A BETTER WAY TO GO

TOILETS AND THE FUTURE OF SANITATION

EDUCATOR RESOURCE GUIDE

Gates Foundation
Discovery Center

EDUCATOR RESOURCE GUIDE

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All Educator Resource Guide materials are available online at discovergates.org/abetterwaytogo/educator-resource-guide.

Scan the QR code to access activity PDFs, worksheets, and PPT presentations.

Introduction

Everybody poops. This means dealing with human waste is an issue everywhere across the globe. Performing this daily activity can look drastically different based on cultural customs, available resources, and access to facilities.

Everybody deserves a toilet that meets their needs, is comfortable to use, and supports the health of their community, yet nearly half of the global population lacks access to a safe, clean toilet that connects to a system which adequately manages their waste. This has enormous implications for urban planning, gender equality, education, and human health. In some places, people have working toilets and sewer systems that allow them to think very little about their waste. Though these systems appear to work well, they deplete valuable resources, often clog or break, and are prone to overflows that can contaminate local waterways.

How can we humans, in every place across the globe, reinvent the toilet to support a healthier, more sustainable future for all?

Student outcomes

The purpose of this resource guide is to provide educators with activities and materials to help students explore the global challenge of sanitation.

Collectively, the activities build toward the following student outcomes:

- Students will understand the global challenge of sanitation, especially issues of access, and develop a nonjudgmental understanding of cultural differences around toilets.
- Students will be able to draw connections between issues of sanitation and other issues like gender equality, human health, poverty, and sustainability.
- Students will consider the future of sanitation, especially how innovation can be used to support human health and environmental sustainability.
- Students will see themselves as able to take action to support water conservation and safe sanitation in their own communities.

How to use this guide

This guide presents four activities for teachers to use to explore toilets and sanitation with their students. It is intended for secondary school use, written to support students around a 9th grade level, but can be adapted for use with most middle or high school students. As an educator, you know your students best. All worksheets and presentations are provided in an editable format. Please download and edit them to fit your students' needs.

Activities 1 and 2 are written to support Washington State Social Studies Learning Standards and are therefore most suitable for social studies classes. Activities 3 and 4 are written to support the Next Generation Science Standards and are intended for science or engineering classes. Specific standards and student outcomes are detailed in the activity descriptions. All four activities are multidisciplinary and could be adapted to suit subject areas other than those for which they were designed.

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Scan the QR code to access activity PDFs, worksheets, and PPT presentations.

Summary of activities

ACTIVITY 1 TOILETS ACROSS THE WORLD

Students will first identify and discuss their own sanitation needs (e.g., privacy, cleanliness, safety, handwashing). The lesson then emphasizes that these needs are universal for human health and wellbeing. Students will next explore global cultural customs around toilets, including sitting or squatting and wiping or washing. The goal of this activity is to build a shared understanding of the enormous diversity of toilets around the world without "othering." For the activity, students will use photography from Dollar Street to explore household toilets in different regions of the world and consider how income impacts available options. Students will leave with a more comprehensive understanding of sanitation across the globe and how their own experience compares.

ACTIVITY 2 MY WATER USE

Students will calculate their own daily water use and compare that to water use in other countries across the world. They will then work together to discuss and plan ways to reduce their water use. Students will explore the wide array of sectors that utilize clean water sources. The goal of the activity is for students to realize water use in wealthy countries (particularly the United States) is unsustainable, but they have agency to conserve water in their own household and communities.

ACTIVITY 3 THE PROBLEM WITH POO

Unfortunately, our toilets and wastewater treatment plants deal with more than just human waste. This activity starts with the different components of wastewater—from cooking oils and trash to feces and pathogens—to help students understand the challenges of treating our waste. Students will then use design and engineering skills to create and test a water filter on simulated wastewater. Students will leave with a more precise understanding of the issues associated with sewer systems and actions they can take to help care for them.

ACTIVITY 4 REINVENTING THE TOILET

The basic designs of toilets and sewer systems haven't meaningfully changed for a few hundred years. It is past time to reinvent the toilet! But what do we mean by a "reinvented toilet," and what could the toilets of the future be like? Students will be given a design challenge to brainstorm their own plan for a toilet inspired by everyday items (e.g., a barbeque, a pressure cooker, and a coffee pot). Students will then explore reinvented toilet designs through video or images. They will reflect on how these designs are similar to or different from their own design.

Visit *A Better Way to Go*

We would love to see your students in the Discovery Center!

These activities are designed to complement the themes and topics of *A Better Way to Go: Toilets and the Future of Sanitation*. The exhibition features interactive displays on toilets around the globe, common challenges with different sanitation systems, and pathbreaking innovations. The stars of the show though are three reinvented toilet machines that represent the cutting edge of rethinking sanitation.

To schedule a visit or a virtual tour you can book online or email DiscoveryCenter@gatesfoundation.org. We hope to see you soon!

ACTIVITY 1 TOILETS ACROSS THE WORLD

Themes: culture

Students will first identify and discuss their own sanitation needs (e.g., privacy, cleanliness, safety, handwashing). The lesson then emphasizes that these needs are universal for human health and wellbeing. Students will next explore global cultural customs around toilets, including sitting or squatting and wiping or washing. The goal of this activity is to build a shared understanding of the enormous diversity of toilets around the world without "othering." For the activity, students will use photography from *Dollar Street* to explore household toilets in different regions of the world and consider how income impacts available options. Students will leave with a deeper understanding of sanitation across the globe and how their own experience compares.

Objectives

- Students will be able to describe shared human needs from sanitation systems.
- Students will be able to explain how global inequalities influence access to sanitation systems.
- Students will be able to express their own cultural toilet preferences within a global context.

