The King's Flower

A Lesson with Eighth Graders

by Ann Lawrence

Ann Lawrence's students had studied about similarity. They were familiar with the idea that similar figures have the same shape but not necessarily the same size. They were also familiar with the idea that reducing or enlarging the dimensions of a figure by the same scale factor produces a similar figure. As a springboard for giving her students additional concrete experience with these ideas, Ann used Mitsumasa Anno's book The King's Flower *(Pan Macmillan, 1986), which tells the story of a king who discovered that bigger isn't always better. She gathered an odd assortment of materials and launched a hands-on activity that linked similarity, measurement, and ratios. (Ann is the coauthor of a forthcoming book of measurement lessons for grades 6, 7, and 8, which will be published by Math Solutions Publications in fall 2007.)*

Along with Anno's book *The King's Flower*, the materials I brought to class for this lesson included clear plastic lids from takeout containers that were stamped with a #6 resin code (6 PS), cut into rectangles (one per student and a few extras in case of mishaps), a toaster oven with a baking sheet that fit inside, a spatula, a dinner knife, sandpaper, colored pencils, and rulers.

I began by reading aloud *The King's Flower*, showing the students each of the illustrations. When I finished, I opened the book to the page with a picture of a birdcage and showed it to the class. I asked, "How is this birdcage similar to others you've seen and how is it different from others you've seen?" Several students volunteered comments. I then talked about my choice of the word *similar*. In this context, I had used *similar* in its general sense, not in a mathematical sense. I could have phrased my question in another way, by asking how the birdcage was *like* other birdcages, but I wanted to take this opportunity to remind students that words often have different meanings when considered in general usage and when considered in mathematical contexts.

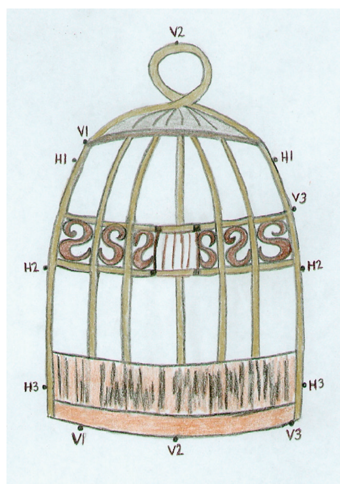
I then asked, "But what do we mean when we talk about a figure being *mathematically* similar to another?" This gave me the chance to review the mathematical ideas of similarity that we had been studying. (See the introduction above.)

I showed the class a small rectangular piece of translucent plastic that had on it a replica of the drawing of the birdcage in the book. To explain what I had done to create it, I held up a lid of a clear plastic takeout container and told the class that I had cut it into a rectangle, traced a drawing of the birdcage onto it, and then put it into a heated oven, where it had shrunk to the smaller version. "Shrinking plastic like this is sometimes called making a 'Shrinky Dink,'" I told them. I then posed a problem. I said, "I know that the birdcage on my Shrinky Dink looks like the larger drawing in the book, but I'm curious about how to investigate whether it is *mathematically* similar to the drawing in the book." I asked the students to think about how I might find out.

After talking in pairs, students shared their ideas. The consensus was that we could take different measurements on the two birdcages and see whether the scale factor of the reduction was the same for all of them. I agreed and told them that they would each test this idea by making their own Shrinky Dink, and that I had a rectangular piece of plastic cut from a lid for each of them to use. I told them that they could draw the birdcage, as I did, or draw any object of their choice, and then investigate whether the drawing on their Shrinky Dink was mathematically similar to the original, larger drawing. I wrote the following directions on the board and explained them.

Make a Drawing

- Choose a drawing that will fit on the plastic.
- Draw first on paper, using a pencil.
- Mark and label dots to determine three horizontal distances and three vertical distances.



Marking Measures on Original Drawing

- Measure each distance (to the nearest millimeter).
- Have your partner verify your measures and then record them in a table like this:

Description and Label of Measure	Original (mm)	Shrunk (mm)	Ratio $\frac{\text{shrunk}}{\text{original}}$	Decimal Form of Ratio
V1 – down left side				
V2 – down middle				
V3 – down right side				
H1 – across top				
H2 – across middle				
H3 – across bottom				

Prepare the Plastic

- Use sandpaper to roughen one side of your plastic until it is frosted.

