Traditional Transformations, Part 3

Rotations: Plains Star Quilts

Michell Eike, Laura Halstied, Teresa Lansford, Patricia McDaniels-Gomez
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Grade Level	9th – 10th Grade	**Time Frame**	90-105 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 Plains tribes and their Star Quilts. They will then use patterns to explore rotations and discover algebraic rules for common rotations. Students will apply what they learn to create their own quilt block and demonstrate their understanding of rotations and rotational symmetry. Prerequisite vocabulary knowledge for this lesson includes transformation, preimage, image, and rigid motion, which are all included in the Traditional Transformations, Part 1 lesson. This is the third lesson of five in the "Traditional Transformations" lesson series.

Snapshot

Engage

Students watch a video about the tradition of Plains Star Quilts.

Explore

Students make observations and discover patterns for rotations about the origin.

Explain

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

Extend

Students apply what they have learned to identify different types of transformations and create their own quilt blocks using rotations.

Evaluate

Students demonstrate their understanding by rotating a point 180° about another point.

Standards

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

G512: Find the coordinates of a point rotated 180° around a given center point
G608: Find the coordinates of a point rotated 90° about the origin

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

- Creating Qulit Blocks—Traditional Transformations, Part 3 - Spanish.docx
- Creating Qulit Blocks—Traditional Transformations, Part 3 - Spanish.pdf
- Creating Qulit Blocks—Traditional Transformations, Part 3.docx
- Creating Qulit Blocks—Traditional Transformations, Part 3.pdf
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 3.docx
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 3.pdf
- Guided Notes—Traditional Transformations, Part 3 - Spanish.docx
- Guided Notes—Traditional Transformations, Part 3 - Spanish.pdf
- Guided Notes—Traditional Transformations, Part 3.docx
- Guided Notes—Traditional Transformations, Part 3.pdf
- Lesson Slides—Traditional Transformations, Part 3.pptx
- Rotation Exit Ticket—Traditional Transformations, Part 3 - Spanish.docx
- Rotation Exit Ticket—Traditional Transformations, Part 3 - Spanish.pdf
- Rotation Exit Ticket—Traditional Transformations, Part 3.docx
- Rotation Exit Ticket—Traditional Transformations, Part 3.pdf
- Star Quilt Transformations—Traditional Transformations, Part 3 - Spanish.docx
- Star Quilt Transformations—Traditional Transformations, Part 3 - Spanish.pdf
- Star Quilt Transformations—Traditional Transformations, Part 3.docx
- Star Quilt Transformations—Traditional Transformations, Part 3.pdf
- Tribal Transformations—Traditional Transformations, Part 3 - Spanish.docx
- Tribal Transformations—Traditional Transformations, Part 3 - Spanish.pdf
- Tribal Transformations—Traditional Transformations, Part 3.docx
- Tribal Transformations—Traditional Transformations, Part 3.pdf

Materials

- Lesson Slides (attached)
- Tribal Transformations 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)
- Star Quilt Transformations handout (attached; one per student; printed front only)
- Rotation Exit Ticket handout (attached; one quarter per student; printed front only)
- Pencils
- Paper
- Graph paper
- Creating Quilt Blocks handout (optional; attached; one per student; printed front only)
- Compass (one per student)
- Protractor (one per student)
- Patty Paper (optional; 1–2 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. This allows students to gain an authentic and concrete understanding of Geometry standards while gaining insights into the indigenous culture of Oklahoma.

This lesson series is centered around the arts and crafts of various tribes of Oklahoma. Inform students about the Indian Arts and Crafts Act of 1990, which prohibits non-Native individuals from creating and selling tribal art as authentic tribal products. During these lessons, inform students that they will create their own artwork that is inspired by specific tribes' customs, but they are not creating the tribes' art in itself.

Introduce the lesson using the attached **Lesson Slides**. Review the lesson series' essential question on **slide 3** and the lesson's learning objectives on **slide 4** to the extent you feel necessary.

Display **slide 5** and introduce the GramIt instructional strategy. Let students know that they are about to watch a video of Crystal Pewo Lightfoot, a member of the Apache Tribe of Oklahoma and a descendant of the Kiowa Tribe, sharing her knowledge of her tribal culture and how she uses rotations in her Star Quilt creations. Explain that, after watching the video, they will be asked to create two hashtags: one representing an aspect of the culture they learned about, and another representing a mathematical concept they learned.

Show **slide 6** and play the "Plains Star Quilts and Rotations" embedded video on the slide.

Embedded video
https://youtube.com/watch?v=YJxmt0dt3mw

Teacher's Note: Giveaways

In the video, Crystal Pewo Lightfoot mentions "gift-giving" and "giveaways". The terms refer to the tradition of giving back and showing appreciation by offering gifts. This practice is a reminder of generosity, humility, and the virtue of giving instead or receiving. For instance, in a celebration gathering, the celebrated individual would often give gifts to the attendees or loved ones instead of being the one who receives the gifts like in many other traditions. In her culture, it would be a very high honor to receive a gift like a Star Quilt because of the significant amount of time and materials needed to create the quilt.

