WATER IN EXTREME ENVIRONMENTS

ENGINEERING A WATER REUSE PROCESS

PLANETS

Engineering Pathway

Water Resource Engineering Activities for Out-of-School Time • Grades 6–8

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Welcome to Water in Extreme Environments!

In This Unit

In this unit, learners think and work like scientists and engineers. They investigate and engineer solutions for the problem of locating and reusing water in extreme environments, including outer space.

The unit is composed of a Science Pathway and an Engineering Pathway. In both pathways, learners have the opportunity to build their problem solving, teamwork, communication, and creative thinking skills. Specifically, the PLANETS units are designed to ensure that learners will

- engage in real-world activities that provide inclusive ways for all learners to connect to science and engineering.
- choose their path through open-ended challenges that have multiple solutions.
- engage in the habits of mind of engineers and inquiry practices of scientists.
- communicate and collaborate in innovative, active problem solving.

Getting to Know PLANETS

Planetary Learning that Advances the Nexus of Engineering, Technology, and Science (PLANETS) is an interdisciplinary and cross-institutional partnership that integrates planetary science, education, technology, and engineering.

The Center for Science Teaching and Learning at Northern Arizona University (NAU), the U.S. Geological Survey (USGS) Astrogeology Science Center, the Museum of Science, Boston, and WestEd have partnered to develop, pilot, and research the impact of three curriculum units and related professional development resources (http://planets-stem.org) for grades 3–8.

The purpose of PLANETS is to increase public awareness and use of NASA resources by highlighting the relationship between science, technology, engineering, and mathematics in the context of planetary science in out-of-school time settings.

Note

Much of the information at the start of this guide is the same for the Science and Engineering Pathways. If you have already read the Science Pathway, you can read just **Learners Working and Thinking Like Engineers,** pg. v, and the **Engineering Pathway Storyline**, pgs. xxiii–xxvi, then skip to the **Engineering Pathway Vocabulary,** pg. 1, and read from there.

Water in Extreme Environments
Unit Overview

This guide contains the **Engineering Pathway**.

Water is fundamental for life. When traveling in outer space, astronauts will need to reuse water efficiently, and the search for life across the solar system is focused on planetary bodies with liquid water. In this unit, learners design water reuse processes for extreme environments and analyze planetary bodies to determine the most promising locations to search for life. The unit contains an Engineering Pathway and a Science Pathway.

A video index for the complete unit is available on the website.

DID YOU KNOW?

Water resource engineering focuses on the design of systems and equipment, including water treatment facilities, to ensure that people are provided with clean water for drinking, living, and recreation. Access to drinkable water is not only a problem here on Earth—it is one of the biggest challenges facing planetary explorers, who must use water filtration systems that purify contaminated water to produce drinkable clean water.

Engineering Pathway Overview:
Engineering a Water Reuse Process

Learners in the Engineering Pathway (this guide) engage in activities as process engineers and water resource engineers. A process is any series of steps designed to meet a goal, such as the steps of an assembly line or directions for creating a product. Process engineers work to optimize and improve processes so they are efficient and result in high-quality products. In this pathway, learners tackle process engineering by creating a step-by-step process to increase the amount of water that can be reused by adjusting the order that water flows through filters.

The Engineering Pathway Storyline that more fully articulates the progression of activities can be found on pgs. xxiii–xxvi.

DID YOU KNOW?

The story of water is the story of life. Oceans define our home planet, covering the majority of Earth's surface and driving the water cycle that dominates our land and atmosphere. Earth isn't the only ocean world in our solar system. Water exists in different forms (solid, liquid, or gas) on other planets, moons, dwarf planets, and even comets. Water plays a significant cultural and spiritual role for many indigenous communities.

