

Measuring Volume and Capacity

Volume and *capacity* are both terms for measures of the “size” of three-dimensional regions. *Volume* typically refers to the amount of space that an object takes up. Volume is measured with units such as cubic inches or cubic centimeters—units that are based on linear measures. The term *capacity* is generally used to refer to the amount that a container will hold. Standard units of capacity include quarts and gallons, liters and milliliters—units used for liquids as well as the containers that hold them. Having made these distinctions, they are not ones to worry about. The term *volume* can also be used to refer to the capacity of a container.

Comparison Activities

By third grade most students will understand the concept of “holds more” with reference to containers. That is, there is no need to develop a concept of that attribute. The concept of volume for solid objects may not be as readily understood. Even if these ideas are understood, one or two comparison activities can be fun.

ACTIVITY 9.9

Capacity Lineup

Given a series of five or six labeled containers of different sizes and shapes, the task is to order them from least capacity to most. This can be quite challenging. Do not provide answers. Let students work in groups to come up with a solution and also explain how they arrived at it.

Even adults have difficulty judging which of two containers will hold more. Try the following task yourself as well as with students. Take two sheets of construction paper. Make a tube shape (cylinder) of one by taping the two long edges together. Make a shorter, fatter tube from the other sheet by taping the short edges together. When placed upright, which cylinder holds the most, or do they have the same capacity?



This task is a good exploration for older students, and the results may be surprising. Before doing this with your class, survey them to see how many select which option. Most groups split roughly in thirds: short and fat, tall and skinny, same. Without using formulas, try using a filler such as Styrofoam packing peanuts or lima beans. Place the skinny cylinder inside the fat one. Fill the inside tube and then lift it up, allowing the filler to empty into the fat cylinder.

The apparent volumes of solid objects are sometimes misleading, and a method of comparison is also difficult. To compare volumes of solids such as a ball and an apple, some method of displacement must be used. Provide students with two or three containers that will each hold the objects to be compared and a filler such as rice or beans. With this equipment some students may be able to devise their own comparison method. One approach is to first fill a container completely and then pour it into an empty holding container. Next, place an object in the first container and fill it again to the top, using filler from the holding container. The volume of filler remaining is equal to the volume of the object. Mark the level of the leftover filler in the holding container before repeating the experiment with other objects. By comparing the level of the leftover filler for two or more objects, the volumes of the objects can be compared.

MEASURING VOLUME AND CAPACITY

Using Units of Volume and Capacity

Two types of units can be used to measure volume and capacity: solid units and containers. Solid units are things like wooden cubes or old tennis balls that can be used to fill the container being measured. The other type of unit model is a small container that is filled and poured repeatedly into the container being measured. The following are a few examples of units that you might want to collect.

- Plastic caps and liquid medicine cups are all good for very small units.
- Plastic jars and containers of almost any size can serve as a unit.
- Wooden cubic blocks or blocks of any shape can be units as long as you have a lot of the same size.
- Styrofoam packing peanuts can be used. Even though they do not pack perfectly, they still produce conceptual measures of volume.

Measuring activities for capacity are similar to those for length and area. Estimation of capacity is a lot more fun because it is much more difficult. Finding ways to measure containers such as a large cardboard carton in terms of a relatively small container-type unit can be an excellent challenge for groups of fourth or fifth graders. This can be done long before volume formulas are developed.

Volumes of rectangular boxes such as a shoebox can be determined by filling with any of the units mentioned earlier. However, here is an opportunity to prepare students for volume formulas in a manner similar to what was discussed for the area of rectangles. If students are given a box and sufficient cubes to fill it, they will most likely count the cubes rather than use any multiplicative structure.

ACTIVITY 9.10

Box Comparison—Cubic Units

Provide students with a pair of small boxes that you have folded up from poster board. (See Figure 9.9.) Use unit dimensions that match the blocks that you have. Students are given two boxes, exactly one block, and an appropriate ruler. (If you use 2-cm cubes, make a ruler with the unit equal to 2 centimeters.) The students' task is to decide which box has the greater volume or if they have the same volume.

Here are some suggested box dimensions ($L \times W \times H$):

$$6 \times 3 \times 4 \quad 5 \times 4 \times 4 \quad 3 \times 9 \times 3 \quad 6 \times 6 \times 2 \quad 5 \times 5 \times 5$$

Students should use words, drawings, and numbers to explain their conclusions.

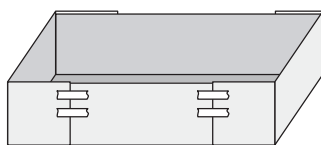
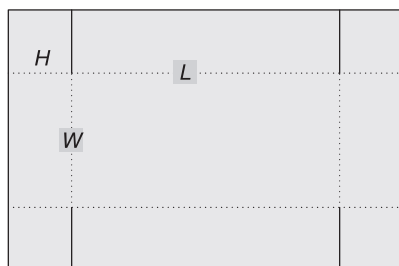


FIGURE 9.9

Make small boxes by starting with a rectangle and drawing a square on each corner as shown. Cut on the solid lines and fold the box up, wrapping the corner squares to the outside and tape or glue them to the sides as shown.

A useful hint in the last activity is to first figure out how many cubes will fit on the bottom of the box. Some, although certainly not all, third-grade students will discover a multiplicative rule for the volume. The boxes can be filled with cubes to confirm conclusions. No formulas should be used unless students can explain them. The development of a formula is not necessarily the goal of this activity.

Making and Using Measuring Cups

Instruments for measuring capacity are generally used for small amounts of liquids or pourable materials such as rice or water. These tools are commonly found in kitchens and laboratories. As with other instruments, if children make their own, they are likely to develop a better understanding of the units and the approach to the measuring process.

A measuring cup can be made by using a small container as a unit. Select a large, transparent container for the cup and a small container for a unit. Fill the unit with beans or rice, empty it into the large container, and make a mark indicating the level. Repeat until the cup is nearly full. If the unit is small, marks may only be necessary after every 5 units. Numbers need not be written on the container for every marking. Students frequently have difficulty reading scales in which not every mark is labeled or where each mark represents more than one unit. This is an opportunity to help them understand how to interpret lines on a real measuring cup.

Students should use their measuring cups and compare the measures with those made by directly filling the container from the unit. The cup is likely to produce errors due to inaccurate markings. This is an opportunity to point out that measuring instruments themselves can be a source of error in measurement. The more accurately made the instrument, and the finer the calibration, the less the error from that source.