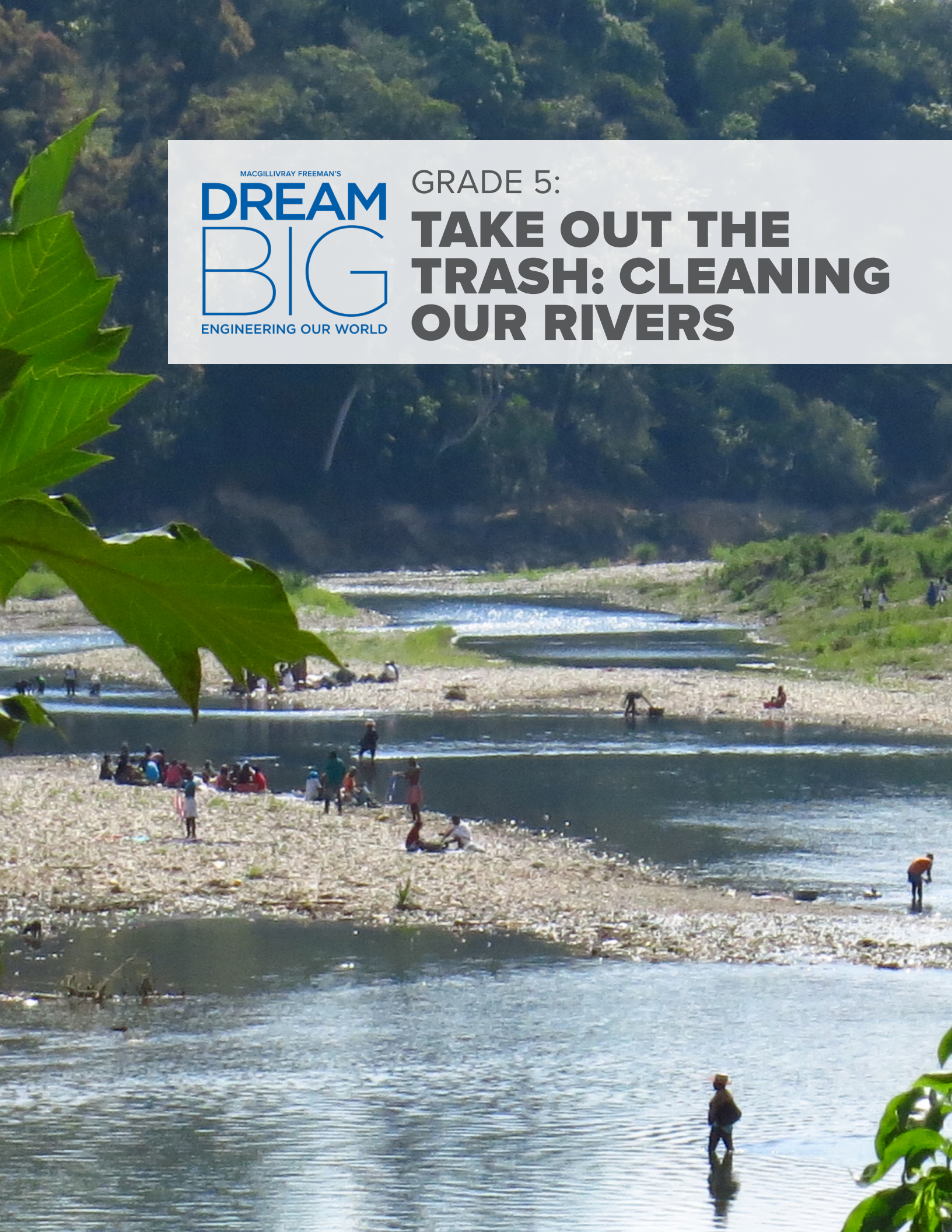


MACGILLIVRAY FREEMAN'S
DREAM BIG
ENGINEERING OUR WORLD

GRADE 5:

TAKE OUT THE TRASH: CLEANING OUR RIVERS

Grade level: 5

Lesson length: 2.5 hours, with optional follow-up excursions to nearby river

As students learn about the components of a river ecosystem, they design a means of eliminating the trash that threatens the health of a river system. Students build their devices entirely out of recycled materials in order to understand the challenges engineers face as they try to minimize the amount of raw material used in their work.

