Y” axis in mathematics and the dependent variable in science.

References

Materials
- Tools of the Trade Student Worksheets 1-3
- Tools of the Trade Transparencies 1-3
- Large chart graph paper
- Colored pencils
- Regular pencils

Management
1. The night before the class, distribute archeological tools list (Tools of the Trade Student Worksheet 1). Have students take the list home and see how many tools they can find. Remind students to count the number of the tools that they find.
2. Students should work either individually or in small groups.

Procedure
1. Brainstorm archaeological use for each tool.
2. Have students list the most probable archaeological use for the tools.
3. Categorize tools according to use and label categories.
4. Construct a table (using Tools of the Trade Student Worksheet 2) that lists each category as the left column entries.
5. Construct a class Archaeological Tool quantity list after the students have inventoried their homes for the tools.
6. Sum the total number of tools in each category from the class list and enter into the table as the right column entries.
7. Explain the difference between independent and dependent (using Tools of the Trade Transparencies 1-3)
8. Have students identify the independent and dependent variable for their data.
9. Review elements of a graph.
10. Have each student create a graph that illustrates the class’s home tool quantities.
   a. Label the horizontal (independent) axis on the graph to correspond to the tool categories.
   b. Determine the scale for the vertical (dependent) axis reminding students that the scale is determined based on the range of values in each category.
   c. Label the vertical axis.
d. Display the data on graph as bars.

11. Have students discuss the graph.

**Follow-up Discussion**

Looking at graphs:
1. Which tools that archaeologists use are the same as general household tools?
2. Which tools are generally not found in homes?
3. Is there another way this data could have been displayed?
4. What is the difference between independent and dependent data?

**Extension**
1. Have an archaeologist as a guest speaker to discuss the uses of tools.
What do we call each axis?
What do we call each axis in mathematics?

Tools of the Trade Transparency 2
What do we call each axis in science?

Dependent Variable

Independent Variable

Tools of the Trade Transparency 3
### Tools of the Trade

<table>
<thead>
<tr>
<th>Archaeological Tools</th>
<th>Tool Use</th>
<th>Found/Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Soil Rake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Shovel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Pick Axe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Hoe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Post Hole Digger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Axe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Saw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Hard Hat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Surveyor's Transit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Toothbrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Whisk Broom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Paint Brush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Bucket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Hand Trowel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Tape Measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Wheelbarrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Screens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Pencil and Paper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Camera</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Tools of the Trade* Student Worksheet 1
Name:___________________

Tools of the Trade
Classroom Data

Directions: Using the list of tools used by archeologists, categorize the tools by their use.

<table>
<thead>
<tr>
<th>Tool Categories</th>
<th>Quantity of Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Independent Variable)</td>
<td>(Dependent Variable)</td>
</tr>
</tbody>
</table>

Example:

**Brushes** (dirt removal)

1. tooth brush
2. whisk broom
3. paint brush

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
Name:___________________

Tools of the Trade
What We Found!

Directions: Create a bar graph that illustrates quantity of class tools.

Which is the most common archaeological tool found in homes? _________________
Activity 20- Constructing a Bar Graph

Materials
- Change Over Time Student Worksheet 1
- Data cards
- Scissors
- Colored pencils
- Regular pencils

Management
1. Students should work in pairs.
2. Have students cut apart data cards before distributing the line graph worksheet.
3. Students should stack data cards in date order.
4. Review elements of a graph.

Procedure
1. Discuss what is the difference between an artifact and a fossil.
2. After looking at the data on the cards, determine whether the graph should be a bar, line, or circle graph and why.
3. Determine what data goes on each axis.
4. Determine scale for vertical and horizontal axis.
5. Assign axis labels.
6. Each student takes a turn drawing a data card from the stack.
7. Display data on graph when each card is drawn.
8. Have students discuss the graph.
9. Each student should write a conclusion about the data set.

