

Teacher Guide: Rock Art



Learning Objectives

Students will...

- Recognize and describe translations, rotations, and reflections.
- Predict the result of applying one of these transformations to an image.
- Use transformations to manipulate an image.
- Given a preimage, identify transformations that will result in a given image.
- Provide different combinations of transformations that will result in the same image.



Vocabulary

clockwise, congruent, counterclockwise, image, preimage, reflection, rotation, transformation, translation



Lesson Overview

A mysterious set of cliff paintings has been found in the New Mexico Desert. The paintings are made of pairs of identical symbols. The first symbol in each pair is always in the same location, but the second symbol has been *transformed* by reflection, rotation, or translation.

In the *Rock Art Gizmo™*, students use transformations to create their own rock art paintings. Students are also challenged to match “ancient” rock art. The Student Exploration sheet contains three activities:



- Activity A – Students compare the properties of translations, reflections, and rotations.
- Activity B – Students explore combinations and sequences of transformations.
- Activity C – Students try to match examples of “ancient” rock art.



Suggested Lesson Sequence

1. Pre-Gizmo activity (🕒 15 – 30 minutes)

To introduce transformations, have each student cut out a shape of their own choosing. The only guideline is that the shape should not be symmetrical. (The shape should look different if it is rotated or flipped over.) Ask students how many different ways they can change their shape.

As students describe how they change the position of their shape, introduce the words “translation,” “reflection,” and “rotation.” Discuss how each of these transformations will affect the shape. Do any of these transformations change the size or shape of their cutout? Which transformations change which direction the shape is facing? Which transformations affect where the object is located? Which transformation flips a shape over, so that directions are reversed? (When an object is reflected, one set of directions is reversed: up becomes down, or left becomes right.)

2. **Prior to using the Gizmo** (🧠 10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class. At this point, letting students share how they thought about the questions is more valuable than “going over” the correct answers. After the discussion, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activity** (🧠 15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Have students work part of the Student Exploration sheet using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

It may be overwhelming for students to do all of the activities in the Student Exploration in one sitting. We recommend starting with the first page of the Student Exploration sheet (Prior Knowledge Questions and Gizmo Warm-up) plus one of the two activities. Extend the lesson if you want using the extensions below. Return to the Gizmo and the unused activities in future class periods to reinforce the concepts.

4. **Extending the Gizmo** (🧠 15 – 20 minutes each)
Here are some suggestions for extending the activities in the Student Exploration sheet.

Activity A Extension – Translations, reflections, and rotations are examples of *isometric* transformations. Isometric transformations preserve the size and shape of images. Introduce and discuss other transformations that are not isometric. For example, *resizing* an image preserves shape but not size. Resizing is also called *expansion*, *contraction*, or *dilation*. *Stretching* an image alters both its size and its shape.

Activity B Extension – Continue to explore different combinations of isometric transformations that result in the same image. For example, a vertical reflection is equivalent to a horizontal reflection, a translation, and a 180° rotation. Ask students if the order of the transformations matters. In which cases does it matter what you do first, and in which cases is the result the same? [Students should discover that when reflections are not involved, the order of transformations does not matter.]

Activity C Extension – Use a projector to show your students a “challenge” rock art painting for them to try to duplicate. Students can also work in pairs, challenging each other to duplicate the art that they create. In each case, ask students to compare the lists of transformations that they used. In many cases, students will discover that there are many different ways to achieve the same result!

5. **Follow-up activity: Symmetry** (🧠 45 – 90 minutes)
The concept of symmetry is closely related to transformations. An object has symmetry if it can look the same after a transformation. For example, the Triskelion symbol at right has symmetry because it looks the same after a 120° rotation.

The [Quilting Bee Gizmo](#) Student Exploration sheet explores two types of symmetry: line symmetry and rotational symmetry. Translational symmetry can also be explored on this Gizmo, but is not covered in the Student Exploration.



Triskelion



Mathematical Background

The *Rock Art* Gizmo was designed as a basic introduction to isometric transformations. The three isometric transformations are rotations, reflections, and translations. All of these transformations are isometric because they preserve area, angles, lengths, and overall shape. (The word “isometric” comes from the Greek, meaning “equal measure.”)

To fully describe a transformation, several pieces of information are required.

- To describe a translation, you must specify the horizontal (x) and vertical (y) distance the image is moved. Alternatively, you can specify the direction and total distance that the object is moved.

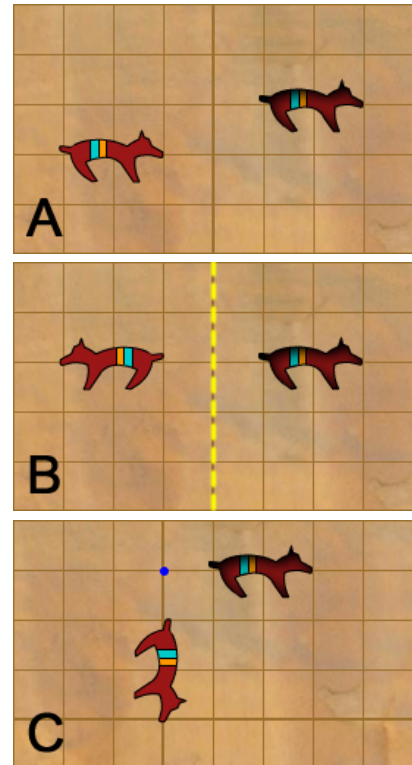
In figure A, the dog has been translated 4 units left and 1 unit down. (The darker dog is the preimage.)

- To describe a reflection, you must specify the line of reflection. The farther the line of reflection is from the original image, the farther the reflected image will be from the preimage. A line of reflection has the same effect as a mirror placed along that line.

In figure B, the dog has been reflected horizontally across the yellow dotted line.

- To describe a rotation, you must specify the *center of rotation*, the angle of the rotation, and whether the rotation is clockwise or counterclockwise.

In figure C, the dog has been rotated 90° clockwise around the small blue dot.



Transformations have many applications in geometry. For example, two shapes are defined as *congruent* if they can be perfectly matched using isometric transformations. Two shapes are defined as *similar* if they can be perfectly matched using isometric transformations and resizing.

Transformations are also involved in symmetry. As explained above, symmetrical images look the same after undergoing an isometric transformation. In college, math students study a field called *linear algebra*. A major topic in linear algebra is using fields of numbers called matrices to represent various kinds of transformations such as shears, stretches, rotations, and reflections.



Selected Web Resources

Types of transformations: <http://www.mathsisfun.com/geometry/transformations.html>

Transformations: <http://oneweb.utc.edu/~Christopher-Mawata/transformations/translations/>

Activities: http://192.107.108.56/portfolios/d/desimone_g/discover2/2transfor.htm

Congruence, symmetry: <http://standards.nctm.org/document/eexamples/chap6/6.4/index.htm>

Symmetry and transformations: <http://mathforum.org/sum95/suzanne/symsusan.html>

Reflecting an “R” activity: <http://mathforum.org/sum95/suzanne/rex.html>

Quilting Bee Gizmo: <http://www.explorellearning.com/gizmo/id?1016>

Rotations, Reflections, and Translations Gizmo: <http://www.explorellearning.com/gizmo/id?269>