Smithsonian Science for the Classroom

HOW CAN WE PROVIDE FRESHWATER TO THOSE IN NEED?

Grade 5 - Engineering

TRAINER GUIDE

CURRICULUM PROFESSIONAL DEVELOPMENT

Smithsonian
Science Education Center

The **Smithsonian Science Education Center** (SSEC) is an education organization within the Smithsonian Institution. The SSEC's mission is to transform K–12 *Education Through Science*™ in collaboration with communities across the globe. The SSEC promotes authentic, interactive, inquiry-based K–12 STEM teaching and learning; ensures diversity, equity, accessibility, and inclusion in K–12 STEM education; and advances STEM education for sustainable development. The SSEC achieves its goals by developing exemplary curriculum materials and digital resources; supporting the professional growth of K–12 teachers and school leaders; and conducting outreach programs through LASER (Leadership and Assistance for Science Education Reform) to help schools, school districts, state education agencies, and ministries of education throughout the world implement inquiry-based science education programs.

The **Smithsonian Institution** was created by an Act of Congress in 1846 "for the increase and diffusion of knowledge . . ." This independent federal establishment is the world's largest museum, education, and research complex and is responsible for public and scholarly activities, exhibitions, and research projects nationwide and overseas. Among the objectives of the Smithsonian is the application of its unique resources to enhance elementary and secondary education.

Acknowledgments

Lead Trainer Guide Developer

Dr. Hyunju Lee

Division Director of Professional Services

Amy D'Amico, PhD, Principal Investigator, Smithsonian Science for North and South Carolina Classrooms

Assistant Division Director of Professional Services

Katie Gainsback, Project Manager, Smithsonian Science for North and South Carolina Classrooms

Addy Allred
Jacqueline Kolb
Alexa Mogck
Layla Sastry
Katherine Blanchard
Dr. Hyunju Lee
Eva Muszynski
Ariel Waldman
Katherine Fancher
Nejra Malanovic
Shellie Pick
Sherrell Williams

Executive Director, Smithsonian Science Education Center

Dr. Carol O'Donnell, Co-PI, Smithsonian Science for North and South Carolina Classrooms

Smithsonian Science Education Center Staff

Executive Office

Kate Echevarria
Johnny F. McInerney

Advancement and Partnerships

Holly Glover, Division Director
Denise Anderson
Inola Walston

Finance and Administration

Lisa Rogers, Division Director
Allison Gamble
Jasmine Rogers

Curriculum, Digital Media, and Communications

Dr. Brian Mandell, Division Director
Sofia Elian
Heidi Gibson
Dr. Sarah J. Glassman
Carolina Gonzalez
Dr. Emily J. Harrison
Victor Lucena
Hannah Osborn
Andre Radloff
Melissa J.B. Rogers
Logan Schmidt
Dr. Mary E. Short
Khadijah Thibodeaux
Logan Werlinger
Raymond Williams, III

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How Can We Provide Freshwater to Those in Need?

Grade 5—Engineering

Trainer Guide

INTRODUCTION

In 2019, the US Department of Education awarded the Smithsonian Science Education Center an early-phase Education Innovation and Research (EIR) grant to support the development, implementation, and initial evaluation of evidence-based innovations to improve student achievement. The project, called Smithsonian Science for North and South Carolina Classrooms (PR# U411C190055), took place between October 2019 and September 2024 in third-, fourth-, and fifth-grade classrooms in North and South Carolina.

Between 2020 and 2023, participating teachers in implementation schools received curriculum professional development tied to two Smithsonian Science for the Classroom curriculum modules and content and pedagogy professional development tied to the content of each module to implement in their classrooms. The Center for Research in Educational Policy (CREP) at the University of Memphis evaluated the impact of these modules and professional development on student achievement using standardized assessments, classroom observations, and teacher focus groups.

This guide was developed as a support for trainers leading curriculum professional development for fifth grade teachers implementing the Smithsonian Science for the Classroom Engineering module *How Can We Provide Freshwater to Those in Need?*

RESOURCES

- Teacher Guide (TG)
- Student Activity Guide (SAG)
- Smithsonian Science Stories Literacy Series: *Water Works* (Reader)
- Carolina Science Online (CSO): Carolinascienceonline.com

HOW TO USE THIS TRAINER GUIDE

This guide shares important ideas and strategies for effectively introducing a Smithsonian Science for the Classroom (SSftC) module with educators, when used in conjunction with the corresponding Teacher Guide. The Teacher Guide contains essential details needed to implement the module in the classroom, while this Trainer Guide outlines how to conduct professional development for that module; therefore, the two guides should be used in tandem.

The professional development plan for each section is outlined in a table at the start of each session. Within each section, there is another table. The first column shows the part of the lesson being addressed, and corresponding page numbers within the Teacher Guide, Student Activity Guide, and Reader. The second column provides the trainer with additional direction in concise bullet points.

ROOM SETUP

To set up a classroom for this workshop:

1. Move tables or desks so groups of three or four participants can work together.
2. Set module materials out on side tables where they can be easily accessed.
3. Locate the nearest restrooms and evacuation routes.

WORKSHOP OVERVIEW

This trainer guide provides direction on facilitating the curriculum sessions highlighted in the table below.

Day 1		Day 2	
10 a.m.	Welcome Session	**10 a.m.** Curriculum Session 3	Focus Questions 2–3 (Lessons 8–12)*
11 a.m. Curriculum Session 1	Introduction and Lesson 1	**12 p.m.**	Lunch
12 p.m.	Lunch	**12:45 p.m.** Curriculum Session 4	Focus Question 4 and Engineering Design Challenge (Lessons 13–15)
12:45 p.m. Curriculum Session 2	Focus Questions 1–2 (Lessons 2–7)	**3 p.m.**	Closing Session
3:30 p.m.	Adjourn	**3:30 p.m.**	Adjourn

**Depending on the workshop design, this section may be led by participants if they have adequate time to prepare.*

Note: Italicized statements are intended to provide supporting information to facilitators.

SESSION 1:

Introduction and Lesson 1

In this session, the trainer leads lessons as a facilitator (wearing their "teacher hat") while teachers act as learners (wearing their "student hats").

Goal: The trainer facilitates the first lesson as an exemplar and introduces the concept storyline of the G5 Engineering module. Participants experience Lesson 1 as learners and debrief the lesson as teachers.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Housekeeping and Introduction	10 minutes	
Lesson 1	30 minutes	Set up water pump set, hand out Readers
SSftC Features and CSO	15 minutes	Log in to CSO
Concept Storyline	5 minutes	

	Key Points
Housekeeping and Introductions	**Introductions** Welcome participants to your session. Remind them that this professional learning workshop is meant to orient teachers to a new Smithsonian Science for the Classroom curriculum module. At times they will be asked to wear their "student hat" and experience lessons as their students will, and at others they'll reflect on the material wearing their "teacher hat." **Icebreaker Activity** Participants introduce themselves through an icebreaker activity. next page →

	Key Points
	Housekeeping Preview the agenda. Verify the safety protocols in the classroom and locate the nearest restrooms, fire exit, tornado shelter.
	Establish the Tone for the Day Divide participants into small groups and ask them to think about what they want to achieve today. What norms do they think will encourage a positive learning environment? Introduce group norm ideas: • Be brave • Be present • Ask questions • Be respectful Have each small group discuss the suggested norms and add to the big group list of norms. Once everyone has added their ideas, ask if there are any changes, additions, or modifications that need to be made. When the discussion is finished, this will be the social contract the group abides by for the next two days.
	General Safety This module requires the use of chemicals. While the risk of injury is low, there should be clear safety guidelines and expectations. These guidelines will vary depending on the situation, but some useful examples can be found in the Stay Safe! contract included in the curriculum, chemistry lab rules, and general classroom safety expectations. Safety guidelines should be discussed before every lesson. Examples of safety guidelines: • Pull hair back • No tasting anything • Wear protective eyewear and gloves when handling chemicals • If something spills, report it immediately to get help cleaning it up • Listen closely to instructions • No running in the classroom

Lesson 1: H_2GO
Accessing freshwater is a problem.

30 minutes

Students define the problem of freshwater not being available where it is needed. Students design and test a system for moving water a short distance.

Group discussion among participants is very important for these lessons. Strategies for supporting group discussions can be found in Appendix 1. Strategies for furthering discussion through guiding thought/questioning can be found in Appendix 2.

On CSO, navigate to Lesson 1 using the numbers at the top of the screen.

