Measuring Space: Seeing Mathematics Everywhere Through the Sculptures of Richard Serra

A Joy2Learn Middle School Mathematics Lesson Plan

Connection to Joy2Learn Professional Development

This lesson plan mirrors the instructional model introduced in the Joy2Learn professional development mini-workshop, *Seeing Mathematics Everywhere: Using Architecture, Sculpture, and Design to Build Mathematical Thinking in Middle School*:

Notice → Wonder → Model → Calculate → Explain → Justify

Rather than beginning with formulas or procedures, students begin by observing Frank Gehry's architecture as mathematicians—looking for patterns, structures, and measurable relationships before applying mathematical concepts.

Grade Level

Grades 6–8

Time

60–75 minutes

Mathematical Focus

Depending on grade level, teachers may emphasize:

- Spatial reasoning
- Geometry
- Measurement
- Scale drawings

- Area and perimeter
- Circumference and arc length
- Surface area and volume
- Mathematical modeling
- Mathematical argumentation: Claim – Evidence – Reasoning (CER)

Learning Objectives

Students will:

- Observe and describe mathematical structures in sculpture.
- Use precise mathematical language to describe shapes and space.
- Model real-world objects using geometry.
- Apply measurement concepts to solve authentic problems.
- Support mathematical claims using observations, measurements, calculations, diagrams, and reasoning.
- Communicate mathematical thinking through discussion and writing.

Alignment with the Standards for Mathematical Practice

- MP1: Make sense of problems.
- MP2: Reason abstractly and quantitatively.
- MP3: Construct viable arguments and critique reasoning.
- MP4: Model with mathematics.
- MP6: Attend to precision.
- MP7: Look for and make use of structure.

(Content standards vary by grade level.)

Materials

- Joy2Learn video clips:
    - Richard Serra | My Gallery - Museum Work: https://youtu.be/wHzs1rAedVM?si=rB_s0cWLN_TQsfPV
    - Richard Serra | My Life - Confusing Questions: https://youtu.be/2YtQ5c3Dz6I?si=FitPgvVFvbu4l2xg
    - Richard Serra | My Gallery - Urban Work: https://youtu.be/U6lqBHzCraQ?si=hCBA_cd-XDdKno75
- Graph paper
- Rulers
- String or flexible measuring tape
- Calculators

Lesson Launch (10–15 minutes)

Step 1: Notice (Whole Class)

- Play the Joy2Learn video clip: Richard Serra | My Gallery - Museum Work: https://youtu.be/wHzs1rAedVM?si=rB_s0cWLN_TQsfPV
- Ask students: "What do you notice?"
- Record every observation publicly on chart paper, a whiteboard, or a shared digital display.
- Accept descriptive observations without evaluating them or introducing mathematical vocabulary.
    - Students might say:
        - The walls are curved.
        - The sculptures are very tall.
        - People can walk inside them.
        - Some spaces are narrow and others are wide.
        - The steel looks smooth.
        - The pathways twist.
        - The sculptures seem to surround people.
- Teacher prompts:

    - "What else do you notice?"
    - "Can you say more?"
    - "Where do you see that?
- **Important**: Resist the urge to label observations as "right" or "wrong" or to introduce terms like *arc*, *radius*, or *concave*. The goal is careful observation.

Step 2: Wonder (Whole Class)

- Next ask: "What mathematical questions do these sculptures make you wonder about?"
- Record all questions.
    - Students might ask:
        - How tall are they?
        - How much do they weigh?
        - Are the curves parts of circles?
        - How much steel was used?
        - How long is the path through the sculpture?
        - How much space is inside?
        - Could we build a scale model?
        - How would you measure a curved wall?
- Teacher prompts:
    - "What could we measure?"
    - "What could we estimate?"
    - "What information would an engineer need?"
    - "Which questions could mathematics help us answer?"
- Teacher: "Mathematicians often begin by observing patterns and asking questions. Now let's see how we can use mathematics to investigate some of the questions we've generated."

Mini-Lesson (15 minutes)

Step 3: Model

- Explain: Mathematicians build models to understand complicated objects.
- Display one Serra sculpture by pausing one of the Joy2Learn video clips.
- Ask: "What simple geometric figures could help us model this sculpture?"
- Students identify:
    - Circles
    - Arcs
    - Rectangles

    - Cylinders
    - Composite figures
- Discuss how complex objects can be represented using simpler mathematical models.

Mathematical Connections

Grade 6

- Area
- Perimeter
- Scale

Grade 7

- Circles
- Arc length
- Surface area

Grade 8

- Transformations
- Similarity
- Composite figures

Investigation (30 minutes)

Design Challenge

- Students work in groups.
- Each group is assigned one Serra sculpture. Their task:
    - Investigate the sculpture mathematically.
    - Choose three questions to answer.

Examples:

Measurement

- Estimate:
    - Height
    - Width
    - Pathway distance
- Explain how estimates were made.

Geometry

- Identify:
    - Circles
    - Arcs
    - Parallel lines
    - Symmetry (if present)
    - Composite figures

Scale

- Create a scale drawing.
    - Example: 1 cm = 2 meters

Area

- Estimate the floor space enclosed.

Pathways

- Estimate how far someone walks through the sculpture.

Modeling

- Sketch the sculpture using only geometric shapes.
- Label measurements.

Mathematical Discussion (10 minutes)

- Groups present findings.
- Teacher asks:
    - What mathematical ideas did your group notice?

