Planning for Student Mathematical Modeling

Name of Project Bridging the Willamette River _______ **Grade Level/Course** Algebra (for middle school) _____ **Duration** 4 standard days _____________

Other subject areas to be included, if any geography, architecture

Project Overview What is the problem, challenge, or issue? Who/what benefits from solving the problem, challenge, or issue? Students will examine a part of their local community to identify a location for a bridge over the river to connect Lake Oswego with Milwaukie/Oak Grove to increase accessibility to other parts of the greater Portland area. Based on its location, students will then determine the quadratic function that models the bridge.	**Mathematical Content Learning Goal (Residue)** What understandings will students take away from this experience? How does this connect to content standards? Students will be able to understand quadratic functions and the parabolic shapes they model as something beyond a graph or an equation and recognize the shape as one that shows up in real life. A.CED.2, A.REI.10, F.LE.5
Essential Question(s) What questions will be used to stimulate thought, to provoke inquiry, and to spark more questions, not just pat answers? *The intent is to be provocative and generative.* Where would you place an arch bridge from Lake Oswego and Milwaukie/Oak Grove? What quadratic function models it?	**Mathematical Practice Learning Goal** What proficiencies will students demonstrate during this experience? How does this connect to standards for mathematical practice? Students will demonstrate proficiency in mathematical practices 1, 2, 3, 4, 5, and 6.

Mathematical Processes Check all that apply.	✓ Problem solving	✓ Reasoning & proving	■ Communicating	✓ Connecting	✓ Representing

Equity-Based Teaching Practices Which equity-based teaching practices are reflected in your plan? In what ways? Be specific.	**Ambitious Mathematics Teaching Practices** Which ambitious mathematics teaching practices are reflected in your plan? In what ways? Be specific.

Task Launch How will you introduce and set up the task to ensure that all students understand and can begin productive work, without diminishing the cognitive demand or taking away opportunities for students to engage deeply in the modeling process?

1. Show students a map of the general Lake Oswego and Milwaukie/Oak Grove areas. Ask about their favorite places to visit on the east side of the Willamette River.
2. Review the previous day's learning about characteristics of quadratics, including how the zeros can be used to find the axis of symmetry, and therefore the vertex of a modeled parabola (problem from lesson included below).
3. Introduce task and resources available to complete the task.

Project Resources What specific scaffolds, supports, materials will be provided by teacher, other staff, outside experts?	**Project Report** What models and representations would be included in a project report? How will the findings be made public?
➔ Google Map of entire area (make sure to pay attention to the scale of the map in the bottom right corner to determine distance) ➔ Bridge resources 1, 2, 3, 4, 5, 6, 7 ➔ Desmos graphing calculator	Students will create a Doc, Slides, Drawing, or other format to identify their intended location using a map or description of the location, any visuals they create of their bridge, a visual of their Desmos graph paired with their equation based on the intended size of the bridge, and any necessary defense of their plan. Students will be placed into groups once they have determined location by like locations to share their own work, then jigsaw groups to share with other location choices.

Evaluation Criteria What will you listen for as students present? What will you look for in their written work? Is there a rubric, checklist, self- or peer- assessment tool that you will use?
Students should be able to defend their choice of location and determine the size of their bridge based on that. They should demonstrate an understanding of arch bridges and how to conceptually construct one across a waterway. They should then be able to connect their specific plan with a quadratic function, using Desmos as a support since they do not yet know specifically how to write a quadratic function based on their model. I will use this rubric to assess them.

