

Traditional Transformations, Part 2

Reflections: Osage Ribbonwork

Michell Eike, Teresa Lansford, Patricia McDaniels-Gomez
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Grade Level	9th – 10th Grade	**Time Frame**	80-95 minutes
Subject	Mathematics	**Duration**	2-3 class periods
Course	Geometry		

Essential Question

How are transformations and symbolism used through indigenous cultures?

Summary

In this lesson, students will explore the culture of the Osage tribe and their ribbonwork. Students will apply what they have learned about math and indigenous cultures to create their own ribbonwork design and demonstrate their understanding of reflections and reflective symmetry. Prerequisite knowledge for this lesson includes the following vocabulary: transformation, pre-image, image, and rigid motion, which are all included in the Traditional Transformations, Part 1 lesson. This is the second lesson of five in the "Traditional Transformations" lesson series.

Snapshot

Engage

Students watch a video about the tradition of Osage ribbonwork.

Explore

Students make observations about and discover patterns of reflections over the axes.

Explain

Students complete guided notes with the class and formalize their understanding of common and uncommon reflections.

Extend

Students apply what they have learned to identify lines of symmetry and create their own ribbonwork design.

Evaluate

Students demonstrate their understanding by reflecting a point over a vertical line.

Standards

ACT College and Career Readiness Standards - Mathematics (6-12)

G607: Find the coordinates of a point reflected across a vertical or horizontal line or across y = x

Oklahoma Academic Standards Mathematics (Geometry)

G.2D.1.11: Use numeric, graphic, and algebraic representations of transformations in two dimensions (e.g., reflections, translations, dilations, rotations about the origin by multiples of 90 °) to solve problems involving figures on a coordinate plane and identify types of symmetry.

Attachments

- Exploring Ribbonwork (Part A)—Traditional Transformations, Part 2 - Spanish.docx
- Exploring Ribbonwork (Part A)—Traditional Transformations, Part 2 - Spanish.pdf
- Exploring Ribbonwork (Part A)—Traditional Transformations, Part 2.docx
- Exploring Ribbonwork (Part A)—Traditional Transformations, Part 2.pdf
- Exploring Ribbonwork (Part B)—Traditional Transformations, Part 2 - Spanish.docx
- Exploring Ribbonwork (Part B)—Traditional Transformations, Part 2 - Spanish.pdf
- Exploring Ribbonwork (Part B)—Traditional Transformations, Part 2.docx
- Exploring Ribbonwork (Part B)—Traditional Transformations, Part 2.pdf
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 2.docx
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 2.pdf
- Guided Notes—Traditional Transformations, Part 2 - Spanish.docx
- Guided Notes—Traditional Transformations, Part 2 - Spanish.pdf
- Guided Notes—Traditional Transformations, Part 2.docx
- Guided Notes—Traditional Transformations, Part 2.pdf
- Lesson Slides—Traditional Transformations, Part 2.pptx
- Over the Line—Traditional Transformations, Part 2 - Spanish.docx
- Over the Line—Traditional Transformations, Part 2 - Spanish.pdf
- Over the Line—Traditional Transformations, Part 2.docx
- Over the Line—Traditional Transformations, Part 2.pdf
- Perfecting Patterns—Traditional Transformations, Part 2 - Spanish.docx
- Perfecting Patterns—Traditional Transformations, Part 2 - Spanish.pdf
- Perfecting Patterns—Traditional Transformations, Part 2.docx
- Perfecting Patterns—Traditional Transformations, Part 2.pdf
- Seeing Symmetry—Traditional Transformations, Part 2 - Spanish.docx
- Seeing Symmetry—Traditional Transformations, Part 2 - Spanish.pdf
- Seeing Symmetry—Traditional Transformations, Part 2.docx
- Seeing Symmetry—Traditional Transformations, Part 2.pdf

