Traditional Transformations, Part 4

Dilations: Beadwork

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Grade Level	9th – 10th Grade	**Time Frame**	85-100 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 Native Americans and their beadwork. They will then use patterns to explore dilations and discover the relationship between the center of dilation, the preimage, and the image. Students will apply what they have learned to create their own beadwork design and demonstrate their understanding of dilations. Prerequisite knowledge for this lesson includes the following vocabulary: transformation, preimage, image, and rigid motion, which are all included in the Traditional Transformations, Part 1 lesson. This is the fourth lesson of five in the "Traditional Transformations" lesson series.

Snapshot

Engage

Students watch a video about the tradition of beadwork in Native American culture.

Explore

Students make observations to find the relationship between the center of dilation, the preimage, and the image.

Explain

Students complete guided notes as a class and formalize their understanding of dilations, scale factors, and centers of dilation.

Extend

Students apply what they have learned to create a beadwork design and trade with a friend to dilate the friend’s design.

Evaluate

Students demonstrate their understanding by finding the scale factor and using it to dilate a point.

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

- Designing Beadwork - Student A—Traditional Transformations, Part 4 - Spanish.docx
- Designing Beadwork - Student A—Traditional Transformations, Part 4 - Spanish.pdf
- Designing Beadwork - Student A—Traditional Transformations, Part 4.docx
- Designing Beadwork - Student A—Traditional Transformations, Part 4.pdf
- Designing Beadwork - Student B—Traditional Transformations, Part 4 - Spanish.docx
- Designing Beadwork - Student B—Traditional Transformations, Part 4 - Spanish.pdf
- Designing Beadwork - Student B—Traditional Transformations, Part 4.docx
- Designing Beadwork - Student B—Traditional Transformations, Part 4.pdf
- Dilation Exit Ticket—Traditional Transformations, Part 4 - Spanish.docx
- Dilation Exit Ticket—Traditional Transformations, Part 4 - Spanish.pdf
- Dilation Exit Ticket—Traditional Transformations, Part 4.docx
- Dilation Exit Ticket—Traditional Transformations, Part 4.pdf
- Exploring Transformations—Traditional Transformations, Part 4 - Spanish.docx
- Exploring Transformations—Traditional Transformations, Part 4 - Spanish.pdf
- Exploring Transformations—Traditional Transformations, Part 4.docx
- Exploring Transformations—Traditional Transformations, Part 4.pdf
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 4.docx
- Guided Notes (Teacher Guide and Model Notes)—Traditional Transformations, Part 4.pdf
- Guided Notes—Traditional Transformations, Part 4 - Spanish.docx
- Guided Notes—Traditional Transformations, Part 4 - Spanish.pdf
- Guided Notes—Traditional Transformations, Part 4.docx
- Guided Notes—Traditional Transformations, Part 4.pdf
- Lesson Slides—Traditional Transformations, Part 4.pptx

Materials

- Lesson Slides (attached)
- Exploring 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)
- Designing Beadwork – Student A handout (attached; one per student; printed front only)
- Designing Beadwork – Student B handout (attached; one per student; printed front only)
- Dilation Exit Ticket handout (attached; one quarter per student; printed front only)
- Pencils
- Paper
- Compass (one per student)
- Straightedge (one per student)
- Calculator (one per student)
- Coloring utensils (optional)
- Graph paper (optional)

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 the 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.

Show **slide 5** and introduce the "Beadwork" video on the slide, which is a video of Laverna Capes, a member of the Kiowa Tribe of Oklahoma and of Wichita descent, sharing her knowledge of her tribe and her beadwork creations.

Embedded video

https://youtube.com/watch?v=szdE303Sdqk

Display **slide 6** and introduce the Elbow Partner instructional strategy. Give students a few minutes to discuss what they learned from the video, using the questions below to guide their discussion:

- Why is beadwork made?
- How could someone represent their culture with beadwork?
- Why do you think she uses a larger bead to make a larger design?

25 minutes

Explore

Teacher's Note: Purpose

The following interactive GeoGebra activity gives students the opportunity to explore the center of dilation, which is likely a new vocabulary word and concept. It includes four applets:

The first applet allows students to move *point Z*, which is the center of dilation, and the second allows students to move the preimage. Both applets are designed for students to see the relationship between the center of dilation, the preimage, and the image without yet introducing the formal language of "center of dilation."

The third applet helps students better see how the center of dilation, *point Z*, relates to the corresponding points of the vertices of the preimage and image. Then it transitions students' thinking to proportions between the preimage and image and making the connection to *k*, the scale factor.

The fourth applet shows that the proportions of the similar figures are not the only proportions, the distance from the center of dilation, *point Z*, to *point A* and the distance from *point Z* to *point A'* form the same proportion.

Show **slide 7** and provide students with the link to the GeoGebra activity: geogebra.org/m/ecyvtdfg. Give students a few minutes to explore the applets and see how things work, especially if this is their first time using GeoGebra. As students are experimenting, pass out a copy of the attached **Exploring Transformations** handout to each student. Share with students that during this activity, they will be working with a nine-point star design that is an example of a design found on beaded medallions.

