Ratios and Scale Lesson Plan

Concept/principle to be demonstrated:

In nearly ever construction occupation, ratio is used to determine scale, capacity, and usage. Ratio is critical to safety on the worksite, and in the finished product. A ratio is a comparison of two or more quantities, and can be expressed in several forms. Understanding is demonstrated by solving a variety of construction-related problems.

Lesson objectives/Evidence of Learning:

- Identify and express ratios in several forms and in simplest terms.
- Use different ratios to show the same scale/proportion of an object.
- Compare and contract how different mathematical procedures could be used to complete a particular task.
- Transfer mathematical vocabulary, concepts, and procedures to other disciplinary contexts and the real world.
- Recognize and explain the meaning of information presented using mathematics.
- Solve a variety of construction related problems.

How this math connects to construction jobs:

Ratios provide an easy way to compare two quantities. When a builder reviews blueprints prepared by architects, she or he checks the scale of the drawing (usually in a key, similar to a geography map) to determine the ratio to which the blueprint was drawn. This lesson will help students comprehend how ratios and proportions are used in construction.

- **Architects** use ratios to draw blueprints to a scale that is easy for builders to interpret.
- **Engineers** use ratios to test structural and mechanical systems for capacity and safety issues.
- **Painters** use ratios to mix pigments to get a desired color.
- **Millwrights** use ratio to solve pulley rotation and gear problems.
- **Operating Engineer**s apply ratios to ensure the correct equipment is used to safely move heavy materials such as steel on worksites.

Teacher used training aids:

- Set of blueprints or other documents that show proportioned scale (i.e., road map)
- Architecture scale (optional)

Additional online aid:

- Reference to www.constructmyfuture.com website – *Top 10 Construction Projects of the 20th Century* pages (optional)

Materials needed per student:

- Calculator with √ key & memory +/- functions
- ***Ratios and Scale Worksheet***
- Rulers (optional)
- Graph paper for each student

Lesson Introduction:

Ratios are used in construction to design buildings to the desired scale; to communicate the scope of a project from an architect's desk to a worksite; and to accurately use and manage products. In today's lesson, we'll first look at concrete mix as an example. It may not sound glamorous, but it's important a cement mason gets the ratio of concrete mix to water just right – too much water can reduce the strength of a foundation, which could lead to cracking and other serious structural safety issues. Other types of materials that construction workers regularly mix on the job site include paints, glues and adhesives, and gasoline.

Ratios are used when an operating engineer calculates how much product can be hoisted in the air above a worksite. He or she must use the correct cabling and equipment to safely move materials, such as steel, in areas where other people are working.

Lesson Components:

1. Look at structures listed in the *Top 10 Construction Projects of the 20th Century* webpage on www.constructmyfuture.com – in reading the descriptions of building these famous structures, (World Trade Center, Hoover Dam, etc.) ask students in what steps of the building project do they think ratio would be important to know, and why.

   Note: It is helpful to ask if any students have been to these famous structures, and what they observed. For example: Since 1937, 1.6 billion cars have crossed the Golden Gate Bridge in San Francisco – what decisions do you think designers of this bridge made to ensure the bridge would be safe? How does would ratio relate to these decisions?

2. A ratio is a comparison of two like quantities that are expressed in the same units of measure. A ratio takes on the form of a fraction; however, the final form of a ratio is not left as a fraction. It is written as a statement of the ratio relationship (this to that).

   Examples to write on the board:

3 inches/5 inches	(any ratio can be expressed as a fraction)
3 inches/5 inches = **3/5**	(whenever possible, cancel identical units)
3 : 5	(read aloud "the ratio of three to five")

3. A ratio written in either form can be reduced like a fraction.

5 : 10	5 can be divided into both numbers (numerator & denominator)
$\frac{5}{5} : \frac{10}{5} = \frac{1}{2}$	Complete the math
1:2	This is the simplified ratio in the referred format.

4. Order of the ratio is established by the problem statement. Placement of the numbers in the numerator and denominator is critical.

   Examples to write on the board:

   What is the ratio of 16 quarts to 5 gallons?

16 qt : 5 gal	Write the ratio.
4 gal : 5 gal	Change to the same units
4 ~~gal~~ : 5 ~~gal~~	Cancel identical units
4 : 5	Ratio is now in lowest terms. This could be used to measure 4 cups to 5 cups, or 4 quarts to 5 quarts.

