Water Project

Lesson Plan

Real-World Context	Possible Math Tools
Students divide into groups, and each group will determine how much water the school would need in an emergency disaster. Students may brainstorm one of many different modeling problems: • How much would all of the water cost? • How much space would all of the water take up? • What is the best way to distribute the water? • How much water does the school need to resupply after a disaster?	Variables, rates, algebraic equations, linear functions, volume, area

Relevant Common Core Standards:

CCSS.MATH.CONTENT.6.EE.A.2
Write, read, and evaluate expressions in which letters stand for numbers.
Task: Write an expression about how much water people drink, consume, and use in a day.

CCSS.MATH.CONTENT.6.RP.A.3.D
Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.
Task: Measure the amount of water in various bottles of water and locations with water using different measurement units. Then sum the total amount of water.

CCSS.MATH.CONTENT.6.RP.A.1
Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
Task: Determine the ratio of the amount of water needed per person.

CCSS.MATH.CONTENT.7.RP.A.2.C
Represent proportional relationships by equations.
Task: Write an equation that uses the information that the amount of water in proportional to the number of people.

CCSS.MATH.CONTENT.7.EE.B.3
Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
Task: Determine a numerical approximation of the amount of water needed for an emergency disaster by doing research or experiments.

This lesson was developed by Laura Pahler, Marcy Santos, Ralph Olaiz, Elizabeth Soto, and Vin Kanchana
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CCSS.MATH.CONTENT.7.EE.B.4
Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Task: Assign variables to the number of people, the duration of the disaster, and/or the cost of water.

CCSS.MATH.CONTENT.7.G.B.6
Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
Task: Measure the amount of space available to store water and then determine the best shape of container to store the water in.

CCSS.MATH.CONTENT.8.F.A.1
Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
Task: Understand that the input is the number of people, duration of the disaster, and/or the cost of water, and the output in the total amount of water needed.

CCSS.MATH.CONTENT.8.F.B.4
Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (*x, y*) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.
Task: Construct a function to model the linear relationship between the number of people and the total amount of water. Other function inputs such as space available to store water, the duration of the disaster, or the cost of water.

CCSS.MATH.CONTENT.8.G.C.9
Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.
Task: Use the formula for the volume of shapes to measure the amount of water certain activities need. Additionally, use the formula for the volume of shapes to find the best shape to store the water in.

Dive In:

Students begin exploring the topic.

Student Actions	Teacher Actions

Students will explore the topic by answering questions such as:
• What do you notice? What do you wonder?
• What is interesting about this topic?
• What about this topic is important?
• What information do you need?
 	
Students will brainstorm these questions in groups.
	What will you show/tell students to launch the real-world context and capture their interest?
	• Can lead a discussion with the following questions:
	    ○ What is a disaster?
	    ○ What happens during a disaster?
	    ○ What do you need to prepare for a disaster?
	    ○ What do you think is the most important thing to prepare to survive?
	    ○ What would you need if you were stuck at school without running water and/or electricity?
	• Have students read articles, watch videos, or look at pictures about disasters that happened near schools
	
	Allow students time to brainstorm. Monitor student progress and group dynamics.
	
	Take note of anything that should be shared with the class:
	• ideas that help students mathematize the problem
	• common misconceptions

Define the Problem:

Ideas are narrowed to a focused, mathematically relevant problem.

Student Actions	Teacher Actions
Students will choose a focused problem that can be answered and justified with information and mathematics. Students should consider questions such as: • What information do you need to make a model? • What quantities are required by the model? Which ones are provided? • Do quantities have only one value, or can they have a range of values? • What mathematical tools could you use in your model?	Guide students towards a focused problem that can be answered and justified with information and mathematics. *What are my expectations for the model? Will the whole class focus on the same problem, or will variation be allowed?* The whole class will focus on the same problem, but extension questions off of the main problem of how much water the school should store for an emergency, can be varied. *What mathematical tools/connections could you suggest to students who aren't using math?* • Volume calculations of how much water is needed • Assigning variables to unknown quantities and quantities students will want to vary. • Creating algebraic equations that equal different variables they want to find out. • Data tables and charts about how much water various age groups, weights, and genders need. *How will you guide your students to use new skills they are less comfortable with?* • Regroup for whole group instruction if there is a new math concept that students are interested in learning. • Provide hands on activities for students to learn about volume such as pouring liquids into different volume containers to see how much space they take up. • Show students how to manipulate algebraic equations.

