Traditional Transformations, Part 2

Reflections: Osage Ribbonwork

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Published by *K20 Center*

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

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

- Desmos account
- Guided Notes handout (attached; one per student; printed front/back)
- Guided Notes (Teacher Guide and Model Notes) document (attached; for teacher use)
- Perfecting Patterns handout (attached; one per student; printed front only)
- Pencils
- Coloring utensils (colored pencils, markers, etc.; 4 per student)
- Paper
- Graph paper
- Scissors (one pair per student)
- Compass (one per student)
- Straightedge (one per student)
- Construction paper (optional; 4 different colored strips per student)
- Student devices with Internet access

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.

Teacher's Note: Desmos Classroom Activity Preparation

To use this Desmos Classroom activity, select the following link: "Traditional Transformations, Part 2." Create an account or sign in under the "Activity Sessions'' heading. After you log in, the green "Assign" dropdown button will be active. Click the arrow next to the word "Assign," then select "Single Session Code." After making some setting selections, select "Create Invitation Code'' and give the session code to students. For more information about previewing and assigning a Desmos Classroom activity, go to Desmos Classroom: Using Activities.

For more detailed information about Desmos features and how-to tips, go to Desmos Resources.

To set up the activity's pacing for students, select "View Dashboard" (next to the session code). In the upper-left corner of your screen, select the icon above the word "Pacing." Desmos Classroom should then prompt you to select the first and last screens that you want students to see. When prompted to set a range, select screens 1 and 4. Select "Restrict to Screens 1–4" to confirm your selection. This allows students to access only screens 1–4 at this time. For more information about teacher pacing, go to Pacing Activities.

Provide students with your session code. Then, have students go to the Desmos Student homepage and enter the session code.

Teacher's Note: Sign-in Options

If students sign in with their Google or Desmos accounts, their progress is saved and they can resume the activity or view their work later. If students continue without signing in, they can complete the activity but they must do so in one sitting. It is strongly recommended that students sign in rather than risk losing their work.

Introduce the lesson with **screens 1–2** of the Desmos Activity. **Screen 1** displays the lesson series' essential question. **Screen 2** identifies the lesson's learning objectives. Review each of these with students to the extent you feel necessary.

Direct students' attention to **screen 3**. 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. Have students watch the "Osage Ribbonwork and Reflections" video on the screen.

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

After watching the video, direct students' attention to **screen 4** and introduce the Elbow Partners strategy to the class. Have students discuss with their partner the following questions, focusing on the 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

On the Dashboard, press the orange plus sign to allow students to progress to **screen 5**. Give students a couple of minutes to learn how to use the Desmos sketch tools.

Press the orange plus sign on the Dashboard three times to allow students to progress to **screens 6-8**.

Share with students that during this activity, they will be working with an arrow pattern from Osage ribbonwork. Direct students to use the sketch tools to complete the pattern in Quadrant III, then answer the prompts on their screen:

- 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 from screen 6. If time allows, ask for a few volunteers to share with the whole class.

Have pairs work together through screens 7-8 where they are looking for patterns between the pre-image and reflected images to attempt to write the algebraic rule on their own.

Guide students to use the “Type Math” button and copy the mapping symbol on the screen to more easily input their coordinate rule. If students see “\to” when they paste the mapping symbol, have them highlight that text, then press the “Type Math” button to convert that syntax into the symbol.

As 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 these screens 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. Example 3 is not in the Desmos activity, since it is a hands-on construction.

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

Give each student a copy of the attached **Guided Notes** handout, then press the orange plus sign on the Dashboard to allow students to progress to **screen 9**. Introduce the vocabulary of *reflection* to the class and guide them to write that vocabulary word on their handout. This is both on screen 9 and on the handout. Then ask the following question: *Is a reflection an example of rigid motion?* Ask students to enter their response with reasoning into screen 9. Then ask for a few volunteers to share. Be sure to have the student provide reasoning. Have students record the answer (yes) with justification on their handout.

On the Dashboard, press the orange plus sign four times to allow students to progress to **screens 10-13**. Go through the algebraic rules of special reflections regarding reflections over the x-axis, the y-axis, the line $y = x$, and the line $y = -x$; there is one special reflection per screen. Consider having students take a moment to talk with their partner about what they think the rule should be and enter that response into the Desmos Classroom activity. Then, bring the class together for a discussion on each one. Have students use the pictures on their Guided Notes or Desmos Classroom activity as well as their work from screens 7-8 to develop the rules.

Students will receive feedback on their algebraic rules on screens 10-13. Be sure to help students see that the rule is already started for them using (a, b); feedback is based on this given. Help students see that a is the x-value and b is the y-value. Have students record on their handout the notation that makes sense to them.

Teacher's Note: Guiding the Lesson

Ask guiding questions, but 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 really 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 press the orange plus sign on the Dashboard twice to allow students to progress to **screens 14-15**. Direct students to follow the directions on the screen and use the Desmos Classroom activity to complete examples 1-2 on their handout. Here, students will see a "Reflect" button when they complete their table. Pressing the button shows the pre-image reflected to where it should go and provides students feedback.

Circulate the room or use the Dashboard to ensure everyone understands. Consider bringing the class together after each example to answer any questions.

Give each student a compass and straightedge, then direct them to set aside their device. 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.

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

25 minutes

Extend

It is time for students to apply what they have learned and to recall some prior knowledge. On the Dashboard, click the orange "Stop" button; now students can complete the Desmos activity at their own pace. Direct their attention to **screen 16** and remind students what a *line of symmetry* is.

Instruct students to work independently on **screens 17-18**. Here, students can use the sketch tool to draw on the given figure and identify how many lines of symmetry the figure has and write the equation(s) for the line(s) of symmetry. Students will receive feedback about their entered equations.

Once students complete question 2, have them find a partner and compare their equations. This can be the same partner from before or a new partner.

Instruct pairs to collaborate to write the equation(s) for the line(s) of symmetry for **screen 19**.

Teacher's Note: Guiding the Activity

On screen 19, 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 sketch tools to draw their lines before writing the equations.

Once students feel comfortable with finding lines of symmetry and writing their equations, direct their attention to the next screen and facilitate a whole-class discussion regarding the following questions. **Screens 20-22** have a place for students to enter their ideas before sharing with the class. Students will also see three other students' responses in the Desmos Classroom activity.

- Screen 20:
  What is something in this room or that is familiar to you that only has 1 line of symmetry?
- Screen 21:
  What is something in this room or that is familiar to you that has zero lines of symmetry?
- Screen 22:
  What is something in this room or that is familiar to you that has at least 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 1 vertical line of symmetry.
- My notebook paper has 1 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 2 lines of symmetry because it is a rectangle.
- The tile on the floor has more than 2 lines of symmetry. It is a square, so it has 4 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.

When students get to **screen 23**, have them set aside their Desmos Classroom activity 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.

Now, 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.

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.

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 issues 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.

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.

Direct the 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.

Then, 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

Use the Exit Ticket strategy to assess what students have learned individually. Have students go back to their Desmos Classroom activity and direct their attention to **screen 24**. Here, students are asked to reflect a point over a vertical line and enter the new coordinates and the Desmos Classroom activity provides feedback on student responses only to the teacher.

Use student responses to determine if your students need additional practice or are ready for the next lesson. If students need additional practice, consider having them 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