Materials

- Activity 1 presentation
- One device per student (ideally, can also be done with one device per small group)
- Internet access

Instructor note

In this lesson students will see images of toilets that are examples of high-quality sanitation as well as images of toilets that represent unsafe and undesirable sanitation. They may also observe toilets that involve unfamiliar cultural contexts. This presents the potential for othering and judgment of communities and sanitation norms that are unfamiliar to some students. Recognizing students come from all backgrounds and experiences, it is important that no student be made to feel lesser or othered because of an experience they have had or they may consider "normal". Strong discussion norms, a respectful classroom environment, and the ability to exercise global curiosity without judgment are essential for the lesson to be successful. Please consider carefully the potential pitfalls which are further enumerated in this lesson plan. The other lessons in this guide approach the topic of sanitation from different perspectives which may work better for some classrooms.

About *Dollar Street*

Dollar Street is a project of Gapminder which exists to presents data in easily digestible ways to help people gain a global perspective. The project founder, Anna Rosling Rönnlund, says *"People in other cultures are often portrayed as scary or exotic. This has to change. We want to show how people really live. It seemed natural to use photos as data so people can see for themselves what life looks like on different income levels.* Dollar Street *lets you visit many, many homes all over the world. Without traveling."* Each family on the site worked with a professional photographer and volunteered to participate in the Dollar Street Project to tell their own stories. Any set of photographs is an incomplete narrative of the world, but we hope you find the resource useful to help students build a broader understanding of the sanitation options and access afforded by different income levels.

Related social studies standards

The following are Washington State Social Studies Learning Standards which relate to the topics in this lesson. This is not an exhaustive list. Each state will have different social studies standards.

- **E1.9-10.2** Analyze how choices made by individuals, firms, or governments are constrained by the resources to which they have access.
- **E2.9-10.4** Analyze the relationship between the distribution of income and the allocation of resources in a variety of economies.
- **E4.11-12.3** Evaluate how individuals and different groups affect and are affected by the distribution of resources and sustainability.
- **G1.6-8.2** Identify the location of places and regions in the world and understand their physical and cultural characteristics.
- **G1.6-8.6** Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions and their political, cultural, and economic dynamics.
- **G1.9-10.4** Explain relationships between the locations of places and regions, and their political, cultural, and economic dynamics, using maps, satellite images, photographs, and other representations.
- **G2.11-12.5** Evaluate how technology can create environmental problems and solutions.

Engage

The goal of this section is to "hook" students on the topic for the lesson (toilets across the world) by having them consider what "good" sanitation means to them.

Ask students to consider what they want in their own sanitation experience. The guiding questions below can start a discussion that can take many forms. For example, students can work together to create a word cloud in small groups based on their responses.

Q1: What are the characteristics of a toilet that you would want to use? Describe it.

Q2: What do you hope happens to your waste after you use the toilet? Put differently, what do you want in a sanitation system?

After students have discussed together, emphasize similarities between group responses. Then expand the discussion to think about the needs of people across the world. Essentially, everyone looks for similar elements in a sanitation system. These include:

- **Clean and smell-free**
- **Ease and comfort of use**
- **Privacy and safety while using**
- **Safe treatment of waste**

Highlight student responses that are similar to these ideas. Emphasize that all people, regardless of where they live or their cultural background, want a very similar toilet experience to what students shared.

Use the presentation to transition to thinking globally. In preparation for exploring different toilets across the world, use images to define the difference between pedestal and squat toilets.

KEY UNDERSTANDING
Everyone knows what "good" sanitation looks and feels like. It is an essential human need.

Explore

The goal of this section is for students to draw their own conclusion about differences between toilets across the world and the relationship between household income and access to "good" sanitation.

Direct students to the *Dollar Street* website to explore how toilets look across the world. Ideally students should have individual devices, but they can also work in small groups. Use the instructions in the presentation to help students navigate the website to view toilets from three countries across the world. Students can choose which countries to explore. Allow students to explore for 5–10 minutes.

After some general exploration, provide students with the three investigation prompts below. They will need to navigate to different families and countries on *Dollar Street* to answer the questions.

Dollar Street investigation:

1. **In what parts of the world are squat toilets most common? In what parts of the world are pedestal toilets most common?**
2. **What patterns do you observe based on family income? What changes about toilets as people have more income?**
3. **Write the name and location of four different families whose toilet you would be comfortable using. Each family must be from a different continent.**

Once students have completed the investigation, you may wish for them to share what they discovered. Help students draw conclusions and summarize their findings using the discussion question below.

Q3: What factors influence what type of toilet/sanitation people have access to?

Prompt students to consider economic, social, and cultural factors. Use the discussion to emphasize that no one type of toilet (squat or pedestal) is better than the other and generally access to "good" sanitation is a matter of income.

Key understanding
Toilets look very different across the world depending on many factors including cultural preferences, income, access to water, and access to sewers.

Explain

The goal of this section is to provide students with factual global information around sanitation to complement the images they explored.

Use the presentation to provide students with a few key stats about types of toilets used across the world. Emphasize that though some customs may feel unusual to people in Western countries, cleansing with water and using squat toilets are very common across the world and are safe, clean, and healthy.

Important note: There is no connection between these stats and global figures around the number of people who lack safe sanitation, and it is important not to conflate them. Both squat and pedestal toilets can attach to safely managed sanitation systems. Washing and wiping are both healthy ways of cleaning oneself. What is "normal" simply looks different across the world. It is important to challenge these misconceptions if they come up with students.

Show the statistic about the number of people globally who lack access to safely managed sanitation. Almost half of the planet experiences this issue. Emphasize that access to clean, effective toilets that safely manage our waste is essential for human health and well-being. Disease can be spread when people don't have access to toilets or when these toilets are so unsuitable that it is preferable to practice open defecation. Ask students to share their reflections or thoughts on these statistics in whatever way works best for your classroom.