Science Pathway Overview:
Water in the Solar System

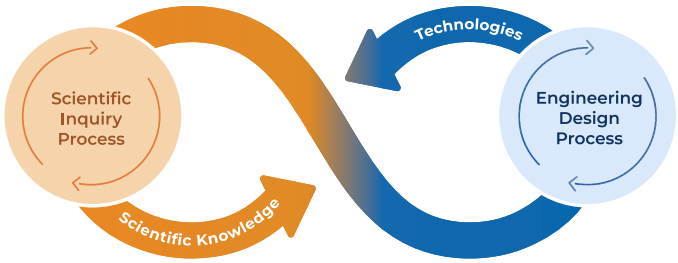
Learners in the Science Pathway engage in activities as planetary scientists. Their goal is to identify planetary bodies in the solar system where life could be present. This goal requires finding water. Future astronauts will need to find, generate, and reuse water to survive long-duration spaceflights, and water is essential to all life as we know it.

Learners explore the reservoirs and states of water on different planetary bodies and choose one as the destination for a mission.

The Science Pathway Storyline that more fully articulates the progression of activities can be found on pgs. xxiii–xxv of the Science Educator Guide.

Connecting Across Science & Engineering

Science and engineering depend on one another. Engineers leverage their scientific knowledge to effectively and efficiently develop new technologies. Scientists rely on a wealth of technologies that have been developed by engineers to advance understanding of the natural world—and their understanding, in turn, helps engineers develop additional technologies.



Scientific inquiry and engineering design require similar skills and practices, such as bringing a lens of curiosity, taking a systems approach, and tapping into creativity to answer questions and solve problems. Neither process follows a set path. Both draw on lived experiences and direct observation, then translate the knowledge gained into inquiry and teaching. And both processes engage thinkers in using tools such as models, mathematics, and computers.

Finding equitable opportunities to engage learners in the habits of mind of engineers and the thinking practices of scientists can increase engagement and catalyze STEM identity and confidence for all learners.

Learning activities that engage learners in the habits of mind and thinking practices of engineers and scientists also fuel development in the 21st Century learning skills of critical thinking, creativity, collaboration, and communication. For more insight into how these skills develop as learners engage in an engineering design process, see the PLANETS educator resource on **Developing 21st Century Skills.**

Learners Working & Thinking Like Engineers

Engineering Design Process

Engineers use structured processes to design technologies to solve problems. Although the particular steps vary, these processes share many elements, including an investigation of criteria and constraints, the generation of various ideas, and the design, testing, and iterative improvement of a technology. These are Engineering Design Processes, or EDPs.

Many communities and cultures have similar structured processes, from Indigenous medicine wheels to community farming processes. For Grades 6–8, the Museum of Science uses a seven-phase EDP. This EDP and a six-step process from NASA are shown on the next page Optional questions throughout the activities promote discussion about EDP, and you have the option to have learners build their own EDP or share one from their community.

Examples of Engineering Design Processes

© Museum of Science

Adapted from NASA's BEST Engineering Design Process

Habits of Mind

Habits of mind describe practices engineers use, such as persisting through failure, constructing models, and communicating ideas. The Museum of Science has articulated 19 Habits of Mind, as shown in the table below, that give insight into the type of thinking learners should be engaging in during the hands-on activities.
As learners use these Habits of Mind, they draw on their scientific content knowledge of natural phenomena to inform their choices.

FEEL	THINK	DO
Collaborate effectively	Apply math knowledge to problem solving	Communicate effectively
Persist and learn from failure	Apply science knowledge to problem solving	Construct models and simulations
See themselves as problem solvers	Consider problems in context	Decompose problems
Weigh the implications of solutions	Consider tradeoffs between criteria and constraints	Innovate processes, methods, and designs
	Envision multiple solutions	Investigate features and uses of tools
	Make evidence-based decisions	Investigate properties and uses of materials
	Use abstraction to create efficient solutions	Use computers to solve problems
	Use systems thinking	

Navigating the Unit

For additional resources, please see the Water in Extreme Environments Unit Website.