Trace the Drawing

- Place the plastic over your drawing with the roughened side up.
- With colored pencils (not crayons or water-based markers), trace and color your drawing onto the plastic.
- Also mark the dots that determined the six distances you measured.

Shrink the Plastic

- Preheat a standard or toaster oven to 325°F.
- Place the plastic on a baking sheet, colored side up.
- Bake one to three minutes. The plastic will curl and then get flat again. If it starts to stick to itself while curling, remove the baking sheet from the oven and gently flatten with a knife.
- Remove the baking sheet after the plastic has been flat again for at least ten seconds. Using a spatula, gently press the Shrinky Dink flat for ten to twenty seconds, if needed.

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Zoey's Shrinky Dink

Measure

- Measure the six distances on your Shrinky Dink that correspond with those in the original drawing.
- Have your partner check your measurements and record them in your table.
- Write the ratio $\frac{\text{shrunk}}{\text{original}}$ for each pair of distances in your table. Also write each ratio in decimal form.

Description and Label of Measure	Original (mm)	Shrunk (mm)	Ratio $\frac{\text{shrunk}}{\text{original}}$	Decimal form of Ratio
V1 – Top of shoe to bottom	39	33	$\frac{33}{39}$	.85
V2 – Front of shoe	16	14	$\frac{14}{16}$	.88
V3 – Back of shoe	25	22	$\frac{22}{25}$	.88
H1 – Top of shoe	45	39	$\frac{39}{45}$	.87
H2 – middle of shoe	88	77	$\frac{77}{88}$	.88
H3 – bottom of shoe	67	56	$\frac{56}{67}$	.84

Zoey's Table of Measurements

- Find the mean ratio of the vertical distances, the horizontal distances, and the overall distances in your data.

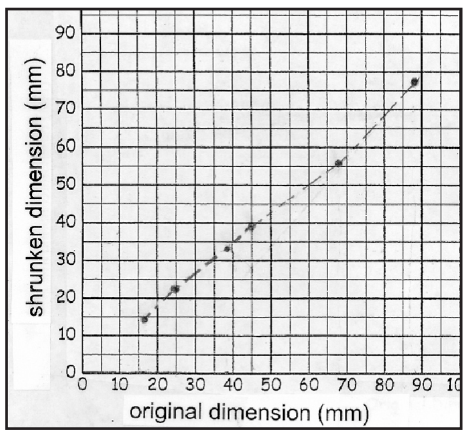
I had prepared five questions for the students to answer, in pairs, after they had completed the experiment. Later we discussed their answers and conclusions. Here are the questions and a sampling of their responses:

1. **Overall, do your figures look like mathematically similar figures?** Almost all students agreed that their large and small drawings satisfied the informal definition of similar figures, that is, they had the same shape.

2. **In general, were the ratios $\frac{\text{shrunk}}{\text{original}}$ close? What does this tell you about whether the two drawings are similar?** Students concluded that close ratios indicated that the two drawings could be similar figures whereas ratios that were not close meant the drawings were not similar figures. As Gideon put it, "Either way, if your measurements are not good, you could be drawing the wrong conclusion."

3. **What would you conclude if each set of your ratios (horizontal or vertical) were close to each other but the means of the two sets were not close?** Most of the students concluded that, in this situation, the plastic shrink more in one direction than in the other. (This actually happened with a few students' drawings.) They also correctly concluded that this meant the figures were not similar because "we already concluded that you must change *all* the dimensions of a figure by the same scale factor to produce a similar figure."

4. **How does a graph display the relationship of the Shrinky Dink to the original drawing?** This class graphed the data before answering this question. After completing and comparing their graphs, the class concluded, "If the points make a line, then the figures are similar since the rate of change (scale factor) stays the same."



Zoey's Graph

5. **Can an equation express the relationship between your Shrinky Dink and the original drawing? What does the answer to this question tell you about whether the two drawings are similar?** Although some students initially wrote an equation using the mean of a wide range of ratios, others in the class convinced them that such an equation didn't really tell us that the figures were similar unless the ratios were all close in value. Zoey's equation—*s* (shrunken dimension) = .87 X *o* (original dimension)—indicated that linear measurements of her Shrinky Dink were 87 percent of the corresponding measures in her original drawing. She expressed her response to the assignment this way: "I liked seeing all the parts together. That's when it finally made sense to me."

I felt these students showed their grasp of some important ideas about similarity, through both their answers and the connections they made among the several representations of pictures, numerical data, words, graphs, and equations.