Direct students to follow the directions on their handout to complete the tables and use the directions in the GeoGebra activity for how to use the applets. Have students begin working independently.

Ask the class to be thinking about the following questions as they work through the front side of their handout:

- What does k seem to do?
- What does *point Z* seem to do?

As students are working, circulate the room. As you notice students finishing the first table: Part A: $k > 1$, have students find a partner and compare their results and what they think *point Z* does.

After discussing for a couple of minutes, have students independently complete the second table: Part A: $0 < k < 1$.

Again, as students complete the second table, have them discuss again with their partner and answer the questions on their handout about the proximity of *point Z* to the preimage and what they think *k* seems to do.

Teacher's Note: Guiding the Activity

If for any reason the GeoGebra activity does not seem to be working as intended or if an applet is not visible, have students refresh the page.

At this time, ask more questions than you give answers. Encourage students to really explore, as they can not break the applets and there are refresh arrows in the top-right corner of the applet to reset it to the original settings.

Remember that this is not the point in the lesson to answer questions or worry about students using proper vocabulary. Some students may remember dilations from middle school while others do not, and that is okay. Encourage kids to not worry if what they think is “right” or “wrong,” but to try their best to make educated guesses based on their observations.

Transition to **slide 8** and direct students’ attention to Part B. Tell students that are going to still adjust *k*, but now move the preimage instead of *point Z* in the GeoGebra applet.

Have students continue to work with their partner. They are to compare what they see with what they have written so far on their handout. In other words, when $k > 1$ and *point Z* was to the left of the preimage, is the image still to the right of the preimage in Part B like they found using the Part A applet?

Encourage students to make adjustments to what they have written on their handout as needed. Let students know, “We want to see if our observations are **always** true or just **sometimes** true.” Tell students that they should record the things that are always true.

If time allows, ask for a few volunteers to share their observations and conclusions.

Sample Student Responses:

- When $k > 1$, then the location of the image is on the opposite side of the preimage as *point Z*.
- When $0 < k < 1$, then the location of the image is on the same side of the preimage as *point Z*.
- The *k*-value seems to make the image bigger or smaller.
- *Point Z* seems to tell me which side of the preimage the image will be.
- When *point Z* is closer to the preimage, the image is also closer to the preimage.

Show **slide 9** and direct their attention to the back of their handout. Direct students to use the Part C applet to draw lines through the corresponding vertices. Ask for a few volunteers to share what they noticed about the lines.

After students conclude that the three lines intersect at the same point, have them complete the table to find the ratios of corresponding side lengths. Ask for a volunteer to share what they noticed about the ratios.

Once students notice that the ratios were all two, move to **slide 10** and direct their attention to Part D. Have them complete the table to find the ratios of distances such as from *point Z* to *point A* and from *point Z* to *point A'*. Ask for a volunteer to share what they noticed about the ratios.

Teacher's Note: Scaffolding the Activity

If students are struggling to find *ZA′*, ask prompting questions to remind them that *ZA* and *AA′* are given lengths and $ZA + AA' = ZA'$.

Again, try your best to not just tell students to add the given length *ZA* and the given length *AA′* to get the length *ZA′*. Instead ask guiding questions and remind students to read the directions in the GeoGebra activity to understand what is given.

Depending on your class, transition to **slide 11** before or after having students close the GeoGebra activity and ask the following question: *What do you think happens when* $k < 0$*?*

You can have students use the GeoGebra applet (Parts A or B) to answer this question, or you can have kids wonder about it and continue to stoke their curiosity. Regardless of your choice, have students jot down their hypothesis on scratch paper or in the margins of their handout. This question will be resolved during the Explain portion of the lesson. If time allows, consider facilitating a short discussion on why they think what they think.

25 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 **Guided Notes (Teacher Guide and Model Notes)** document as reference. If you only want students to work with dilations 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 12** and provide the attached **Guided Notes** handout to each student.

Introduce the vocabulary of *dilation*, *scale factor*, and *center of dilation* to the class and guide them to write those vocabulary words on their handout. Then ask the class what they think the *center of dilation* and the *scale factor* were in the GeoGebra activity.

After students conclude that the center of dilation was *point Z* or the point where all the lines through the corresponding vertices intersected and that the *k*-value was the scale factor, ask for a volunteer to answer the following question: *Is a dilation an example of rigid motion?* Be sure to have the student provide reasoning. Have students record the answer (no) with justification on their handout.

Now go through how different *k*-values affect the preimage and the words one could use to describe these transformations:

- When $k > 1$, then the image is an enlargement of the preimage.
- When $0 < k < 1$, then the image is a reduction of the preimage.

Ask the class the following questions: *What do you think would happen if* $k = 0$*? What do you think would happen if* $k = 1$*?* Students do not need to write down the answers to this information as they are not values of *k* that they would ever see. Use these questions as a way to help students find a pattern and understand the relationship between *k*, the preimage, image, and the center of dilation.