Considerations for Using the Water in Extreme Environments Unit

- The following pathways present suggested orders in which to teach the activities. However, you can adapt the order of activities as appropriate for your learners and setting. (For example, you can alternate between pathways.)
- If you have time, it is beneficial for learners to engage in the Science Pathway and then Engineering Pathway. Learners do not need to repeat the context-setting activity or Activity 1.
- It is not necessary for learners to complete the Science Pathway activities to participate in the Engineering Pathway.

CONTEXT-SETTING ACTIVITIES: ***Ready, S.E.T., Go!***
Learners investigate water. As scientists, they figure out where water is located. As engineers, they design a technology to get the water.

ACTIVITY 1: ***Water Stories: Sharing Experiences***
Learners share experiences with and stories about water.

Science Pathway

ACTIVITY 2: ***Water on Earth***
Learners explore the different reservoirs of water on Earth.

ACTIVITY 3: ***Water Habitability***
Learners explore how different living things need liquid water to survive.

ACTIVITY 4: ***Exploring the Solar System***
Learners explore the physical properties of planetary bodies in the solar system.

ACTIVITY 5: ***Water in the Solar System***
Learners explore the different reservoirs of water on planetary bodies in the solar system.

ACTIVITY 6: ***Choose a Potential Water Reservoir to Explore***
Learners combine what they have learned to choose an extraterrestrial water reservoir to explore for life.

ACTIVITY 7: ***Science Share-Out***
Learners recommend a water reservoir to explore.

Engineering Pathway

ACTIVITY 2: ***Water Where We Are From***
Learners consider who uses water in their community and how, and they make water samples.

ACTIVITY 3: ***Investigating Water Quality***
Learners measure the water quality of the samples they have made.

ACTIVITY 4: ***Investigating Filters***
Learners investigate the ability of various filter materials to remove contaminants from a water sample.

ACTIVITY 5: ***Investigating a Reuse Process***
Learners apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

ACTIVITY 6: ***Create a Process***
Learners work in groups to plan, create, and test a water reuse process for an extreme environment.

ACTIVITY 7: ***Improve a Process***
Learners improve their water reuse processes to better meet the criteria for their environment.

ACTIVITY 8: ***Preparing for Engineering Share-Out***
Learners prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

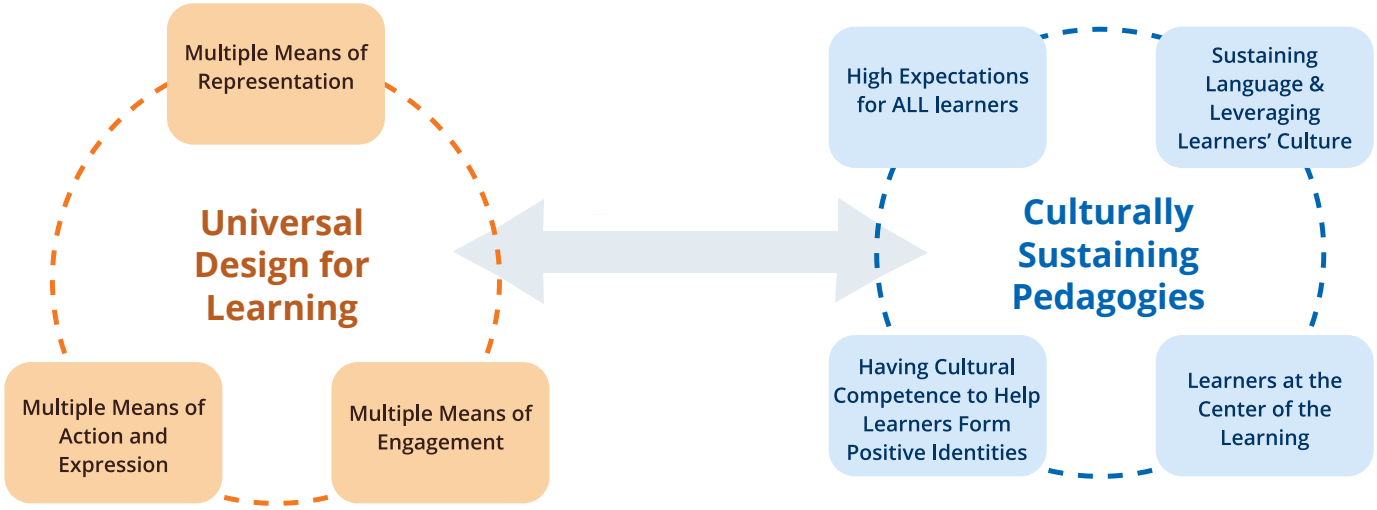
ACTIVITY 9: ***Engineering Share-Out***
Learners communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Educator Resources to Support Learning