Materials

- Lesson Slides (attached)
- Exploring Ribbonwork (Part A) handout (attached; one per student; printed front only)
- Exploring Ribbonwork (Part B) handout (attached; one per student; printed front/back)
- Guided Notes handout (attached; one per student; printed front/back)
- Guided Notes (Teacher Guide and Model Notes) document (attached; for teacher use)
- Seeing Symmetry handout (attached; one per student; printed front only)
- Perfecting Patterns handout (attached; one per student; printed front only)
- Over the Line handout (attached; one quarter per student; printed front only)
- Pencils
- Coloring utensils (colored pencils, markers, etc.; 4 per student)
- Paper

- Graph paper
- Scissors (one pair per student)
- Compass
- Straightedge
- Patty Paper (optional; 1-2 per student)
- Plastic reflective device, such as GeoMirror, Mira, etc. (optional; one per student)
- Construction paper (optional; 4 different colored strips per student)

15 minutes

Engage

Teacher's Note: Respecting Native Cultures

To provide a real world example of geometric transformations, we are incorporating tribal culture from some of the 39 Tribes of Oklahoma. Students will be able to experience real-world connections and learn more about a few of the indigenous tribes of Oklahoma in order to learn these Geometry standards in a more authentic and concrete way.

This lesson series is centered around arts and crafts of various tribes of Oklahoma. Tell students about the Indian Arts and Crafts Act of 1990, which says that no non-Native person is to create tribal art and sell it as tribally made. During these lessons, inform students that they are creating their own artwork inspired by specific tribes' customs, but they are not creating the tribes' art.

Introduce the lesson using the attached **Lesson Slides**. **Slide 3** displays the lesson series' essential question. **Slide 4** identifies the lesson's learning objectives. Review each of these with your class to the extent you feel necessary.

Display **slide 5** and let students know that they are about to watch a video of Dana Daylight sharing her knowledge of her tribe and how she uses reflections in her Osage ribbonwork creations. Explain that after watching the video, they will be asked to share something new they learned from the video and something that they already knew.

Show **slide 6** and play the "Osage Ribbonwork and Reflections" video on the slide.

Embedded video
https://youtube.com/watch?v=CCU7hBirn9c

Transition to **slide 7** and introduce the Elbow Partners strategy to the class. Have students discuss the following questions with their partner, focusing on mathematics of ribbonwork and the Osage culture:

- What is one new thing you learned?
- What is one thing that you already knew?

If time allows, ask for volunteers to share with the class.

15 minutes

Explore

Show **slide 8** and pass out a copy of the attached **Exploring Ribbonwork (Part A)** handout to each student. Share with students that during this activity, they will be working with an arrow pattern from Osage ribbonwork.

Have students work individually to complete the pattern in Quadrant III, then ask them to answer the following prompts on the handout:

- How did you complete the pattern?
- Describe how the pre-image transformed into *image 2*.
- Describe how the pre-image transformed into *image 4*.

Teacher's Note: Guiding the Activity

Ask more questions than you give answers. The purpose here is for students to reflect either *image 2* or *image 4* over the *x*-axis or *y*-axis, respectively. Some students may see rotational symmetry from *image 1*. Challenge those students to not use *image 1* to create *image 3* and ask if there is something other than rotations or translations that might help them complete the pattern.

Remember that this is not yet the point in the lesson to answer questions or worry about proper vocabulary. Some students may remember reflections from middle school while others do not, and that is okay.

Have students find partners or assign students partners. Direct them to compare their work and responses. If time allows, ask for a few volunteers to share with the whole class.

Transition to **slide 9** and distribute a copy of the attached **Exploring Ribbonwork (Part B)** handout to students. Direct their attention to the top of the page: *Reflect Over the y-Axis*. Instruct pairs to complete the table and answer the following questions:

- Does your rule apply when *image 4* is reflected over the *y*-axis to get *image 3*?
- Does your rule apply when *image 2* is reflected over the *x*-axis to get *image 3*?

Here, students are looking for patterns to write an algebraic rule to describe a reflection over the *y*-axis. If time allows, ask for a few volunteers to share their responses with the whole class.

Direct their attention to the back of the page: *Reflect Over the x-Axis*. Instruct pairs to complete the table and answer the following questions:

- Does your rule apply to the other pair of reflections over the *x*-axis?
- What else do you think we could reflect a figure over?