In the Film

As our population grows exponentially, raw materials become more and more limited—so engineers are becoming imaginative in how they recycle and repurpose materials already available to them. Just as the engineers in Haiti, as seen in *Dream Big*, worked under the constraint of using only immediately available materials, all engineers work under resource constraints. In this engineering challenge, students will create a device that cleans plastic pollution from a river system by using only reclaimed plastic from that very system.

NGSS Disciplinary Core Ideas

5-LS2.A Interdependent Relationships in an Ecosystem

Organisms can only survive in environments in which their particular needs are met.

A healthy ecosystem is one in which multiple species of different types are each able to meet their particular needs in a relatively stable web of life.

5-ESS3.C Human Impacts on Earth Systems

Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space.

NGSS Engineering Practices

5-ETS1.A Defining and Delimiting an Engineering Problem

Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired function of a solution (criteria).

5-ETS1.B Developing Possible Solutions

Research on a problem should be carried out before beginning to design a problem. Testing a solution involves investigating how well it performs under a range of likely conditions.

At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be changed.

Dream Big: Engineering Our World is a film and educational project produced by MacGillivray Freeman Films in partnership with the American Society of Civil Engineers and presented by Bechtel Corporation. The centerpiece of the project is a film for IMAX and other giant screen theaters that takes viewers on a journey of discovery from the world's tallest building to a bridge higher than the clouds and a solar car race across Australia. For a complete suite of *Dream Big* hands-on activities, educational videos, and other materials to support engineering education, visit discovere.org/dreambig. The *Dream Big* Educator Guide was developed by Discovery Place for the American Society of Civil Engineers.

Key Words/Vocabulary

Ecosystem: Everything living and nonliving in an area.

Abiotic: Nonliving. Examples of abiotic factors include soil, water, temperature, and bedrock.

Biotic: Living. Examples include producers, consumers, and decomposers.

Consumers: Animals; must eat other organisms to survive.

Producers: Plants; make their own "food" via photosynthesis.

Materials

Per group:

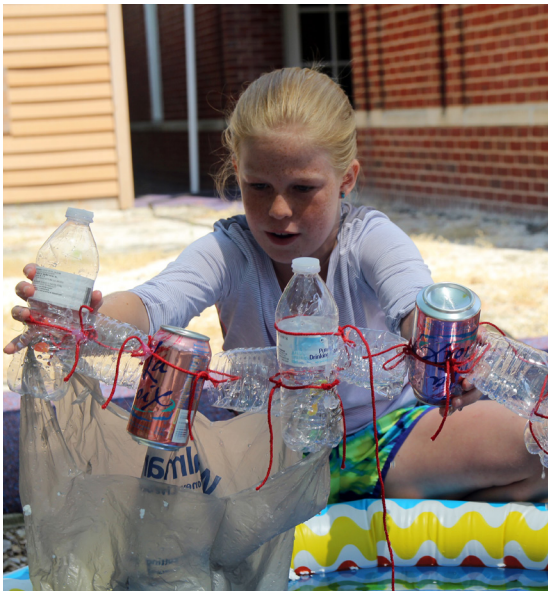
- ☐ Materials collected from recycle bins at school for 1–2 weeks prior to lesson (plastic bottles, soda cans, plastic bags, cups, paper, straws, etc.)
- ☐ Nylon string or fishing line
- ☐ Scissors
- ☐ Lego pieces or pool toys that are less buoyant to represent fish
- ☐ Inflatable children's pool
- ☐ Video "Boyan Slat Unveils the Ocean Cleanup Prototype": youtube.com/watch?v=RLAq19hGTBw
- ☐ Means of showing video to class
- ☐ Water Pollution Engineering Sheet

Teacher Prep Notes

To test the student devices, inflate the pool and fill it with water. Place materials in it to represent typical human pollution in a water system (plastic straws, fast food cups, and so on).