Key understanding
Much of the world may have a very different sanitation experience from what is most common in wealthy Western countries. That's okay! There is no single way for safe, clean, healthy sanitation to look. However, everyone deserves access to a comfortable experience that prevents the spread of disease.

Extend (optional)

Students can create their own *Dollar Street* of toilets in their own lives.

Prompt students to take a photograph of a toilet they encounter which they would want to use, as well as one they wouldn't want to use. Compile into a gallery walk or slide show for students to view and discuss.

Evaluate

The goal of this section is to see how well students reached the lesson objectives.

To wrap up the lesson ask students to reflect on their answer to the following questions. This could be through an exit ticket, discussion, or any other way you evaluate student learning.

Q4: What does "good" sanitation mean to you? What does it look like? How might it look different in different places?

Use student responses to check progress toward the lesson objectives.

ACTIVITY 2 MY WATER USE

Themes: sustainability

Students will calculate their own daily water use and compare that to water use in other countries across the world. They will then work together to discuss and plan ways to reduce their water use. Students will explore the wide array of sectors that utilize clean water sources. The goal of the activity is for students to realize water use in wealthy countries (particularly the United States) is unsustainable, but they have agency to conserve water in their own household and communities.

Objectives

- Students will be able to calculate their own water use in a day.
- Students will consider the many ways fresh water is used in the United States.
- Students will be able to determine different ways to reduce their water use.

Materials

- Activity 2 presentation
- "My water use" worksheet or access to online water use calculator
- "Indirect water use in the U.S." worksheet
- "Water use in the United States" handout
- Videos on creative water use (optional)
- Color pencils

Related social studies standards

The following are Washington State Social Studies Learning Standards which relate to the topics in this lesson. This is not an exhaustive list. Each state will have different social studies standards.

- **E2.6-8.1** Describe the production, distribution, and consumption of goods, services, and resources in societies from the past or in the present.
- **E2.6-8.3** Analyze the production, distribution, and consumption of goods, services, and resources in societies from the past or in the present.
- **E4.6-8.5** Analyze the distribution of wealth and sustainability of resources in the United States.
- **G2.6-8.6** Analyze how the environment has affected people and how people have affected the environment in the United States in the past or present.
- **E1.9-10.2** Analyze how choices made by individuals, firms, or governments are constrained by the resources to which they have access.
- **E2.11-12.7** Evaluate the relationship between the distribution of income and the allocation of resources in a variety of economies.
- **E4.9-10.1** Evaluate how people across the world have addressed issues involved with the distribution of resources and sustainability.
- **E4.11-12.1** Evaluate how people in the United States have addressed issues involved with the distribution of resources and sustainability.
- **E4.11-12.3** Evaluate how individuals and different groups affect and are affected by the distribution of resources and sustainability.
- **G2.9-10.1** Analyze human interaction with the environment across the world in the past or present.
- **G2.9-10.3** Explain that the environment is modified through agriculture, industry, settlement, lifestyles, and other forms of activity.
- **G2.11-12.1** Evaluate human interaction with the environment in the United States in the past or present.

Engage

The goal of this section is to "hook" students on the topic for the lesson: water use across the world and their own role in reducing it.

Start by showing the students the two charts comparing water use in the United States and other countries. The charts show drastically different numbers for per capita water use in the United States. That is because the first chart is measuring direct water use while the second is measuring indirect water use. See this explainer from the Water Education Foundation to learn more about the two types of water use.

Start with a discussion to help students explore the types of water use and why the United States uses so much water. These concepts will drive the rest of the lesson.

Q1: What are some ways you directly use water?

Q2: What are some ways you indirectly use water? (Think about the things you use or need.)

Q3: Why do you think water use (both direct and indirect) in the United States is so high compared to other countries?

KEY UNDERSTANDING
Water use in the United States is very high, even compared to other wealthy countries. Our choices as individuals and communities contribute to this high use of water.

Explore

The goal of this section is for students to calculate their own direct water use. This will help them identify ways to reduce their water use.

Ask students to use the provided worksheet to get a rough estimate of their own direct water use. Emphasize that this is only water that they use directly. If they see the water being consumed (i.e., going down a drain), then it is direct water use. Indirect water use will be explored in the next section. If devices are available, you may have student use instead an online water use calculator.

Ask students to reflect on their direct water use individually or in small groups.

Q4: What are the three daily activities you do that directly use the most water? Are any surprising?

Key understanding
We directly use water in a variety of ways in our own households. Low-flow and well-maintained appliances can drastically reduce this water use.

Explain

This section focuses on all the indirect ways water is used in the United States. The goal is to give students a fuller understanding of water use, then to consider how they can reduce it.

Students just calculated their direct water use. These numbers are much lower than the per capita water use we saw in the bar chart. We will now explore all the indirect ways water is used in our lives. Frame for students that we will be thinking about water use across different sectors. Put students in small groups to work together to guess which sectors use the most water. Pass out the worksheet of an empty bar chart for the group to fill in. Review the box of sectors at the top and help students understand any that may be unfamiliar.

Note: The direct water use calculated in the previous section could be accounted for in the public supply *or* domestic *sectors of the stacked bar chart. Most students will be connected to a water supply managed by their local municipality (public supply), but some may be on well water (domestic supply). Businesses and some industries may also be connected to the public supply. For more details, please access or download the source of this chart, the US Geological Survey 2015 Water Use Report.*

Once students have finished filling in their guess as to what the bar chart looks like, pass out the actual data. Discuss as a class, using your preferred discussion method:

Q5: How was your group's guess compared to the actual water use? Which areas were more than you expected? Which were less?

Q6: Why is it important to reduce water use in the United States?

Q7: Which of the ways that water is used in the United States could you influence? In what ways could you influence them?