Resource/Page #	Lesson 1
Overview TG: p. 77	Objectives: • Define the problem of freshwater not being where it is needed. • Design and test a solution to the problem of moving water a short distance. Lesson Background Information: • Water is one of Earth's most precious resources. Individuals and communities need water, but because only a tiny fraction of accessible water is freshwater, this can cause problems. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 78–79	Materials: • Water pump set • Reader • SAG • Chart paper (optional) • STEM Notebook Printed Materials: • Lesson 1 Notebook Sheet A • Lesson 1 Notebook Sheet B Digital Materials: • Water Matrix file • California Snowpack file • H_2GO Criteria and Constraints file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

<table>
<tr><th>Resource/Page #</th><th>Lesson 1</th></tr>
<tr><td>Procedure: Getting Started
TG: p. 80-81</td><td>Getting Started
Water Matrix file
Defining the problems: Students use prior knowledge to identify water-related problems.
Ask participants to copy the chart shown in Figure 1.7 in the TG onto a notebook sheet.
<table><tr><th>Observations</th><th>Problems</th><th>Solutions</th></tr><tr><td></td><td></td><td></td></tr></table>
Open the Water Matrix file.
Ask participants to write down their observations of the pictures on the left side of the chart.
Ask participants to share their observations and record them on a class chart.
For each observation, ask participants to write possible problems and/or possible solutions observed in the picture.
Ask participants to share their problems and solutions.
Tell participants that freshwater is what they use at home and they will learn more about it later.
California Snowpack file
Defining a problem: Participants begin to think about how accessing freshwater is a problem.
Analyzing and interpreting data: Participants identify the decreasing snowpack and interpret its impact on the amount of accessible water.
Open the California Snowpack file.
Hand out Lesson 1 Notebook Sheet A.
Ask participants to read the text and answer the questions.</td></tr>
</table>

Resource/Page #	Lesson 1

Procedure: Activity
 	
TG: p. 82-84
Reader: p. 1-2
SAG: p. 1-3
	Activity
	
	Obtaining, evaluating, and communicating information: Students read a grade-appropriate informational text on the different ways water moves and does not move in a system. Students will refer to the text for information that will inform a discussion about how there can be problems associated with each.
	• Introduce the Reader, *Water Works*. The Reader has multiple versions. They all have the same readings but in multiple forms.
	  • On-Grade Readers: 16 physical copies shipped with your supplies with Lexile scores for third grade
	  • CSO Readers: All CSO readers can be assigned to students using the CSO system
	  • Spanish Reader: on-grade reader in Spanish has notes and text-to-speech
	  • Digital copy of on-grade reader with note-taking and text-to-speech
	  • Below-grade reader: reader with the same information but simpler sentence structure to decrease the Lexile score by about 100 points
	  • Smithsonian Science Stories: *Speed Bumps* Student Reader: e-book version of the on-grade reader with annotation toolbar
	• Organize pairs and ask them to read the "Water Around You" section from reading 1, "Water in Our World," in the Reader.
	• Ask the three reflection questions:
	  • What went well?
	  • What didn't go well?
	  • What to change?
	
	Reading Summary
	
	This reading introduces the concepts of freshwater, surface water, watershed, groundwater, spring, and well.
	
	next page →

Resource/Page #	Lesson 1

	Introduce the SAG and hand out Lesson 1 Notebook Sheet B.
	• Hold up the airline tubing, valves, plastic syringes, and beakers, and tell participants that they will be attempting to solve the problem of how to move water from a place that has water to a place that does not.
	• Open the H_2GO Criteria and Constraints file (direct participants to find it in the SAG, p. 2), and read it aloud. Explain what criteria (goals) and constraints (limits on the possible solutions) are.
	• Divide the participants into groups of four and have each group collect materials (except water).
	• Individually, have participants think about the problem and follow the SAG steps 1–3 to sketch out a design on the Notebook Sheet.
	  • Collect materials (except water) as a group.
	  • Individually think about the problem.
	  • Individually sketch out My Design on the notebook sheet.
	• In groups, have participants follow the SAG steps 4–9.
	  • Each group member shares their design.
	  • As a group, choose one design option.
	  • Each group will place the beakers 100 centimeters apart, build and test their design (without water), and make adjustments as needed.
	  • Sketch out the final design for the group on the Notebook Sheet.
	• Following the SAGE steps 10–12, test the design with water.
	  • Explain how to use the graduated cylinder. Have each group get 100 mL of water.
	  • Following SAG steps 10–12, test the design.
	  • Measure the amount of water moved using the graduated cylinder. Write the amount in their STEM Notebook.

Resource/Page #	Lesson 1
Procedure: Bringing It All Together TG: p. 85-86	***Bringing It All Together*** Designing solutions: Students demonstrate their understanding of solving a problem by generating, comparing, and discussing multiple solutions to a problem. • Have each group share their designs. Two participants from each group should stay and explain their design, and the other two participants visit other designs (allot 5 to 10 minutes). • Have the two participants who visited other designs share what they learned. • Ask the groups to discuss one thing that went well and one thing to change in their design. • Ask the reflection questions (what went well, what didn't go well, and what to change).
Assessment, Enrichment & Extension TG: p. 86-88	Briefly review, as time allows: • Assessment Rubrics: Pre-Assessment • Extension: Scale It Up (Math)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports that can be applied?

Smithsonian Science for the Classroom Features and Carolina Science Online

15 minutes

	Key Points
TG	Hand out TGs. Briefly review the physical items that accompany a module: • Teacher Guide (1) • Student Activity Guide (8) • Smithsonian Science Stories (16) • Materials (for 32 students)
CSO	Carolina Science Online (CSO) is the virtual platform that hosts the teacher guide, digital copies of the student readers, digital readers in Spanish, and other digital resources for the module. **Set Up a Carolina Science Online Account** Before training, you should receive an email directing you to create your teacher login on CSO (www.carolinascienceonline.com). On the main page, hover over the "Teacher login" button. "Create a Teacher Account" will appear as an option. Enter the required information. Make sure you choose a password you can remember. Return to the main page and log in. At the top of the page, click "redeem code." Enter the code that was emailed to you. The account is now ready to use. On the main page, all the titles available to you will be in bright colors. Click on the module you need. The module will open in the "Module Overview" tab. The "Home" button in the top left of the screen will take you back to the main screen with all of the available titles. "Bookmarks" will open your bookmarks folder. You can bookmark any of the digital resources on CSO by clicking on the star underneath the resource. next page →

	Key Points
	"Assignments" shows all assignments you have created using CSO digital resources. You can add a digital resource to assignments by clicking "add to assignment" on any CSO digital resource.
TG and CSO TG: p. 1–17	Navigate to the "Curriculum Overview" section in the TG, which is also found under the "Module Overview" tab in CSO. This section provides an introduction to the curriculum and the research-based methods integrated into Smithsonian Science for the Classroom.
TG: p. 20–21	**Concepts and Practices Storyline** Modules are broken down into areas that revolve around a single focus question. The focus questions build a storyline that provides a coherent experience that builds toward solving a problem. The storylines are carefully integrated with the 5E model and each lesson is identified as to where it fits in the model. This module has four focus questions, with the final focus question being the Engineering Design Challenge.
TG: p. 22–24	**Prerequisite Concepts and Practices** The listed items are the skills and knowledge students will lean on to incorporate new skills and content learning. Each set of concepts and practices identifies where the prerequisites should have been taught.
TG: p. 24–27	**Module Background Information** This section provides background information for the teacher. It covers content that is not directly discussed in the module but may prove useful in understanding where content or practices are headed. It also provides information that is a fundamental building block for content and practices used in the module. next page →

	Key Points
TG: p. 28-31	**Common Misconceptions** Students may express misconceptions throughout the lesson. This section provides a list of common misconceptions identified in research for both content and practices, an explanation of the misconception, and a possible example of how it may come up. The number after the misconception refers to which reference the misconception is described in. Throughout the module, misconception callouts will be highlighted using the Good Thinking! bubble. Good Thinking! is a YouTube video series created by the Smithsonian Science Education Center focused on misconceptions and learning.
TG: p. 31-37	**Materials Management and Safety** This section provides information on materials that will be provided with the module kit, needed but not supplied materials, safety concerns, and a safety contract for students. Under the "Materials Lists" section you will need to click on the hyperlink to download the materials lists. These lists show you everything that will be included in the module kit and items teachers will need to supply. The lists also show how much of each material is needed and in which lesson. In the "Safety" section, there are callouts for specific concerns for this module and a link to a Stay Safe! contract. The contract lists expectations for students to keep themselves and others safe during science investigations. It has lines for both students and guardians to sign.
TG: p. 40-41	Navigate to the "NGSS Alignment and Planner" tab in CSO. **Module Alignment to NGSS** These modules are aligned to the Next Generation Science Standards, which teachers can use as an additional tool to identify student objectives and goals for learning. next page →

	Key Points
TG: p. 42-71	**Lesson Planners** The lesson planners highlight everything that will happen in a lesson, such as: • Focus Question • Step of 5E model • Number of class periods needed • Vocabulary that will be introduced • Student objectives • Misconceptions: more information can be found in the "Module Overview" tab or TG p. 29-31 • Disciplinary core ideas: content focus • Science and engineering practices • Crosscutting concepts: ideas that are multidisciplinary • ELA and math connections: numbers reference the Common Core Standards • Extensions: additional lessons that are not necessary to move forward in the module
TG: p. 74-75	In the TG, review the callout icons itemized in the Guide to Module Investigations: • NGSS • Common Core • Misconceptions • Digital Resource • ELL Strategy • Teacher Tips and Tech Tips • Guiding Questions • Safety Notes • Class Period Break
Readers and CSO	All the written materials (Readers, Student Activity Guides, Notebook Sheets) are available digitally on CSO. Navigate to the student readers under the "Digital Resources" tab in CSO. There are multiple versions. The on-grade reader cover has a matchstick with the round end pointing up. The below-grade reader cover has a matchstick with the round end pointing down. The Spanish reader is only available on grade. next page →