    - Did different groups see different mathematics?
    - Which measurements were estimates?
    - Which conclusions were supported by calculations?
- Emphasize: The same object can be analyzed in many mathematical ways.

CER: Supporting Mathematical Arguments

- Students answer one question.

Example

- Question: Which sculpture provides more enclosed space?

Claim

- Sculpture A encloses more space.

Evidence

- Students support their claim using:
    - Observations
        - The curved walls extend farther.
        - The opening is wider.
    - Measurements
        - Estimated width = 12 meters
        - Estimated length = 20 meters
    - Calculations
        - Estimated enclosed area: $12 \times 20 \approx 240$ m²
    - Diagram
        - Annotated sketch showing dimensions.

Reasoning

- Because the sculpture has larger estimated dimensions, it encloses a greater area.
- Students explain how their evidence supports the claim.

Reflection

- Students complete:
    - Today I noticed…

- Today I measured…
- Today I calculated…
- One mathematical idea I understand better is…
- One question I still have is...

Assessment

Formative

- Teacher listens for:
  - Mathematical vocabulary
  - Mathematical reasoning
  - Collaboration
  - Evidence-based discussion

Summative

Mathematical Investigation Portfolio

- Students submit a portfolio demonstrating how they used the inquiry process to investigate one mathematical question about Richard Serra's sculpture.

Portfolio Components

- Original Wonder Question: Students select one question from the class Wonder list.
  - Example:
    - How much space is inside the sculpture?
    - How long is the walking path?
    - Are the curved walls part of circles?
    - How tall is the sculpture?
- Mathematical Model: Students create an appropriate mathematical representation.
  - Possible models include:
    - Labeled sketch
    - Scale drawing
    - Geometric decomposition
    - Diagram showing measurements
- Evidence: Students support their investigation using at least three forms of mathematical evidence.
  - Possible evidence:

        - Observations
        - Measurements
        - Estimates
        - Calculations
        - Diagrams
        - Geometric vocabulary
- Explanation: Students explain:
        - How they investigated the question
        - Why they chose their mathematical model
        - What assumptions they made
- Justification (CER): Students complete a CER.
    - Claim: Answer the mathematical question.
    - Evidence: Support your claim using observations, measurements, calculations, and/or diagrams.
    - Reasoning: Explain why your evidence supports your conclusion.
- Reflection: Students answer:
    - Which Wonder question did your investigation answer?
    - What new mathematical question do you have now?
    - How did observing first help your mathematical thinking?

Assessment Rubric

Criteria	Advanced	Proficient	Developing
Observation & Questioning	Uses detailed observations to develop a meaningful mathematical question	Develops a relevant mathematical question from observations	Needs support generating a mathematical question
Mathematical Modeling	Creates an appropriate and well-labeled mathematical model	Creates an appropriate model with minor omissions	Model is incomplete or not connected to the question
Evidence	Uses multiple forms of mathematical evidence effectively	Uses at least three forms of evidence appropriately	Limited or weak evidence

Reasoning & Justification	Clearly explains how the evidence supports the claim	Provides adequate reasoning	Reasoning is incomplete or unsupported
Reflection	Thoughtfully reflects on learning and generates new mathematical questions	Reflects on learning with some insight	Reflection is limited or incomplete

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Closure (5–10 minutes)

Return to Our Wonder Questions

- Display the class's original Wonder list from the beginning of the lesson.
- Ask students:
  - Which mathematical questions were we able to answer today?
  - Which questions did we answer using measurements or calculations?
  - Which questions still require more information or a different mathematical approach?
  - Which question would you like to investigate next?
- Invite students to identify the evidence they used to answer one question. For example:
  - Wonder: How much space is inside the sculpture?
  - Evidence: We estimated the dimensions, created a scale drawing, and calculated an approximate area.
  - Reasoning: Because we modeled the sculpture using geometric figures, we could estimate the enclosed space.

Final Reflection

Students complete one of the following prompts:

- Today I discovered mathematics in...
- One mathematical idea I understand better is...
- One question I still want to investigate is...
- One way mathematicians think is...

Teacher Closing

- "Today we began by noticing and wondering. Then we built mathematical models, made measurements, performed calculations, explained our thinking, and justified our conclusions with evidence. That's what mathematicians do—they use observation and inquiry to better understand the world around them."

Connection to the Joy2Learn "Seeing Mathematics Everywhere" Professional Development

This lesson plan explicitly models the instructional progression introduced in the Joy2Learn professional development mini-workshop:

PD Framework	Classroom Application
Notice	Students observe Serra's sculptures without mathematical labels.
Wonder	Students generate mathematical questions based on what they see.
Model	Students represent the sculptures using geometric figures and scale drawings.
Calculate	Students estimate, measure, and compute area, distance, circumference, or other quantities appropriate to the grade level.
Explain	Students discuss how they approached the problem and communicate their mathematical thinking.
Justify	Students complete a CER response using observations, measurements, calculations, diagrams, and reasoning to support a mathematical claim.

By following this progression, the lesson shifts from a traditional "apply the formula" approach to an inquiry-based model that emphasizes the Standards for Mathematical Practice. Students experience mathematics as a process of investigation, modeling, communication, and justification, reinforcing the central message of the Joy2Learn professional development: Students learn mathematics most deeply when they begin by seeing it in the world around them.