Follow-up Discussion
Answer the following questions looking at the graph:
1. How many fossils were found?
2. During what work week (one work week = consecutive days) were the most fossils found?
3. How many fossils were found during this period?
4. During what 6 day period were the least fossils found?
5. How many fossils were found during this period?
6. This was the data for a dig that lasted for three weeks. Why do you think there were different numbers of fossils found during these 3 weeks.

Extension
1. Explore fossil records on the internet.
2. Discuss Stratigraphy and explore data at:
   http://www.ucmp.berkeley.edu/mesozoic/jurassic/jurassicstrat.html
What does this data suggest about what the archaeologist founds during their dig?

*Change Over Time* Student Worksheet 1
<table>
<thead>
<tr>
<th>Date</th>
<th>Number of fossils</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/1/94</td>
<td>3</td>
</tr>
<tr>
<td>6/2/94</td>
<td>4</td>
</tr>
<tr>
<td>6/3/94</td>
<td>1</td>
</tr>
<tr>
<td>6/4/94</td>
<td>1</td>
</tr>
<tr>
<td>6/5/94</td>
<td>1</td>
</tr>
<tr>
<td>6/6/94</td>
<td>4</td>
</tr>
<tr>
<td>6/8/94</td>
<td>2</td>
</tr>
<tr>
<td>6/9/94</td>
<td>1</td>
</tr>
<tr>
<td>6/10/94</td>
<td>1</td>
</tr>
</tbody>
</table>
## Fossil Data Cards

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of fossils</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/11/94</td>
<td>3</td>
</tr>
<tr>
<td>6/12/94</td>
<td>4</td>
</tr>
<tr>
<td>6/13/94</td>
<td>3</td>
</tr>
<tr>
<td>6/15/94</td>
<td>2</td>
</tr>
<tr>
<td>6/16/94</td>
<td>3</td>
</tr>
<tr>
<td>6/17/94</td>
<td>3</td>
</tr>
<tr>
<td>6/18/94</td>
<td>4</td>
</tr>
<tr>
<td>6/19/94</td>
<td>4</td>
</tr>
<tr>
<td>6/20/94</td>
<td>3</td>
</tr>
</tbody>
</table>
Activity 21- Circle Graph

Materials
- Let’s Dig Student Worksheet 1
- Archeological artifacts such as pieces of pottery, tools, etc.
- Several full trash bags (full of non perishable trash)
- Circle pattern worksheet
- Scissors
- Colored pencils
- Regular pencils

Management
1. Choose artifacts that have uses that are not apparent that students can discover through measuring and labeling.
2. Each bag of artifacts should represent a different strata (depth/time period) for example week one, week two, etc.
3. One bag of non perishable trash will be needed for each student group. Teachers in your building are good sources for collecting trash bag donations.

Procedure
1. Discuss what is archeology?
2. What is excavation?
3. How do you preserve sites?
4. Discuss how archaeologists excavate units in layers and screen soil to find artifacts.
5. Distribute artifacts to student groups.
6. Have students brainstorm possible uses for object.
7. Have student groups speculate on the most probable use for their artifact.
8. Distribute one trash bag to each student group.
9. Have students list all the artifacts.
10. Have students measure and determine the mass of their artifacts to create a system for grouping and labeling them. (This will vary based on the objects chosen for artifacts)
11. Sort and classify artifacts according to labeling system.
12. List artifacts using labeling system.
13. Have students choose a representative example from each artifact group and draw an exact model of their artifact and label the measurements.
14. If the artifact is larger than a piece of paper a scale drawing will need to be made.
15. Determine percentage of each group to the whole group of artifacts.
17. Have students make inferences about the ages, gender, likes, dislikes, and values of the people who owned these artifacts.

Follow-up Discussion
1. Why were some bags easier to interpret than others?
2. When would you use a circle graph?
3. What are some examples of circle graphs?
4. What percent data can be used in a circle graph?
5. What is an example of percent data that can not be used in a circle graph?

Extension
1. Create an archaeological site for children to excavate. This can easily be done in a children’s swimming pool. A rectangular pool is preferable if one is available. Bury the artifacts at various levels in the sand and dirt strata that you create. Tape stings across the pool to create a grid for mapping objects.
2. Draw a mural of one wall of a dig site including strata changes. Include one or more features of the profile of the dig.
Let’s Dig
What we found!
Percent of Artifact Types

What inferences could be made from this data about the people and their culture?