	Key Points
	The on-grade reader exists in two forms on CSO. One is an interactive book and the other is an e-book. The other readers are only available in the e-book format. Both formats have tools for students. In the interactive book, students can highlight and make notes using the tools in the toolbar. In the e-book format, students can use the text-to-talk feature by highlighting the text and selecting the speaking icon.
Support and CSO	Carolina Science Online provides a number of supports to teachers, including: • Teacher Resource videos: These videos provide an overview of the focus questions and show any lessons with a potentially tricky setup. They're available under the "Digital Resources" tab. • Tutorial videos: For help using CSO's features, choose "Support" from the vertical toolbar on the left side of the homepage. • Get Ready! Professional Learning: These short videos offer information on-demand and teacher tips about the program. They can be found at https://www.smithsonianstc.com/ssftc-get-ready-campaign-172N7-44857Z.html

Concept Storyline

Grade 5 Engineering: *How Can We Provide Freshwater to Those in Need?*

5 minutes

CSO /TG	Concept Storyline
TG and CSO TG: p. 20-21	**Concepts and Practices Storyline** Return to the "Concepts and Practices Storyline" tab and walk through the module's structure. This module has four focus questions, with the final focus question being the Engineering Design Challenge. Explain each focus question with its objectives, as below: next page →

CSO /TG	Concept Storyline
	FQ#1: Where does the water you need come from? (Lessons 1–4) *Students collect evidence and experiences on their water footprints and on how little accessible freshwater actually exists. The culminating activity in the first focus question asks students to create a water scarcity-based public service announcement for a region in distress.* FQ#2: How have humans impacted the water we need? (Lessons 5–9) *The second focus question asks students to solve a water pumping challenge, develop models based on the interaction of Earth's four spheres, and then design a solution to a water pollution problem.* FQ#3: How have humans tried to solve the problem of getting freshwater to where it's needed? (Lessons 10–12) *Students use a digital game and a newspaper activity to see how humans have tried to solve the global and regional problems of getting freshwater to where it's needed. The unintended consequences of our solutions are a point of emphasis in this focus question.* FQ#4: How can we provide freshwater to agriculture, industry, the environment, and housing in your town? (Lessons 13–15) *In the final focus question, students engage in a two-part summative assessment. The written summative assessment complements the performance-based summative assessment and both focus on how key stakeholder groups must work together to design solutions to the water access, treatment, and allocation issues facing individuals and communities around the Earth.*

Assessment	There are four different types of assessment throughout the module.
	• Pre-Assessment (Lesson 1)
	• Formative Assessment (Lessons 2–12)
	• Summative Assessment (Lessons 13–15)
	  • Written Summative Assessment
	  • Performance Summative Assessment
	• Self-Assessment (SAG): Stop & Check

SESSION 2:

Lessons 2–7

The trainer introduces Lessons 2-4 (Focus Question 1), and Lessons 5-7 (Focus Question 2).

Goal: The trainer facilitates Lessons 2-7, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 2	20 minutes	Beaker (1 liter), Water Footprint Cards Hand out Readers
Lesson 3	30 minutes	Beakers, plastic cups, syringes, pipet, food coloring, stirring rod, index cards
Lesson 4	20 minutes	Construction paper, markers, colored pencils, World Aquifer Card Hand out Readers
Short break	10 minutes	
Group Roles	5 minutes	Make sure Group Roles poster is visible
Lesson 5	30 minutes	Set up water pump set
Lesson 6	25 minutes	Hand out Readers
Lesson 7	25 minutes	Water Web Cards, dice, chart paper

Lesson 2: Water Footprint

Human activities require freshwater.

20 minutes

Students analyze and interpret data in order to construct explanations about how much water is required to produce different foods. Students learn how the food they eat, activities they participate in, and materials they use all affect their own water footprint.

On CSO, navigate to Lesson 2 using the numbers at the top of the screen.

Resource/Page #	Lesson 2
Overview TG: p. 89	Objectives: • Analyze and interpret data on common food sources. • Apply mathematical reasoning by recording observations about their water footprint. • Apply mathematical reasoning to graph the amount of water needed for common food sources. Lesson Background Information: • Humans use water for bathing, cleaning clothes, washing dishes, and drinking. One overlooked area where water is also needed is in the production of our food. Water is needed in everything from raising chickens to making cheese, and even in the production of chocolate. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 90	Materials: • 1 beaker (1 liter) • Water Footprint Cards set • Reader Printed Materials: • Lesson 2 Notebook Sheet A • Lesson 2 Notebook Sheet B • Lesson 2 Notebook Sheet C Digital Materials: • My Water Footprint Example file • Food Sources Water Footprint file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 2
Procedure: Getting Started TG: p. 91–92	***Getting Started*** • Show how much is 1 liter by filling the 1-liter beaker with water. • Distribute Lesson 2 Notebook Sheet A. • Open the My Water Footprint Example file and explain it.
Procedure: Activity TG: p. 92–95	***Activity*** • Divide into groups and give each group a Water Footprint Cards set. • Have each group match the food type with the appropriate amount of water needed to produce it. • Let each group share one match of food type and water use, using the sentence frame. • Ask guiding questions for deeper explanations. • Hand out Lesson 2 Notebook Sheet B. Have participants write down their predicted matches. • Open the Food Sources Water Footprint file, which has the correct answers. • Ask participants to write the correct answers in the second column, and ask them to write why these answers may have surprised them. • Hand out Lesson 2 Notebook Sheet C. • Explain the graph elements (title, vertical and horizontal axes, labels, and scale) and that bar graphs are a way to compare different categories of data. • Ask participants to draw a bar graph to show the total water usage for each food source. • Ask a guiding question.
Procedure: Bringing It All Together TG: p. 96 Reader: p. 5–10	***Bringing It All Together*** • Read reading 2, "Water in My Day," in the Reader. next page →

Resource/Page #	Lesson 2
	Reading Summary How many things do you do every day that require water? Could you come up with 10 things? Some tasks that require water are obvious because we can see the water we use. But water is used for more than you might realize. The reading introduces the amount of water we use without realizing it throughout a day—approximately 80 to 100 gallons of water for one person in one day, which is a lot! • Remind participants to complete their 24-hour water record before the next lesson.
Assessment, Enrichment & Extension TG: p. 97-98	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Take Action (Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 3: Our Water Picture

Freshwater is limited and not easily accessible.

30 minutes

Students use a model to create a graph that shows how little freshwater is available compared to the large amount of water on Earth. Students define the problem of humans' need for freshwater and the limited amount of freshwater available.

On CSO, navigate to Lesson 3 using the numbers at the top of the screen.

Resource/Page #	Lesson 3
Overview TG: p. 99–100	Objectives: • Use a model to explore how little freshwater is actually accessible for humans. • Define the problem of humans' need for freshwater and limited accessible freshwater on Earth. Lesson Background Information: • Groundwater is water that is found in and between the soil, sand, and rocks below the water table. • Freshwater is incredibly scarce, making up only 3 percent of the total water found on Earth. The other 97 percent of water is found in our oceans and seas. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 100–101	Materials: • 2 beakers (2 liter) • 14 clear plastic cups • 1 Plastic syringe (60 mL) • 1 Plastic syringe (1 mL) • 1 Pipet • Food coloring (blue, red, yellow, and green) • 1 Stirring rod • 7 Index cards next page →

Resource/Page #	Lesson 3
	Printed Materials: • Lesson 3 Notebook Sheet *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • In the center of the room, place 2 beakers, each filled with 1 liter of water, along with 14 clear plastic cups, 1 plastic syringe (60 mL), 1 plastic syringe (1 mL), 1 plastic pipet, and food coloring. • Fill one of the clear plastic cups with 60 mL of clear water. • Label seven index cards with these words: freshwater, salt water, lakes, rivers, wetlands, groundwater, glaciers.

Procedure: Getting Started
TG: p. 101-102
	Getting Started
	• Tell participants to take out their My Water Footprint records from Lesson 2.
	• Divide into groups of four and discuss the following questions as a small group:
	  • How much water did you use?
	  • Where did you use the most water?
	  • What was missing from your record?
	  • How have your ideas about your water footprint changed?
	• Bring the whole class together to discuss:
	  • How did your group use the majority of your water?
	  • What was missing from your record?
	  • How have your ideas about your water footprint changed?
	• Explain the difference between freshwater (water that contains very little or no salt) and salt water (saline water).

Resource/Page #	Lesson 3

Procedure: Activity
TG: p. 102–105
	Activity
	• Gather two (2-liter) beakers of water, a 60-mL syringe, nine cups, and blue and red food coloring.
	• Hand out the Lesson 3 Notebook Sheet.
	• Indicate the two beakers and tell participants this represents all the water on Earth.
	• Remove 60 mL of water using the syringe to one of the plastic cups. Add one drop of blue food coloring.
	• Slowly pour the rest of the water in the other eight plastic cups. Put one drop of red food coloring in each cup. Tell participants that the red water represents all the water found in the oceans (which we can't drink and can't use to raise crops or animals).
	• Point out that the red water = 97 percent of all the water on Earth. The blue water is freshwater = 3 percent of all the water on Earth.
	• Place the freshwater index card near the blue cup, and the saltwater index card near the red cups.
	• Ask participants to color their pie chart using blue and red.
	• Explain about freshwater:
	  • Only 3 percent of all the water on Earth.
	  • Glaciers, lakes, rivers, streams, wetlands, and groundwater are the major places we find freshwater.
	  • Wetland is an area of land saturated with water, and a glacier is a very large mass of ice.
	• Gather 5 cups, syringe, pipet, yellow, green, and blue food coloring, and 60 mL of clear water.
	• Remove one freshwater source at a time, following Figure 3.5 (Freshwater Sources table) in the TG. Place the water in an empty cup and use the food color to dye the water.
	
	next page →

Resource/Page #	Lesson 3
	• Ask participants to draw their second pie chart (see Figure 3.7 in the TG) on the Notebook Sheet. • Ask participants to draw a big X on the glacier pie piece, which can't be accessed because it is frozen.

