Lesson 15

Using Water Efficiently

Goals

- Apply reasoning developed in this unit to determine whether a proportional relationship models a situation about water usage.
- Make simplifying assumptions and determine what information is needed to solve a problem about water usage.
- Use proportional relationships to analyze (orally and in writing) a problem about water usage.

Learning Target

I can answer a question by representing a situation using proportional relationships.

Lesson Narrative

In this lesson, students apply their understanding of proportional relationships to solve an open-ended, real-world problem—whether baths or showers use more water. The *Warm-up* orients students to thinking about quantifying a rate of water flow. Then students brainstorm what they would need to know in order to solve the problem. They make assumptions about the situation and then seek out resources to help them answer the question. As students work to determine relevant quantities and conditions, make approximations, and apply what they know to analyze relationships and draw conclusions, students practice modeling with mathematics.

Preferably, students work on their own to find values to aid in their solutions. For example, sizes of typical bath tubs are usually listed on websites for hardware stores that carry baths for installation. If these resources are unavailable, the teacher can share some typical ranges or reasonable estimates.

The last activity is optional because it provides an opportunity for additional practice graphing a proportional relationship.

Student Learning Goal

Let's investigate saving water.

Lesson Timeline

5 min	20 min	10 min
Warm-up	Activity 1	Activity 2

Access for Students with Diverse Abilities

- Action and Expression (Activity 1)

Access for Multilingual Learners

- MLR1: Stronger and Clearer Each Time (Activity 2)
- MLR7: Compare and Connect (Activity 1)

Instructional Routines

- MLR1: Stronger and Clearer Each Time
- MLR7: Compare and Connect
- Notice and Wonder

Required Materials

Materials to Gather

- Internet-enabled device: Activity 1
- Tools for creating a visual display: Activity 2

Activity 1:
Internet enabled devices are only needed if students will conduct their own research.

Warm-up

Notice and Wonder: Water

5 min

Activity Narrative

The purpose of this *Warm-up* is to elicit the idea of comparing and quantifying water flow, which will be useful when students estimate the water usage of a bath or shower in a later activity. While students may notice and wonder many things about these images, the important discussion point is quantifying the rate of water flow.

This *Warm-up* prompts students to make sense of a problem before solving it by familiarizing themselves with a context and the mathematics that might be involved.

Launch

Arrange students in groups of 2. Display the images for all to see. Ask students to think of at least one thing they notice and at least one thing they wonder. Give students 1 minute of quiet think time, and then 1 minute to discuss the things they notice and wonder with their partner.

Student Task Statement

What do you notice? What do you wonder?

Students may notice:

- There are two photos of water coming out of a pipe or hose.
- In one photo, the water is flowing into a bathtub.
- In the other photo, the water is being sprayed into the ocean.
- There is more water in the ocean than the bathtub.
- There is more water flowing out of the big hose than the bathtub spout.

Students may wonder:

- Where were these photos taken?
- How long will it take to fill the bathtub?
- Why is the person spraying water into the ocean?
- How much more water is coming out of the big hose than the bathtub spout?

Inspire Math

Golden Temple video

Go Online

Before the lesson, show this video to review the real-world connection.

ilclass.com/l/614229

Please log in to the site before using the QR code or URL.

Instructional Routines

Notice and Wonder

ilclass.com/r/10694948

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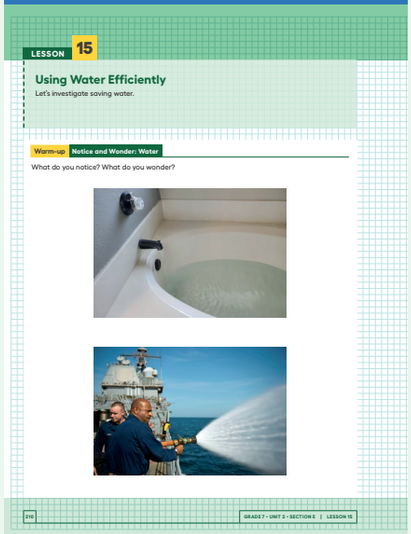
Student Workbook



Activity Synthesis

Ask students to share the things they noticed and wondered. Record and display their responses for all to see without editing or commentary. If possible, record the relevant reasoning on or near the images. Next, ask students,

- *"Is there anything on this list that you are wondering about now?"*

Encourage students to respectfully disagree, ask for clarification, or point out contradicting information.

If comparing or quantifying the water flow from each pipe does not come up during the conversation, ask students to discuss this idea.