Do the Math:

Iterate the model until it is done and can be evaluated.

Student Actions	Teacher Actions
Use mathematical tools to develop a model. Mathematically justify all estimations and numerical values in model. Use the model to suggest a solution. Record work.	Note the mathematics that develops during model building. *What are some common misconceptions that could arise at this stage, and how might you address them?* Students may misunderstand different unit conversions they need to carry out. Solve by giving students different containers with different labeled units on the sides. Have them create their own conversions by pouring a set amount of liquid from one container to another. Or provide students with a conversion chart. Address misconceptions individually or as a group. *When are natural times to regroup?* • After students brainstorm questions about the problem. • After students have identified assumptions they may have made in their model. • After students have decided what type of experiments they want to perform.

Decide Whether You're Satisfied, and Declare Victory:

Evaluate your model and decide when the model is ready to be presented.

Student Actions	Teacher Actions
Students should be evaluating their model by asking questions such as: • If there is a rubric or checklist, see if you did everything. • Is your solution reasonable? Why or why not? • Is your solution useful for answering your question?	*What components do you expect the students' models to include?* The model should include an equation of how to determine the volume of water needed with parameters such as number of people and number of days of the disaster. The model should also include the cost of the bottles of water based on specific parameters such as the number of packages needed, the number of bottles needed, and the size of the package. Students should provide justification for numbers that they use in their equations, a definition of each variable, and assumptions they made. Recall that specific tasks are detailed in "Relevant Common Core Standards" above. *What will a useful model be able to do?* A useful model will be able to predict the amount of water needed for various durations of disasters, varying amounts of people, and varying sizes of bottles of water. **Define an ending point** for your students' models, and set clear expectations. Guide students through reviewing their models by considering the questions on the left.

Demonstrate Solution:

Present and interpret your model that solves the problem.

Student Actions	Teacher Actions
Students will reflect, justify, and present their models by asking and answering questions such as: • Why would you recommend your model to someone? • What mathematical tools did you use, and how did they help solve the problem? • What did you change in your model throughout the modeling process? • Are there situations where your solution wouldn't work or your model wouldn't apply? • How would you need to change your model to apply to more situations? • If you had more time, what else would you do? • Are there any mathematical tools or pieces of information that would have been helpful to have?	*What expectations do you have for students' presentations?* Group names Define the problem Make assumptions Define variables Show math Analysis and model Report the results Explain their model and results Calculations Reasoning/findings Cost Guide students in evaluating their solutions by answering the questions on the left, as a whole class or in groups. (A presentation rubric from IMMERSION is available on the Math Modeling Hub.)

Revisit:

These questions may help you consider possible extensions to the problem. Tying the problem to more advanced math gives students a frame of reference for newer mathematical tools.

Q: *When could you recall the math used in this lesson as a starting point or an example later in your curriculum?*

A: Students can learn about creating equations with variables in this modeling project which can be brought up more formally when creating equations is taught. When students learn about volume of various shapes this modeling project can be recalled.

Q: *Is there a time later in the year when you might come back to this real-world scenario with different mathematical tools? Remember that students sometimes reach for tools that are most familiar and it might take them a while to build confidence to use a new tool in a modeling situation.*

A: Once linear functions, including slope, graphing, and writing linear equations, are taught the modeling problem can be revisited.

Q: *Throughout the year, will you be collecting new information about this scenario? Are there times you could use that information to reflect on and improve your model?*

A: Throughout the year more information about how much water the body needs can help improve the model. Information about how much water one shower needs, or how much water brushing teeth needs can also help improve the model.

Q: *Are there other similar scenarios where you could use the same kinds of models? What might change? What might stay the same?*

A: A similar model could be used to determine how much food would be needed in an emergency. The amount of people and length of the disaster would stay the same, but the sources of food consumption versus water consumption would be different.

For more resources on how to change parameters and constraints or how to extend this task to other grades, consider consulting the GAIMME report pages 136-139 http://www.siam.org/reports/gaimme.php.