An Inclusive and Equitable Approach for STEM Learning

The Water in Extreme Environments unit has been designed with an explicit focus on promoting STEM learning for all, and particularly Indigenous learners, emergent multilingual learners, and learners experiencing differing physical and/or sensory abilities. The Universal Design for Learning (UDL) and culturally sustaining pedagogies (CSP) conceptual frameworks informed the instructional design of this unit. This purposeful design supports all learners by reducing as many barriers as possible and incorporating planning for variability in learner strengths, needs, and interests.

These principles include the following:



Creating Inclusive & Collaborative Learning Environments

To create an inclusive learning environment, educators need to approach their learners with an asset-based mindset. Each learner possesses assets that contribute to the development and maintenance of that person's identity. Assets can be intellectual, physical, or social skills and personal strengths or qualities. A few ideas for cultivating inclusive and cooperative learning environments include the following:

Practices and Strategies for Inclusive Learning Environments

- Facilitate inclusive and cooperative learning environments.
- Build relationships with learners and their communities for learning partnerships.
- Build rapport to establish an emotional connection.
- Affirm the personhood of each learner by appreciating all aspects that they bring into a learning space and creating accessible and inclusive learning spaces.
- Design learning experiences that are authentic and relevant to the contexts of learners.
- Incorporate multisensory instruction.
- Provide options for multiple forms of expression to demonstrate understanding.
- Model and support self-advocacy.

Designing Instruction to Reach Diverse Learners

The strategies outlined below appear in this unit to support three groups of learners:

Multilingual learners: Youth who speak languages other than English at home and are in the process of becoming fluent speakers of English.

Indigenous learners: Youth who descend from the original, culturally distinct ethnic peoples of a land.

Learners with diverse abilities: Youth who experience differing physical abilities: (a) physical traits that affect mobility and/or dexterity; (b) sensory abilities that affect sight; and (c) sensory abilities that affect hearing.

DID YOU KNOW?

Some of these strategies, initially designed and highlighted below for specific learners, have shown potential benefits for all learners.

These strategies have been adapted from the *PLANETS Practical Guide for Inclusive and Engaging STEM Learning: Promoting Inclusion and Engagement in STEM Learning: A Practical Guide for Out-of-School-Time Professionals.*

The icons shown on the following pages appear throughout this guide in tips that are especially relevant for each group of learners.

Strategies for Multilingual Learners

Want to learn more about how PLANETS activities support Multilingual Learners? Please watch this educator support video.

Encourage translanguaging: learners using all the languages they know and making connections between those languages.

Why is this important?

Translanguaging signals to multilingual learners that their languages, culture, and experiences are valued and enrich learning.

It empowers learners to participate and can increase their comprehension and engagement.

Note that not all words have exact counterparts in English.

Strategy in Action

Encourage learners to share key vocabulary in their home or preferred languages. You can capture terms visually.

Note that some learners, including many Indigenous ones, communicate through gestures instead of speech.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 3: "Encourage Translanguaging and Storytelling" on pg. 20 of the Practical Guide.