Place materials in the pool to represent healthy parts of the ecosystem that should remain undisturbed and not be caught in the pollution cleaning solution (e.g., Lego blocks to represent fish).

Optional: Dye some vegetable oil with black oil-soluble food coloring and place it in the pool to represent industrial oil spills and waste.



To Do

Determine the Problem or Question to Solve: 15 minutes

1. Before watching the IMAX movie *Dream Big*, give students an overview of what they are about to experience. This film is about engineering and the ways that engineering can inspire, challenge, and enrich our lives. Give students the following questions to think about as they are watching the film:
   - **a.** Which engineers wished they had more or different materials to work with as they built their creations?
   - **b.** How did these engineers find a way to come up with materials that they needed?
2. Debrief as a whole class after viewing the film. Allow students to verbally reflect on the guiding questions you gave them.
3. Introduce the design challenge: Today in class we are going to learn about local river ecosystems and the human actions that threaten their health. Then we are going to get creative in designing a solution to solve the problem of pollution in rivers. We are going to recycle and repurpose the very same pollution that goes into rivers to create a system to clean them. We will test our devices in a small kiddy pool. After, we will decide what parts of the designs in each group worked well to determine a class design to make for a local stream or river. We will then make it and try it in that river system to judge its effectiveness at cleaning a real water system.

Research and Gather Information: 45 minutes

1. Give an overview of biotic and abiotic factors of ecosystems, in which students learn about the components of a healthy river ecosystem by examining typical river food webs. Guide students to identify the producers, consumers, and decomposers of the river system. Ask students to predict what would happen if one of the members of the food web were removed.
2. Teach students about human factors that can threaten the health of a river ecosystem. Examples are overfishing, animals ingesting plastic debris, and animals being caught in discarded fishing line.
3. Describe the innovative ideas that young engineers are devising to clean water ecosystems. Before watching the Boyan Slat video, explain to students that it's about a teenager who engineered a way to clean up the plastic pollution from the oceans. Though his design is for an ocean ecosystem, we can identify parts of his design that will also work for us in our river system cleanup device. Play Boyan Slat's video on the revealing of his prototype to clean the ocean. Ask students how his device worked and what similar things we could use to collect trash from a river.
4. Show students what recycled materials you have collected over the past few weeks for them to use. Also give them fishing wire that is typically left behind by fishers to use in their designs. Allow students time to use the "brainstorm" part of the Water Pollution Engineering Sheet and come up with ideas for how each material could be used.

Plan a Solution: 30 minutes

If students are unfamiliar with the concepts of criteria and constraints in engineering, take the time now to introduce these two key fundamental ideas. Engineers look at challenges through the lens of criteria (what does my device have to do) and constraints (what are the limitations I face in making, testing, and using the device). Spend some time with students as a whole class brainstorming the criteria and constraints of this particular engineering challenge.

Organize students into small groups. Show them the materials that they will use and instruct them to begin designing their prototype. The prototype should include a drawing as well as a written description of its functionality. Tell students to use the Plan section of their Water Pollution Engineering Sheet for this step. On their diagram, they should label the material they will use and the amount of that material they will need. Students should write a step-by-step process for how the device will be built and deployed.

Make It: 30 minutes

Once students have drawn their plan, tell them to begin building their device. As students are building, visit each group, reviewing what they learned about river ecosystems and how the device will capture plastic without capturing members of the food web. Allow students to make mistakes along the way and struggle. When they do, ask questions about what the students observed and what they could change to fix the problem. Avoid offering solutions and instead encourage students to test ideas as they build.

Test: 20 minutes

Part 1:

- ☐ Prep: Inflate a children's pool and fill it with water and different forms of garbage (Styrofoam cups, soda bottles or cans, straws, Styrofoam peanuts). Also add in a few sinkable items to represent fish and other living organisms.
- ☐ Instruct students to use their device in the pool to remove whatever garbage is accessible. Ask students what the failure point of the system was (where it broke, where it failed to do its job) and what they could do to fix it.