*Let’s Dig* Student Worksheet 1
Activity 22- Line Graphs

Topic
Line graphs
Line of Best Fit

Key Questions
1. What is the relationship between independent and dependent variables?
2. What is a line of best fit?

Guiding Documents
Virginia Standards of Learning
- Science 4.1, 5.1, 6.1, 6.2, LS.1, PS.1
- Mathematics 4.20, 5.18, 5.19, 7.17, 8.12

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
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- collect data using observations, surveys, and experiments;
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- recognize the differences in representing categorical and numerical data. (NCTM, 178)

Science
Data Analysis
Representing Data

Mathematics
Statistics
Representing Data

Integrated Methods
Collecting and recording data
Comparing and contrasting
Applying
Generalizing
Inferring

Background Information
A graph is made by plotting data points on a coordinate plane (a plane formed by two intersecting number lines). Every point on the plane can be named by an ordered pair of numbers to show the relationship between two variables in a data set.

A line of best fit is drawn to represent the whole data set and should pass through as many data points as possible. The line should have roughly the same number of points equidistant above and below it. The less scattered the points are about the best-fit line, the stronger the relationship is between the two quantities. If the points are close to the best-fit line there is a strong correlation. If the points are loosely scattered, there is a weak correlation. If there appears to be no trend in the pattern of points then there is no correlation between the variables. Straight
lines best represent the relationships in most classroom data as opposed to curved lines that represent more complex relationships.

References:


Materials
- Student Worksheet 1
- Transparencies # 1-3
- Chart Graph Paper
- Colored pencils

Management
1. Students may work individually or in small groups.

Procedure
1. Define scatter plot and line of best fit using transparency 1.
2. Distribute student worksheet 1.
3. Have students identify independent and dependent variables.
4. Have students plot the data for the variables identified in #3 on the worksheet.
5. We can now approximate where the line fits best between the points of data that we have. Students should draw a straight line that touches as many points as possible.
6. Remind students to check their graphs for axis labels and scales.

Follow-up Discussion
1. What is the relationship between the variables?
2. Explain why you think this relationship occurs.

Extension
Have students collect and graph weather data http://www.nws.noaa.gov.
A Scatter Plot

A scatter plot is a graph that is made by plotting points on a coordinate plane to show the relationship between two variables in a data set.

Line of best fit

The line of best fit is a straight line drawn through as much data as possible on a scatter plot.
Data Set: The Effect of the Amount of Fertilizer on the Height of Plants

<table>
<thead>
<tr>
<th>Amount of Fertilizer (mg)</th>
<th>Plant Height (mm)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
<td>Trial 3</td>
<td>Mean (mm)</td>
<td>Range (mm)</td>
<td></td>
</tr>
<tr>
<td>0 (control)</td>
<td>25</td>
<td>27</td>
<td>23</td>
<td>25</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>50</td>
<td>49</td>
<td>51</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>82</td>
<td>74</td>
<td>78</td>
<td>78</td>
<td>8</td>
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<td>20</td>
<td>135</td>
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<td>25</td>
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<td></td>
</tr>
<tr>
<td>30</td>
<td>202</td>
<td>211</td>
<td>196</td>
<td>203</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>
The Effect of the Amount of Fertilizer on the Height of Plants

![Graph showing the effect of fertilizer on plant height.](Height of Plants Transparency 3)
The Effect of the Amount of Fertilizer on the Height of Plants

![Graph showing the relationship between Fertilizer (mg) and Height (mm). Height increases linearly with the amount of fertilizer.]
The Effect of the Amount of Fertilizer on the Height of Plants

3. Define the variables in this data set.
   a. Independent Variables __________________________
   b. Dependent Variables ___________________________