Many of the ways water is used indirectly are more difficult for students to influence. Remind them that they have influence beyond their individual direct water use. They can use their voice together with others to advocate for smarter water use by their communities. They can learn more about what choices as a consumer can reduce water use. They can also talk with others about choices that reduce direct and indirect water use.

Key understanding
Agriculture and industrial uses account for most of the freshwater use in the United States. Students can still use their voice and make choices that reduce use of this precious resource.

Extend (optional)

In the extension students consider what it would take to reduce water use in their own communities, drawing inspiration from across the globe.

If you want to extend students' learning, ask them to explore ways their own community could reduce water use. Share the videos below to provide inspiration of ways that communities and individuals across the world are saving water on both the individual and the community scale.

- Japanese sink toilet
- Greywater lawn water
- Ted Talk on countries across the world saving water

Ask students to research other ways that communities are saving water and then propose one activity they think would be effective in their community.

Evaluate

The goal of this section is to see how well students reached the lesson objectives.

To wrap up the lesson ask students to reflect on their answer to the following questions. This could be through an exit ticket, discussion, or any other way you evaluate student learning.

Q8: How can you (or your family or community) reduce your water use? Which actions would be most effective? Use evidence from your two worksheets to help make that decision.

ACTIVITY 3 THE PROBLEM WITH POO

Themes: health

Unfortunately, our toilets and wastewater treatment plants deal with more than just human waste. This activity starts with the different components of wastewater—from cooking oil and trash to feces and pathogens—to help students understand the challenges of treating our waste. Students will then use design and engineering skills to create and test a water filter on simulated wastewater. Students will leave with a more precise understanding of the issues associated with sewer systems and actions they can take to help care for them.

Note: This activity is inspired by the NASA Water Filtration Challenge lab activity. Please consider reviewing their materials. A similar activity for younger age groups is available from Teach Engineering.

Objectives

- Students will be able to explain why it is important to safely treat human waste.
- Students will be able to evaluate their own design of a water filtration system.
- Students will be able to explain some of the challenges associated with sewered sanitation.

Materials

- Activity 3 presentation
- “Water filter design” worksheet
- Simulated wastewater creation materials (all amounts below per gallon)
  - 2 cups vinegar
  - ¼ cup cooking oil
  - Several drops yellow food coloring
  - ½ cup fine particles, such as dust, soil, or sand (unwashed)
  - ¼ cup dish soap
  - A handful of pet or human hair
  - A handful of trash-like materials (e.g., pieces of candy wrappers, paper towel, pieces of plastic wrappers, Styrofoam peanuts)
  - Water to fill the gallon
- Any of a variety of filtration materials in variable sizes
  - Cotton balls
  - Clean or washed play sand
  - Clean aquarium gravel
  - Uncooked macaroni
  - Zeolite or Perlite
  - Rinsed, activated carbon
  - Uncooked pasta
- Large spoons or cups for scooping
- Clean, empty plastic bottles
- Scissors
- Collection containers, such as beakers or extra plastic bottles
- Wastewater sample containers, such as beakers
- 10cm x 10cm cheesecloth (1 per team)
- Rubber band (1 per team)
- Cleaning materials for spills

Related science standards

This lesson most closely supports the Next Generation Science Standards Science and Engineering Practice of *Modeling*. Students will create a filter modeling wastewater treatment. The description for middle and high school modeling practices are below.

Middle school standard Modeling in grades 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Evaluate limitations of a model for a proposed object or tool.
- Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.
- Use and/or develop a model of simple systems with uncertain and less predictable factors.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop a model to describe unobservable mechanisms.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

High school standard Modeling in grades 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
- Design a test of a model to ascertain its reliability.
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Background Information

This activity is written as an engineering and design activity but has relatively little quantitative measurement. Instead, it asks students to compare test results to consider what design elements will be most effective as a water filter. You can adapt the activity to be more quantitative. The NASA Water Filtration Challenge lab activity suggests different dependent variables for students to measure.

Prior to doing the lab with your students, you will need to create the simulated wastewater which they will filter. Start with a rinsed milk jug or large pitcher and add the suggested materials. It is not necessary to include all of them. If you plan to extend the activity with a discussion of trash in sewers, be sure to include some simulated trash in your wastewater. Fill the container to the top with water. Stir or shake vigorously and repeat before pouring water into student filters. The water should be visibly dirty and gross, smell bad, and include particles of different sizes.

Engage

The goal of this section is to "hook" students on the topic for the lesson: wastewater treatment.

Pour out samples of the simulated wastewater into a beaker or other container, one per group. **Emphasize that at no point today will this water be drinkable, even after it is filtered.** Pass the sample around and ask for student observations. How does it smell? How does it look? What color or texture does it have? Have students record their observations on their worksheet.

Explain to students that this is simulated wastewater or "influent," the liquid that flows through our sewers which is also known as blackwater. It is made up of everything that goes down a drain. If this were real wastewater it would contain human feces. Show either the video about the pathogens in poo or the slide with the jar of poo. Wastewater also contains many other components like cooking oils, chemicals, trash, and toilet paper that must be removed before the water is treated to make it safe to release into the environment. Emphasize that it is essential to human health to be able to safely treat wastewater. We will be exploring that process by creating a filter to clean the simulated wastewater.

KEY UNDERSTANDING
The wastewater that flows through sewers and is treated at treatment plants contains many components that must be removed, especially pathogens that can harm human health.

Explore

The goal of this section is to have students work in small groups to design and test a filter. They will then compare their filters to others to evaluate filter designs.

Share that the goal today is to create a water filter using various materials and then to test them and compare the results to determine which group's filter is most effective. Show students the diagram in the slideshow that illustrates their filter setup. Next, share the materials that they can use to create their filter. Walk through the instructions for setting up the filter. Have students refer closely to their instruction sheet.