Procedure: Bringing It All Together
TG: p. 105–106
	Bringing It All Together
	• Ask participants to answer the question, "What did you learn about freshwater on Earth?" in their STEM Notebook.
	• Ask them to write one or two questions on their notebook: What questions did this activity and the water footprint activity make you think about?
	• Discuss the guiding questions:
	  • What did you learn about freshwater on Earth?
	  • What is the problem?
	  • What questions does this lesson and the water footprint lesson make you think about?

Assessment, Enrichment & Extension TG: p. 106–109	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Runoff (Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 4: Water Scarcity Explored

Water scarcity is a global problem.

20 minutes

Students analyze and interpret data showing the scale of the global water scarcity issue and communicate their findings in a public service announcement.

On CSO, navigate to Lesson 4 using the numbers at the top of the screen.

Resource/Page #	Lesson 4
Overview TG: p. 111	Objectives: • Analyze and interpret data from satellite images on increases and decreases in groundwater reserves around the Earth. • Communicate information about the problem of water scarcity by integrating text, images, and graphs in a public service announcement. Lesson Background Information: • When it rains or snow melts, the water eventually makes its way underground. The water that is not absorbed by plants makes its way farther underground. The water moves deeper through the rocks and empty spaces in the soil, sand, and rocks until it is stopped by an impermeable layer of rock, sand, or soil. The water begins to fill up behind that layer and eventually tops out at a certain layer. That layer is called the water table. Everything underneath is called groundwater. • Students learn about groundwater and the huge storehouses of groundwater known as aquifers. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 112	Materials: • Construction paper • Markers • Colored pencils • 1 World Aquifer Card • Reader next page →

Resource/Page #	Lesson 4
	Printed Materials: • Lesson 4 Notebook Sheet Digital Materials: • Groundwater video • Earth's Major Groundwater Reservoirs file • Public Service Announcement Examples file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Procedure: Getting Started
TG: p. 112-114
Reader: p. 2-4
	Getting Started
	• Tell participants to take out their pie charts from Lesson 3.
	• In reading 1 in the Reader, direct participants to the watershed illustration and groundwater illustrations. Point out:
	  • Precipitation and runoff can become groundwater.
	  • Groundwater is stored not as a "lake" underground, but between and around soil and pieces of rock.
	  • Groundwater can even be stored inside rocks.
	
	Reading Summary
	The reading introduces freshwater, surface water, and the watershed. It explains what groundwater is and how the water is stored.
	• Show the first 1 minute, 30 seconds of the Groundwater video. Explain what "aquifer" means.
	• Open the Earth's Major Groundwater Reservoirs file, which is a map of the major aquifers of the world (not the surface water). Explain how to read the map by colors: the bluer is more replenished, and the redder is more depleted. Yellow means the amount of groundwater is stable over time.
	• Ask the guiding questions from the TG, and let participants share their answers by providing evidence from the map.

Resource/Page #	Lesson 4

Procedure: Activity
TG: p. 114–116
	Activity
	• Hand out the Lesson 4 Notebook Sheet.
	• Tell participants that they will create a public service announcement (PSA) for one of the regions of the world with decreasing groundwater. The purpose of the PSA is to alert people to the problem of water scarcity.
	• Open the Public Service Announcement Examples file.
	• Discuss the guiding questions.
	  • What are some of the problems addressed by these PSAs?
	  • What features of the PSAs help to get the message across?
	• Divide participants into groups of two. Ask them to brainstorm with their partners to answer the questions on the Lesson 4 Notebook Sheet.
	• Distribute a World Aquifer Card to each pair of participants and explain that they will be designing a PSA for this specific area of the world.
	• Have participants use their resources from previous lessons and the World Aquifer Card to help them answer the four key questions on the Lesson 4 Notebook Sheet.
	• Have pairs of the participants design their PSA on construction paper, using color, and include at least one image (photo or drawing) and at least one graph.
	• Have them write their name in the lower right-hand corner and hang their PSA posters around the classroom.

Procedure: Bringing It All Together TG: p. 117	***Bringing It All Together*** • Tell participants they will be using a think-pair-share strategy to revisit their focus question: Where does the water you need come from?

Resource/Page #	Lesson 4
Assessment, Enrichment & Extension TG: p. 117-119	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Prove It (Literacy, Technology)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Many of the lessons use group roles to assign specific jobs. For strategies on using group roles effectively, please see Appendix 3.

Group Roles

5 minutes

Starting in Lesson 5, students will be assigned group roles. The assignments and a possible rotation system can be found in Appendix 3. Group roles are a common tool to build teamwork skills such as turn taking, communication, and responsibility for individual and group needs. Additionally, having a specific role can increase student involvement and confidence by ensuring they know what is expected of them in a given situation. You can learn more about collaborative groups and group roles in the Zero Barriers in STEM Education Accessibility and Inclusion Workbook found at https://ssec.si.edu/zero-barriers.

Lesson 5: Water Pump

Identifying failure points informs how to improve a design.

30 minutes

Students consider the structure and function of various tools in order to design a solution for pumping groundwater to the surface. Students communicate possible solutions to failure points encountered during system testing.

On CSO, navigate to Lesson 5 using the numbers at the top of the screen.

Resource/Page #	Lesson 5
Overview TG: p. 121–122	Objectives: • Explore the structure and function of various tools in order to design a system for pumping water vertically. • Communicate possible solutions to failure points encountered during system testing in order to inform improvements to the original design. • Evaluate whether all but one variable was controlled during two separate design tests, such that the two tests can be considered a fair test. Lesson Background Information: • Engineers solve problems. How humans can access water that is stored underground is a problem. Engineers define the criteria and constraints of a problem before designing a solution. Then they test to see how well their solution meets the criteria and constraints. During testing, engineers identify potential failure points that may negatively impact the results of the test. Engineers use a fair test to test solutions to a failure point. A fair test isolates one variable to test the effect of changing it and controls (keep the same) all the other variables as best as possible. • In this lesson, students simulate pumping groundwater to the surface by designing a water pump to move water from the floor to their desktop. Class Periods: 2 (1 class period = about 35 minutes)

Resource/Page #	Lesson 5

Materials & Preparation
TG: p. 122-123
	Materials:
	• Water pump set
	  • 2 beakers, 1,000 mL
	  • 5 lengths of airline tubing, 30 centimeters
	  • Plastic syringe, 60 mL
	  • 4 connectors
	  • Three-way valve
	  • Graduated cylinder, 100 mL
	• SAG
	Printed Materials:
	• Lesson 5 Notebook Sheet A
	• Lesson 5 Notebook Sheet B
	Digital Materials:
	• Water Pump Criteria and Constraints file
	The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.
	
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should set out the following materials:
	• Water pump set
	• Water

Procedure: Getting Started
TG: p. 124
	Getting Started
	• Ask the guiding questions:
	  • How do you think humans can get groundwater to the surface of the Earth?
	  • If the water is really deep under the surface, how can we get it? Think about the activity we did during the first lesson.

Procedure: Activity TG: p. 124-130 SAG: p. 4-6	***Activity*** • Hand out the SAG and Lesson 5 Notebook Sheet A. • Make groups of four participants, and assign group roles: Materials Manager, Organizer, Tester, and Speaker. next page →

Resource/Page #	Lesson 5
	• Have participants complete the activity in the SAG and fill out Notebook Sheet A. • Ask participants to share their work and failure points. • Hand out Lesson 5 Notebook Sheet B and have participants complete the rest of the steps in the SAG.
Procedure: Bringing It All Together TG: p. 130–131	***Bringing It All Together*** • Ask for definitions of the term "failure point." • Ask, "Why it is important to identify failure points before and during testing?" • Ask participants to articulate the importance of sharing ideas or suggestions on designs or failure points before and during testing. • Discuss what was controlled between test 1 and test 2, and share about what a fair test is.
Assessment, Enrichment & Extension TG: p. 132–134	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Opportunity Knocks (Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 6: The Global Water Connection

Humans impact Earth's four spheres.

25 minutes

Students evaluate informational text in order to communicate information with peers about a particular sphere of the Earth. Students explain how one component of the Earth system is affected by or affects humans.

On CSO, navigate to Lesson 6 using the numbers at the top of the screen.

Resource/Page #	Lesson 6
Overview TG: p. 135	Objectives: • Obtain and communicate information from texts about Earth's major spheres. • Construct an explanation of how humans impact Earth's spheres, based on evidence from texts. Lesson Background Information: • Geosphere: solid and molten rock, soil, and sediments • Biosphere: living things, including humans • Hydrosphere: water and ice • Atmosphere: air Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 136	Materials: • SAG • Reader Printed Materials: • Lesson 6 Notebook Sheet Digital Materials: • Water Matrix file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Procedure: Getting Started
TG: p. 137
	Getting Started
	• Ask the guiding questions:
	  • What are all of the things that water must have come into contact with before it settles underground?
	  • How long do you think this might take?

Resource/Page #	Lesson 6
Procedure: Activity TG: p. 138 SAG: p. 7–9 Reader: p. 17–24	***Activity*** • Divide participants into four Explainer groups. Each Explainer group is responsible for becoming the experts on one of the four spheres (atmosphere, biosphere, geosphere, and hydrosphere). In the Reader, read assigned sphere from reading 4, "Four Spheres." • Identify the VIP (SAG, steps 1–2). • Share, summarize, and identify (SAG steps 3–6). • Reorganize the groups so there is an Explainer from each sphere in every group. • Once each group has finished, ask them to return to their Home groups. **Reading Summary** The reading introduces top 10 facts about Earth's major spheres: geosphere, biosphere, hydrosphere, and atmosphere.