Provide multiple means of accessing language.

Why is this important?

Providing learners enough support and tools (e.g., images, videos, diagrams with headings) to understand texts on their own empowers them to independently make sense of content without compromising the complexity of language.

Instead of simplifying language, amplify speech and text with supports and offer assistance to help learners grasp concepts effectively.

Strategy in Action

Actively listen and capture learners' ideas and use of vocabulary and language during partner, small-group, or whole-group discussions using written words, diagrams and pictures.
In PLANETS, this strategy is called the *Our Ideas Poster.*

Use icons and images to anchor language.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Welcoming Learning Environments" on pg. 13 of the Practical Guide.

Teach vocabulary in context.

Why is this important?

Exposing learners to vocabulary and concepts together and not separately helps learners make sense of key concepts and ideas.

Strategy in Action

Learners engage in activities and then use their experiences to make sense of vocabulary.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the Practical Guide.

Provide multiple means of expressing ideas.

Why is this important?

Multiple forms of expression, such as spoken, visual, and written, help learners share their understanding of science and engineering, make sense of concepts, and clarify their ideas.

Offering space to use different levels of formality (e.g., casual language from home vs. academic language from school) helps learners make sense of ideas.

Strategy in Action

Share-outs during group activities encourage multiple means of expression. Learners can share in diverse ways (e.g., posters, graphs, writing, drawings, audio, gestures, or videos).

Rather than "correcting" learners' speech, help them connect less-formal and more-formal words with similar meanings.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 3, "Provide options for multiple forms of expression to demonstrate understanding" on pg. 28 of the **Practical Guide**.

Use strategic grouping.

Why is this important?

Conversations among peers who share languages (e.g., pairs, small groups, or whole-group share-out) provide a safe environment for learners to participate and gain comfort and confidence while testing out ideas. Educators can then build on the ideas expressed in whole-group discussions.

Strategy in Action

Activities engage learners in peer-to-peer conversations and sense-making discussions, including in pairs, small groups, and the whole group, depending on the needs of the learners.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 1, "Facilitate inclusive and cooperative learning environments" on pg. 16 of the **Practical Guide**.

Prioritize precise name pronunciation and understanding.

Why is this important?

Names are important in culture and personal identity. Pronouncing names correctly shows respect for individuals and their culture. (Because different languages use different sounds, it can take practice to pronounce names correctly.)

This approach is particularly beneficial for multilingual learners but creates an inclusive environment for all learners.

Strategy in Action

When meeting new learners, educators are encouraged to ask about, practice, and model pronouncing learners' names correctly.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the **Practical Guide**.

Strategies for Indigenous Learners

Want to learn more about how PLANETS activities support Indigenous Learners? Please watch this educator support video.

Encourage narratives.

Why is this important?

Indigenous communities have strong narrative traditions. These traditions serve as vital conduits of cultural heritage, transmitting knowledge, values, and history across generations. Through oral narratives, these communities forge a profound connection to their ancestral roots, fostering a sense of identity.

Relating narratives lets learners receive stories and tell their own. Narratives can be spoken, written, in song, or in pictures.

Strategy in Action

Make time for learner narratives that connect their learning to existing knowledge, stories, and culture. The "Building Community and Family Connections" section on p. xvi offers extension activities to engage community and family.

Take time to understand how stories are told in a particular community. Rhetorical style and the expected parts of a narrative vary between groups.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 3: "Encourage Translanguaging and Storytelling" on pg. 20 of the Practical Guide.

Use strategic grouping.

Why is this important?

Collaborative decision-making is more effective than individual spotlights in some Indigenous cultures. Small-group rather than large-group work enhances communication for Indigenous learners.

Thoughtful talk is often valued over spontaneous contributions, and delayed engagement may signify politeness rather than disinterest or shyness.