5. Concrete mix is an example of how ratios can show the relationship of more than two quantities. Cement, sand and crushed stone are mixed in the ratio of 1 : 2 : 5 by weight. For every pound of cement used, two pounds of sand and five pounds of crushed rock are used. How much of each component are needed for 4000 pounds of concrete?

1 + 2 + 5 = 8	There are 8 parts to the mix (denominator)
1/8	There is one part of cement in the mix
2/8 or 1/4	There are 2 parts of sand in the mix.
5/8	This is the portion of the ratio that is crushed rock

   1/8 x 4000 = 500 lbs cement
   1/4 x 4000 = 1000 lbs sand
   5/8 x 4000 = 2500 lbs crushed rock

   500lbs cement + 1000 lbs sand + 2500lbs crushed rock = 4000 lbs total mixture

6. Show students the blueprint drawings and/or road map. Point out the key features of the blueprint or map, asking what these features are called (such as a map legend). Invite a student to review the blueprint or map, and tell the class the scale of the document. Explain this is a ratio used to make it possible to precisely draw and convey actual measurements in a usable document.

7. Architects and engineers use ratio in technical drawings and blueprints. By the way, blueprints aren't always the color blue – before computer aided drafting, copies of building specifications were drawn using blue lines (hence the name which is still used, "blueprint"). Nowadays, most technical drawings and blueprints are reproduced in black and white.

8. Pass out of 8 1/2" x 11" graph paper to students, asking them to orientate the paper in landscape (11" sides being the top and bottom of the page). Have students draw a "legend" in the bottom right hand corner on each side of the paper, with these different scales:

   Side One: 1/4" = 1'0" (most graph paper boxes equal 1/4")
   Side Two: 1/4" = 5'0"

Tell the students they will draw a basic, one story house "shell" plan (exterior walls only) to these different scales/ratios, with the final shell dimensions matching in both drawings (square footage, placement of windows and doors, etc.). When two ratios can be set equal to each other, a proportion is formed. Explain how this activity will help them understand the relationship between ratios and proportion as a way to communicate information and make decisions.

Students can determine the overall square footage and shape they want for their house, but need to use these perimeters:

Front door opening = 36"
At least five windows = 28"
A bay window = 24"x42"x24" (may need to draw this on the board)
A sliding glass door = 6' in width
A two-car attached garage with one or two doors

For extra credit or homework, students can take home their drawings, and add interior rooms and features, such as fireplaces, sunken tubs, and other fun and creative additions.

8. Use ***Ratios and Scale Worksheet*** in class or as homework.

Name ______________________________

Ratios and Scale Worksheet

Solve the following problems and reduce answers to simplest terms without units:

Problem #1

3 feet : 6 inches

Problem #2

25 / 80

Problem #3

25 lb cement : 50 lb sand : 75 lb crushed rock

Problem #4

3 rejections to 24 good welding joints

Problem #5

The blueprint for a building is drawn to a scale of 1/4" = 1 ft. If the dimensions measure 6 1/2 inches by 11 inches on the print, what are the building dimensions?

Problem #6

Two gears have 64 and 40 teeth. What is their ratio?

Problem #7

What is the ratio of 3 yards to 12 inches?

KEY

Ratios and Scale Worksheet

Solve the following problems and reduce answers to simplest terms without units:

Problem #1

3 feet : 6 inches **36 : 6** **6 : 1**

Problem #2

25 / 80 $\frac{\mathbf{25 : 80}}{\mathbf{5 \quad 5}}$ **5 : 16**

Problem #3

25 lb cement : 50 lb sand : 75 lb crushed rock $\frac{\mathbf{25 : 50 : 75}}{\mathbf{25 \quad 25 \quad 25}}$ **1 : 2 : 3**

Problem #4

3 rejections to 24 good welding joints $\frac{\mathbf{3 : 24}}{\mathbf{3 \quad 3}}$ **1 : 8**

Problem #5

The blueprint for a building is drawn to a scale of 1/4" = 1 ft. If the dimensions measure 6 1/2 inches by 11 inches on the print, what are the building dimensions?

26' x 44' **1/4 : 6 1/2** **(X4)** **1: 26**

1/4 : 11 **(X4)** **1: 44**

Problem #6

Two gears have 64 and 40 teeth. What is their ratio? $\frac{\mathbf{64 : 40}}{\mathbf{8 \quad 8}}$ **8 : 5**

Problem #7

What is the ratio of 3 yards to 12 inches? **9 : 1**