Procedure: Bringing It All Together
TG: p. 139–140
SAG: p. 7–9
	Bringing It All Together
	• Hand out the Lesson 6 Notebook Sheet.
	• In their Home groups, participants complete the rest of the SAG (steps 7–9).
	• Open the Water Matrix file. Pick a single picture and discuss the questions:
	  • What spheres do you see?
	  • How are the spheres interacting?

Assessment, Enrichment & Extension TG: p. 140–142	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Systems in the News (Community and Home, Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 7: Water Web

Earth's four spheres interact.

25 minutes

Students develop a model by connecting the components of Earth's four spheres. Students use that model to make predictions about the effects of possible future events.

On CSO, navigate to Lesson 7 using the numbers at the top of the screen.

Resource/Page #	Lesson 7
Overview TG: p. 143	Objectives: • Develop a model of Earth's four major spheres using components from the Water Web lesson. • Use a model to make predictions on the outcomes of possible future events. Lesson Background Information: • Models are representations of real things. • The interaction of Earth's four major spheres in any region is incredibly complex. There are thousands of variables that must be understood on their own and then understood within the larger system. Models can help scientists and engineers make predictions on these interactions and how they might change in the future. • Students use a strategic set of Water Web cards to develop their simplified models. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 144	Materials: • Water Web Cards • Dice • Chart paper • SAG Printed Materials: • Lesson 7 Notebook Sheet Digital Materials: • Groundwater video *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

Resource/Page #	Lesson 7
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Place sets of Water Web cards and one die into a plastic bag.

Procedure: Getting Started
TG: p. 144–146
	Getting Started
	• Review the Earth's spheres and groundwater.
	• Show the Groundwater video.
	• Ask the guiding questions:
	  • What components of the Earth system interact with groundwater?
	  • Where does groundwater come from?
	  • How do humans impact groundwater?
	• Show a model: Rainwater => Groundwater => Housing
	• Ask, "What would happen if the amount of water needed for housing increased?"

Procedure: Activity TG: p. 146–148 SAG: p. 10–12	***Activity*** • Hand out the Water Web Cards and dice and a piece of chart paper to each group. • Hand out the SAG and ask participants to complete step 1 in Lesson 7. • Once participants have connected all cards in a Water Web, show them how their models can be used to make predictions about the future. • Ask participants to complete steps 2 and 3 in the SAG.
Procedure: Bringing It All Together TG: p. 148–149	***Bringing It All Together*** • Discuss possible futures, and direct and indirect impacts on the future. • Discuss the benefits and the limitations of using models.

Resource/Page #	Lesson 7
Assessment, Enrichment & Extension TG: p. 149-152	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Anacostia River—Back to the Future (History), Pipes, Pumps, and Paces (Literacy, Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

SESSION 3:

Lessons 8–12

The trainer introduces Lessons 8-9 (Focus Question 2), and Lessons 10-12 (Focus Question 3).

Goal: The trainer facilitates Lessons 8-12, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 8	20 minutes	Water treatment kit, Water contamination materials Hand out Readers
Lesson 9	30 minutes	Water treatment kit, Water contamination materials
Short break	10 minutes	
Lesson 10	20 minutes	Plastic cups, Computer device and Internet access
Lesson 11	20 minutes	Computer device and Internet access Hand out Readers
Lesson 12	20 minutes	Computer device and Internet access, newspaper Hand out Readers

Lesson 8: Clean the Water—Design It

Human activities impact groundwater.

20 minutes

Students develop a model to show how human activities interact with components of the Earth system to cause groundwater pollution. Students design a solution to a water pollution problem.

On CSO, navigate to Lesson 8 using the numbers at the top of the screen.

Resource/Page #	Lesson 8
Overview TG: p. 153	Objectives: • Develop a model to show how human activities interact with other components of the Earth system to cause groundwater pollution. • Design a solution to a water pollution problem. Lesson Background Information: • Nitrates are chemicals that, in high concentrations, can be toxic to aquatic life, animals, and humans. Agricultural fertilizers and animal wastes are the largest sources of nitrates in the groundwater. • Water treatment systems can be used to improve water quality. Many water treatment systems use filters to remove small particles and activated carbon to absorb nitrates. The activated carbon absorbs the nitrates when the contaminated water passes through it. Class Periods: 1 (1 class period = about 35 minutes)

Materials & Preparation
TG: p. 154–155
	Materials:
	• Water treatment kit
	  • 1 Beaker, 1,000 mL
	  • 5 Plastic cups, 10 oz
	  • 3 Large rubber bands
	  • 2 Large coffee filters
	  • 2 Small coffee filters
	  • 1 paper cup, 3 oz (will be filled with carbon in Lesson 9)
	
	next page →

Resource/Page #	Lesson 8

	• Water contamination materials
	  • Soil
	  • All-purpose fertilizer
	  • 2 Plastic cups, 10 oz
	  • 1 Large scoop
	  • 1 Small scoop
	  • 1 Graduated cylinder, 100 mL
	  • 1 Beaker, 1,000 mL
	  • Water
	  • 2 stirring rods
	  • 1 Water Contamination Station card
	• Safety googles
	• Safety gloves
	• Water Web cards
	• Sheet of blank white paper
	• SAG
	• Reader
	Printed Materials:
	• N/A
	Digital Materials:
	• What's Inside a Water Filter video
	The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.

Procedure: Getting Started TG: p. 155-156	***Getting Started*** • Reflect the Water Web activity from Lesson 7. • Holding one Agriculture Water Web Card, ask how agriculture impacts humans and where in their model fertilizers ended up. • Holding one Groundwater Water Web Card, ask participants to categorize as either positive or negative the impact agriculture can have on groundwater.
Procedure: Activity TG: p. 156-160 Reader: p. 33-34 SAG: p. 13-14	***Activity*** • Distribute the Readers and ask participants to read reading 6, "Thirsty for Clean Water." next page →

Resource/Page #	Lesson 8
	Reading Summary The reading is about a farmer living in the Tulare Lake Basin area of California who is concerned about the water quality in that area and hoped to find a solution in the community. • Ask participants to identify the components of the Earth system in the reading and share the answers. • Have participants make a model in their STEM Notebook showing how the components of the Earth system interact to contaminate the drinking water in the Tulare Lake Basin. • Discuss with guiding questions the water pollution problem and possible solutions. • Wearing safety goggles and gloves, put water in a plastic cup and add five large scoops of soil and two small scoops of fertilizer. Stir. • Watch the What's Inside a Water Filter video and ask guiding questions. • Divide participants into groups of four, and assign group roles: Materials Manager, Recorder, Tester, and Speaker. • Have groups follow steps 1–5 in the SAG, using the materials in the water treatment kit (without activated carbon in this lesson).
Procedure: Bringing It All Together TG: p. 161	***Bringing It All Together*** • Discuss how to judge the performance of water treatment systems. • Create a water treatment chart (see Figures 8.7 and 8.8 in the TG).
Assessment, Enrichment & Extension TG: p. 162–164	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Water Pollution Around the World (Literacy)

Resource/Page #	Lesson 8
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 9: Clean the Water—Test It

Design solutions should be compared based on how well they meet the criteria.

30 minutes

After testing water treatment systems, students analyze and interpret quantitative data in order to compare different design solutions. Students use evidence to construct an explanation about which solution best meets different criteria.

On CSO, navigate to Lesson 9 using the numbers at the top of the screen.

Resource/Page #	Lesson 9
Overview TG: p. 165	Objectives: • Test a solution to a water pollution problem. • Analyze and interpret data in order to compare different solutions to the water pollution problem and make a claim about which solution best meets different criteria. Lesson Background Information: • Participants use a water clarity scale to quantify how "dirty" or "muddy" their water is and perform nitrate tests to measure fertilizer concentrations. • They analyze and interpret the water clarity and nitrate test data to compare each group's three-step water treatment process. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 166-167	Materials: • Water treatment kit from Lesson 8 • Water contamination materials from Lesson 8 • 1 Plastic bag with 2 nitrate test strips and 1 Nitrate Scale card • 1 paper cup, 3 oz, filled with activated carbon • Safety googles • Safety gloves • SAG Printed Materials: • N/A next page →

Resource/Page #	Lesson 9
	Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Place two nitrate test strips and one Nitrate Scale Card into plastic bags. Add these bags to the water treatment kits. • Fill paper cups with activated carbon and add one to each water treatment kit. • Prepare a contamination station. At each station, place a plastic cup with soil, a large scoop and a stirring rod, a plastic cup with fertilizer, a small scoop and a stirring rod, a beaker full of water, a graduated cylinder, and a Water Contamination Station Card.
Procedure: Getting Started TG: p. 167	***Getting Started*** • Ask participants to take out the three-step water treatment process they developed in Lesson 8.

Procedure: Activity
TG: p. 167–170
SAG: p. 13, 15–17
	Activity
	• Hand out the SAG.
	• Have participants wear safety goggles and safety gloves.
	• Ask participants to complete steps 6–15 in the SAG.
	  • Contaminate the water.
	  • Test the nitrate and water clarity level of the water.
	  • Use their three-step process to treat the water.
	  • Test the clarity and nitrate level of the water again.
	  • Record test results on the class chart.
	• Clean up after the experiment.