Modeling Process

Stage 1: Identify and specify the problem to be solved--telling the story
Stage 2: Make assumptions and define essential variables-- Make decisions
Stage 3: Use mathematics to get a solution-- mathematizing
Stage 4: Analyze and assess the model and solution--does it make sense
Stage 5: Iterate as needed to refine and extend the model--repeat
Stage 6: Implement the model and report results--tell the story

Lesson and Learning Goals concepts, processes, practices, knowledge and skills	**Modeling Process** applicable stages	**Strategies Supporting Engagement of All Learners** Teacher actions/questions/moves to assure engagement in learning aligned with learning goals and connected to formative assessments	**Formative Assessments** look/listen fors that will indicate students are on track
Review understandings of quadratic functions, including standard form, identifying direction of the parabola, vertex, maximum or minimum, domain and range, zeros, and axis of symmetry. Show map of the area. Ask essential questions. Give constraints	1, 2	Interactive slide or jamboard in small groups reviewing previous learnings, whole group revisit before moving on. Discuss map and information it gives. Pinpoint favorite locations. Needs to connect to a road on either side (road might not currently come all the way to the water, but should be close). Must allow boats to pass under "What do boats require with other bridges on the Willamette?" Should follow general rules of arch bridge construction so that it is sturdy and will not collapse.	Participation from everyone. Ability to use keywords. Recognition of resources when they're not sure what something means or how to calculate (textbook locations). Everyone has a voice.
Brainstorm questions. Provide resources. Demonstrate Desmos calculator and sliders with y=mx+b. Research time regarding	1, 2, 3	"What might we need to know in order to answer these questions?" Compile questions in a public space for students to see and access. "This may not be everything you need, but will get you started." "How do the sliders impact y=mx+b?" "What are some things we know can change about a quadratic function? How do we see those show up in standard form?" Provide a document to compile.	Questions are relevant to the situation. Understanding of impact of changes in m and b to the graph. Ability to make a connection to a, b, and c of a quadratic. Information on each major element:

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location, specifics about arch bridges, existing Portland area bridges, possible widths and heights of the bridge based on location. Formulate initial plan.		Partner check in on research. “What else do you still need to know? Is there anything the resources I’ve provided don’t answer for you?” Access to me to ask clarifying questions.	location, width, possible heights. Ability to make connections to the constraints, existing bridge system in our area, and their reasoning for bridge location.
Partner check in regarding plan. Students finalize and revise location and size planning. Students create a visual on Desmos and determine the equation that fits their bridge.	3, 4, 5	Partners ask: “Why did you choose your location?” “How did you decide on the width and height of your bridge?” “What do you think the equation for your bridge might look like?” Provide rubric. Access to me to ask clarifying questions.	Ability to defend their “whys” and “hows” Possible adjustments to plan based on partner conversations and rubric.
Create report. Like location small groups for sharing model. Jigsaw groups of different locations.	6	Provide a list of ways students can share. Make small groups based on students determinations for location in a like location cohort for sharing similarities and differences with a common variable (location). Students share their plans with those who made other choices for locations, looking for similarities and differences in plans. “How does your graph and equation demonstrate what your bridge will look like?”	 Clear reason for why they chose their location. Ability to articulate their decisions and the implications of them.

Make a copy of this page to flesh out additional lessons.

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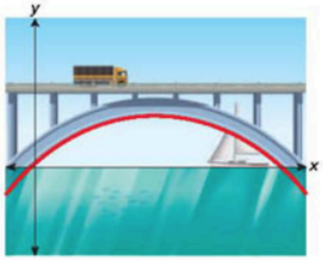
Architecture Application

The height above water level of a curved arch support for a bridge can be modeled by $f(x) = -0.007x^2 + 0.84x + 0.8$, where x is the distance in feet from where the arch support enters the water. Can a sailboat that is 24 feet tall pass under the bridge? Explain.



The vertex represents the highest point of the arch support.

Step 1 Find the x-coordinate.

$a = -0.007$, $b = 0.84$ — *Identify a and b.*

$$x = -\frac{b}{2a}$$

$$= -\frac{0.84}{2(-0.007)} = 60$$ — *Substitute −0.007 for a and 0.84 for b.*

Step 2 Find the corresponding y-coordinate.

$f(x) = -0.007x^2 + 0.84x + 0.8$ — *Use the function rule.*

$= -0.007(60)^2 + 0.84(60) + 0.8$ — *Substitute 60 for x.*

$= 26$

Since the height of the arch support is 26 feet, the sailboat can pass under the bridge.

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