Ask groups to discuss their design and illustrate their filter set-up on the back of the worksheet. Once they're done, they can get filter materials.

Monitor while students build their filters. Prompt students to rethink filters that they might expect to be unsuccessful. In general, filters work best when large particles are filtered first and finer ones later.

Have students share their results by a method of your choice. You could create a class data table that is visible to all. Students could share in a class discussion. You could also have groups visit each other to share what they did and their findings. This last option is reflected in the Activity 3 slide show.

Key understanding
Our wastewater includes many components that are dealt with in different ways. Filtration can be an effective way to remove contaminants from water, but simple filters are not enough to treat wastewater to make it safe.

Explain

The goal of this section is to connect the design activity that students just completed to how wastewater is treated in sewered sanitation systems.

Emphasize to students that, with the many different components that go into wastewater, safely treating it is a complicated process. They started to understand this through the filtration simulation. To help students understand the rest of the wastewater treatment process in sewered sanitation systems, choose any or all of the following resources.

- This TED Ed video explains how wastewater treatment works. You could also use this video which goes into more detail of sewage treatment plants. These two videos are embedded in the slideshow but there are many different videos on the sewage treatment process available on YouTube. Choose whichever video you like best.

- If you are in King County, consider educational resources from the Wastewater Treatment Division, including maps and processes at the different treatment plants.

Emphasize that, though sewered sanitation is generally safe and effective, it is very wasteful in terms of natural resources, including water and energy, and expensive to maintain.

Key understanding
Wastewater treatment is a complicated and expensive process that is essential to protecting human health. It uses a lot of water and energy.

Extend (optional)

The goal of this section is to encourage students to think about their own role in their local sanitation system.

Sanitation systems are far from perfect. In the previous section, we considered the resources required to keep these systems operating. Other issues occur when these systems are disrupted and don't function properly. This section focuses on two common disruptions that can be experienced by sewer systems. You can choose to share one or both.

Sewage overflow: Seattle has a significant amount of "combined sewer overflows." This means there are many underground pipes that carry both sewage and stormwater (water from storm drains). When there is a large storm, these pipes can overflow into Puget Sound, contaminating ocean water with wastewater and causing issues for fisheries and recreation. This article from KUOW explains how this issue impacts local tribes and how it will only get worse as Seattle experiences stronger storms related to climate change. This resource includes diagrams that explain how heavy rains contribute to sewage overflows during a storm and how green infrastructure like rain gardens can make a difference.

Fatbergs: Sewer systems all over the world are plagued by the issue of fatbergs. These "fat icebergs" are created by a buildup of oil and fats that solidify and attract non-biodegrade items like wet wipes and trash, eventually growing and clogging the pipes. This video from Adam Ruins Everything provides an engaging explanation of this process and the importance of flushing nothing but toilet paper.

After sharing one or both issues ask students to consider what their own role is in addressing these problems. You could use the following discussion questions:

Q1: Whose responsibility is it to care for sewer systems? How should our communities address disruptions that can occur with sewers?

Q2: What role could we each play as individuals? Do we have a responsibility to take action? Why or why not?

Key understanding
Sewers are not perfect systems. They use lots of resources and there are situations where they can be clogged or overflow. Our actions as individuals and collectively can help support functioning sewer systems.

Evaluate

The goal of this section is to see how well students reached the lesson objectives.

To wrap up the lesson ask students to reflect on their answer to the following questions. This could be through an exit ticket, discussion, or any other way you evaluate student learning.

Q3: What were the characteristics of the most effective water filters? What in general worked the best?

Q4: Why is it important to safely treat human waste (poo)?

Q5: What are some challenges that occur with sewered sanitation systems?

ACTIVITY 4 REINVENTING THE TOILET

Themes: innovation, sustainability

The basic designs of toilets and sewer systems haven't meaningfully changed for a few hundred years. It is past time to reinvent the toilet! But what do we mean by a "reinvented toilet," and what could the toilets of the future be like? Students will be given a design challenge to brainstorm their own plan for a toilet inspired by everyday items (e.g., a pressure cooker, a barbecue, and a coffee maker). Students will then explore reinvented toilet designs through video or images. They will reflect on how these designs are similar to or different from their own design.

Objectives

- Students will be able to explain why it is important to "reinvent the toilet."
- Students will be able to brainstorm their own reinvented toilet design inspired by a household object.
- Students will be able to compare the strengths and weaknesses of different reinvented toilet designs.

Materials

- Activity 4 presentation
- "Reinventing the toilet" worksheet
- Diagrams of a pressure cooker, barbecue, and coffee maker
- Pressure cooker or instant pot, small barbecue or camp stove, coffee maker (optional)
- Poster paper (one sheet per group)
- Markers

Related science standards

This lesson most closely supports the Next Generation Science Standards Science and Engineering Practice of *Constructing Explanations and Designing Solutions*. Students will design their own solution for the problem of dealing with human waste. Below are the descriptions for middle and high school *Constructing Explanation and Designing Solutions* practices edited to include the most relevant bullets.

Middle school standard Constructing explanations and designing solutions in grades 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system.
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.

High school standard Constructing explanations and designing solutions in grades 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Engage

The goal of this section is to get students excited about rethinking how we deal with human waste.

Toilets connected to sewered sanitation systems are one way to safely deal with human waste. They are often considered the ideal type of sanitation, but they have many real issues and challenges. Sewered sanitation is very wasteful, using tons of water, electricity, and materials (e.g., pipes) to manage and treat human waste. It also underutilizes the value of human waste as a resource that can be recycled and reclaimed as treated water, compost or biosolids, and methane gas.

