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Curriculum topics:

- Proportions
- Ratios
- Scale Modeling & Scale Factors
- Self-Similarity & Fractals
- Surface Area
- Russian Culture
- Artistic Exploration

Subject:
Mathematics

Grade range: 6 – 8

Mathematical Russian Matryoshka Figures

Explore Russian culture and mathematical properties of proportions, scale modeling, scale factors, surface area, and self-similarity while creating this version of a nesting Matryoshka doll!

Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning

Materials required

For each student:

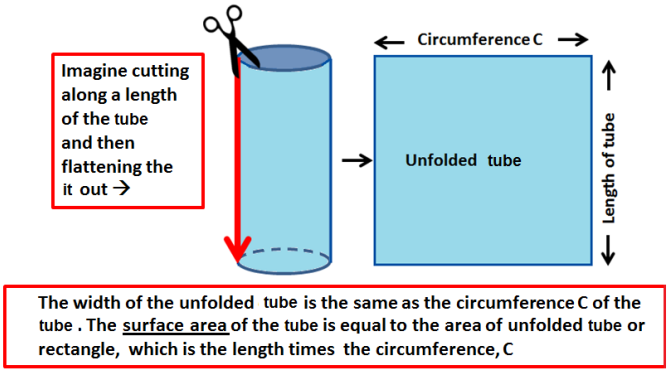
- Copy of Mathematical Matryoshka Chart, 1
- Cylindrical tubes of different widths & heights, 3. Make sure tubes stack within each other leaving approx. 2cm of each inserted tube taller than previous shorter outer tube.
- Pens, assorted colors
- Floral stickers, assorted
- Yarn, hair color, 3 sets of 3 lengths each ½ meter long
- Small ribbon, 3 sets of 2 lengths each 10 cm long
- White circle stickers, approx. 3 cm diameter, 3
- Compass, protractor, ruler
- Scissors
- Tape, hot glue, or other adhesive
- Fabric or paper square, approximately 15 cm by 15 cm
- Rubber bands, small, 6
- Optional: Calculators

To do and notice

1 Measure the BODY of each figure on the *Mathematical Matryoshka Chart*.

Record all **measurements** (made by hand) on the left side of the chart.
Record all **calculations** (computed using a formula) on the right side of the chart.

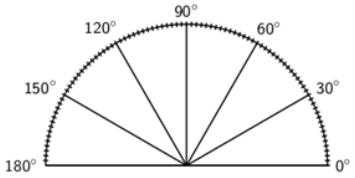
- Measure the diameter (width) of each tube using a ruler.
- Measure the circumference, C, of each tube by wrapping a string around the curved surface once until it meets the starting position. Cut the string, and then measure its length with a ruler.
- Calculate the diameter of each tube by solving for d in the equation $C = \pi d$, where:
  C = circumference of the tube
  π = 3.14 (approximately)
  d = diameter of the tube
- Compare the measured diameters to the calculated diameters of each tube
- Measure the length (L) of each tube.
- Calculate the surface area of each tube by solving the equation: Surface Area = LC.



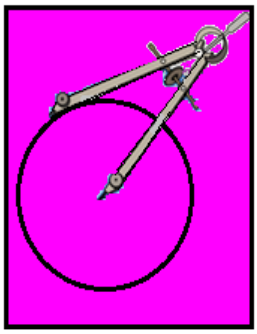
2 Analysis of Matryoshka tubes:

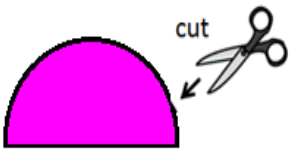
- Compare the heights, widths, and surface areas of the tubes to each other. Are they similar to one another? If not, what would need to change in order to make them proportional and/or similar?
- If you made another set of Matryoshka figures using a scale factor of 3, what would be the new width, height, and surface area of each tube?

3 Make a **SCARF** for each figure:



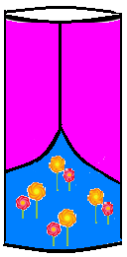
Half of a tube's diameter is its radius. Open a compass to three times the radius of the tube (to the nearest cm). With a protractor, measure the number of angle degrees in the compass opening. With this opening for a radius, use the compass to draw a circle onto the paper or fabric square. Cut out the circle and then cut along the diameter as shown below. Use one half circle as a scarf for each tube.