4. Construct a table of ordered pairs for your variables.

<table>
<thead>
<tr>
<th>Amount of Fertilizer (mg)</th>
<th>Plant Height (mm)</th>
<th>Mean (mm)</th>
<th>Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
<td>Trial 3</td>
</tr>
<tr>
<td>0 (control)</td>
<td>25</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>10</td>
<td>82</td>
<td>74</td>
<td>78</td>
</tr>
<tr>
<td>15</td>
<td>102</td>
<td>110</td>
<td>118</td>
</tr>
<tr>
<td>20</td>
<td>135</td>
<td>128</td>
<td>148</td>
</tr>
<tr>
<td>25</td>
<td>176</td>
<td>159</td>
<td>163</td>
</tr>
<tr>
<td>30</td>
<td>202</td>
<td>211</td>
<td>196</td>
</tr>
</tbody>
</table>
5. Plot the ordered pairs on the coordinate plane.

6. Draw a line on the graph to approximate the relationship between the independent and dependent variables. Draw the line through as many points as you can.

7. What is the relationship between the variables?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

8. Explain why you think this relationship occurs.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

*Height of Plants* Student Worksheet 1
Activity 23- Constructing a Stem and Leaf Plot

Materials

* Stem and Leaf Student Worksheet 1-2
* Stem and Leaf Transparencies 1-5

Management

1. This lesson works well as direct presentation.
2. Have students use Stem and Leaf student worksheet 1 during the presentation.

Procedure

1. Display original data.
2. The first step is to order the numbers from least to greatest.
3. For step 2 separate each observation into a stem that consists of the first digit and a leaf that is the final digit.
4. In step 3 draw a vertical line and list the stem digits on the left side of the vertical line. List each stem digit only one time even if that digit is repeated in the original data set.
5. Add the leaves for step 4. The digits on the right side of the vertical line are the leaves. List each leaf in the row to the right of its stem in increasing order (from lowest to highest value).

Follow-up Discussion

1. Briefly, have the participants discuss with their partner what they see on the plot. Have them share their ideas.
   Be certain to discuss:
   • All the data is visible on a stem-and-leaf plot.
   • It is easy to find the range (the difference between the largest and smallest piece of data) and mode(s) (the piece or pieces of the data that occurs most often) just by looking. This would be an appropriate time to introduce the terms bimodal (having two modes) and trimodal (having three modes) as it often happens in this type of data collection.
   • Share finding the median of the data by counting in from both ends to find the middle number.
   • The mean can be found in the normal manner.
   • Discuss any other interesting clusters or trends that the group sees.
1. Have students complete What’s My Score? worksheet.

Extension

Have students collect numeric data from the class and represent the data in a Stem and Leaf Plot.
Data Set

Ages of Teachers’ Children

26, 2, 10, 15, 3, 15, 17, 39, 23, 3, 14, 16
Step 1: Order Data

Order data from least to greatest.

Ages of Teachers’ Children

2, 3, 3, 10, 14, 15, 15, 16, 17, 23, 26, 39
Step 2: Create Stems and Leaves

Separate each observation into a stem that consists of the first digit and a leaf that is the final digit.

Ages of Teachers’ Children

<table>
<thead>
<tr>
<th>Data</th>
<th>2, 3, 3, 10, 14, 15, 15, 16, 17, 23, 26, 39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stems</td>
<td>0, 0, 0, 1, 1, 1, 1, 2, 2, 3, 3, 3, 3</td>
</tr>
<tr>
<td>Leaves</td>
<td>2, 3, 3, 0, 4, 5, 5, 6, 7, 3, 6, 9</td>
</tr>
</tbody>
</table>

*Stem and Leaf* Transparency 3
Step 3: Create Stem Chart

Draw a vertical line and list the stem digits on the left side of the vertical line. List each stem digit only **one time** even if that digit is repeated in the original data set.

**Ages of Teachers’ Children**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>stems</td>
</tr>
</tbody>
</table>
Step 4: Add Leaves
The digits on the right side of the vertical line are the leaves. List each leaf in the row to the right of its stem in increasing order.

