Assignment Discovery Online Curriculum

Title:
Architects in Action

Grade Level: 6-8, with an adaptation for older students

Subject area:
Physical Science, Mathematics

Duration:
Two class periods

Objectives:
Students will
1. understand that ratios are used to create scale models of buildings and structures;
2. understand the principles of ratio and apply these principles in the solution of problems; and
3. understand how to calculate scale using ratio.

Materials:
- 0.25-inch graph paper
- map(s) of the United States
- pencils
- ruler (metric or inches)
- tape measure
- Take-Home Activity Sheet: Home Measurements

Procedures:
1. Begin by introducing the concept of scale. Write the word *scale* on the board and brainstorm examples of where scales are found and what they measure. For example, we use scales to measure the weight of an object, the temperature of air, the length of an object, and so on.

2. Show students a map of the United States and point out the scale in the map key. Remind them that this map is a smaller, scaled-down representation of the United States, not an actual representation. Explain that sometimes we shrink objects or make them larger so they are easier to work with. The map is a scale model of an object that is too large to represent on paper. Other scale models represent objects that are too small, such as a diagram of an atom or a magnified view of a computer chip. Review the scale on the map. For example, the scale may say that 1 inch is equal to 50 miles. Explain that a scale is a ratio used to determine the size of a model of a real object. In this case, the map of the United States is the model.

3. A ratio is a relationship between two objects in quantity, size, or amount. For example, four quarters are in a dollar, so the ratio of quarters to dollar is 4 to 1. In other words, a quarter is one-fourth the value of a dollar. Have students think of other examples of how money can be turned into a scale, such as dimes to dollars (10:1 or 1:10) or pennies to dollars (100:1 or

1:100).

4. Illustrate how to draw an object to scale. Use a ruler to draw a square on the board with sides that equal 10 inches in length. Ask students how they might use this square to draw another that is half its size. Explain that an object is not simply cut in half when it is scaled down. The whole object is shrunk *proportionally,* meaning that it doesn't change shape but is reduced to a smaller size. For example, if you could scale a carrot to half its size, you wouldn't simply cut the carrot in half. All parts of the carrot need to shrink equally in size.

5. Now measure and draw a second square with 5-inch sides. Explain that when an object is scaled down, the length of its sides must be reduced by the same amount. Compare the corresponding sides of the two squares. The ratio of the small square to the larger is 5:10. Explain that a ratio can be expressed in three ways: 5:10, 5 to 10, or 5/10, which is a fraction that reduces to 1/2.

6. Remind students that the perimeter of an object is the sum of the length of its sides. So if an object has been scaled down proportionally, the perimeter of the object will scale down by the same ratio. For example, the perimeter of the smaller square is 20, or 5 x 4, which is half the perimeter of the larger square, which is 40, or 10 x 4.

7. Explain that students will use ratio to make a scale drawing of the classroom floor plan. First invite students to brainstorm a list of the kinds of people who might use scale drawings. (Examples include architects, construction workers, and cartographers.)

8. Divide students into teams of four. Explain that each team will measure the surface areas of objects in the classroom—the desks, tables, closets, and so on. The class may choose to use either metric or English measurements. Explain to students that their floor plan will show objects in the classroom as seen from above. Each group should have access to a tape measure, pencils, and paper to record their measurements.

9. Construct a class data table on the board with three columns labeled “object,” “measurement,” and “scaled measurement.” Students should copy this table in their notebooks and fill in the answers as they measure the objects.

10. Once teams have recorded all their data, they will decide on the scale of their floor plan. Distribute graph paper. With the class, discuss the proportions that would allow students to draw the entire room on one sheet of 8.5" x 11" graph paper. (For example, if the longest wall in the classroom is 16 feet long, then a scale of 1" = 1' will not work. But 0.5" = 1' will work perfectly.)

11. Use the agreed-upon ratio to create the proportion for your classroom. Then have groups convert their measurements into scaled equivalents. For example, if a desktop measures 2 feet in width and the scale is 0.5" = 1', use the following equation to figure out how large the scaled drawing of the desktop should be.

0.5 inches divided by 1 foot = the scaled down length of the object divided by 2 feet

Or, written as an equation of two ratios:

$$\frac{0.5 \text{ inches}}{1 \text{ foot}} = \frac{y \text{ inches}}{2 \text{ feet}}$$

$y = 1$ inch

12. Students can determine their scaled equivalents by cross-multiplying. Students should recall that when both sides of an equation are multiplied by the same amount, the equation remains balanced. In cross-multiplication, both sides of an equation are multiplied by the denominators (the bottom numbers in the fractions). The result is the same as multiplying across the "equals" sign diagonally (i.e., the "bottom left" number times "top right" number equal to the "top left" number times the "bottom right" number). Have students consider the following example:

$$\frac{0.5 \text{ inches}}{1 \text{ foot}} = \frac{y \text{ inches}}{2 \text{ feet}}$$

1 foot x y inches = 0.5 inches x 2 feet

Solving for the unknown yields the following:

$$y = \frac{0.5 \text{ inches x } 2 \text{ feet}}{1 \text{ foot}}$$

$y = 1$ inch

13. Have students use their scaled measurement, rulers, and graph paper to draw the floor plan their team measured. Remind them to include a title, labels, and a scale.