Here, students are looking for patterns to write an algebraic rule to describe a reflection over the *x*-axis and consider reflections over something other than an axis. If time allows, ask for a few volunteers to share their responses with the whole class.

Teacher's Note: Guiding the Lesson

Students will refer back to their algebraic rules from the Exploring Ribbonwork handout during the Explain portion of the lesson. That will be when students get confirmation on the accuracy of their rules.

20 minutes

Explain

Customizing Student Learning

The Guided Notes handout has vocabulary with illustrations and three practice problems. The first two examples are polygons on the coordinate plane, while the third example is a polygon not on the coordinate plane. Use the attached **Guided Notes (Teacher Guide and Model Notes)** document as reference. If you only want students to work with reflections on the coordinate plane, delete example 3 before printing the handout.

The activities that follow during Extend and Evaluate are all on the coordinate plane.

Display **slide 10** and provide the attached **Guided Notes** handout to each student.

Introduce the vocabulary of *reflection* to the class and guide them to write this vocabulary word on their handout. Then ask for a volunteer to answer the following question: *Is a reflection an example of rigid motion?* Be sure to have the student provide reasoning. Have students record the answer (yes) with justification on their handout.

Go through the algebraic rules for reflections over the x-axis, the y-axis, the line $y = x$, and the line $y = -x$. Have students use the pictures on their Guided Notes as well as their work from the Explore portion of the lesson to develop the rules.

Teacher's Note: Guiding the Lesson

Try not to directly tell the students what the algebraic rules are. Students should be able to come up with these rules on their own or with some prompting questions. Consider the following questions, if needed.

- What happens to the x-values of the ordered pairs when the figure is reflected over ...?
- What happens to the y-values of the ordered pairs when the figure is reflected over ...?
- When reflecting over the line $y = x$, how could we algebraically describe that the x- and y-values traded places?
- When reflecting over the line $y = -x$, every y-value is now the negative of the original x-value? Could we solve the equation $y = -x$ for x to see what every new x-value should be?

For students who consistently struggle with the pattern for $y = x$ and $y = -x$, it can also be helpful to rephrase it, using the words *same* and *opposite*.

- If the point (2, 3) is on the pre-image, and the pre-image were reflected over the line $y = x$, then the y-value for the image would be the same as the original x-value. In other words, the new y-value would be 2, the original x-value. Similarly, the new x-value would be the same as the original y-value: 3. So, the corresponding point on the image is (3, 2).
- If the point (4, 1) is on the pre-image, and the pre-image were reflected over the line $y = -x$, then the y-value for the image would be the opposite of the original x-value. In other words, the new y-value would be the opposite of 4: –4. If we solve $y = -x$ for x, we get $x = -y$. So the new x-value would be the opposite of the original y-value: –1. Therefore, the corresponding point on the image would be (–1, –4).

Direct students' attention to the back of their handout and complete the examples as a class. After example 1, consider asking the students to work with their partner to try example 2, before bringing the class back together to ensure everyone is understanding.

Help students see that example 2 is a vertical reflection and just like the vertical reflection over the *x*-axis, the *x*-values of the corresponding vertices did not change.

Give each student a compass and straightedge, then guide the class through how to complete a reflection not on the coordinate plane with example 3.

Teacher's Note: Guiding the Lesson

Encourage academic vocabulary by having students drop the middle school language of "flip" and adopt the high school language of "reflect".

This is also the time in the lesson to correct any misunderstandings and directly answer questions.

Additional Scaffolding

For the Explain and Extend portions of this lesson, consider using patty paper. Patty paper is a great supply to use to help students who struggle with seeing transformations. If patty paper is not available, consider using parchment paper, wax paper, or tracing paper instead. Give each student a piece of patty paper to help take the pre-image and reflect it with the following steps:

1. Trace the pre-image (or at least the vertices) and the reflection line with a pencil.
2. Label the vertices.
3. Flip the paper over.
4. Line up the traced reflection line with the given reflection line.
5. Use the see-through property of the paper to trace the figure or the vertices on the patty paper such that the pencil lead transfers from the patty paper to the handout.
6. Label the new vertices on the handout. Consider just lifting part of the patty paper at a time to keep track of the original vertices.
7. Lift the patty paper and use a straightedge to connect the vertices, if needed.