<table>
<thead>
<tr>
<th>Ages of Teachers’ Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

leaves
Stem and Leaf Plots

The following data are the ages of the children of a group of seventh grade teachers. Construct a stem-and-leaf plot from the data.

<table>
<thead>
<tr>
<th>Ages of Teachers’ Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>26, 2, 10, 15, 3, 15, 17, 39, 23, 3, 14, 16</td>
</tr>
</tbody>
</table>
What’s My Score?

The following are scores from one class of sixth grade students on a math test. Construct a stem-and-leaf plot from the data. What conclusions might you draw by studying the data displayed in this way?

<table>
<thead>
<tr>
<th>Class A</th>
<th>74</th>
<th>75</th>
<th>42</th>
<th>93</th>
<th>88</th>
<th>62</th>
<th>62</th>
<th>37</th>
<th>73</th>
<th>76</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>96</td>
<td>54</td>
<td>80</td>
<td>75</td>
<td>68</td>
<td>66</td>
<td>81</td>
<td>79</td>
<td>83</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>88</td>
<td>80</td>
<td>52</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record

<table>
<thead>
<tr>
<th>Sixth Grade Math Class Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Reorganize

<table>
<thead>
<tr>
<th>Sixth Grade Math Class Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Student Worksheet 2
What’s My Score?

The following are scores from one class of sixth grade students on a math test. Construct a stem-and-leaf plot from the data. What conclusions might you draw by studying the data displayed in this way?

Class A 74 75 42 93 88 62 62 37 73 76
96 54 80 75 68 66 81 79 83 56
69 88 80 52 59

Record

Sixth Grade Math Class Test Scores

<table>
<thead>
<tr>
<th>stem</th>
<th>leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4 6 2 9</td>
</tr>
<tr>
<td>6</td>
<td>2 2 8 6 9</td>
</tr>
<tr>
<td>7</td>
<td>4 5 3 6 5 9</td>
</tr>
<tr>
<td>8</td>
<td>8 0 1 3 8 0</td>
</tr>
<tr>
<td>9</td>
<td>3 6</td>
</tr>
</tbody>
</table>

Reorganize

Sixth Grade Math Class Test Scores

<table>
<thead>
<tr>
<th>stem</th>
<th>leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>
| 5    | 2 4 6 9 | Range – 59
| 6    | 2 2 6 8 9 | Median – 74
| 7    | 3 4 5 5 6 9 | Mode – 62, 75, 80, 88
| 8    | 0 0 1 3 8 8 | Mean –71
| 9    | 3 6 |
Activity 24- Constructing a Box and Whisker Plot

Topic
Box and Whisker Plots

Key Questions
1. When do you use a Box and Whisker Plot and a Stem and Leaf Plot?
2. What type of data do you use for a Box and Whisker Plot and a Stem and Leaf Plot?

Guiding Documents
Virginia Standards of Learning
Science 5.1, 6.1
Mathematics 5.18, 6.18, 7.17, 7.18, 8.12, A.17

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry.

NCTM Standards
In grades 6–8 all students should 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 or different characteristics within one population;
• select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.

Science
• Data Analysis
• Representing Data

Mathematics
• Statistics
• Representing Data

Integrated Methods
Collecting and recording data
Comparing and contrasting
Applying
Generalizing
Inferring

Background Information
A box and whisker plot, sometimes called a box plot, is used to show the distribution of data from a large data set. It is a diagram along a horizontal axis that uses a five number summary system to show the distribution of data. Box plots are graphical representations of data that provide information about a set of data while showing only certain statistics rather than the complete data set. A box-and-whisker plot is useful for identifying situations that require further study. The five-number summary consists of the median, upper quartile, lower quartile, upper extreme value, and lower extreme

When a data set is small, fewer than 50 items, a stem and leaf plot provides a picture of the shape of a distribution while including the actual numerical values in the diagram.

References:
Materials
Handouts
Transparencies

Management
4. This lesson works well as direct presentation.
5. Have students use Student worksheet 1 during the presentation.