Optional Part 2 (multiple field trips to nearby stream):

If you have a local stream or river nearby, have students improve their device and test it in a true stream environment. Students can leave the device in place for 1–7 days, visiting the device each day and recording the state of the device (is it holding up in the stream environment? Where is it failing?). Students should collect and assess if they were able to gather any plastic or pollution with the device they created.

Evaluate: 10 minutes

Allow students to reflect on the following questions and to write their answers in the Evaluate section of the Water Pollution Engineering Sheet:

1. How much of the plastic or oil pollution were you able to gather with your device?
2. Did your device interfere with the ecosystem by damaging or capturing animals as bycatch? If so, how?
3. Did your device interfere with the ecosystem by permanently changing any of the abiotic factors in the ecosystem? If so, how?

As time allows, discuss students' thoughts about the success of their devices and what they would do to improve them.

Taking It Further

Extend the impact of your device: Test within real streams or rivers, increasing the scope and scale of the project as a citizen science/entrepreneurism experiment. Have students educate the public on what they learned. Display the amount of plastic taken out of the river system each week. Have students estimate how much plastic could be taken out of the river if the device lasted all year.

Learn about this engineering in the real world: As we learned about in this lesson, the plastic pollution that enters our riverways eventually drains into the ocean. Our oceans contain a large percentage of plastic that collects in the center of circular currents called gyres. Engineers are challenged with devising a plan to clean the oceans that will work in a timely manner as well as operate without the environmental stress of using fossil fuels. Learn about the machines they are engineering, the tests they are conducting, and the challenges they face by visiting this site: theoceancleanup.com

Document your students' work through our social media outlet: #dreambigfilm

WATER POLLUTION ENGINEERING SHEET

Name: _____

Problem to Be Solved

Create a system that is capable of catching the plastic and trash from a water system without damaging the ecosystem.

Research and Gather Information

1. What do we know about river ecosystems?

2. What do we know can threaten river ecosystems?

3. How have other people cleaned water ecosystems?

4. Brainstorm: What could each of the available materials do?

Material	Purpose
Example: plastic water bottles	☐ When the bottle is filled with air and capped, it could float, keeping the device at water level. ☐ If the bottle is cut in half, it could create a barrier to catch plastic floating by.

Plan

☐ The criteria of the engineering and design challenge are:

☐ The constraints of the engineering and design challenge are:

☐ Draw a picture of what you plan to make.

☐ Write a step-by-step process of how to create your design.

Make It!

Evaluate

1. How much of the plastic or oil pollution were you able to gather with your device?

2. Did your device interfere with the ecosystem by damaging or capturing animals as bycatch? If so, how?

3. Did your device interfere with the ecosystem by permanently changing any of the abiotic factors in the ecosystem? If so, how?