Consider asking questions such as:

- *"Which pipe has more water coming out of it? About how many times more water?"*
- *"How could we measure the amount of water coming out of a pipe?"*

Activity 1
Comparing Baths and Showers

20 min

Activity Narrative

In this activity, students are presented with the question of whether baths or showers use more water. First, they brainstorm information that might help them investigate the question. Then, they determine values for the quantities of interest and complete their calculations.

As students identify relevant quantities, research or estimate necessary values, and make assumptions about a situation to solve a problem, they are engaging in aspects of mathematical modeling.

Launch

Introduce the problem context:

- *"Some people take showers, some people take baths. There is disagreement over which one takes more water."*

Ask students to think for a minute about whether a shower or a bath uses more water. (This is just to record their first instinct—they should not spend any time researching or calculating right now.) Poll the class and record the total number of students predicting each answer for all to see.

Arrange students in groups of 2–4. Either tell them that they should research relevant information (and provide access to internet enabled devices) or tell them that they can ask you for the information they need.

Values that may be useful for students:

- Typical (modern) shower heads have a flow rate of 1.9 to 2.5 gallons per minute. Older shower heads (pre-1992) could have flow rates up to 5.5 gallons per minute.
- Bathtubs hold approximately 120 to 180 gallons of water when completely filled to the top.
- The interior of a typical bathtub has an approximate width of 30 to 32 inches, length of 55 to 60 inches, and depth of 18 to 24 inches.

- There are approximately 230 cubic inches in 1 gallon of water.
- 1 liter is 1,000 cubic centimeters.
- 1 liter is approximately 0.26 gallons
- 1 inch is 2.54 centimeters.
- Typical showers last approximately 10 minutes. During a drought, it is recommended to reduce the time to about 5 minutes. During normal circumstances, some people appreciate much longer showers.

Student Task Statement

Some people say that it uses more water to take a bath than a shower. Others disagree.

1. What information would you need in order to answer the question?

   Sample responses: length of the shower, how fast water comes out of the shower head, size of the bathtub, how much of the bathtub is filled with water

2. Describe how you could get the information and how you would use the information to find the answer.

   Sample responses:

   - Use a bucket to collect all the water that comes out of the shower head for 30 seconds and then measure its volume. Time how long each shower lasts for a week. Find the average shower length and multiply it by the amount of water used per minute.
   - Use a bucket to collect the water that comes out of the tub spigot for 30 seconds and then measure its volume. Time how long it takes to fill the tub to the usual level. Multiply the time by the amount of water added per minute.

3. Find out values for the measurements you need to use the method you described. You may ask your teacher or research them yourself.

   Sample responses:

   - shower head flow rate: 3 gallons per minute
   - average shower length: 10 minutes
   - tub spout flow rate: 4 gallons per minute
   - time to fill the tub: 8 minutes

4. Under what conditions does a bath use more water? Under what conditions does a shower use more water? Explain or show your reasoning.

   Sample responses:

   - For a bath filled with 40 gallons of water and a shower head that uses 2 gallons per minute, any showers less than 20 minutes long will use less water than a bath. Longer showers will use more water than a bath.
   - For a bath filled with 30 gallons of water and a shower head that uses 4 gallons per minute, any showers less than 7.5 minutes long will use less water than a bath. Longer showers will use more water than a bath.
   - A 10-minute shower with a 3.5 gallon per minute shower head will use 35 gallons of water. Filling the bath with less water than that will use less water than the shower. A bath that is filled more than that 35 gallons will use more than the shower.

Student Workbook


1 Comparing Baths and Showers

Some people say that it uses more water to take a bath than a shower. Others disagree.

1. What information would you need in order to answer the question?

2. Describe how you could get the information and how you would use the information to find the answer.

3. Find out values for the measurements you need to use the method you described. You may ask your teacher or research them yourself.

4. Under what conditions does a bath use more water? Under what conditions does a shower use more water? Explain or show your reasoning.

Access for Students with Diverse Abilities (Activity 1, Synthesis)

Action and Expression: Internalize Executive Functions.
To support development of organizational skills in problem-solving, chunk this task into more manageable parts. For example, check to make sure students have a valid method for comparing the water usage for a bath and a shower prior to allowing them to research typical values of measurements.

Supports accessibility for: Organization, Attention

Access for Students with Diverse Abilities (Activity 2, Launch)

Action and Expression: Internalize Executive Functions.
Give students a checklist or list of steps to provide access to the tools or assistive technologies students will use, such as a graphing calculator or graphing software.

