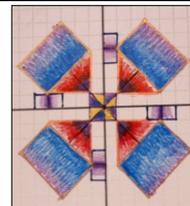


ARTS IMPACT LESSON PLAN

Visual Arts and Math Infused Lesson

Lesson Three: *Mathematical Mandalas*

Author: Meredith Essex Grade Level: Eighth



Enduring Understanding

Congruency and rotation of figures guided by the coordinate plane can create mathematically precise artistic designs.

Lesson Description (Use for family communication and displaying student art)

Students analyze translations, reflections, and rotations of congruent figures seen in art. Next students graph a quadrilateral, noting the coordinates of its vertices, on the first quadrant of the coordinate plane. This quadrilateral is then rotated at 90° and drawn within each quadrant. Students then develop a "mathematical mandala" design by adding additional rotated, congruent lines, and shapes within each quadrant. Last, students enhance their rotating, balanced, repeating designs by adding color pen and pencil.

Learning Targets and Assessment Criteria

Target: Identifies translations, reflections and rotations in art.

Criteria: Describes congruent figures that slide, flip, or turn relative to a center of rotation or point of origin.

Target: Graphs a quadrilateral.

Criteria: Draws a four-sided figure in the first quadrant of the coordinate plane and records coordinates of vertices.

Target: Graphs quadrilaterals in rotation.

Criteria: Rotates congruent four-sided figures around the center of rotation/origin using all quadrants of the coordinate plane.

Target: Enhances design in rotation.

Criteria: Adds shapes/lines and repeats within each quadrant. Traces lines in fine-tipped pens and adds color to shapes in color pencil and repeats within each quadrant.

Target: Uses craftsmanship.

Criteria: Uses grid, dots vertices, and uses straightedge to create all lines and shapes in design.

Vocabulary

Arts Infused:

Horizontal
Reflection
Rotation
Symmetry
Vertical

Math:

Center of Rotation
Congruent
Coordinate Plane
Flip
Grid
Origin
Quadrilateral
Similar Figures
Slide
Translation
Turn
Vertices
X-axis
Y-axis

Arts:

Craftsmanship
Mandala
Radial Balance
Repetition

Materials

Museum Artworks or Performance

Seattle, WA

Seattle Art Museum

Tacoma, WA

Tacoma Art Museum

Materials

Drawing pencil: 4H; Vinyl erasers; Arts Impact sketchbooks; Cardstock: 8.5x11", white, print – do not copy – coordinate plane grid from lesson; Pens: extra-fine tipped color or gel pens; Color pencils; Protractor; Ruler; Classroom Assessment Worksheet

Seattle Art Museum images:
Mandala, 1970, Robert Sund, 71.3

The Birth of a Saint, 1968, Richard Kirsten, 68.229

C367, 1967, James B. Johnson, 68.197



Learning Standards

WA Arts State Grade Level Expectations

For the full description of each WA State Arts Grade Level Expectation, see:

<http://www.k12.wa.us/Arts/Standards>

- 1.1.2 Elements: Shape
- 1.1.7 Principles of Design: Repetition, Balance
- 1.2.1 Skills and Techniques: Drawing
- 2.1.1 Creative Process
- 2.3.1 Responding Process
- 4.2.1 Connection between Visual Arts and Math

Common Core State Standards (CCSS) in Math

For a full description of CCSS Standards by grade level see:

<http://www.k12.wa.us/CoreStandards/Mathstandards/>

- 8.G. Understand congruence and similarity using physical models, transparencies, or geometry software.
- 8.G.1. Verify experimentally the properties of rotations, reflections, and translations:
 - 8.G.1.a. Lines are taken to lines, and line segments to line segments of the same length.
 - 8.G.1.b. Angles are taken to angles of the same measure.
 - 8.G.1.c. Parallel lines are taken to parallel lines.
- 8.G.3. Describe the effect of dilations, rotations, and reflections on two-dimensional figures using coordinates.

CCSS Mathematical Practices

- MP.4. Model with mathematics.
- MP.5. Use appropriate tools strategically.
- MP.6. Attend to precision.