Strategy in Action

Group work is built into each activity. Grouping suggestions provide a comfortable group setting for Indigenous learners and others, such as grouping learners in even numbers to avoid a single designated leader.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 1, "Facilitate inclusive and cooperative learning environments" on pg. 16 of the Practical Guide.

Prioritize precise name pronunciation and understanding.

Why is this important?

Names are important in culture and personal identity. Pronouncing names correctly shows respect for individuals and their culture. (Because different languages use different sounds, it can take practice to pronounce names correctly.)

Note that Indigenous learners may want to share other information, such as their connections to tribes and locations.

Strategy in Action

When meeting new learners, educators are encouraged to ask about, practice, and model pronouncing learners' names correctly.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the Practical Guide.

Design authentic and relevant learning experiences.

Why is this important?

Learners are most engaged when what they are learning is connected to their lives and communities. Providing a relevant cultural context helps to drive this engagement.

Strategy in Action

Spend time in learners' community and make connections with local knowledge keepers.

Learn about the cultural approaches of the community regarding competition and collaboration, communication styles, and systems of observation.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 1, "Design learning experiences that are authentic and relevant to the contexts of learners" on pg. 23 of the **Practical Guide**.

Strategies for Learners with Diverse Abilities

Want to learn more about how PLANETS activities support Learners with Diverse Abilities? Please watch this educator support video.

Ask learners what they need.

Why is this important?

The needs of learners with diverse sensory and physical abilities vary. Learners and caregivers, being the most knowledgeable about their capabilities, provide valuable insights. Educators should emphasize learners' strengths and rely on them to guide facilitation of activities.

Strategy in Action

Ask learners directly about their needs prior to beginning an activity. This guide gives some ideas to consider when offering learners options.

Learn about etiquette for working with **blind learners**, etiquette for working with **D/deaf learners**, or etiquette for working with **wheelchair users**.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Create safe, accessible, and welcoming learning environments" on pg. 11 of the **Practical Guide**.

Incorporate multisensory activities.

Why is this important?

Visual representations can be particularly beneficial for learners who are deaf or hard-of-hearing. Visual science and engineering models are powerful tools to illustrate observations, processes, and connections.

Auditory modalities of instruction can facilitate access to learners who are blind or have low vision.

Tactile models and physical objects are beneficial for all learners but are particularly important for blind and low vision learners.

Strategy in Action

Learners are given diverse means to participate in activities. For instance, spectrographic information is presented both visually and aurally so that all learners can access it.

Allow blind and low-vision learners to explore pre-made models ahead of time and to join the educator during demonstrations to follow the educator's movements.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 2, "Incorporate multisensory instruction" on pg. 26 of the **Practical Guide**.

Use strategic grouping.

Why is this important?

For blind and low vision learners, although a note-taking role may be a preferred option, provide learners with the flexibility and opportunity to choose from a variety of roles, fostering exploration and skill development.

For deaf and hard-of-hearing learners, group work can be challenging due to elevated noise levels. Engage learners in smaller groups, move groups to quieter spaces, and encourage learners to speak clearly so everyone can follow the conversation.

Strategy in Action

Educators are provided with guidance on **surfacing learners' diverse abilities** through activities.

It's essential to ask individual learners about their preferences and needs, as learners with diverse abilities have widely varying preferences.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Create safe, accessible, and welcoming learning environments" on pg. 11 of the **Practical Guide**.

Building Community and Family Connections

Strong relationships are key to learner success. Building community and family connections with learners encompasses having ongoing and meaningful two-way interactions between educators and families and/or other communities of supportive adults. It also involves creating a learning environment within OST (Out-of-School Time) programs that is familial, supportive, and empowering. OST programs with strong learning environments and communities recognize the assets that learners bring and allow learners to express themselves, making them feel comfortable engaging in STEM content. Family connections set the stage for social-emotional learning in the unit via

- **Relevance—**Family connections allow learners to draw connections between NASA science and engineering and the science and engineering in their daily lives and communities. This type of connection allows learners to bring their own funds of knowledge to the activities.
- **Belonging—**When learners see how their cultures and families use science and engineering principles, they feel that they belong in STEM.
- **Cultural responsiveness—**Family connections allow for relevant aspects of learners' cultures to enter or ground the learning in ways that the educator may not have been aware of. Learners' cultural knowledge can play an important scaffolding role in learning science and engineering while simultaneously sustaining that cultural knowledge for the next generation.