Resource/Page #	Lesson 9

Procedure: Bringing It All Together
TG: p. 170-171
	Bringing It All Together
	• Have participants reflect on their design:
	  • How it meets the criteria
	  • A summary of the process
	  • Advantages and disadvantages of their designed system
	• Have the Speaker from each group summarize their water treatment process, along with one advantage and one disadvantage of their process.
	• As a whole class, compare and contrast each water treatment system.
	• Refer back to the model of the cause of the Tulare Lake Basin pollution problem and their solution to the model (Figure 9.7 in the TG).

Assessment, Enrichment & Extension TG: p. 172-174	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Something in the Water (Literary)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 10: Aquation

Human activities impact water availability and distribution.

20 minutes

Groups of students use a model simulation to define the problem and design a solution to the water scarcity and water equity problem using existing technologies.

On CSO, navigate to Lesson 10 using the numbers at the top of the screen.

Resource/Page #	Lesson 10
Overview TG: p. 175	Objectives: • Define the problem and design a solution to the water scarcity and water equity issue using existing technologies. • Use a model simulation to test solutions to the water scarcity and water equity problem. Lesson Background Information: • Aquation is digital strategy game in which a player or group must manage water and wealth resources to make sure nobody on the planet goes thirsty. The player may move between regions of the world, build pipelines to transfer water between regions, build and maintain desalination plants to purify salt water, and conduct research to reduce water consumption and increase conservation. • Throughout the game, the player's efforts may be disrupted by events, such as droughts, water surpluses, and economic depressions and prosperities. To win, the player must meet the water needs of each region. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 176	Materials: • 3 plastic cups • Marker • Computer device and Internet access Printed Materials: • Lesson 10 Notebook Sheet next page →

Resource/Page #	Lesson 10
	Digital Materials: • Earth's Major Groundwater Reservoirs file • Aquation Basics file • Aquation: The Freshwater Access Game (https://ssec.si.edu/aquation) *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Procedure: Getting Started
TG: p. 176-178
	Getting Started
	• Draw a line around the middle of three plastic cups. Fill one with water.
	• Ask for three volunteers. Have them pour the water between the three cups until they are satisfied with the final amounts.
	• Tell participants that this simple game was a simulation.
	• Open and show the Earth's Major Groundwater Reservoirs file from Lesson 4 and remind participants that groundwater is not evenly distributed on Earth.
	• Open the Aquation game and ask the guiding questions.
	  • What similarities do you see between the Aquation map and the GRACE satellite map?
	  • What differences do you see?
	  • Why do you think wealth is important when we look at getting water to where it is needed?

Procedure: Activity TG: p. 178-179	***Activity*** • Divide participants into groups of two. • Open the Aquation Basics file and hand out the Lesson 10 Notebook Sheet. • Watch the tutorial and play the game. Use the Aquation Transferring Water and Wealth file for details as needed. • Answer the reflection questions on the Notebook Sheet.

Resource/Page #	Lesson 10

Procedure: Bringing It All Together
TG: p. 179–180
	Bringing It All Together
	• Have a whole-class discussion about water scarcity and water equity, using the guiding questions.
	  • Which regions of the world had the most trouble meeting their water goals? Which had the least trouble? Why do you think this is?
	  • Which strategy did your group find was most effective at getting water to the places it was needed: building pipelines, desalination, or research? Why do you think this was the case?
	  • What negative aspects do you see to building pipelines to transport freshwater around the world? What about desalination of salt water?
	  • When you ran out of wealth in a particular region, how did you solve this problem? How do you think your solution is different than what might happen in the real world?
	  • Can anyone think of one or two limitations to using a simulation like Aquation to model events and interactions like water scarcity and water equity?

Assessment, Enrichment & Extension TG: p. 180–182	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Reality Check (History, Community)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 11: Unintended Consequences—Read All About It!

Human activities can have unintended consequences.

20 minutes

Students obtain and evaluate information from two different perspectives on the cause and effects of the Aral Sea environmental crisis.

On CSO, navigate to Lesson 11 using the numbers at the top of the screen.

Resource/Page #	Lesson 11
Overview TG: p. 183	Objectives: • Obtain and evaluate information from two different perspectives on the cause and effects of the Aral Sea environmental crisis. Lesson Background Information: • The Aral Sea, fed by the Amu Darya and the Syr Darya rivers, used to be the fourth largest lake in the world. In the late 1960s, the Soviet Union decided to divert much of the water in these two rivers to irrigate the areas in what is now Kazakhstan and Uzbekistan to grow cotton. They needed to do this because the surrounding areas were very dry. As a result, cotton production increased rapidly, but changes to the Aral Sea led to serious environmental effects. Seal levels plummeted, salt content in the Aral Sea increased to near toxic levels, and many fish and wildlife species were killed. • Students use the Somebody-Wanted-But-So strategy to help them determine the important details and unique perspectives found in informational texts. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 184	Materials: • Computer device and Internet access • Reader next page →

Resource/Page #	Lesson 11
	Printed Materials: • Lesson 11 Notebook Sheet Digital Materials: • Aquation Basics *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Procedure: Getting Started
TG: p. 185–186
	Getting Started
	• Start the Aquation game to see the map.
	• Tell participants that in Aquation they were trying to solve the problem of getting freshwater to where it is needed by building pipes and desalination plants, and conducting research.
	• Ask guiding questions:
	  • What did your group do to address the water shortage in North Africa?
	  • Who paid for the changes?
	  • Do you think someone living in Spain would have the same opinion about building all the plants and pipes, and doing the research, as someone living in Morocco?

Procedure: Activity TG: p. 186–187 Reader: p. 41–48	***Activity*** • Divide groups of four into two pairs. • Hand out the Lesson 11 Notebook Sheet. • Hand out the Reader and open to chapter 8, "The Aral Sea." Ask each pair to read either "A Fish Story" (fisher) or "A Farm Story" (cotton farmer). **Reading Summary** The reading introduces two stories: one from the perspective of Anna, who lived in a fishing village, and the other from the perspective of Leo, who lived in a farm village near the Aral Sea. The stories are about what their villages were like in 1960 and how they were changed in 1977 by the government's irrigation project. • Ask them to complete the Lesson 11 Notebook Sheet and summarize the events, using the Somebody-Wanted-But-So strategy.

Resource/Page #	Lesson 11

Procedure: Bringing It All Together
TG: p. 188-189
	Bringing It All Together
	• Ask groups to share their work on the Notebook Sheet.
	• Facilitate a whole-class discussion using the guiding questions:
	  • What happened to the Aral Sea?
	  • How do you know this?
	  • Use your senses—taste, sound, sight, touch, and smell—to describe how it must have been to be the fisher or the cotton farmer at the end of the readings.

Assessment, Enrichment & Extension TG: p. 189-191	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: What Goes In (History, Math)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 12: Unintended Consequences—Write All About It!

Human activities can have unintended consequences.

20 minutes

Groups of students evaluate and communicate information on the cause and effects of the Aral Sea environmental crisis by writing a newspaper article.

On CSO, navigate to Lesson 12 using the numbers at the top of the screen.

Resource/Page #	Lesson 12
Overview TG: p. 193	Objectives: • Evaluate and communicate information on the cause and effects of the Aral Sea environmental crisis by writing a newspaper article. Lesson Background Information: • Newspapers are digital and/or print publications that contain current news and articles related to a particular theme or topic. Writing a fact-based newspaper article requires students to develop a catchy and strong lead, include specific details to support the main idea, and avoid bias. • The purpose of this newspaper article is to present to the public the facts of an event. • Students use the two perspectives of the Aral Sea readings to develop content for a newspaper article. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 194	Materials: • Computer device and Internet access • Newspaper • SAG • Reader Printed Materials: • Newspaper next page →

Resource/Page #	Lesson 12
	Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*
Procedure: Getting Started TG: p. 195	***Getting Started*** • Distribute newspapers (such as today's front pages). • Write down the newspaper components on the board (headlines, images, quotes, titles, date, etc.). • Introduce the five Ws: who, what, where, when, and why. • Select an article from the front page and read the headline to the class. • Read the article to the class.
Procedure: Activity TG: p. 196-197 SAG: p. 18-20	***Activity*** • Distribute the SAGs. • Divide participants into groups of four. (Each group should include at least one participant who read "A Fish Story" and at least one who read "A Farm Story.") • Have them decide who will complete each of the sections of the newspaper article: Title and picture; History; Anna's story; and Leo's story • Ask them to complete steps 1-3 (first draft of sections) in the SAG. • Ask them to complete steps 4-6 (share and revise sections, input all the sections, final review and revision) in the SAG.

Procedure: Bringing It All Together
TG: p. 197
	Bringing It All Together
	• Ask each group to briefly share their newspaper article.
	• Ask the guiding questions:
	  • What is the most engaging part of your newspaper article?
	  • What specific detail did you find most powerful and why?
	  • What surprised your group the most about writing a newspaper article?

Resource/Page #	Lesson 12
Assessment, Enrichment & Extension TG: p. 198–200	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Graphical Evidence (History, Math)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

SESSION 4:

Lessons 13–15

The trainer introduces the final Engineering Design Challenge (Lessons 13–15/ Focus Question 4).

