USING MATHEMATICS TO EXCAVATE THE ANCIENT WORLD

ART AND MATH
GRADES: 5-12

Corinth/Greece
Plate with a Seated Lioness, ca. 580 BCE
Clay decorated in the black-figure technique
Israel and Caroline Wilson Endowment, William W. Taylor Endowment and various funds, 1976.205

OBJECTIVES

Students will:

- Compare and contrast artifacts from the antiquities collection at the Cincinnati Art Museum.
- Explain the connections between archaeology, mathematics, and Corinth.
- Act as archaeologists as they determine the radius, diameter, and circumference of a modern-day plate with given sherds and flakes.
- Use ratio, proportional reasoning, and (possibly) a grid system to create an actual size drawing/replica of "Plate with a Seated Lioness."
- Employ mathematical vocabulary/academic language (see list below) to explain how they created their actual size drawing/replica.

CONCEPT

When students ask, "When are we ever going to use this?" you can provide a response. Archaeology! Acting as archaeologists, students will use the following big ideas for this lesson:

- A perpendicular line through the midpoint of a chord always passes through the center of the circle.
- The intersection of two perpendicular lines through the midpoints of two distinct chords determines the center of the circle.
- Ratios and proportions can be used to scale up a photo of an artifact to its actual size.

[Please note: Other geometric methods might be used by students to determine the radius, diameter, and circumference of a circle. In fact, my students used two others, one with tangent lines and one with a formula that they found online.]
When an archaeologist finds a sherd (a fragment of a larger object) from the circumference of a circular artifact, she/he can use the first two geometric big ideas above in order to determine the radius, diameter, and circumference of the circular artifact. Furthermore, knowing the circumference will be beneficial when other sherds and flakes (pieces of stone removed from a larger piece of stone) are found during excavation and the artifact is eventually reconstructed.

Given a sherd and flakes from a modern-day plate, students, working in groups, will determine the plate's radius, diameter, and circumference and speculate about the image on the plate.

Next, given an image of "Plate with a Seated Lioness" from the CAM collection, students will create an actual size drawing/replica of the plate using their own methods (e.g., a grid system) and proportional reasoning.

Finally, they will share their mathematical strategies and answer questions: Suppose it is 3017 and archaeologists excavate on UC's campus. They find a plate dated 2017. What would it be made of? Why? What design would be on it? Why? Etc.

MATERIALS

Sherds: Wrap a plate in bubble wrap and use a hammer to smash it so that parts of the circumference or edge of the plate are intact. Each group will need one of these sherds.
Flakes: These are not necessary but might help students speculate about the design on the plate.
Packing tape: Use this to tape the sharp edges of the sherds so that students do not get cut/injured.
Rulers/meter sticks (one per group)
Chart paper for work and smaller scaled drawing/replica (one sheet per group)
Colored pencils and markers
Protractors (optional)
Compasses (optional)
String (optional)

VOCABULARY

- **Ratio** – the comparison of two quantities by division
- **Proportion** – two ratios that are equal
- **Scale factor** – the ratio of corresponding sides in two similar geometric figures
- **Similar/similarity** – plane figures (2-dimensional) and solid figures (3-dimensional) which have the same shape but not necessarily the same size
- **Circumference** – the perimeter of a circle
- **Diameter** – a line segment that passes through the center of a circle and intersects any two points on the circle
- **Radius** – a line segment that connects the center of a circle to any point on the circumference
- **Sherd** – a fragment of a larger object
- **Flake** – a piece of stone removed from a larger piece of stone

PROCEDURE

Activity 1

Launch

Show the youtube.com videos:

- Science and Mathematics – Archaeologists (1:42)
- Corinth & The Archaeological Museum of Ancient Corinth (4:49)

Show photos of artifacts from the Cincinnati Art Museum antiquities collection and discuss aspects of the "Plate with a Seated Lioness" (see Label Copy, page 1).
Ask:

- How is mathematics used in archaeology?
- What mathematics do you see in the plate design?
- What mathematics do you see in the designs?

