Building with Curves: Seeing Mathematics Everywhere Through Frank Gehry's Architecture

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

Teachers can adapt the lesson to emphasize:

- Geometry
- Measurement
- Scale drawings
- Area and perimeter

- Surface area and volume
- Ratio and proportional reasoning
- Transformations and symmetry
- Mathematical modeling
- Mathematical argumentation: Claim – Evidence – Reasoning (CER)

Learning Objectives

Students will:

- Observe and describe mathematical structures in architecture.
- Identify geometric shapes, patterns, and spatial relationships.
- Develop mathematical models of real-world structures.
- Apply measurement and proportional reasoning to authentic design 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 and persevere in solving them.
- MP2: Reason abstractly and quantitatively.
- MP3: Construct viable arguments and critique the reasoning of others.
- MP4: Model with mathematics.
- MP5: Use appropriate tools strategically.
- MP6: Attend to precision.
- MP7: Look for and make use of structure.

(Content standards vary by grade level.)

Materials

- Joy2Learn video clips:
    - Intro - Architecture with Frank Gehry - 01: https://youtu.be/UNan60CYKI4?si=V9sj8YO_bB79eO2K
    - Bilbao: https://youtu.be/bVDzLB1jrHw?si=LzATZ0G4nHf224SE
    - Disney Concert Hall: https://youtu.be/vgM3TOYM5vk?si=RDmpT3T8QG8fbydw
- Graph paper
- Rulers
- Calculators
- Observation sheet
- Colored pencils

Lesson Launch (10 minutes)

Step 1: Notice

- Play the Joy2Learn video clips.
    - Intro - Architecture with Frank Gehry - 01: https://youtu.be/UNan60CYKI4?si=V9sj8YO_bB79eO2K
    - Bilbao: https://youtu.be/bVDzLB1jrHw?si=LzATZ0G4nHf224SE
    - Disney Concert Hall: https://youtu.be/vgM3TOYM5vk?si=RDmpT3T8QG8fbydw
- Pause after each building shown in the clips to allow students to complete the "Notice" and "Wonder" portions of the observation guide (see below) before moving into mathematical modeling and discussion.
- Prompt students: What do you notice?
- Students record only observations.
- Possible responses:
    - Curved walls
    - Shiny metal panels
    - Repeating shapes
    - Unusual rooflines
    - Angled surfaces
    - Overlapping forms

    - Few straight lines
- Teacher says: "Today we're beginning like mathematicians—with careful observation before introducing mathematical vocabulary or formulas."

Step 2: Wonder

- Ask:
    - What mathematical questions do these buildings make you wonder about?
    - What could we measure?
    - What shapes do you recognize?
    - How might an architect calculate the materials needed to build this structure?
- Record student questions.
- Possible examples:
    - How tall is the building?
    - How much metal covers the outside?
    - Are some curves parts of circles?
    - How much interior space does the building contain?
    - How could you build a scale model?

Mini-Lesson (15 minutes)

Step 3: Model

- Explain: "Architects and engineers simplify complex structures into mathematical models before they build them."
- Pause one of the Joy2Learn video clips to display one Gehry building
- Ask: What geometric figures could help us model this building?
- Students identify:
    - Rectangles
    - Triangles
    - Circles
    - Arcs
    - Cylinders
    - Prisms
    - Composite figures
- Discuss how architects combine simple geometric shapes to create complex structures.

Mathematical Connections

Grade 6

- Ratios
- Scale
- Area
- Nets

Grade 7

- Surface area
- Volume
- Circles
- Composite figures

Grade 8

- Transformations
- Similarity
- Coordinate geometry
- Linear relationships

Investigation (30 minutes)

Design Investigation

- Working in groups, students analyze one Gehry building.
- Their task is to investigate the building mathematically by choosing three of the following questions.

Measurement

- Estimate:
    - Building height
    - Building width
    - Roof dimensions
- Explain how your estimates were made.

Geometry

- Identify:
  - Polygons
  - Circles
    Arcs
  - Angles
  - Symmetry (if present)
  - Repeated patterns

Scale

- Create a scale drawing.
  - Example: 1 cm = 5 meters
- Label all measurements.

Area

- Estimate the footprint of the building.
- Compare different methods for estimating irregular shapes.

Surface Area

- Estimate how much exterior material might be required.
- Explain what assumptions you made.

Modeling

- Redraw one portion of the building using only basic geometric figures.
- Label dimensions.

Mathematical Discussion (10 minutes)

- Groups share their investigations.
- Teacher asks:
  - What mathematics did your group notice?
  - Did different groups investigate different mathematical ideas?
  - Which measurements were estimates?
  - Which conclusions were supported by calculations?
  - What assumptions did you make while modeling the building?

- Emphasize: "The same building can be explored through many different mathematical lenses."

CER: Supporting Mathematical Arguments

Students respond to one mathematical question.

Example Question

Which section of the building would require the most exterior material to cover?

Claim

- The curved roof section would require the most exterior material.

Evidence

- Students support the claim using multiple forms of mathematical evidence.

Observations

- The roof covers a larger visible area.
- The curved surface extends farther than the walls.