ICON KEY:

 = Indicates note or reminder for teacher

 = Embedded assessment points in the lesson

Pre-Teach

Ask students to search for and share examples of objects or images from diverse cultural art forms, nature, and machines that show rotation around a center point: baskets, mandalas, ceramic tile work, snowflakes, flowers, gears, wheel. Guide students in creating sketches of objects or design ideas featuring rotation, multiple lines of symmetry, or radial symmetry.

Lesson Steps Outline

1. Introduce and guide art analysis of *Mandala* by Robert Sund, *The Birth of a Saint* by Richard Kirsten, and *C367* by James B. Johnson from the Seattle Art Museum collection. Guide math and art analysis with focus on similar and congruent figures and the properties of rotations, reflections, and translations. Guide student partners in sketching and noting relationships of geometric figures in sketchbook.

 Criteria-based peer assessment and teacher checklist: Describes congruent figures that slide, flip, or turn relative to a center of rotation or point of origin.

2. Demonstrate and guide students in graphing a quadrilateral on the first quadrant on the coordinate plane and recording its coordinates to begin mapping out a *Mathematical Mandala*.

 Criteria-based teacher checklist: Draws a four-sided figure in the first quadrant of the coordinate plane and records coordinates of vertices.

3. Demonstrate and guide rotating and graphing the quadrilateral in each quadrant. Emphasize the origin as the center of rotation and the relationship of coordinates from quadrant to quadrant.

 Criteria-based teacher checklist: Rotates congruent four sided figures around the center of rotation/origin using all quadrants of the coordinate plane.

4. Demonstrate artistic development of design in rotation by adding additional congruent lines and geometric shapes that are placed precisely in rotation (at 90°) within each quadrant using coordinates as a guide. Facilitate peer check for mathematical accuracy.

☑ Criteria-based teacher checklist and peer assessment: Adds shapes/lines and repeats within each quadrant. Uses grid, dots vertices, and uses straightedge to create all lines and shapes in design.

5. Demonstrate and guide creatively defining and enhancing mathematical mandalas using fine-tipped pens and color pencil. Emphasize rotation of same line and color as well as shape within each quadrant to create balance.

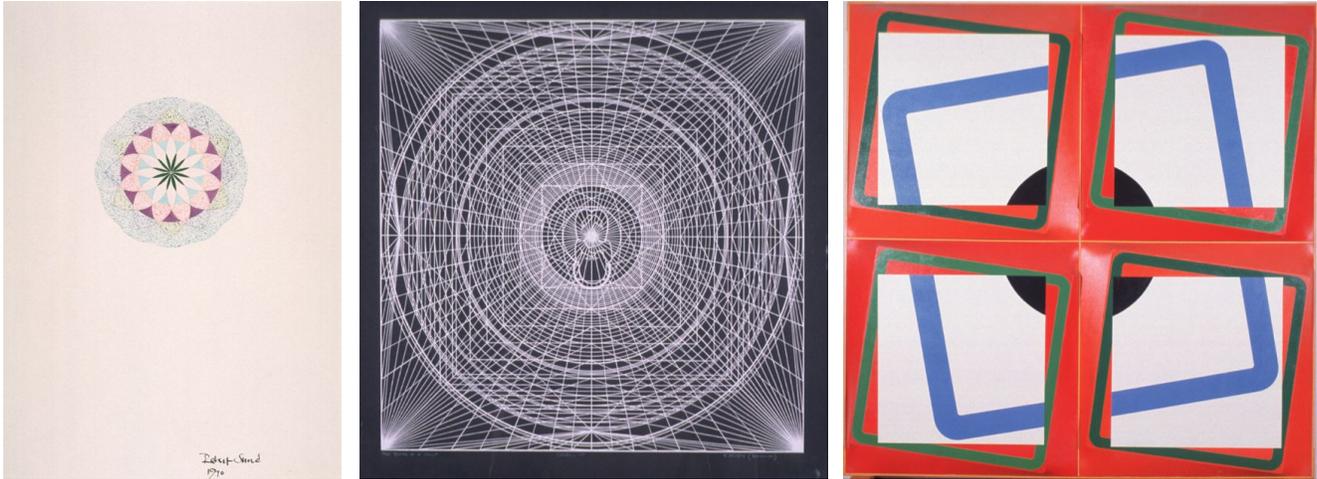
☑ Criteria-based teacher checklist: Traces lines in fine-tipped pen, adds color to shapes in color pencil, and repeats within each quadrant. Uses straightedge to create all lines and shapes in design.