Supports accessibility for: Memory, Attention

Activity Synthesis

The goal of this discussion is to show different ways that students used proportional reasoning to determine whether a bath or shower uses more water. There is no clear cut answer to this question, because it depends on the interaction of a variety of factors. As students share their reasoning with the class, highlight how their estimates and assumptions affected their final answer. For example, using a shorter average shower length in the calculations may suggest that a shower uses less water than a bath, while using a longer average shower length may give the opposite impression.

Invite groups to prepare a visual display that shows the strategy they used to decide what conditions cause the bath or shower to use more water. Encourage students to include details that will help others interpret their thinking. Examples might include using specific language, different colors, shading, arrows, labels, notes, diagrams, or drawings. Give students time to investigate each other's work. During the whole-class discussion, ask students:

- *"What did the approaches have in common? How were they different?"*
- *"Why did some approaches lead to the same outcome? Why did some approaches lead to different outcomes?"*
- *"What kinds of additional details or language helped you understand the displays?"*

Activity 2: Optional

Representing Water Usage

10 min

Activity Narrative

This optional activity gives additional review for the material from the unit in the context of this lesson. Students build on the work they did in the previous activity and see that water used in the shower is proportional to time spent in the shower, with a constant of proportionality equal to the flow rate of the shower head.

Launch

Keep students in the same groups. Tell them they will continue considering the situation about water usage in baths and showers from the previous activity. Give students 5–6 minutes of partner work time.

Student Task Statement

1. Continue considering the problem from the previous activity. Name two quantities that are in a proportional relationship. Explain how you know they are in a proportional relationship.

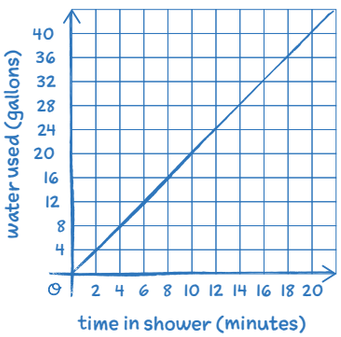
   Amount of water used in the shower and time spent in the shower is a proportional relationship. The amount of water used divided by the amount of time spent in the shower is always the same constant.

2. What are two constants of proportionality for the proportional relationship? What do they tell us about the situation?

   2 gallons per minute and $\frac{1}{2}$ minute per gallon

3. On graph paper, create a graph that shows how the two quantities are related. Make sure to label the axes.

   Constant of proportionality: 2 gallons per minute



4. Write two equations that relate the quantities in your graph. Make sure to record what each variable represents.

   $w = 2t$ and $t = \frac{1}{2}w$, where w represents the amount of water used in the shower and t represents the amount of time in the shower.

Activity Synthesis

Invite students to share their equations and graphs with the class. Use their examples to review the characteristics of a proportional relationship, such as:

- A constant of proportionality that relates the two quantities multiplicatively.
- An equation of the form $y = kx$.
- A graph that makes a straight line through the origin.

Access for Multilingual Learners (Activity 2, Student Task)

MLR1: Stronger and Clearer Each Time.
Give students time to meet with 2–3 partners to share and get feedback on their first draft response to the first question, about how they know the two quantities are in a proportional relationship. Invite listeners to ask questions and give feedback that will help their partner clarify and strengthen their ideas and writing. Give students 3–5 minutes to revise their first draft based on the feedback they receive.

Advances: Writing, Speaking, Listening

Student Workbook


2 Representing Water Usage

1. Continue considering the problem from the previous activity. Name two quantities that are in a proportional relationship. Explain how you know they are in a proportional relationship.

2. What are two constants of proportionality for the proportional relationship?

   What do they tell us about the situation?

3. On graph paper, create a graph that shows how the two quantities are related. Make sure to label the axes.

4. Write two equations that relate the quantities in your graph. Make sure to record what each variable represents.

Learning Targets
+ I can answer a question by representing a situation using proportional relationships.

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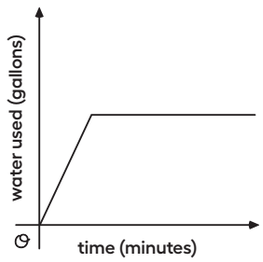
Consider displaying a graph representing the water usage in a bath for all to see. Ask students to interpret the graph and compare it to their graph of water usage in a shower. Consider asking

"Why is this relationship not proportional?"

The water does not flow at a constant rate during the whole bath.



If time permits, consider adding a line to the graph to represent the water usage in a shower. Ask students to interpret the meaning of the point where the two graphs cross.

It shows the amount of time in which a shower uses the same amount of water as a bath. A shower longer than that would use more water than a bath.