DREAM BIG VIDEO SERIES

WATCH *WATER WISHES: ENGINEERING FOR THOSE IN NEED*

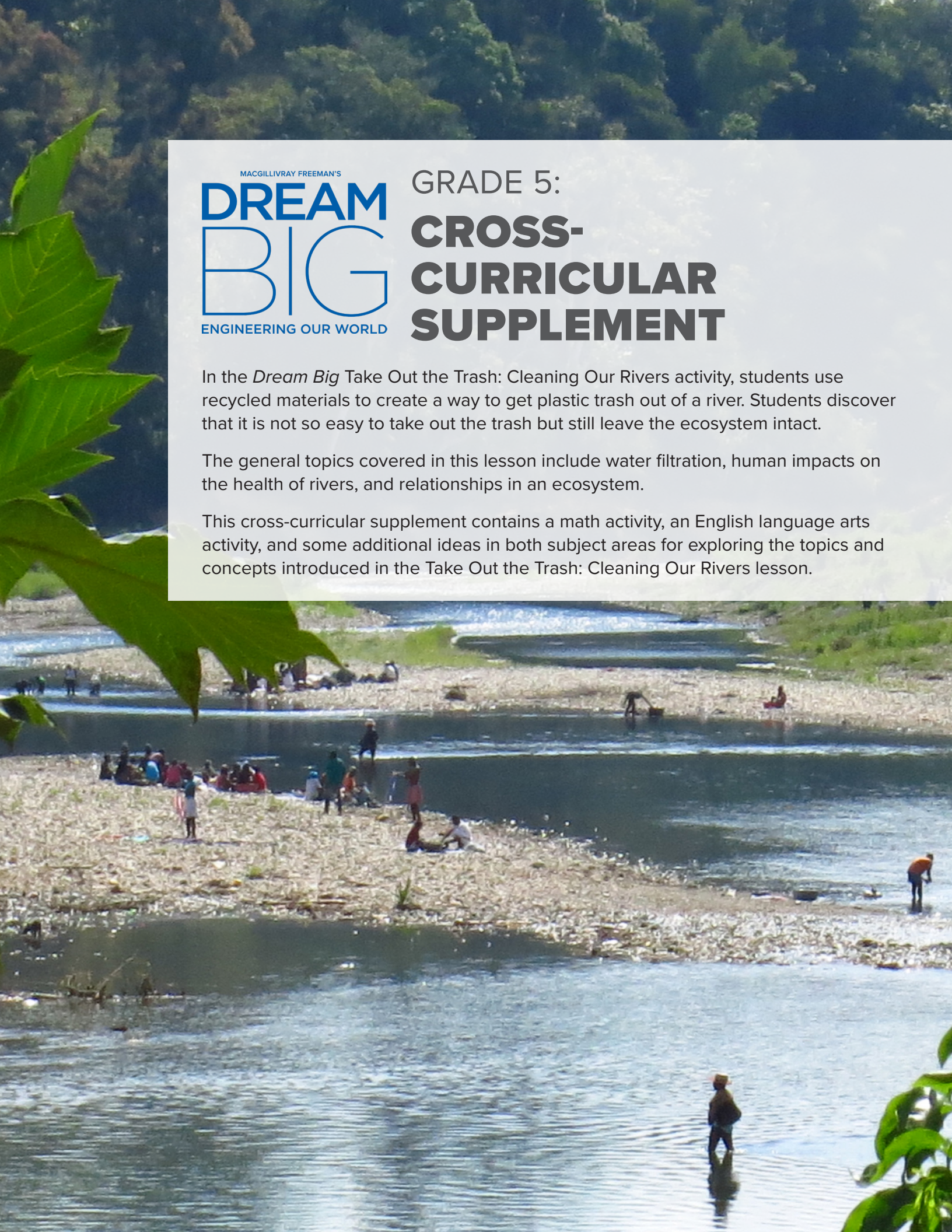
What can an engineering student in New Jersey do to help mountain villagers in Peru who lack clean water to drink? Building a safe water system for people halfway across the globe is an example of how Engineers Without Borders and other organizations are helping people build healthier communities. Go to discovere.org/dreambig/media-assets and visit Educational Webisodes.

MacGillivray Freeman

NCEES advancing licensure for engineers and surveyors

ASCE American Society of Civil Engineers

BECHTEL



MACGILLIVRAY FREEMAN'S DREAM BIG ENGINEERING OUR WORLD

GRADE 5: CROSS-CURRICULAR SUPPLEMENT

In the *Dream Big* Take Out the Trash: Cleaning Our Rivers activity, students use recycled materials to create a way to get plastic trash out of a river. Students discover that it is not so easy to take out the trash but still leave the ecosystem intact.

The general topics covered in this lesson include water filtration, human impacts on the health of rivers, and relationships in an ecosystem.

This cross-curricular supplement contains a math activity, an English language arts activity, and some additional ideas in both subject areas for exploring the topics and concepts introduced in the Take Out the Trash: Cleaning Our Rivers lesson.