Goal: The trainer facilitates Lessons 13–15, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 13	30 minutes	Computer device and Internet access
Lesson 14	40 minutes	Water pump set, Water treatment set, Design Challenge Town Cards
Short break	10 minutes	
Lesson 15	40 minutes	Water pump set, Water treatment set, Design Challenge Town Cards
Wrap Up	15 minutes	

Lesson 13: Water Ready?

Earth's four spheres interact.

30 minutes

Students prepare for a design challenge by developing and using models to show the interactions of groundwater with other components of the Earth system. Students communicate a strategy to preserve water to a specific stakeholder.

On CSO, navigate to Lesson 13 using the numbers at the top of the screen.

Resource/Page #	Lesson 13
Overview TG: p. 201	Objectives: • Develop a model to show how groundwater interacts with components of the atmosphere, biosphere, geosphere, and/or hydrosphere. • Use a model to identify a cause-and-effect relationship between Earth's spheres. • Graph the amount of freshwater compared to salt water on Earth and describe where freshwater is found on Earth. • Communicate a strategy to preserve water to a specific stakeholder. Lesson Background Information: • In this lesson, students begin to answer the final focus question, "How can we provide freshwater to agriculture, industry, the environment, and housing in your town?" • Students begin the lesson with a written summative assessment in which they create and use models portraying how groundwater interacts with other components of the Earth system. After the written assessment, they are introduced to the design challenge they will complete in the final two lessons. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 202	Materials: • Computer device and Internet access Printed Materials: • Lesson 13 Notebook Sheet next page →

Resource/Page #	Lesson 13
	Digital Materials: • Model for Summative Written Assessment file • Stakeholder Description file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*
Procedure: Getting Started TG: p. 203	***Getting Started*** • Distribute the Lesson 13 Notebook Sheet. • Open the Model for Summative Assessment file. • Let participants work on completing the Notebook Sheet.
Procedure: Activity TG: p. 203–204	***Activity*** • Divide participants into small groups for the Engineering Design Challenge. • Read the scenario: Your town is running out of water! There has been a drought for four years and you now need to begin pumping and treating water from your local groundwater reservoir. Your town has key stakeholders in agriculture, industry, housing, and the environment that must work together to purchase supplies to pump the water up from underground, treat the water, and then develop a plan to allocate the water to where it is needed. Each student will be given a stakeholder role and a minimum water requirement. Each group will be given $100 to buy supplies. To successfully supply your town with all the water it needs, you must work together, compromise, and search for ways to improve your design and allocation plan. Good luck! • Ask students to draw the stakeholder chart (Figure 13.2) in their STEM Notebook.

Resource/Page #	Lesson 13

Procedure: Bringing It All Together
TG: p. 204
	Bringing It All Together
	• Get ready for the design challenge in the next two lessons.
	• Open the Stakeholder Description file and ask participants to complete the chart (Figure 13.2 in the TG) in their STEM Notebook.
	• Ask the guiding questions:
	  • What do you think is the key constraint for this design challenge?
	  • Looking at your list of possible effects of the drought, which ones seem the worst? Which ones don't seem to be as bad?
	  • How will you determine who gets most of the water first, second, and so on?

Assessment, Enrichment & Extension TG: p. 205–208	Briefly review, as time allows: • Assessment Rubrics: Written Summative Assessment • Extension: Community Connects (Literacy, Community)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 14: Get It, Treat It, Share It Part 1

Communication with peers is an important part of the design process.

40 minutes

Groups of students evaluate information about a specific town in order to design a solution for accessing and treating water that meets specified criteria and constraints. Students analyze and interpret data to figure out effects of design choices in previous testing.

On CSO, navigate to Lesson 14 using the numbers at the top of the screen.

Resource/Page #	Lesson 14
Overview TG: p. 209	Objectives: • Evaluate information about a specific town in order to design a solution for accessing and treating water that will meet the criteria and constraints of the challenge. • Analyze and interpret data to figure out the effects of design choices in previous testing. • Argue from evidence for a stakeholder's claim to the water. Lesson Background Information: • For the end-of-module performance-based assessment, students participate in an engineering design challenge focusing on the question, How can we provide freshwater to agriculture, industry, the environment, and housing in your town? • Students advocate for their stakeholder role while also working with their group to access and treat the water. Working as a team, while at the same time advocating for their stakeholder role, this activity represents a real-world challenge faced by many communities. Class Periods: 1 (1 class period = about 35 minutes)

Resource/Page #	Lesson 14
Materials & Preparation TG: p. 210–211	Materials: • Water pump set • Water treatment set • Design Challenge Town Cards • Paper cups • Water • Safety goggles • Safety gloves • SAG Printed Materials: • Lesson 14 Notebook Sheet A • Lesson 14 Notebook Sheet B • Lesson 14 Notebook Sheet C Digital Materials: • Stakeholder Description file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Connect two lengths of airline tubing with a connector. • Connect six lengths of airline tubing with five connectors. • Fill one beaker with 750 mL of water. • Set up a whole-class materials center with prices.
Procedure: Getting Started TG: p. 211–212 SAG: p. 21	***Getting Started*** • Distribute the SAG and Lesson 14 Notebook Sheet A. • Read the design challenge scenario out loud again.

Resource/Page #	Lesson 14
Procedure: Activity TG: p. 212–218 SAG: p. 22–24	***Activity*** 1. Assigning Stakeholder Role • Open the Stakeholder Description file. • Assign each participant a stakeholder role, as described on Lesson 14 Notebook Sheet A. • Direct participants to read and discuss the Criteria and Constraints in the SAG. Ask guiding questions. 2. Going through the Design Challenge Town cards • Randomly assign each group a town and hand out the Design Challenge Town Card (Port Saturn, Smithsonville, or Blossom City). • Review with them the different aspects of their town. Point out that water depth is measured in lengths of airline tubing. • Highlight the water quality, showing a beaker with 750 mL of water. • Ask participants to write their town name and summarize the problems on Notebook Sheet A. • Direct participants to the Stakeholder Stats section of the Town Card. Tell them that one unit of water will be represented by one paper cup, and if they are able to access and treat all 750 mL of water, that will fill 10 paper cups. • Hand out 10 small paper cups to each group. 3. Planning Budget • Hand out Lesson 14 Notebook Sheet B to each group and show them the materials and their prices. Each group will be given a total of $100. • Point out that the water treatment process no longer needs to have three steps, and they will be given only seven minutes to treat all the water they pump. next page →

Resource/Page #	Lesson 14
	• Give one empty beaker and five plastic cups to each group for free. • Give participants time to complete Lesson 14 Notebook Sheets A and B, to make their plan. 4. Allocation Plan • Remind participants that they must provide the minimum water requirements for each stakeholder, and to do so they will need to decide who gets water first, next, and so on. • Hand out Lesson 14 Notebook Sheet C to each group. • Tell participants use the sentence frames when discussing their allocation plan. • Participants should identify the potential risks of their allocation plan, and every group member must agree and sign at the bottom.
Procedure: Bringing It All Together TG: p. 218–220	***Bringing It All Together*** • Ask guiding questions: • What have you learned from previous water pumping activities? • What have you learned from previous water treating activities? • What are the unique challenges facing your town? • What materials will be important to your design? • What would you say is the biggest risk your group identified from your allocation plan? • Each group collects their purchased materials and builds their final design (steps 1 and 2 in the SAG).
Assessment, Enrichment & Extension TG: p. 220–223	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extension: Water Rights (History, Community)

Resource/Page #	Lesson 14
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 15: Get It, Treat It, Share It Part 2

Identifying failure point informs how to improve a design.

40 minutes

Groups of students carry out a live system test and analyze and interpret their findings. Groups communicate failure points that affected the overall system and a possible solution to that failure point.

On CSO, navigate to Lesson 15 using the numbers at the top of the screen.

Resource/Page #	Lesson 15
Overview TG: p. 225	Objectives: • Carry out a live system test and analyze and interpret findings. • Communicate results, including failure points that affect the overall system and a possible solution to that failure point. Lesson Background Information: • For the final lesson of the end-of-module summative performance-based assessment, the students test their solution and present their results. The test requires students to make final adjustments to their water pump and water treatment designs, execute their final allocation plan, and then present their findings to the class. • This is a limited version of a process called system testing. System testing is a process whereby the user tests the entire design solution from beginning to end, detecting defects in the individual components and the system as a whole. Results are analyzed and discussed, and then plans are made to optimize their design. Class Periods: 2 (1 class period = about 35 minutes)

Resource/Page #	Lesson 15

Materials & Preparation
TG: p. 226-227
	Materials:
	• Water pump set
	• Water treatment set
	• Design Challenge Town Cards
	• Paper cups
	• Water
	• Safety goggles
	• Safety gloves
	• SAG
	Printed Materials:
	• Lesson 15 Notebook Sheet
	Digital Materials:
	• N/A
	The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.
	
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should:
	• Place one nitrate test strip and one Nitrate Scale Card into each of eight plastic bags.
	• While wearing safety goggles and gloves, prepare the starting water for each town. For this purpose the measurement on the beaker itself is accurate enough.
	  • Blossom City: 750 mL of water + 5 small scoops of fertilizer + beaker
	  • Port Saturn: 750 mL of water + 8 small scoops of fertilizer + beaker
	  • Smithsonville: 750 mL of water + 10 small scoops of fertilizer + beaker

Procedure: Getting Started TG: p. 227-228	***Getting Started*** • Hand out the SAGs. • Remind participants that they will have only five minutes to pump water and will have an additional seven minutes to treat the water. • Distribute safety goggles and safety gloves. • Give participants time to make final adjustments to their water pumping and treatment system.