6. Facilitate criteria-based group math and art reflection.

☑ Criteria-based peer and group reflection: Analyzes mathematical and artistic process and finished product.

LESSON STEPS

1. Introduce and guide art analysis of *Mandala* by Robert Sund, *The Birth of a Saint* by Richard Kirsten, and *C367* by James B. Johnson from the Seattle Art Museum collection. Guide math and art analysis with focus on similar and congruent figures and the properties of rotations, reflections, and translations. Guide student partners in sketching and noting relationships of geometric figures in sketchbook.



▣ The Seattle Art Museum’s collection is available on-line at: <http://www.seattleartmuseum.org/emuseum/code/collection.asp>. To find the images in this lesson, enter the accession number for the work of art in the search box on the collections page of SAM’s website. Accession numbers for these works of art are listed in the materials box at the beginning of the lesson.

- *Designs radiating from a center point, often called “Mandalas”, are seen in cultures and art forms all over the world. Often they have multiple lines of symmetry or show rotating figures that “turn” on a center of rotation like a fan or pinwheel.*
- *In art, images with repeated elements “radiating” from a center-line are thought to have radial symmetry.*
- *In analyzing and comparing these artworks, which geometry/transformation concepts come to mind?*
- *Talk with a partner: Find and share an example of congruent figures, rotation, reflection, and/or translation. Sketch the figures/geometric shapes seen in art and note their relationships in your sketchbook.*

☑ Criteria-based peer assessment and teacher checklist: Describes congruent figures that slide, flip, or turn relative to a center of rotation or point of origin.

2. Demonstrate and guide students in graphing a quadrilateral on the first quadrant on the coordinate plane and recording its coordinates to begin mapping out a *Mathematical Mandala*.

▣ First use a very light, hard 4H pencil to graph the quadrilaterals and add additional lines and shapes to design in the next few steps. Protractors make great straightedges for small drawings, since they are easier to manipulate than a full size ruler.

- *Using the grid to guide placement, dot the vertices (aligned with intersecting vertical and horizontal lines on the grid) of a quadrilateral. This is the beginning of your mathematical mandala.*
- *Be sure to use craftsmanship in your drawing: artistic and mathematical precision. Dot the vertices, then always using a straightedge to draw lines for figures.*
- *Next, note the coordinates for your quadrilateral at the bottom left of the grid.*

Criteria-based teacher checklist: Draws a four-sided figure in the first quadrant of the coordinate plane and records coordinates of vertices.

3. Demonstrate and guide rotating and graphing the quadrilateral in each quadrant. Emphasize the origin as the center of rotation and the relationship of coordinates from quadrant to quadrant.

- *Graph congruent quadrilaterals rotating at 90° around the origin or center of rotation.*
- *What do you notice about the coordinates you use as you graph the quadrilateral in each quadrant?*

Criteria-based teacher checklist: Rotates congruent four-sided figures around the center of rotation/origin using all quadrants of the coordinate plane.

4. Demonstrate artistic development of design in rotation by adding additional congruent lines and geometric shapes that are placed precisely in rotation (at 90°) within each quadrant using coordinates as a guide. Facilitate peer check for mathematical accuracy.

- *Using craftsmanship, add additional straight lines or geometric shapes to your mandala design that precisely rotate at 90° . Use coordinates to help you add these artistic embellishments that enhance your design with mathematical precision.*
- *Every time you add a straight line or geometric figure to a quadrant, use the coordinates and grid to guide you.*
- *Rotate by adding precisely the same lines/shapes to each quadrant, again using the grid and coordinates as a guide.*
- *Make sure every line you draw is drawn with a straightedge for good craftsmanship!*
- *Switch designs with a partner. Check for accurate congruence and placement showing rotation in each quadrant.*

Criteria-based teacher checklist and peer assessment: Adds shapes/lines and repeats within each quadrant. Uses grid, dots vertices, and uses straightedge to create all lines and shapes in design.