Move to **slide 7** and have students take out a piece of paper. Then, ask them to write two hashtags, each representing a cultural and mathematical aspect they learned from the video.

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

15 minutes

Explore

Show **slide 8** and pass out a copy of the attached **Tribal Transformations** handout to each student. Share with students that, for this activity, they will work with an arrow symbol from a Plains-style quilt design.

Ask students to partner up or assign them their partners to complete the Tribal Transformations handout. For question 1, direct them to complete the table next to the coordinate plane. Then, ask students to use that table to try to figure out an algebraic rule for that transformation and to then describe the transformation.

Have students repeat this procedure for questions 2–3.

Teacher's Note: Helping Students

At this time, ask more questions than you give answers. The purpose here is for students to find a pattern from the preimage to *image 2* and to notice that the transformation is a rotation.

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

Teacher's Note: Guiding the Lesson

Students will refer back to their algebraic rules from the Traditional Transformations handout during the Explain portion of the lesson. During that part of the lesson, students will receive a confirmation of the accuracy of their rules.

20 minutes

Explain

Customizing Student Learning

The Guided Notes handout illustrates the vocabulary and provides students with three practice problems. The first two problems include polygons on the coordinate plane, while the third includes a polygon without a coordinate plane. The **Guided Notes (Teacher Guide and Model Notes)** document contains the answers for reference. If you only want students to work with rotations on coordinate planes, delete example 3 before printing the handout.

The activities on Extend and Evaluate are all on coordinate planes.

Display **slide 9** and provide the attached **Guided Notes** handout to each student.

Introduce the vocabulary of *rotation* and *angle of rotation* to the class and guide them to write those vocabulary words on their handout. Remind students of the difference between *clockwise* and *counterclockwise* and let them know that all rotations are assumed to be counterclockwise unless otherwise stated. Then ask for a volunteer to answer, "Is a rotation an example of rigid motion?" Make sure to ask the student to provide their reasoning. Have students record the answer ("yes") with justification on their handout.

Now, go through the special rotation algebraic rules for rotations of 90°, 180°, and 270° about the origin. Have students use the illustration on their Guided Notes and their work from the Explore part to develop the rules.

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 rotated ...°? Did you see those same values somewhere else on the points from the preimage?
- What happens to the *y*-values of the ordered pairs when the figure is rotated ...°? Did you see those same values somewhere else on the points from the preimage?

Ask the class to finish the following prompts at the bottom of their handout:

- Rotating a figure 90° CCW is the same as rotating the figure ...°.
- Rotating a figure 180° CCW is the same as rotating the figure ...°.
- Rotating a figure 90° CW is the same as rotating the figure ...°.

Teacher's Note: Guiding the Lesson

Use the prompts above to help students see why counterclockwise is implied (counterclockwise is both the direction of positive angle measures and quadrant numbering). In other words, rotating a figure –90° about the origin would be the same as rotating clockwise +90°, while rotating a figure +90° about the origin is the same as rotating counterclockwise +90°.

Help students see that their algebraic rules work when they rotate a figure about the origin. Moreover, they can still apply the same rules to other figures about any point.

Give each student a compass and protractor. Then, with example 3, guide the class through rotating a figure that is not on a coordinate plane.

Teacher's Note: Guiding the Lesson

Help students learn academic vocabulary by encouraging them to drop the middle-school language of "turn". Instead, ask them to use the high-school language "rotate" instead.

During this part of the lesson, answer questions and correct misunderstandings that students may have.

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

Additional Scaffolding

For the Explain and Extend portions of this lesson, consider handing out pencils and patty paper to help students who struggle visualizing transformations. Patty paper is great for this activity because of its see-through property and low graphite adhesion, which means that pencil marks made on the paper can be easily smudged onto another surface. Alternatively, you can also use parchment paper, wax paper, or tracing paper for this activity.

Here are the steps to use patty paper to capture and rotate a figure's preimage:

1. Place the patty paper on top of the handout.
2. On the patty paper, trace the figure's center of rotation and sketch short horizontal and vertical line segments that intersect at the center of rotation (e.g., when the center of rotation is the origin, sketch part of the x- and y-axes as the horizontal and vertical lines). These segments will help students visualize 90° rotations later.
3. Trace the preimage (or at least the vertices) of the figure with a pencil.
4. Label the vertices.
5. Flip the patty paper over.
6. On the back of the patty paper, use its see-through property to trace and draw the figure's vertices. The vertices need to be drawn boldly so that the lead of the pencil will later transfer onto the handout paper later. During this step, make sure students move away their patty paper from their handout to prevent lead transfer.
7. Once the vertices are drawn boldly, flip the patty paper to its original side.
8. Align the traced preimage and center of rotation with those on the handout.
9. Press the pencil tip on the center of rotation and use the pencil to secure the patty paper in place as you rotate it.
10. Use the sketched vertical and horizontal line segments to help rotate the preimage in 90° increments, following the given transformation.
11. Once the figure reaches the desired rotation, retrace the vertices on the patty paper. The pressure from the pencil will transfer the pencil lead from the back of the patty paper onto the handout.
12. Label the new vertices on the handout. To keep track of the original vertices, consider just lifting part of the patty paper when writing on the handout.
13. Lift the patty paper and use the edge of the protractor to connect the vertices on the handout.