Procedure
1. Show a data set (transparency 1).
2. Describe the 5-number summary (transparency 2).
3. Distribute the Box and Whisker Plot worksheet to aid student note taking.
4. To construct a box-and-whisker plot first find the median, the lower quartile, the upper quartile, and the extreme values of a given set of data.
   a. To find the median locate the data point that is exactly in the middle of an ordered set of numbers. (In the example provided 65 is the median.)
   b. Next, have the students find the lower quartile. To find the lower quartile we consider only the values to the left of the median: 20 24 35 52 54 57 60. Now find the middle value in this set of numbers. Thus 52 is the median of the lower half of the data. This point is called the lower quartile.
   c. To find the upper quartile we repeat this process using the data in the upper half (the data to the right of the median) Now find the middle value in the data to the right of the median: 77 82 85 88 90 96 100. The median 88 is therefore called the upper quartile.
   d. Have the students identify the extreme values (highest and lowest values) in the data set. Therefore 20 and 100 are the extreme values.
   e. The median, the upper quartile, the lower quartile, the highest extreme value and the lowest extreme value is called the five number summary.
5. The next step in constructing a box and whisker plot is to draw the diagram.
   a. Have the students draw and label a horizontal axis.
   b. Determine the scale for the axis based on the highest and lowest value in the data.
   c. Above the axis, plot the lower quartile and the upper quartile placing a vertical line through each of these data points.
   d. Join the vertical lines with two horizontal lines forming a box.
   e. Plot the median and draw a vertical line from the top to the bottom of the box.
f. Plot the lower and upper extreme values connecting these values to the box with horizontal lines (whiskers).

Follow-up Discussion
1. Have students identify any outliers (a significantly high or low value) in the data set.
2. Discuss the significance of Interquartile Range
   The lower quartile, the median, and the upper quartile divide the data into four equal groups with 25% of the data falling in each group. These groups are generally labeled $Q_1$ - quartile one, $Q_2$ – quartile 2, $Q_3$ – quartile three and $Q_4$- quartile
   4. The 50% of the data included in quartile two ($Q_2$) and quartile three ($Q_3$) -- the data encompassed within the “box” -- is called the Interquartile Range.
3. When would you use this type of graph?
4. Have students define the following terms:
   a. Median: the middle item in a set of data listed in numerical order; for an even number of items, the median is the average of the two middle items
   b. Lower Extreme Value: the smallest numerical piece of data in a set
   c. Upper Extreme Value: the largest numerical piece of data in a set
   d. Lower Quartile: the median of the lower half of the data; the point that separates the first and second quartiles
   e. Upper Quartile: the median of the upper half of the data; the point that separates the third and fourth quartiles
   f. a significantly high or low value in a data set
   g. Outlier: a significantly high or low value in a data set
   h. Interquartile Range: the data included in the second and third quartiles; the data encompassed within the “box”.
5. Have students complete the How Do They Compare? worksheet.

Extension
Have students collect numeric data from the class and represent the data in a Box and Whisker Plot.
Test Scores for a Class of Fifteen Students
(Sample Data Set)

24, 60, 54, 35, 96, 88, 90, 100, 52, 20, 85, 65, 57, 77, 82
Five Number Summary

• Median
• Lower Quartile
• Upper Quartile
• Lower Extreme Value
• Upper Extreme Value
Median

• Place data in numerical order

  20 24 35 52 54 57 60 65 77 82 85 88 90 96 100

• Find the middle number, which is the median.

  65
Lower Quartile

• List the values to the left of the median.

20 24 35 52 54 57 60

• Find the middle number, which is the lower quartile.

52
Upper Quartile

• List the values to the right of the median.

  77 82 85 88 90 96 100

• Find the middle number, which is the upper quartile.

  88
Lower Extreme

The lowest number in the data set is the lower extreme value.

20
Upper Extreme

The highest number in the data set is the upper extreme value.

100
Step 1: Horizontal Axis

Draw and label a horizontal axis. Determine the scale for the axis.