4 Calculate the surface area of each scarf:

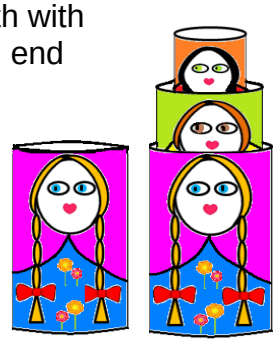
- The area of a complete circle is equal to πr^2, where "r" is the radius of the circle.
- The area of the scarf is one-half the area of the circle, or ½ (πr^2).



5 Fold a half circle "scarf" around the top edge of each tube. Adjust where needed. Optional: Decorate the "dress" of each figure with stickers →

6 Attach a circle sticker onto each tube for a face. Add eyes and a mouth with pens or stickers. Braid 3 lengths of yarn for each face. Tie each braid end with a ribbon. Glue the braid to the top and sides of a face.

Nest each tube as shown →



The content behind the activity

The math behind the activity: When any two items have the same ratio to each other, they are said to be "in proportion." In this activity:

- Say tube #1 has a length of 100 cm and a diameter of 25 cm.
- Say tube #2 has a length of 20 cm and a diameter of 5 cm.
- Then tube #1 and #2 are in proportion because the ratio of 100/25 is equal to the ratio of 20/5.

Tube #1 is a scale model of tube #2 by a **scale factor of 5** because the dimensions of tube #1 are 5 times those of tube #2.

Curriculum Standards:

Geometry (Solve real-world mathematical problems involving area & surface Area: 6G.1; 7G.4,6) Scale Models: Common Core Math Standards: 7G.1) (Angles, Surface Area: 7G.4,6) (Congruence and Similarity with physical models: 8G.1,4)

Ratios and Proportional Relationships: 6RP, 7RP.1,2)

Problem Solving and Reasoning (Common Core Math Standards: Mathematical Practices 1- 8)

Traditions & culture (National Curriculum for Social Studies: Theme 1, Culture)

Content Behind the Activity (continued)

Students look for strategies by using the circumference formula to calculate diameters. They use number sense, repeated reasoning, and math tools (e.g. compasses and protractors) to make scarves and to investigate scale models.

Students use precise words, numbers and symbols to explore proportions and self-similarity. They make conjectures about how the dimensions of the tubes would need to change in order to be in proportion to one another. Another idea: explore how to make proportional scarves!

Historical Background

Russian Matryoshka figures are hollow wooden figures made in decreasing sizes and placed one inside the other (nested). Traditional Matryoshka often feature a woman outfitted in a long Russian peasant dress called a sarafan. Each figure nested inside could be either male or female. The innermost doll is typically a small baby.

The "Matryoshka Principle" is a metaphor for a relationship of "object-within-similar-object" that appear in other natural and crafted objects such as the Matrioshka brain, the Matroska media-container (able to hold many different types of content streams), and in self-similar fractal patterns and dimensions. The onion is a similar metaphor where, as the outer layer of an onion is peeled off a similar onion exists within.

Designers use the Matryoshka Principle in applications such as the layering of clothes or the nesting of tables where a smaller table nests within a larger table, and a smaller one within that.

Related activities: See RAFT Idea Sheets:

Mathematical Hopi Kachina Figures –
http://www.raftbayarea.org/ideas/Mathematical%20Hopi%20Kachina%20Figures.pdf

Mathematical African Akuaba Figures –
http://www.raftbayarea.org/ideas/Mathematical%20African%20Akuaba%20Figures.pdf

Mathematical Japanese Kokeshi Figures –
http://www.raftbayarea.org/ideas/Mathematical%20Japanese%20Kokeshi%20Figures.pdf

Resources

Visit www.raft.net/more for "how-to" video demos & more ideas!

More on the history of Russian nesting dolls and Russian crafts –
http://russian-crafts.com/crafts-history/nesting-dolls-history.html

Further Math investigations with Matryoshka dolls –
http://www.quora.com/What-is-the-math-equation-you-can-learn-from-nested-dolls