Grade 5 Math: Measuring Trash

Estimated class time: 60 minutes

Summary

In the *Dream Big* Take Out the Trash: Cleaning Our Rivers activity, students use recycled materials to create a way to get plastic trash out of a river. The different methods students devised varied in how successful they were. This activity shows students another aspect of the challenge of cleaning up our rivers: measuring trash. Students explore these questions:

- How can you tell how much trash you really collected?
- How can you tell which method collects the most trash?

Learning Objectives

- Determine the accuracy of different ways to measure three-dimensional quantities
- Demonstrate the ability to measure volumes by counting different types of units
- Propose a solution to the problem of measuring amounts of trash accurately

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Materials

Per class:

- ☐ Several kitchen food scales able to weight up to 10 pounds
- ☐ Several luggage/fishing/spring scales able to measure up to 80 pounds; available for $8–$10
- ☐ Several sewing tape measures
- ☐ Collection of paper bags, mesh bags, boxes
- ☐ Measuring cups and scoops
- ☐ Paper and pencil
- ☐ Gallon-sized bin or container
- ☐ A range of classroom materials, with a mixed variety for each group, such as:
  - ☐ Paper clips
  - ☐ Legos
  - ☐ Pencils, crayons
  - ☐ Counting chips
  - ☐ Tiles
  - ☐ Cotton balls
  - ☐ Crumpled paper

Per group of 3–4 students:

Preparation

Revisit the Take Out the Trash activity by asking students, how did we decide which method of collecting trash worked the best? Answers may include which method disturbed the ecosystem the least and which one held together best and was sturdiest; but someone might also suggest that the best method was the one that collected the most garbage. Ask students how they can tell which method collected the most.

Explain that measuring trash is an important consideration. It is one way to determine the effectiveness of a trash-collecting method, not to mention a form of proof that the trash is in fact a big problem. How do they think Boyan Slat is going to measure how much garbage his device will remove from the ocean?

In this activity, students will undertake an investigation into best methods for measuring trash.

Instruction

1. Show students where the measuring and weighing materials are located. Explain that each group of students will receive a bin of materials representing trash collected from a river. Their task is to measure the trash in different ways and then pick the best one. They will take notes on each method so that they can explain why they thought one method was best. Write the following questions on the board to guide students:
   - What amounts did each method yield?
   - What are the advantages of each method?
   - What are the disadvantages?
   - Which method worked best and why?

   Have students take notes on the methods they use.
2. Divide the class into groups of three or four students and give each group a bin of "trash" and note-taking materials. Observe how each group tackles the problem so that you can refer to different ideas in the post-activity discussion. Note: if your students require some hints, have them consider these common approaches: total weight of the trash, volume of the trash, and number of items in the trash.
3. Once students have exhausted their ideas for measuring their pile of trash, invite each group to present their findings by answering the questions on the board. Record the means and amounts on the board as each group presents.
4. When the amounts are all on the board, ask students which group had the most amount of trash. They should observe that it depends on the units they used. For example, if one group used a paper bag and a luggage scale to measure their trash by weight, and another one measured theirs in the bin on a kitchen scale, how are their weights comparable? An even bigger issue is among the methods of measurement: what if one group had more weight but another had bigger volume—and yet another group had the greatest number of items? Have the students debate which method they think is the best for measuring the amount of trash collected.

Closure

- Note that it is one thing to measure one bin of objects; it's another to measure vast numbers of them. Engineers have to work with truly unwieldy quantities and still measure them accurately. Whatever method we use, we also have to convert data to the metric system in order to share research and successful techniques with engineers around the world. For example, a metric ton equals 1,000 kilograms, or 2,204.6 pounds.

Activity Extensions

- Create two bins of materials of the same weight but different volumes. Ask students which bin they think contains the most trash before measuring the amounts in each. When students realize that the trash weighs the same, does their thinking around which bin contains the most trash also change?
- Conduct research into how engineers really do measure the trash they collect. Have students make posters that demonstrate their findings by using photos and graphs.