---

*Box and Whisker* Transparency 8
Step 2: Lower and Upper Quartiles

Above the axis, plot the lower quartile and the upper quartile placing a vertical line through each of these data points.
Step 3: Box
Join the vertical lines with two horizontal lines forming a box.
Step 4: Median
Plot the median and draw a vertical line from the top to the bottom of the box.
Step 5: Extreme Values
Plot the lower and upper extreme connecting these values to the box with horizontal lines (whiskers).
Box and Whisker Plots

1. The following set of numbers is a set of test scores for a class of fifteen students.

   20 24 35 52 54 57 60 65 77 82 85 88 90 96 100

2. List the Five Number Summary for the data.
   a. Median __________
   b. Lower Quartile _________
   c. Upper Quartile _________
   d. Lower Extreme _________
   e. Upper Extreme _________

3. List the steps needed to construct a Box and Whisker plot.
   a. Step 1:____________________________________________________________
      __________________________________________________________________
      __________________________________________________________________
   b. Step 2:____________________________________________________________
      __________________________________________________________________
      __________________________________________________________________
   c. Step 3:____________________________________________________________
      __________________________________________________________________
      __________________________________________________________________
   d. Step 4:____________________________________________________________
      __________________________________________________________________
      __________________________________________________________________
   e. Step5: ____________________________________________________________
      __________________________________________________________________
      __________________________________________________________________
4. Using the steps listed above, construct a Box and Whisker Plot.
How Do They Compare?

The following box-and-whisker plots represent the test scores for students in two different classes:

Class A

Class B

Compare how these two classes did on this test. Give as much information as you can.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Activity 25- Graph Stories

Topic
Graph Interpretation

Key Questions
1. How do we read a graph?

Guiding Documents
Virginia Standards of Learning
Science 4.1, 5.1, 6.1, 6.2, LS.1
PS.1
Mathematics 6.18, 7.18

NSES Standards
Content Standard A: As a result of activities in grades 5-8, all students should develop
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry.

NCTM Standards
In grades 3–5 all students should
Use mathematical models to represent and understand quantitative relationships
• model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions.

Integrated Methods
Observing
Predicting
Collecting and recording data
Comparing and contrasting
Applying
Generalizing
Inferring

Background
Some research suggests that 80% of people can not interpret graphs.

References

Science
Reading Graphs
Interpreting Graphs

Mathematics
Reading Graphs
Interpreting Graphs
Materials
Student Worksheets 1-2
Transparencies 1-3

Management
1. Students should work in small groups

Procedure
1. Display *Graph Stories* transparency 1.
2. Explain that a graph tells a story.
3. Ask students what story this graph is telling them.
4. Demonstrate by telling them a story about *Graph Stories* transparency 1. Be sure to include information each time the graph changes direction.
5. Distribute *Graph Stories* Student Worksheet 1.
6. Display *Graph Stories* transparency 2.
7. Tell students that they are to discuss the graph and answer the questions with their partner.
8. Distribute *Graph Stories* Student Worksheet 2.
9. Display *Graph Stories* transparency 3.
10. Tell students that they are to discuss the graph and answer the questions with their partner.

Follow-up Discussion
1. What information does the graph from *Graph Stories* Student Worksheet 1 & 2 tell us?
2. Have students compare answers to the questions on worksheets with another group.
3. Did you have the same answers? Why/why not the same?

Extension
1. Have students watch a graph being created while using a temperature probe to collect temperature change data.
The Effect of Fertilizer on Plant Growth

Graph Stories Transparency 1
Temperature Above the Surface of the Earth
Graph Stories Transparency 3

Name:___________________________

Directions: Use the graph to answer the following questions.
1. What happens to the air temperature from the Earth's surface up to about 15 kilometers?

2. Which atmospheric layer has the greatest temperature change? What is the change in temperature?

3. In which layer is the temperature decreasing most rapidly? What specifically about the graph led you to this conclusion?
Directions: Use the graph to answer the following questions.

1. If you are driving to a friend’s home and you leave at noon, what time do you arrive at your friend’s house?

2. How long did you stay at your friend’s house?

3. How far away does your friend live?

4. What time did you arrive back home?

5. How long did it take you to get to your friend’s house?

6. How long did it take you to get home?

7. Why are these numbers different?

Graph Stories Student Worksheet 2
Activity 26- Data Analysis Post-Assessment

Materials
Post-Assessment worksheets

Management
Students work individually.