Prompt students to start thinking about human waste differently. Let's try thinking about poo in a new way. Have them brainstorm and list the challenges and benefits of poo. Some ideas that you could prompt students towards are below.

CHALLENGES OF POO/HUMAN WASTE

- **smelly**
- **people don't want to be around it**
- **gross or icky**
- **spreads disease**
- **needs to be treated to be safe**
- **there's lots of it with more being produced all the time**

BENEFITS

- **lots of nutrients for plants**
- **lots of energy stored in it**
- **keeps us healthy**
- **tells us about our health**
- **can be a resource**
- **employment opportunity**

Next, present students with a challenge to design a "reinvented toilet." This video highlights some of these amazing toilet machines and the problems they are trying to solve. Use the presentation to define what is meant by a "reinvented toilet." Tell students their challenge is to brainstorm ideas for a reinvented toilet inspired by an everyday object.

KEY UNDERSTANDING
Poo isn't just a problem; it can also be useful. We can use human creativity and design thinking to reinvent our toilets to be less wasteful, appealing to use, and safe for communities.

Explore

The goal of this section is to encourage students to use their creativity to create an initial design for a reinvented toilet.

Split students into small groups to work collaboratively on a design for a reinvented toilet. Provide diagrams of a pressure cooker, barbecue, or coffee maker. Each object uses heat and other processes (pressure, combustion, or filtration) to transform its contents. You could also consider having a physical example of each object to further inspire students. You can allow students to choose which simple machine they would like to use for inspiration or assign a machine for each group to focus on.

Provide student groups with the brainstorming worksheet that contains questions to help students address all the elements of a reinvented toilet. There are quite a few! You could consider refining student focus by removing some of the questions. Much will depend on your students' experience in creating designs.

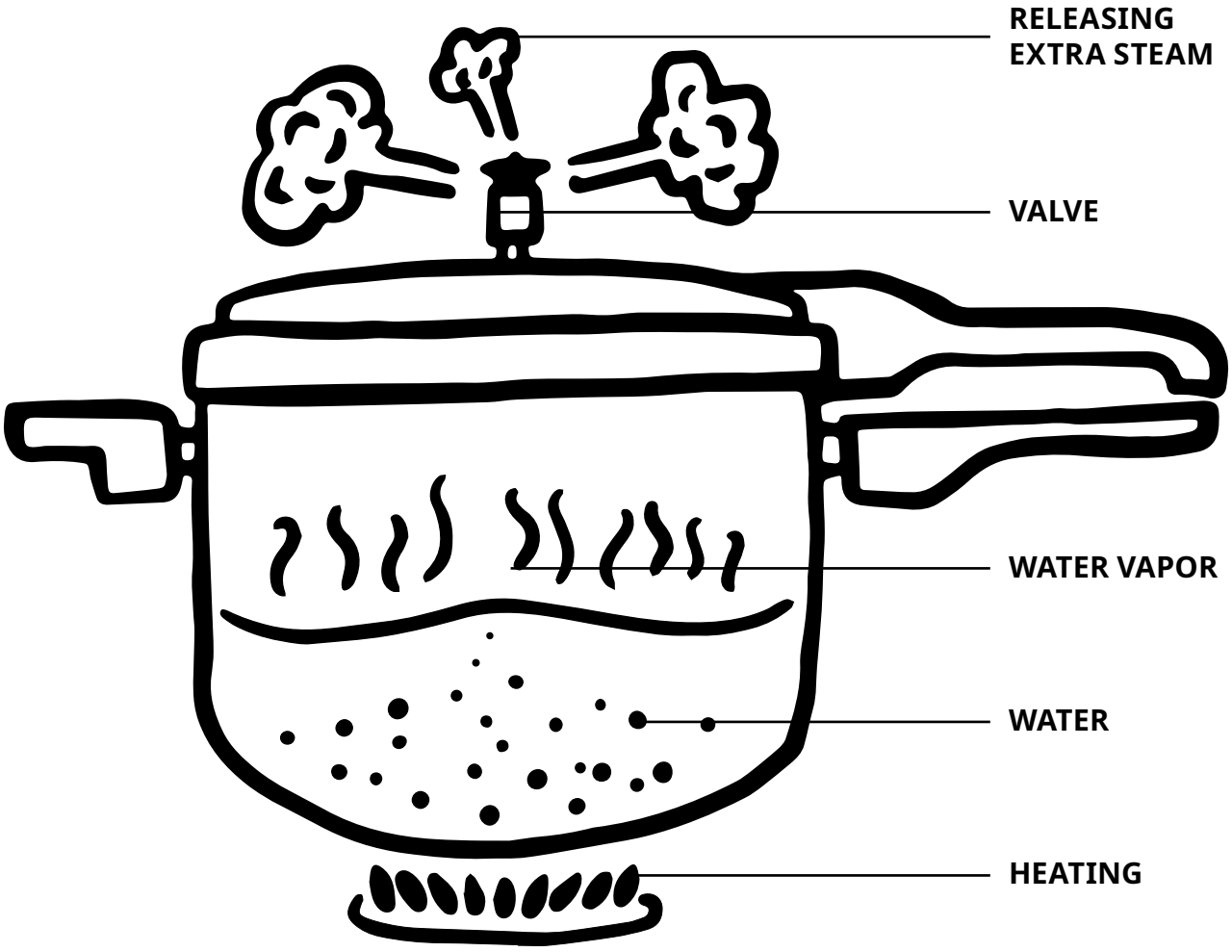
Once students have considered their design from these different angles, they should begin sketching out their idea. Distribute poster paper and markers to each group. Their end goal should be a diagram of a reinvented toilet that they can share with the class. It should be labeled and connect to the brainstorming questions.

Ask students to share their designs with the class using your preferred classroom discussion or presentation procedures.