Measurements

- Estimated roof length = 45 meters
- Estimated width = 20 meters

Calculations

- Students estimate the roof's surface using an appropriate geometric model and compare it with another section of the building.

Diagrams

- Students annotate a photograph or sketch, labeling dimensions and identifying the geometric figures used in their model.

Reasoning

- Because the roof covers the largest estimated surface and extends across the widest portion of the structure, it would require more exterior material than the walls or entrance.
- Students explain how their evidence supports the claim.

Reflection

- Students complete the following prompts:
    - Today I noticed...
    - Today I measured...
    - Today I modeled...
    - Today I calculated...
    - One mathematical idea I understand better is...
    - One question I still have is...

Assessment

Formative

- Teacher listens for:
    - Precise mathematical vocabulary
    - Mathematical reasoning
    - Collaborative problem solving
    - Evidence-based discussion

Summative

- Students submit:
    - Observation guide (see below)
    - Annotated building sketch
    - Scale drawing
    - Measurements and calculations
    - CER response

Rubric

Criteria	Advanced	Proficient	Developing
Observation	Identifies multiple mathematical structures and relationships	Identifies key mathematical features	Limited observations
Modeling	Develops an accurate geometric model with appropriate assumptions	Creates a mostly accurate model	Needs support creating a model
Measurement & Calculation	Accurate estimates, calculations, and justification	Minor errors in estimation or calculation	Significant errors or incomplete work
Mathematical Reasoning	Supports claims with multiple forms of evidence and clear reasoning	Supports claims with appropriate evidence	Limited evidence or explanation
Communication	Uses precise mathematical vocabulary and clear explanations	Mostly precise mathematical language	Relies primarily on everyday language

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Closure

- Return to the opening question: Where do you see mathematics?
- Students complete the sentence: "Today I discovered mathematics in..."
    - Possible responses:
        - Architecture
        - Engineering
        - Design
        - Public spaces
        - Curved buildings
        - Everyday structures
- Conclude: "Mathematics helps us understand how architects transform creative ideas into buildings that are beautiful, functional, and structurally sound. Like mathematicians, we began by observing, asked questions, built mathematical models, made measurements and calculations, and justified our thinking with evidence."

Connection to the Joy2Learn "Seeing Mathematics Everywhere" Professional Development

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

PD Framework	Classroom Application
Notice	Students observe Gehry's architecture without immediately naming mathematical concepts.
Wonder	Students generate mathematical questions based on the buildings they observe.
Model	Students represent complex architectural forms using geometric figures and scale drawings.
Calculate	Students estimate, measure, compare, and compute quantities such as area, scale, and surface area appropriate to their grade level.
Explain	Students discuss their mathematical thinking, compare solution strategies, and communicate how they approached the investigation.
Justify	Students complete a CER response using observations, measurements, calculations, annotated diagrams, and mathematical reasoning to defend a claim.

By following this sequence, the lesson emphasizes inquiry before procedure and positions students as mathematical investigators. It aligns with the central message of the Joy2Learn "Seeing Mathematics Everywhere" professional development: mathematics is not merely a collection of formulas but a way of observing, modeling, analyzing, and explaining the world through evidence-based reasoning.

Observation Guide

Building with Curves: Seeing Mathematics Everywhere Through Frank Gehry's Architecture

Name: _____

Step 1: Notice

- Observe before using mathematical vocabulary.
- What do you notice?
    - Examples:
        - Curved surfaces
        - Repeating shapes
        - Shiny panels
        - Sharp angles
        - Overlapping forms
        - Tall sections
- Record at least 8 observations.

My Observations:

1.
2.
3.
4.
5.
6.
7.

8.
9.
10.

Step 2: Wonder

- Write at least 5 mathematical questions.
    - Examples:
        - How tall is the building?
        - How much metal covers the outside?
        - Are these curves parts of circles?
        - How much space is inside?

I wonder …

Question 1	
Question 2	
Question 3	
Question 4	
Question 5	
Additional Question	
Additional Question	
Additional Question	

Step 3: Mathematical Structure

- Circle every idea you notice.
  - Circles
  - Arcs
  - Rectangles
  - Triangles
  - Composite figures
  - Parallel lines
  - Perpendicular lines
  - Angles
  - Symmetry
  - Transformations
  - Patterns
  - Scale
  - Other: _____

Step 4: Model

- Which simple geometric figures could help model this building?
- Draw and label your model.

Step 5: Measure/Estimate

- Estimate the following.

Measurement	Estimate	How did you estimate?
Height		
Width		
Roof length		
One curved section		

Step 6: Calculate

- Choose one calculation to complete for your model building.
    - Area
    - Perimeter
    - Circumference
    - Surface Area
    - Volume
    - Scale
- Complete the calculation and show your work.

Step 7: Explain

- What mathematics helped you understand this building?

Step 8: Justify using Claim - Evidence - Reasoning (CER)

Claim

One mathematical claim I can make is:

Evidence

- Support your claim using:
  - Observations
  - Measurements
  - Calculations
  - Diagram

Reasoning

Explain why your evidence supports your claim.