5. Demonstrate and guide creatively defining and enhancing mathematical mandalas using fine-tipped pens and color pencil. Emphasize rotation of same line and color as well as shape within each quadrant to create balance.

- *Trace over all pencil lines that define your design in color pen.*

- *Keep the rotation of your design congruent and consistent by making sure you repeat the same combination of color, line, and shape within each quadrant.*
- *Use craftsmanship by always using a straightedge every time you trace over a line in pen within your design.*
- *In adding color to shapes, consider blending or using a range of values to add interest.*
- *Remember that the use of color needs to stay consistent from quadrant to quadrant to create balance mathematically and artistically.*

Criteria-based teacher checklist: Traces lines in fine-tipped pen, adds color to shapes in color pencil, and repeats within each quadrant. Uses straightedge to create all lines and shapes in design.

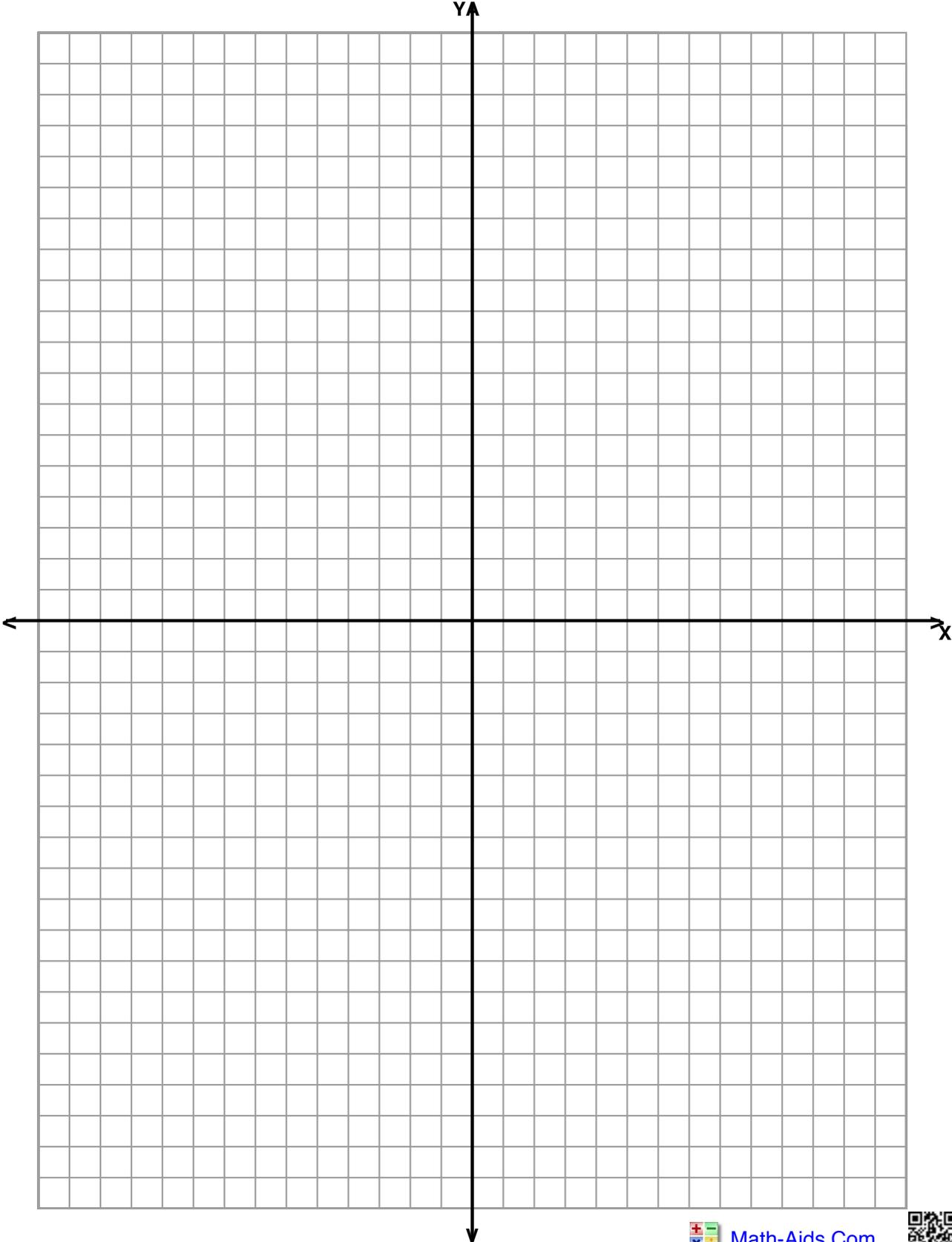
6. Facilitate criteria-based group math and art reflection.