Other Ideas for Math

Here are a few more ways to connect the Take Out the Trash lesson with your math curriculum.

- Awareness of quantity can be useful for helping people change their behaviors around generating pollution. For example, set up a classroom recycling bin. After one week, measure how much recycling has been collected. Then set a goal of reducing this amount by 5% and see if the class can meet it.
- Visit your community recycling center and take a tour. Tell students to take notes on how this material is measured. Ask whether the amounts have changed over time and how. Which substance is recycled the most? Which the least?

Grade 5 English Language Arts: Solving the Plastic Problem

Estimated class time: 120 minutes

Materials

Per class:

- ☐ Grade-appropriate research materials (books, websites, videos, and articles) describing the magnitude of the plastic problem. Note that several websites are listed in the student handout.
- ☐ Grade-appropriate research materials on engineering solutions to the plastic problem. Note that several applicable websites are listed in the student handout.

Per student:

- ☐ Plastic Research Handout
- ☐ Writing implements

Summary

In the *Dream Big* Take Out the Trash: Cleaning Our Rivers activity, students use recycled materials to create a way to get plastic trash out of a river. This lesson makes the enormity of the plastic problem evident and then tasks students with presenting one engineering solution that they think will make a big difference. Students think about questions like these:

- What is the proof that plastic is causing a problem?
- Why are engineers key to solving the plastic crisis?
- What can one fifth grader do to halt the use of plastic?

Learning Objectives

- Demonstrate the ability to conduct research effectively on the topics of the plastic crisis and engineering solutions to it
- Synthesize information from several sources in order to knowledgeably speak on the topic of plastic and how engineers are finding ways to mitigate the problem
- Decide how best to present information about the problem of plastic and one engineering solution to an audience of peers

Preparation

Ask student volunteers to summarize their experiences with the Take Out the Trash activity. Remind students of the video they saw about a teenager who came up with an idea for getting rid of the plastic in the ocean. Update students on the progress Boyan Slat is making to test his prototype for removing plastic from the ocean (theoceancleanup.com/updates). The assembly of the first cleanup system was completed in the spring of 2018, in Alameda, California. It is expected to be launched in the summer of 2018.

Explain that this activity will deepen their understanding of how serious the plastic problem is and provide an opportunity to learn, or dream, about how to solve it. Now that students have had a firsthand experience with the challenges involved in designing an effective way to remove plastic from water, they can better appreciate the ingenuity required to find good solutions.

Instruction

1. Explain that there are three steps to this activity: first, students will do research to learn about the impact plastic is having and gather facts and statistics that make this impact crystal clear. Second, they will find information about an engineering solution that they think is really helpful. They will take notes on how this solution works and why they think it's such a great idea. Alternatively, they will propose their own solution, how it works, and why it will help. Finally, they will make a short oral presentation of their findings to the class. They can use visuals to make their presentation really persuasive as well.

   Caution students that as they research, they will find public policy solutions to the problem as well as engineering solutions. For example, a city banning the use of plastic bags is a public policy solution; a new kind of disposable bag that biodegrades into garden compost is an engineering solution. Ensure that students see the difference and understand that for this activity, they must search for engineering solutions.

2. Organize students into pairs or triads. Show them where the research materials are and distribute the Plastic Research Handout to each student. Give students time to both find data on the plastic problem and explore solutions.
3. When students are ready to start making choices about what to include in their presentations, tell them to divide up the material so that every group member has a chance to speak. Tell them that their goal is to be persuasive. They should also discuss whether a visual would help make their presentation more interesting, such as a photo or an example. Tell students to practice their presentations, which should each be between 2–3 minutes in length.
4. If time allows, have each group present to the whole class. Alternatively, have four groups present to each other so that each group hears at least three other presentations.

Closure

Generate a brief class discussion around the following questions:

- Of all the information presented on the problem of plastic, which fact or statistic made the biggest impression on you?
- Which solution seemed the most promising to you? It might not be the one you chose to research!