Reflective Device

The plastic tool used to allow students to see the reflection, like a mirror, and be able to reach around it to sketch the reflection are often called a GeoMirror, Mira, GeoReflector Mirror, etc. This tool is an alternative to using patty paper.

Go to MathBitsNotebook to check out how to use this tool.

Have students add their completed Guided Notes to their math notebooks if that is a classroom norm.

25 minutes

Extend

Now it is time for students to apply what they have learned and to recall some prior knowledge. Give each student a copy of the attached **Seeing Symmetry** handout. Display **slide 11** and remind students what a *line of symmetry* is.

Transition to **slide 12** and have students independently work to write the equation(s) for the line(s) of symmetry of the given figure for question 1.

As students complete question 1, transition to **slide 13** and give students time to check their work and ask questions.

Show **slide 14** and have students again work independently to write the equation(s) for the line(s) of symmetry for question 2.

Once students complete question 2, have them find a partner and compare their equations. Then, display **slide 15** so pairs can check their work. Give pairs time to discuss their work and make changes as needed.

Display **slide 16** and have pairs write the equation(s) for the line(s) of symmetry for question 3.

Teacher's Note: Guiding the Activity

Question 3 is quite a bit more challenging than the first two since the second line of symmetry is not quite as obvious. Where the color changes in the image, there is a line with a slope of a negative one-third, which is relatively simple to find since that line visually goes through nice coordinate points. The second line of symmetry is perpendicular to this. Prompt students to imagine where they think the line is and ask them to recall the relationship between slopes of perpendicular lines (negative reciprocals). This prompt should help them see that the slope of the second line of symmetry is three.

Encourage students to use their straightedge to sketch their lines before writing the equations.

As students finish the last question, transition to **slide 17** and allow time for pairs to check their work.

Once students feel comfortable with finding lines of symmetry and writing their equations, move to **slide 18** and facilitate a whole-class discussion regarding the following questions:

- Where else do you see reflective symmetry?
- What is something in this room or that is familiar to you that only has one line of symmetry?
- What is something in this room or that is familiar to you that has zero lines of symmetry?
- What is something in this room or that is familiar to you that has two lines of symmetry? More than two lines of symmetry?

Sample Student Responses:

Responses will likely vary greatly.

- I see reflective symmetry when I take a selfie.
- The dry erase board has one vertical line of symmetry.
- My notebook paper has one horizontal line of symmetry.
- The classroom door has zero lines of symmetry because there is only a window on the left (not also on the right), and the handle is not both above and below the window.
- The ceiling tile has two lines of symmetry because it is a rectangle.
- The tile on the floor has more than two lines of symmetry. It is a square, so it has four lines of symmetry.

Teacher's Note: Copying Art

While we want to celebrate the important contributions of Native people and ensure students learn about these art forms, we must be mindful that copying tribal designs is considered disrespectful and is strongly discouraged because many of these designs hold historical and familial meaning. Please help students be aware of this historic theft from Native people and understand why it is important that such theft does not continue.

Show **slide 19** and give each student a copy of the attached **Perfecting Patterns** handout. Instruct students to get into groups of 3-4 or assign groups. Then share with the class the Pass the Problem strategy.

Explain to the class that they are now to follow the directions for "Student A" and to write their name at the top of the upper-left box. Instruct everyone to think about the ribbonwork designs that they have learned about and create their own polygon design (pre-image) in Quadrant II.

Move to **slide 20** and have everyone pass their paper to the person on their right within their group. Explain that they are now to follow the directions for "Student B" and to write their name at the top of the upper-right box. Direct everyone to label the vertices of Student A's design. Remind students that the letters should go in alphabetical order but can go clockwise or counterclockwise.

Then direct the class to use the space in their handout to create a table of the corresponding points if the pre-image was reflected over the x-axis. In other words, students are expected to use what they have learned during this lesson to write the new ordered pairs for the corresponding vertices of the image without drawing the reflection.