Resource/Page #	Lesson 15
Procedure: Activity TG: p. 228–229 SAG: p. 22–24	***Activity*** • Distribute the starting water to each town. • Let the groups begin pumping (five-minute limit). • Have the groups set up for treating the water using their purchased materials. • Let the groups treat the water (seven-minute limit). • Ask participants to complete steps 3 and 4 in the SAG and questions 1–3 in the Lesson 15 Notebook Sheet: measure the nitrate levels, record the results, allocate the water, record the total amount of water allocated and the amount of water allocated to each stakeholder. • Ask participants to complete steps 5 and 6 in the SAG and questions 4–8 in the Notebook Sheet.

Procedure: Bringing It All Together
TG: p. 229–231
	Bringing It All Together
	• Each group presents their design and solutions.
	• Facilitate a whole-class discussion with the guiding questions:
	  • How did your group finally agree on your allocation plan?
	  • Do you think anything else may have influenced your results?
	  • What is a failure point in your system?
	  • How would you change your system?
	  • What finding surprised you the most?

Assessment, Enrichment & Extension TG: p. 231–234	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extension: My Water Plan (Home, Math)

Resource/Page #	Lesson 15
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Wrap Up

Take a few minutes to check in with the group before dismissing everyone.

15 minutes

	Key Points
Q&A	Invite participants to ask any final questions about materials, implementation, strategies, or anything else on their mind.
Continuing Support	If you are willing, provide your contact information for questions and concerns the participants may have in the future.

APPENDIX 1: GROUP DISCUSSION

The goal of group discussions is to provide an opportunity for shared learning by asking multiple people to propose connections between their individual experience and the new content of focus.

The facilitator has three primary jobs during group discussions:

1. Support individuals sharing.
   It may be unnerving for individuals to share their thoughts in a group. When facilitating group discussions, use the following techniques to boost individuals' confidence and likelihood of sharing their thoughts:
   - Pay attention to speakers.
   - Smile and nod at appropriate moments to nonverbally communicate that you are engaged.
   - Provide anonymous sharing opportunities using chart paper or sticky notes.
2. Manage group participation.
   It is important to have active and balanced participation from the group to gain as many perspectives as possible. While it is important to hear from everyone, not every person needs to comment on every question. Here are some techniques to help you manage participation of individuals during a group discussion:
   - Use small groups with a designated sharer/speaker.
     - Assigning roles: Change roles for each lesson.
   - When no one wants to speak up:
     - Use the silence. Generally someone will speak up within 15 seconds.
     - Make eye contact with someone you would like to hear from.
   - How to stop a monopolizing speaker:
     - Do not make eye contact with them.
     - Redirect comments and questions from monopolizers to others.
3. Support group thinking.
   - Record individual member suggestions or points in a central location.
   - Ask guiding questions to have the group highlight connections.
   - Summarize.

If you would like to see group discussions in practice, please visit:
TERC Inquiry Project videos: https://inquiryproject.terc.edu/prof_dev/library.cfm.html

APPENDIX 2: QUESTIONING/GUIDING THOUGHT

Questioning is a useful tool with many applications. For this application we will focus on questioning as a way to discover what people are thinking, encourage further thought, and develop group understanding.

The best questions to use are open-ended questions, which do not have a set answer and often require a sentence or more to answer. Questions like:

- What do you know about . . . ?
- Does anyone have anything to add?
- Why do you agree/disagree?

Generally the first level will be eliciting new ideas by asking questions about what people already know or can observe during the lesson:

- What did you observe?
- Has anyone ever encountered . . . ?
- What are some ways to introduce students to . . . ?

The second level is encouraging further thought by asking people to reflect on what has been said, to identify connections to the current topic:

- What do you mean by . . . ?
- Can you tell me more about . . . ?
- What is the evidence for/against . . . ?

The final level we will look at is creating a group understanding by coming to consensus on what has been discussed:

- What idea do you think best connects what everyone is saying?
- Can someone summarize for me?
- Based on what the group is saying, how would this affect . . . ?

Further suggestions for questioning:

- Give thinking time of three to five seconds after posing a question.
- Avoid saying “correct/incorrect.” Instead, let the group validate or clarify what someone is saying.
- Avoid the habit of only collecting one “correct” response and moving on. Always have at least two people answer a question, even if their answers are similar.
- Questioning can also be used to help keep time by letting people know how much longer the discussion can go on.
- Validate everyone’s input by thanking them for speaking up.

APPENDIX 3: GROUP ROLES

Each person in a group having a role can provide many positive outcomes. Some benefits of using group roles include:

- Increases participant motivation by having a unique role
- Models positive classroom behaviors
- Decreases the amount of time spent waiting for a group to decide or discuss who will do what
- If a job is assigned, it pushes participants to participate in different ways

Here are some ideas for how to begin using group roles:

- Change roles regularly to maintain interest.
- Try to give everyone a chance at each role.
- Have a system in place for assigning roles. Possible systems include:
    - Colored dots and frames—Give each person in the group a colored dot. Place a matching color frame around their role for the day. Change the frame placement as needed.
    - Numbers—Assign each member of the group a number (1-4). Place a sticky note with the corresponding number on their role for the day.
    - Badges—Give each person in the group a badge or card with their role for the day listed.
    - Desk tents—Give each person in a group a desk tent with their role for the day.

More information about group roles can be found at: https://ctl.wustl.edu/resources/using-roles-in-group-work

The chart here shows which roles are used in each lesson. The roles and rotation are based on having four members in each group. The numbers in each column suggest how to rotate roles.

	Lesson #													
Group Role	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**15**
Recorder								1						
Artist														
Builder														
Tester					1			2						
Materials Manager					2			3						
Speaker					3			4						
Gardener/Zookeeper														
Questioner														
Organizer					4									
Messenger														

For these trainings, use the roles listed in each lesson, as described on the Group Roles poster.

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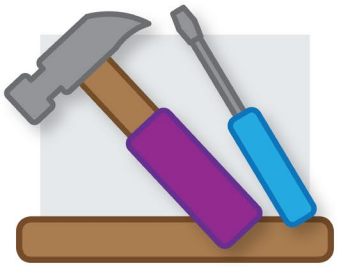
Scientists and Engineers in Our Classroom: Group Roles

Artist

Draws any sketches, diagrams, or graphs.

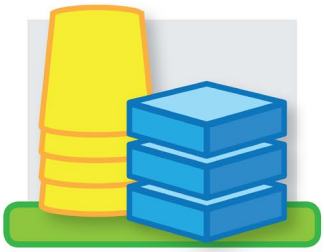


Builder

Takes the lead in putting together materials.

Gardener/Zookeeper

Makes sure live organisms are cared for and treated with respect.



Materials Manager

Collects, cleans up, and puts away materials neatly.

Messenger

Asks questions of the teacher for the group.

Organizer

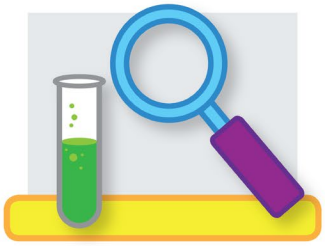
Makes sure group members work together and complete work on time.

Recorder

Writes down data, observations, and explanations.

Speaker

Shares the group's final work or ideas with the whole class.



Tester

Takes the lead in carrying out investigations and testing designs.

Questioner

Asks questions of group members to make sure all points of view are considered.

APPENDIX 4: MANAGING DIFFERING OPINIONS

At some point, it is highly likely that participants will have different opinions and thoughts. Working through these differences and coming to a point of mutual understanding is important to keep the group moving forward. This is also at the core of inquiry science and changing education practices.

Hearing different opinions and thoughts shows there is not always one "right" answer and there are multiple ways to interpret evidence. Often we are trying to come to consensus, which may require each participant to compromise or focus on where they agree and come back to the other areas.

To have meaningful conversations around different interpretations and ideas, it is important to build a culture of discussion and argumentation. At the beginning of the training, set group norms for how to interact when people do not agree, such as:

- Disagree with an idea, not the person.
- Use respectful language.
- Use phrases like "I disagree about . . ." or "I agree on . . ."
- Listen quietly to other people.
- Ask questions politely.
- Speak loudly and clearly.
- Always use evidence.

As with any other discussion, everyone needs to have the opportunity to be heard. Make sure you are allowing a variety of people to speak and that people are not cutting each other off.

Not every discussion of different opinions can come to a complete end every time. One way to table a discussion in order to move on is to take advantage of a parking lot or other idea repository. The chart on the next page lists a few ideas about when the parking lot should be used instead of having the discussion continue. Note: Every circumstance is different. These are suggested criteria, not hard rules.

Parking Lot	Keep Going
Requires input from people outside of training	Is specific to the current topic
Will be covered more in future lessons or sessions	Will likely be wrapped up in the session
Not related to the current topic	Multiple participants are highly engaged
Discussion becomes combative	Group has good evidence to come to consensus
Only one participant is speaking	

Sometimes the difference of opinions and ideas stems from a misconception. The Teacher Guide has a list of content and practice-based misconceptions that may come up in each module. Additionally, it is important to ask participants about what sources they are using, why they believe this information, or other questions to get at the root of their misconception while avoiding an accusatory or negative tone of voice. You can also use their peers' input to help clarify. If you must correct misconceptions to support learning later in the module, try using a supportive phrase such as, "Many people think that is true but the evidence so far supports . . ."

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