14. As students complete their drawings, encourage them to calculate the perimeter of their classrooms. What is the relationship between the perimeter of the drawing and the perimeter of the actual classroom?

15. For homework, ask students to complete the sheet, asking them to make a floor plan of a room in their home.

Adaptation for older students:
Have students determine the relationship between the area of the drawing and the area of the actual classroom. They should notice that the ratio of these areas is the square of the scale they chose. For example, if a scale of 0.5 inch = 1 foot was used, the ratio of areas of the drawing to the actual

room will be $(0.5 \text{ inches})^2 = (1 \text{ foot})^2$ or 0.25 square inches = 1 square foot. Students can also conduct experiments to determine how volume changes with scale.

Questions:

1. Using what you have learned about ratios, proportions, and scale models, create four word problems for other students in your class to solve. For example: A square carpet measures 8 feet x 4 feet. Suppose the scale of a drawing containing the carpet is 1 foot to 1/4 inch. What are the dimensions of the carpet in the drawing? *The answer: 2 inches x 1 inch*.

2. Is it possible to draw scale models that are completely accurate? Why is accuracy important in the creation of maps, blueprints, and other scale models?

3. Compare your classroom floor plan to that of another student. How are they similar and different? Which would be more useful to a construction worker trying to build a classroom in a new school? Why?

4. List other instances in which you use ratio to compare objects in your daily life. Why is it important to maintain the same scale for each measurement you record when making your model?

5. Debate the merits of using the metric system and the English system to measure lengths. Explain how to convert between the two systems.

6. Compare your classroom to a nearby classroom using scale models of each. Explain how you could use estimation to create a scale model. Would the model be more or less accurate?

Evaluation:
You can evaluate students' work using the following three-point rubric:

Three points: records and converts all of the measurements accurately; uses measurements to draw a classroom floor plan to scale in precise detail.

Two points: records and converts most of the measurements correctly; uses measurements to draw a classroom floor plan that is not entirely accurate.

One point: records and converts some or few of the measurements accurately; is unable to create a classroom floor plan that is accurate.

Related links:

Artifice: Great Buildings Online
http://www.greatbuildings.com

This site documents a thousand buildings and hundreds of leading architects. It includes 3-D models, photographic images, and architectural drawings, as well as commentaries, bibliographies, and Web links.

Architecture Magazine
http://www.architecturemag.com
This magazine features trends and designs in architecture for professionals. It is useful in the classroom for its graphs, articles, and glossy photographs.

The History of Cartography Project
http://feature.geography.wisc.edu/histcart/
The History of Cartography Project is a research, editorial, and publishing venture drawing international attention to the history of maps and mapping.

Suggested Reading:

Distance
Brenda Walpole. Gareth Stevens, 1995.
Learn how standardized measurements developed, as early civilizations used parts of the body for measurements like cubits and fathoms, which gradually became inches and feet. Ways of estimating distances and heights are included along with lots of easy measuring experiments you can do with just a few simple objects. A timeline of important measurement "events" shows the progress of standardization to the present.

The Story of Weights and Measures
Anita Ganeri. Oxford University Press, 1996.
An excellent introduction to the concepts of weight and measurement is encompassed in this slim book. Learn about the history of the development of instruments for accurate weighing and measuring. A short timeline and glossary are included, as well as illustrations and short descriptions

Vocabulary:

equivalent
Definition: Being the same or effectively the same; equal.
Context: The length of the front wall is **equivalent** to the length of the back wall in our rectangular classroom.

perimeter

Definition: The boundary, or border, of a closed, two-dimensional figure or area.
Context: We built a fence around the **perimeter** of our yard to keep the dog from running away.

ratio
Definition: The relation of one part to another or to a whole.
Context: We have twice as many girls as boys in our class. Therefore the **ratio** of girls to boys is 2 to 1, or 2:1.

scale
Definition: The ratio of the size of a model or other representation, such as a map, to the actual size of the object represented.
Context: By looking at the **scale**, we could tell that 1 inch represented 1 mile on our map of New York.

symmetry
Definition: A state in which parts on opposite sides of a plane, line, or point display the same size, form, or arrangement.
Context: The butterfly's wings were exactly alike, displaying perfect **symmetry**.

Academic standards:

Grade level:
6-8
Subject area:
Mathematics
Standard:
Understands and applies basic and advanced properties of the concepts of measurement.
Benchmark:
Solves problems involving units of measurement and converts answers to a larger or smaller unit within the same system (i.e., standard or metric).

Grade Level:
6-8
Subject area:
Mathematics
Standard:
Understands and applies basic and advanced properties of the concepts of measurement.
Benchmark
Understands formulas for finding measures (e.g., area, volume, surface area)

Credit: Jessi Hempel, communications team member, Bay Area School Reform Collaborative, San Francisco, California; former fourth-grade teacher in New York City Public School 92.

Take-Home Activity Sheet: **Architects in Action**

Name: ____________________

Home Measurements

Directions: Create a floor plan of a room at home. Your floor plan should represent all the major objects in the room. Use the data table below to record your information. Then draw your room on graph paper.

Room: ______________________

	OBJECT	MEASUREMENT	SCALE RATIO	SCALED MEASUREMENT
EXAMPLE:	WALL	12’ x 12’	1’ = 1”	12 inches