- *Reflect on the challenges in creating mathematically accurate rotation of lines and shapes.*
- *How did working with a grid /coordinate plane help you to create an accurate and balanced design?*
- *Describe the effect of rotating forms visually. Which designs are the quietest? Why? Which are the most dynamic? Why?*

Criteria-based peer and group reflection: Analyzes mathematical and artistic process and finished product.

Mathematical Mandalas

Coordinate Plane Grid



ARTS IMPACT LESSON PLAN Visual Arts and Math Infusion

Eighth Grade Lesson Three: *Mathematical Mandalas*

Teachers may choose to use or adapt the following self-assessment tool.

STUDENT SELF-ASSESSMENT WORKSHEET

Disciplines	VISUAL ARTS AND MATH			VISUAL ARTS		Total 5
Concept	Congruence/Transformations			Design	Craftsmanship	
Criteria	Describes congruent figures that slide, flip, or turn relative to a center of rotation or point of origin.	Draws a four-sided figure in the first quadrant of the coordinate plane and records coordinates of vertices.	Rotates congruent four sided figures around the center of rotation/origin using all quadrants of the coordinate plane.	Adds shapes/lines and repeats within each quadrant. Traces lines in fine-tipped pens and adds color to shapes in color pencil: repeats within each quadrant.	Uses grid, dots vertices, and uses straightedge to create all lines and shapes in design.	
Student Name						

ARTS IMPACT LESSON PLAN Visual Art and Math Infusion

Eighth Grade Lesson Three: *Mathematical Mandalas*

CLASS ASSESSMENT WORKSHEET

Disciplines	VISUAL ARTS AND MATH			VISUAL ARTS		Total 5
	Concept	Congruence/Transformations		Design	Craftsmanship	
Criteria	Describes congruent figures that slide, flip, or turn relative to a center of rotation or point of origin.	Draws a four-sided figure in the first quadrant of the coordinate plane and records coordinates of vertices.	Rotates congruent four sided figures around the center of rotation/origin using all quadrants of the coordinate plane.	Adds shapes/lines and repeats within each quadrant. Traces lines in fine-tipped pens and adds color to shapes in color pencil: repeats within each quadrant.	Uses grid, dots vertices, and uses straightedge to create all lines and shapes in design.	
Student Name						
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Percentage						

What was effective in the lesson? Why?

What do I want to consider for the next time I teach this lesson?

What were the strongest connections between visual arts and math?

Teacher: _____ Date: _____

VISUAL ARTS AND MATH LESSON: *Mathematical Mandalas*

Dear Family:

Today your child participated in an **Arts and Math** lesson. We analyzed examples of translations (slides), reflections (flips) and rotations (turns) of congruent (same size) shapes in art. We talked about examples of radial symmetry where designs radiate from a center point, and designs that have multiple lines of symmetry. We then created a *Mathematical Mandala* design.

- We graphed a four-sided figure, a quadrilateral, in the first quadrant of the coordinate plane and noted the coordinates of its vertices (corners.)
- We then drew that same congruent quadrilateral three more times in precise 90° rotation around the center of rotation, which in this case, is also the origin on the coordinate plane.
- We used straightedges and the coordinate grid to help us draw precisely as we added more repeating congruent lines and shapes to artistically enhance our rotating design.
- We enhanced our rotating, balanced, repeating designs by adding color pen and pencil.

At home, you could create intricate rotational designs by making layered crayon rubbings of objects rotated at 45° . You could also cut four congruent shapes each from found patterned or translucent papers and layer and glue them within a dynamic, rotating collage design.

Enduring Understanding

Congruency and rotation of figures guided by the coordinate plane can create mathematically precise artistic designs.