Remind students that it takes a lot of persistence to turn an idea into an actual solution; Boyan Slat and many supporters have been working on his idea for years now. But it's about to make a huge difference to the health of our oceans.

Activity Extensions

- Turn students' oral presentations into podcasts or ask students to present to a larger audience, such as other classes or parents.
- Periodically check in on the progress of Boyan Slat's work or follow the progress of a different engineering solution that students presented on.
- Challenge students to commit to changing one personal behavior in order to lessen their plastic footprint. Make a class chart and check in with students over the rest of the school year to see if they are honoring their commitment (reminding them that change is a process, and most people will slip up here and there at first!).
- Investigate the state of plastic usage at your school and propose ways to use less plastic.

Book Connections for English Language Arts

The following books relate to the Take Out the Trash activity. They can be incorporated into your ELA curriculum or used as a warmup for the activity provided in this supplement.

Ayer, Paula, Banyard, Antonia, and Wuthrich, Belle, *Water, Wow! (A Visual Exploration)*, Annick Press, 2016. This book combines a highly visual format with clear text to delve into the water footprint, the impact of water on our lives, and ways to clean polluted water.

McLaren, Goffinet, *Sullie Saves the Seas*, Prose Press, 2012. With humor and whimsy, this story reveals the plight of sea life from pollution. What would happen if seabirds could save their habitats?

Newman, Patricia, *Plastic, Ahoy! Investigating the Great Pacific Garbage Patch*, Millbrook PR Trade, 2014. This book describes the expedition of three young female scientists as they study the impact of the Garbage Patch on marine life. This book won multiple awards.

PLASTIC RESEARCH HANDOUT

Name:

Use this handout to take notes on the problems plastic is causing. Write down facts, statistics, and ways that plastic is harmful. When you're done, circle the information that you think best explains how bad the problem is.

Next, research some solutions that engineers have come up with. Which ones are new to you? Write down how they work and how they can help.

Part 1: How Bad Is the Problem?

To get started, here are some websites to check out. Write down the other places you find information too, in case you want to go back and find more information for your presentation.

National Geographic Kids, Plastic Pollution kids.nationalgeographic.com/explore/science/plastic-pollution/#earth-day-pollution.jpg

Scholastic, Oceans of Trash scholastic.com/browse/article.jsp?id=3752034

Science News for Students: Tiny Plastic, Big Problem sciencenewsforstudents.org/article/tiny-plastic-big-problem

Facts and statistics about how plastic is harmful and how bad the problem is:

1.

2.

3.

4.

5.

6.

Part 2: Engineering Solutions to the Plastic Problem

Here is where you research different solutions engineers are coming up with. After you find a few, you will work with your partner to pick one to talk about.

Below are some websites to start with. You may search for other ideas too.

Triple Pundit: 4 Innovative Solutions to the Ocean Plastic Crisis, triplepundit.com/2016/02/innovative-solutions-to-the-ocean-plastic-crisis/

Independent: Plastic-eating Enzyme Accidentally Created by Scientists Could Help Solve Pollution Crisis, independent.co.uk/news/science/plastic-eating-enzyme-pollution-solution-waste-bottles-bacteria-portsmouth-a8307371.html

GreenWorld 365: What Are Corn Starch Biocompostables aka PLA Plastics? greenworld365.com/what-are-corn-starch-biocompostables-aka-pla-plastics/

Ted Talk: The Surprising Solution to Ocean Plastic, ted.com/talks/david_katz_the_surprising_solution_to_ocean_plastic

Ted Talk: To Eliminate Waste, We Need to Rediscover Thrift, ted.com/talks/andrew_dent_to_eliminate_waste_we_need_to_rediscover_thrift

Other useful resources I discovered:

Ideas that I think will work:

1. What is the idea?

How does it work?

Why do you think it's a good solution?

2. What is the idea?

How does it work?

Why do you think it's a good solution?

3. What is the idea?

How does it work?

Why do you think it's a good solution?