Key understanding
Better toilets of the future have a lot to consider! These are complicated machines with huge potential to improve people's lives.

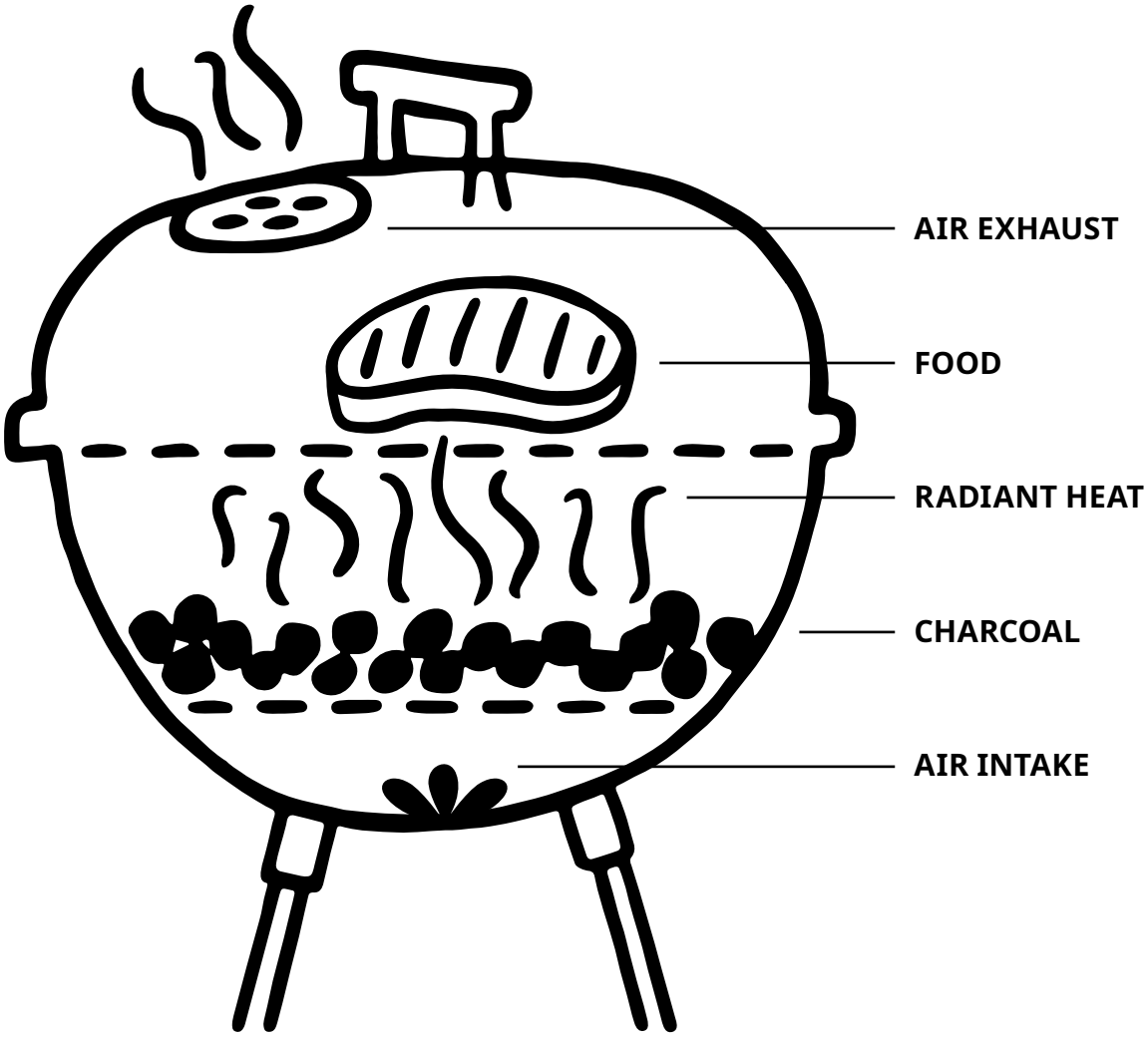
ACTIVITY 4 SIMPLE MACHINES

Pressure Cooker



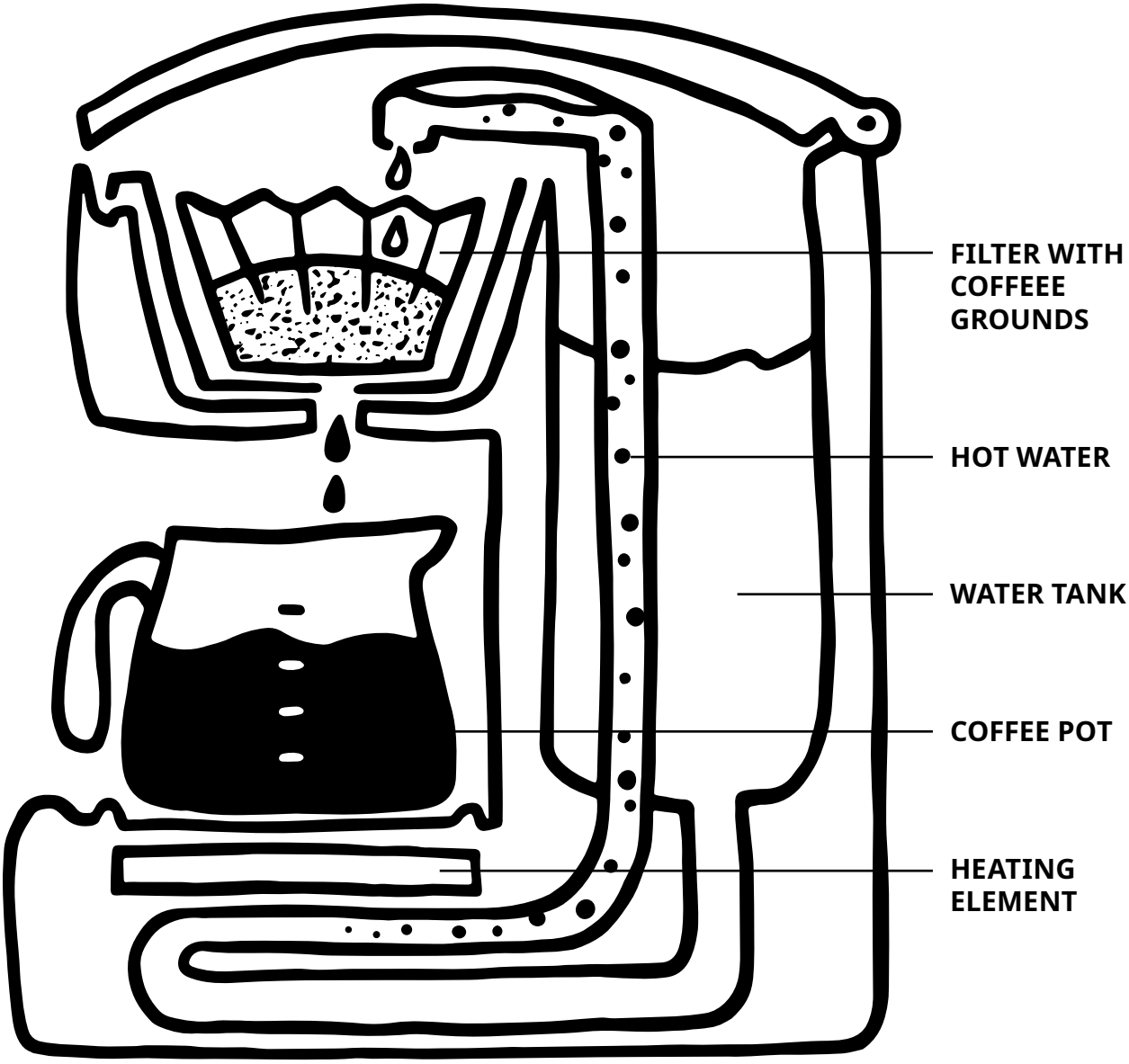
ACTIVITY 4 SIMPLE MACHINES

Barbecue



ACTIVITY 4 SIMPLE MACHINES

Coffee Maker



Explain

The goal of this section is to have students compare their own designs to ones that are about to be in production.

Show students the design of the Eco-San reinvented toilet, using the video embedded in the slideshow. The machine in the video is very complicated. Ask students to discuss how the designs they created in class compare to this reinvented toilet design. Emphasize this is just one of many possible designs for a reinvented toilet machine.

Q1: In what ways is the design similar to ones created in your class? In what ways is it different?

Q2: What do you think might be some strengths and weaknesses of this design?

Many other organizations have created reinvented toilets including Georgia Institute of Technology, Cranfield University, Helbling Technik, and Nespresso. You could choose to also share some of these designs with students.

Key understanding
Reinvented toilet designs that are currently being engineered and manufactured underwent a years-long research and development process that included a similar process to what you did today.

Extend (optional)

The goal of this section is to allow students to continue refining their designs.

If you want to extend the design thinking process, have students edit and refine their designs based on what they saw from their classmates designs and the reinvented toilet video. Emphasize that design thinking is a process.

The next step would be to work with communities to clarify their needs and then prototype their designs. The Standford d.school has many resources for teaching design thinking.