What does building community and connections look like in action?

A few examples of how to purposefully develop these relationships with learners and their families include the following:

- **Use a variety of communication methods.**
- **Acknowledge challenges to family and community engagement.**
- **Invite families to engage in and design STEM learning activities.**

Consider using some of the following ways to build family connections during this unit based on your capacity and/or your learners' ability to include family members:

- Add an activity in which you invite families to be guest speakers.
  (Families can also work with you to find guest speakers from the community.)
- A Level Up! tip at the end of each activity invites learners to discuss a particular question with their families. (You can also suggest family activities to spark conversation around a particular topic.) Learners can share what they discussed at the start of the next activity.
- Invite families to the Engineering and Science Share-Outs at the end of each pathway to not only share in celebration of their learners' accomplishments but also to provide their knowledge (cultural or otherwise) about the engineering or science discussed and used in the pathway.

Instructional Support Tips for Learning

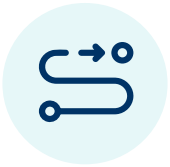
Within each activity across the Water in Extreme Environments unit, several strategic tips are provided as opportunities for additional instructional support. These tips are guided by the following PLANETS core design principles:

- Support Thinking
- Teaching Tips
- Connecting Across Activities
- Support Learner Differences
- Level Up

The table below provides guidance on the purpose and use of each of the tips found within the activities.

Instructional Support Tip: **Support Thinking** 	**Purpose:** Provides ideas for educators to productively support learners' thinking, such as • suggestions of targeted language to use with learners to increase social emotional supports. • things to emphasize during student collaboration. • language that explicitly helps students to realize they are working, thinking, and looking like engineers or scientists (metacognitive and representation/identity/ confidence in STEM). • additional resources that may enhance student engagement/thinking about the current instructions of the activity (e.g., videos, audio).
Instructional Support Tip: **Teaching Tip** 	**Purpose:** Provides additional recommendations for educators with regards to the mechanics of the activity, such as • modifying materials. • grouping and/or roles of learners during parts of the activity based on materials, timing, and engagement. • additional procedural tips to increase effectiveness of investigations and designs. • modifying timing of activities with different procedures.

Instructional Support Tip: Connecting Across Activities



Purpose:
Highlights ways that the activities connect within the pathways and across the disciplines of engineering and science.

Instructional Support Tip: Support Learner Differences

Purpose:
Provides just-in-time supports during the activity that help educators ensure they are meeting the needs of all STEM learners—especially Indigenous learners, emergent multilingual learners, and learners experiencing differing physical and/or sensory abilities—such as

- ways to support multiple pathways for ensuring all learners can equitably engage in the activity.
- strategic peer grouping(s) to enhance engagement equity.
- additional challenges or ways to increase the learning rigor for learners who are ready.
- additional resources that increase equity to ensure that all learners can engage effectively in the activity (e.g., videos, audio).

Unique icons are used in PLANETS activities to help educators quickly identify specific tips that may apply to their learners:

Multilingual learners

Indigenous learners

Learners with diverse abilities

Engaging all learners

Instructional Support Tip: Level Up

Purpose:
Provides supplemental guidance to educators facilitating activities, such as

- ways to make the activities more inclusive to all STEM learners.
- extensions to broaden both content and options provided within each activity. Note that time estimates for Level Up activities are provided separately from the main activity timing.