35 minutes

Extend

Display **slide 10** and remind students what *rotational symmetry* and the *center of symmetry* mean.

Transition to **slide 11** and facilitate a whole-class discussion regarding the question, "Where else do you see rotational symmetry?"

Sample Student Responses:

Responses will likely vary.

- I see rotational symmetry in my ceiling fan at home.
- My #2 pencil has rotational symmetry because it is a hexagonal prism.
- Our table has rotational symmetry of 180° because it is a rectangle.

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 12** and give each student a copy of the attached **Star Quilt Transformations** handout and four coloring utensils that students can share. Have students work individually to color code their Star Quilt pattern: one color should be the preimage, and the other three colors should each indicate either a translation, reflection, or rotation. Let students know that not every rhombus needs to be fully colored by the end of this activity.

Encourage students to collaborate with a partner to help each other see the different transformations.

Teacher's Note: Guiding the Activity

Encourage students to fold or overlap their papers with one another to compare the rhombi with the preimage.

This activity will have multiple right answers; use the hidden **slide 13** for an idea of what to expect from students.

Students may observe that if they applied more than one transformation to their preimage, the multiple transformations would result in a certain rhombus. That is an accurate observation, so commend students who make that connection and let them know that multiple transformations will be discussed later in this lesson series (specifically during part 5). For now, they are challenged to consider only one transformation to the preimage as they color code their Star Quilt design.

Once students complete the activity, get them into groups of four and compare their results. As time allows, ask for volunteers to share any observations with the whole class.

Transition to **slide 14** and give each student a piece of graph paper or the attached **Creating Quilt Blocks** handout. If students are using graph paper, ask them to draw the *x*- and *y*-axes in the center of the page.

Share the Pass the Problem strategy with the class. Explain that each group will work together to create four unique quilt blocks. Explain that each person will create their own preimage in Quadrant III, then pass the problem around to complete the quilt block design collaboratively. Tell students that their preimage creation can be a tessellation—like the Plains Star Quilt pattern—but is not required to be. Take a moment to introduce or remind students of the vocabulary *tessellations*, which is the repetition of one or more shapes such that the shapes cover a surface with no gaps or overlap.

Show **slide 15** and direct each student to create their own preimage in Quadrant III. Then instruct them to label at least four vertices.

After a few minutes, transition to **slide 16** and have everyone pass their paper to their right. On the paper they received, have them draw the image by rotating the preimage 270° about the origin, then have them label the corresponding vertices.

After a few minutes, show **slide 17** and have everyone pass their paper to their right. Ask them to check the work of the previous student, draw another image by rotating the preimage 180° about the origin, and label the corresponding vertices.

After a few minutes, display **slide 18** and have everyone pass their paper to their right, check the previous student's work, draw the image by rotating the preimage 90° about the origin, and label the corresponding vertices. Encourage students to work together to adjust any points that need to be corrected.

After a few minutes, transition to **slide 19** and have everyone pass their paper to their right. The paper should now return to the student who drew the preimage. Have them check the previous work and for rotational symmetry.

Consider having students display their quilt blocks on the wall to make a class quilt.

5 minutes

Evaluate

Display **slide 20** 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 **Rotation Exit Ticket** handout. Alternatively, give students a sticky note or an index card to write their responses. Use the hidden **slide 21** for a sample response.

Collect student responses and use them to determine if your students need additional practice or if they are ready for the next lesson. If students need additional practice, consider having students practice with more basic shapes, like rotating triangles or even just individual points about the origin 90°, 180°, or 270°.

The "Traditional Transformations, Part 4" lesson will discuss dilations and beadwork.

Teacher's Note: ACT Prep

Determining the new coordinates after a rotation of 90° and 180° are skills needed for the ACT exam. These questions often only ask students to rotate one point as opposed to a whole figure since it is a timed exam.

Cross-Curricular Opportunity

If you are interested in a cross-curricular lesson, share the lesson: https://learn.k20center.ou.edu/lesson/2936 with your art teacher, as it also celebrates the art of creating Star Quilts.

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.). Gramit. Strategies. https://learn.k20center.ou.edu/strategy/2554
- K20 Center. (n.d.). Pass the Problem. Strategies. https://learn.k20center.ou.edu/strategy/2554
- K20 Center (2023, July 5). *Plains star quilts and rotations* [Video]. YouTube. https://youtu.be/YJxmt0dt3mw