Key understanding
Designing a solution to a problem is a long process that often involves modifying designs several times.

Evaluate

The goal of this section is to see how well students reached the lesson objectives.

To wrap up the lesson, ask students to reflect on their answer to the following questions. This could be through an exit ticket, discussion, or any other way you evaluate student learning.

Q3: Why is it important to reinvent the toilet? Provide at least three reasons.

Q4: What was challenging about designing your own reinvented toilet?

EDUCATOR RESOURCE GUIDE

Website links

Pages 3, 8 & 13 ospi.k12.wa.us/sites/default/files/public/socialstudies/standards/OSPI_SocStudies_Standards_2019.pdf

Page 3, 20 & 29 www.nextgenscience.org

Page 5 discovergates.org/tours/school-workshops

Pages 7 & 10 www.gapminder.org/dollar-street

Page 7 www.gapminder.org/

Page 13 & 16 www.watercalculator.org/wfc2/q/kitchen-sink-flow

Page 15 www.watereducation.org/post/water-use-virtual-water

Page 17 www.usgs.gov/publications/estimated-use-water-united-states-2015

Page 18 www.youtube.com/shorts/FcRd5MSIvVU

Page 18 www.youtube.com/watch?v=CiHw3zmqDkg

Page 18 www.youtube.com/watch?v=nLB8A--QdHc

Page 19 www.jpl.nasa.gov/edu/teach/activity/water-filtration-challenge

Page 19 www.teachengineering.org/activities/view/cub_environ_lesson06_activity2

Page 23 www.youtube.com/watch?v=ZPDd1IXL0pg&t=10s

Page 25 www.youtube.com/watch?v=SYia4zqcE4g

Page 25 www.youtube.com/watch?v=cUFKay8VPqo

Page 25 kingcounty.gov/depts/dnrp/wtd/system/treatment-process.aspx

Page 26 www.kuow.org/stories/heavier-rainfall-to-cost-seattle-area-billions-to-avoid-sewage-spills

Page 26 ecoss.org/combined-sewer-overflow-stormwater-pollution-gsi-explainer

Page 26 www.youtube.com/watch?v=TgHVO-RZ8c4&t=206s

Page 30 www.youtube.com/watch?v=TGEoK17CoD4

Page 33 dschool.stanford.edu/resources