Teacher's Note: Guiding the Lesson

Students should be able to reason that if $k = 1$, then the preimage and image would be the same. They may struggle with the idea of $k = 0$, as the image would be reduced to nothing, located at the center of dilation. Help students see this by asking them what the image would look like when $k = 1$, 0.5 (50%), 0.25 (25%), 0.1 (10%), etc. and discuss where those images would be: closer and closer to the center of dilation.

Additional Center of Dilation Scaffolding

Students may struggle with the idea of the center of dilation and may need to hear it explained in more than one or more than two ways. Consider having students watch the following "Find the Center of Dilation" video.

Some students may interpret the preimage and image as three-dimensional, while others may not. For those who do, consider explaining that when $k > 1$, the image is larger because it is closer to the viewer, while the center of dilation is back in the distance.

Alternatively, try the analogy of the center of dilation being a light **source**, like a flashlight or projector, and it "projects" a preimage and resizes it in a certain direction.

You may also consider having students go back through the GeoGebra activity with this new lens of understanding to help solidify these new vocabulary words.

Once students feel confident about the center of dilation, ask the class: *What do you think happens when k < 0?* Have students use the graph on their handout and try to describe what they see. Have students compare what they see with what they thought would happen from the Explore portion of the lesson.

Help students see that the lines through the corresponding vertices still all intersect at the center of dilation. Use this to transition to the algebraic rule. Consider asking the class where they have seen $(-1 \cdot x, -1 \cdot y)$ before. Use this time to remind the class of the algebraic rules of rotations for 180° about the origin to help describe what they are seeing. The graph on the handout has $k = -1$. Share with students how that graph would differ if $k = -2$, for example.

Then help students understand why the ratio for k is the image over the preimage by having them algebraically solve for k. If we multiply the coordinates of the preimage to get the image: k·(preimage) = image, then k = (image) / (preimage).

Direct students' attention to the back of their handout and complete the examples together as a class. After example 1, ask the class if it was an example of a reduction or an enlargement. Have students justify their answer. Then consider asking the students to work with their partner to try example 2 before bringing the class back together to ensure that everyone understands.

Teacher's Note: Guiding Example 2

If students struggle with example 2, consider having them dilate one point at a time using what they learned from the Explore activity.

We know that the center of dilation, *point A*, and *point A'* are collinear, so let's look at the slope. To get from *point Z* to *point A*, we need to go up 3 units and right 2 units. To get to *point A'*, we will need to go 2.5 times as far. So, we need to multiply both the rise and run by 2.5.

To get from *point Z* to *point A'*, we will need to go $3 \cdot 2.5 = 7.5$ units up from *point Z* and then $2 \cdot 2.5 = 5$ units right.

After example 2, ask the class if that was an example of a reduction or an enlargement. Have students justify their answer.

Give each student a compass and protractor, then guide the class through how to complete a dilation 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 “make bigger” or “make smaller” and adopt the high school language of “dilate”.

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

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

15 minutes

Extend

Display **slide 13** and facilitate a whole-class discussion regarding the following question: *Where else do you see dilations?*

Sample Student Responses:

Responses will likely vary greatly. Some possible responses may include:

- I see dilations when I watch a movie on my phone compared to when I watch it on my television.
- The picture on my phone is a smaller version of the person who I took a picture of.
- The business logo on their sign compared to it printed on my soft drink cup is an enlargement.

Show **slide 14** and give each student a copy of the attached **Designing Beadwork – Student A** handout. Share the idea that many native dancers wear matching pieces and the design on a pair of earrings is likely a reduction of the design on a medallion with students.

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.

Instruct students to create their own design for a cuff, which would be worn around the wrist. Let students know they have approximately five minutes to create their design. Tell students that their design needs to be a polygon and that they must include six labeled vertices. If time allows, give students coloring utensils and ask them to imagine that each square represents a bead.

Transition to **slide 15** and have students trade designs. Distribute a copy of the attached **Designing Beadwork – Student B** handout. Tell the class that they are to create a dilation of their classmate's design by a scale factor of two; this dilated image design is intended to be worn on a vest. Remind them to label the corresponding vertices and that the center of dilation is at the origin.

Optional Differentiation

For students who are ready for an extra challenge, consider having them use a piece of graph paper and use a center of dilation other than the origin.

5 minutes

Evaluate

Display **slide 16** 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 **Dilation Exit Ticket** handout or give students a sticky note, an index card, etc. for them to write their response. Use the hidden **slide 17** 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 dilating triangles or even just individual points with a center of dilation of the origin.

The "Traditional Transformations, Part 5" lesson is about compositions of transformations and fashion design.

Teacher's Note: ACT Prep

Understanding and using scales and scale factors are skills needed for the ACT exam. These questions often ask students to find or use the scale factor to compare similar figures or determine the dimension of one of the figures.

Resources

- K20 Center. (2023, July 5). *Beadwork* [Video]. Retrieved July 6, 2023, from https://youtu.be/szdE303Sdqk
- 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
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- School, JoAnn's. [JoAnnsSchool]. (2016, September 3). *Find the Center of Dilation*. https://youtu.be/LsTUlfld1ww