Teacher's Note: Guiding the Activity

Challenge students to not draw the reflected image but think about their algebraic rules. Remind the class that their tables should have corresponding points clearly labeled. For example, if Student A's design has a vertex at $H(2, 3)$, then $H'(2, -3)$ should be in Student B's table.

Move to **slide 21** and have everyone pass their paper to the person on their right within their group. Explain that they are now to follow the directions for "Student C" and to write their name at the top of the lower-left box. Direct everyone to check Student B's table. Give time for students to check and talk through and correct any mistakes.

Now direct the class to use the space in their handout to create a table of the corresponding points if the pre-image (from Student A) was reflected over the *y*-axis. In other words, students are expected to use what they have learned during this lesson to write the new ordered pairs for the corresponding vertices of the image without drawing the reflection.

Show **slide 22** and have everyone pass their paper back to Student A. Give each student a piece of graph paper.

Instruct everyone to copy their pre-image to their graph paper and then plot the points from Student B's table and Student C's table, then work together to adjust any points that need to be corrected.

Display **slide 23** and direct students to complete the ribbonwork design by completing the pattern in Quadrant IV. Then let them know that instead of appliquéing their designs onto an article of clothing, they will be using their pattern to make a bookmark.

Have students use 4 coloring tools to color their design. Remind the class to use contrasting light and dark colors like the Osage tribe does. Consider giving students the challenge of using more than 4 colors while keeping the symmetry. Give students scissors and time to cut out their design, which they can use as a bookmark.

Alternative Approach

Instead of coloring the design, consider having students cut out their design, that is on graph paper, to use as a template to cut construction paper to create their bookmark. This is more similar to what the Osage people do when they create their ribbonwork, except they use their template to cut fabric instead of construction paper.

This approach would take additional time and preparation but would be more authentic. Consider cutting strips of construction paper to distribute instead of full sheets to save materials.

Watch the video "Grow Gather Hunt Virtual Camp 03 - Ribbon work Bookmarks" from Dana Daylight and the Cultural Center for additional details on creating the bookmark with construction paper. Keep in mind that you are not receiving but creating the "packet" that is referred to during the video.

5 minutes

Evaluate

Display **slide 24** and use the Exit Ticket strategy to individually assess what students have learned from the lesson. Give each student a quarter-sheet of the attached **Over the Line** handout or give students a sticky note, an index card, etc. for them to write their response. Use the hidden **slide 25** for a sample response.

Collect student responses and use them to determine if your students need additional practice or are ready for the next lesson. If students need additional practice, consider having students practice with more basic shapes, like reflecting triangles or even just individual points over a line. Also, consider giving students problems where the line of reflection goes through the polygon instead of being next to the polygon.

The "Traditional Transformations, Part 3" lesson is about rotations, rotational symmetry, and Lakota star quilts.

Teacher's Note: ACT Prep

Identifying lines of symmetry and determining the new coordinates after a reflection are skills needed for the ACT exam. These questions often only ask students to reflect one point as opposed to a whole figure since it is a timed exam.

Resources

- K20 Center. (n.d.). Bell Ringers and Exit Tickets. Strategies. https://learn.k20center.ou.edu/strategy/125
- K20 Center. (n.d.). Desmos classroom. Tech Tools. https://learn.k20center.ou.edu/tech-tool/1081
- K20 Center. (n.d.). Elbow Partners. Strategies. https://learn.k20center.ou.edu/strategy/116
- K20 Center. (n.d.). Pass the Problem. Strategies. https://learn.k20center.ou.edu/strategy/151
- K20 Center. (2023, July 5). *Osage ribbonwork and reflections* [Video]. YouTube. https://youtu.be/CCU7hBirn9c?si=hDNjlL8FbxcZELAV
- Osage Nation. [OsagenationnsnGovmedia]. (2020, July 21). *Grow Gather Hunt Virtual Camp 03 - Ribbon work Bookmarks* [Video]. YouTube. https://youtu.be/8IofzcZUXzg