Explore

Working in small groups, students will determine the radius, diameter, and circumference of the original plate given sherds and flakes. Please note: I assigned students to heterogeneous groups based on their mathematical skills/achievement. Students used their geometry books as references. Each group received one sherd and one flake.
Here is a photo of the original intact plate (you can use any plate) I used:

Here is a photo of the smashed plate (I wrapped it in bubble wrap and then gave it one good strong whack with a hammer) with sherds and flakes:

Note: There are enough edge/circumference pieces for 4 or 5 groups of students. Also, I used clear packing tape and taped the sharp edges so students would not get cut.

Summarize

After groups have used the geometric big idea to determine the plate's circumference, have a large group conversation about strategies they used. Ask the following questions:

- What strategies did you use to determine the plate's radius, diameter, and circumference?
- What design do you think is depicted on this modern-day plate? Why?
- For what purposes are designs on objects such as plates, mugs, etc. used for today?

Activity 2

Launch

Give groups (I used the same groups for Activity 2 that I did for Activity 1) a photo copy of the "Plate with a Seated Lioness" which is smaller than the original size (see Appendix). The dimensions of the original are 1-3/16 by 11-1/4 in. (3 by 28.5 cm). Solicit general ideas about how they might make an actual size drawing/replica of the original. Stop after a few ideas.

Explore

Make colored pencils, markers, rulers, protractors, compasses available if students want them. Students work in their groups to make an actual size drawing/replica of "Plate with a Seated Lioness" on chart paper. As they are working and you are walking around observing ask: What strategies will give you the most accurate actual size drawing/replica? What mathematics can you use to do this?

Summarize

Come together as a whole class and allow groups to show their actual size drawings/replicas of "Plate with a Seated Lioness." Pose the following questions:

- What mathematics did your group use to create the actual size drawing/replica of the "Plate with a Seated Lioness?"
- Suppose it is 3017 and archaeologists excavate on UC's campus. They find a plate dated 2017. What would it be made of? Why? What design would be on it? Why? Etc.

ASSESSMENT

Exit Slips – 1) How can you determine the radius, diameter, and circumference of a circular object given only a portion of the outside edge (circumference) of the object? Explain in detail. 2) What strategies can you use to make an actual size drawing/replica from a smaller or larger-sized photo? Explain in detail.

NATIONAL STANDARDS

National Standards for Arts Education:

Visual Arts (Grades 5-8, Content Standard 6)

Making connections between visual arts and other disciplines. Compare the characteristics of works in two or more art forms that share similar subject matter, historical periods, or cultural context. Describe ways in which the principles and subject matter of other disciplines taught in the school are interrelated with the visual arts. (http://artsedge.kennedy-center.org /teach/standards/standards_58.cfm#04

Common Core Standards for School Mathematics:

Mathematical Practice 4. Model with Mathematics–Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace.

Mathematical Practice 6. Attend to Precision–Mathematically proficient students try to communicate precisely to others.

Grade 6 RP–Understand ratio concepts and use ratio reasoning to solve problems.

Grade 7 RP–Analyze proportional relationships and use them to solve real-world and mathematical problems.

Grade 7G–Draw, construct and describe geometrical figures and describe the relationships between them.

Grade 8G–Understand congruence and similarity using physical models, transparencies, and geometry software.

High School Geometry, Circles, C.A.2–Identify and describe relationships among inscribed angles, radii, and chords. (www.corestandards.org)

RESOURCES

Gridding an Archaeological Site, George Brauer
Website: Society for American Archaeology
Retrieved from:
http://www.saa.org/ForthePublic/Resources/EducationalResources/ForEducators/UsingArchaeologyContentandSkillsforClassroom/LessonPlansbyGeographicalLocationlistedbys/ArchaeologyLessonPlansMaryland/tabid/1003/Default.aspx

To Dig or Not to Dig: The Stadium Showdown, George Brauer
Website: Society for American Archaeology
Retrieved from:
See above

Moyer, P. S., & Hsia, W. S. (2001). The archaeological dig site: Using geometry to reconstruct the past. *Mathematics Teacher 94* (3), 193-197).

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