Procedure
1. Distribute the post-assessment worksheets to students.
2. Assess student worksheets for common mistakes.

References


1a. The graph shows the amount of money earned per week by 5 students in their summer jobs.

1a. Tanya earned $80 per week more than Silas. Which could be her weekly salary?
   A) $115  
   B) $250  
   C) $275  
   D) $290  

1b. Explain how you determined your answer.

Source: Assessment items taken from the Standards of Learning for Virginia Public Schools Assessment, the Third International Math and Science Study [TIMSS] and the National Assessment of Educational Progress [NAEP].
On which day were more boxes of lemons picked than either boxes of oranges or boxes of grapefruit?

A. Monday
B. Tuesday
C. Wednesday
D. Thursday
E. Friday
F. No Day
G. I don’t know

2b. Explain how you determined your answer.
3a.

| HAIR COLOR SURVEY RESULTS |  
|---------------------------|---
| Color of Hair             | Percentage |
| Blond                     | 17 |
| Brown                     | 50 |
| Black                     | 33 |
| Totals                    | 100 |

The table above shows the results of a survey of hair color. On the circle below, make a circle graph to illustrate the data in the table. Label each part of the circle graph with the correct hair color.

3b. Explain how you determined your answer.
4a.

The picture shows the growth curve of a bacterial population. According to this information, the bacterial population doubles every-

A. 5 minutes
B. 20 minutes
C. 30 minutes
D. 60 minutes

4b. Explain how you determined your answer.
5a. The graph shows the number of books checked out at the public library each day last week.

<table>
<thead>
<tr>
<th>Books Checked Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
<tr>
<td>Saturday</td>
</tr>
</tbody>
</table>

Each 📚 represents 10 Books

On which day were there 3 times as many books checked out as on Tuesday?

A  Wednesday  
B  Thursday  
C  Friday  
D  Saturday

5b. Explain how you determined your answer.
6a. Rhea took a survey of the students in her class to find out about their career interests. The results are shown in the graph.

![Favorite Careers Graph]

The mode of the data is associated with which career?

A. Health Related  
B. Engineering / Science  
C. Education  
D. Computers

6b. Explain how you determined your answer.
7a. Hypothesis: If the amount of nitrogen fertilizer is increased, then the height of the corn increases. Which of these is the independent (manipulated) variable for an experiment testing this hypothesis?

A  The height of the corn in each experimental group  
B  The number of corn plants in the experimental groups  
C  The size of the experimental groups  
D  The amount of fertilizer added to each experimental group

7b. Explain how you determined your answer.
8a. This is a list of Beth’s English homework scores for the grading period.

93, 83, 64, 84, 76, 83, 78, 76, 60, 81

Which stem-and-leaf plot correctly displays the information?

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>II</td>
</tr>
<tr>
<td>7</td>
<td>III</td>
</tr>
<tr>
<td>8</td>
<td>I</td>
</tr>
<tr>
<td>9</td>
<td>I</td>
</tr>
</tbody>
</table>

B

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

C

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6, 6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 3, 4</td>
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<td>3</td>
</tr>
</tbody>
</table>

D

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0, 4</td>
</tr>
<tr>
<td>7</td>
<td>6, 6, 8</td>
</tr>
<tr>
<td>8</td>
<td>1, 3, 3, 4</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

8b. Explain how you determined your answer.
9a. The list shows the scores made by each member of Jaime’s discussion group on the last test.

   69, 79, 62, 93, 73, 81, 73, 78

Which box and whiskers plot correctly displays the information?

A

B

C

D

9b. Explain how you determined your answer.
10a. An adult toad lays 6,000 eggs at a time in a pond. Which graph shows the number of tadpoles and toads that will most likely result in the pond from these eggs?

A)  

B)  

C)  

D)  

10 b. Explain how you determined your answer.