References

Elsayed, R., Clark, J. G., Daehler, K. R., & Bloom, N. E. (2022). *A practical guide for out-of-school-time professionals to promote inclusion and engagement in STEM learning*. PLANETS, Northern Arizona University and WestEd.

Inclusion Activities

At the beginning of each activity, you can lead an inclusion activity that is appropriate for your group. Below are some possible activities:

Story of Your Name

In pairs or small groups, have learners share their names and stories behind them. For example, what do they mean? Why were they given? Have learners share other important information about their identities, such as locations they are from and tribes or other groups they belong to.

Handshakes and High Fives

Play three rounds of this inclusion activity. Each round, have learners pair up and introduce themselves in some way (e.g., handshake, high five, elbow bump, dance, nod, codeword). Then ask a question and have them discuss it for one minute. Once learners have completed all three rounds, have them re-find their three partners in order and repeat the introduction for each.

Paper Toss

Give each learner a piece of paper and a writing utensil. Ask a question and have them write an answer on the paper (for example, What is your name? What do you do for fun?) Have learners crumple the papers and throw them around. Then have them uncrumple the papers and share the answers with the group.

Choose an Object

Lay out a set of objects, such as small figurines, playing cards, or craft supplies. Ask a question (for example, How is your day going? What is a strength you bring to the group?) and have each learner choose an object that represents their answer (for example, *I chose the owl because I am good at watching what is happening*). Have learners share their objects and answers in pairs or small groups.

Interviews

Have learners pair up and spend three minutes each interviewing each other, then have them share about their partners in a large group. Possible interview questions include the following:

- What is your favorite place to hang out that is not school or home?
- What are some things you are good at?
- What tools or machines do you know how to use?
- What languages do you speak at home?
- What is something you did this week with someone else?
- How do you like to express yourself?

Accessibility Check

Have learners go around a circle and share their names and access needs. Access needs are things they might need to fully participate and feel comfortable in an activity or space. They can be anything that helps people learn, communicate, move around, or feel safe and included. As needed, share first yourself and give some examples, such as "I need short breaks during long activities to stay focused," "I need to refill my cup of water," "I feel more comfortable lying on the floor," or "I need pictures to help me understand what we are learning." Learners can also say "I'm still thinking about my access needs" or "All my access needs are met, check." Note that learners may not be comfortable sharing their needs until after several days of participation.

Design a NASA Mission Patch

NASA mission patches are special symbols that tell the story of each space mission. They use pictures, colors, and symbols to show the mission's goals, who the astronauts are, and important parts of the crew's lives. Have learners form groups of three, choose a mission name, choose a patch shape, and draw or write three things to include on their patch. Patches can include meaningful images, symbols, and colors. As needed, show examples from **NASA's Human Spaceflight Mission Patches.**

Transition

Say:

Let's talk about why we did this. Inclusion isn't just a nice idea–it's crucial for success, both here and in the real world. At NASA, every astronaut needs to know their team well. Why? Because in space, your crew is your lifeline. Similarly, in our group, everyone matters. We learn better when we understand each other. Knowing our teammates helps us work together and solve problems. By sharing parts of ourselves, we build trust and respect. This makes our "mission"–learning together–more fun and more effective. Remember, great teams are built on understanding and appreciating each person's unique strengths.

Conclude by connecting the inclusion activity to what learners are doing next. For example, say:

You just made different partners. Now you are going to work with one of those partners to...

Intentional Grouping Strategies

Intentional Grouping can support learners in a variety of ways.

Group roles can play to learners' **diverse abilities and strengths**. For instance, a blind or low vision learner might be much more skilled at tactile or auditory tasks, and having a role that plays to this strength will elevate that learner and strengthen the group. Never assume which tasks learners will prefer, because they can feel othered and misunderstood. Give them the first choice of group roles.

Grouping learners with **similar spoken or signed languages** can help multilingual learners bounce ideas off each other in their native language before translating them for the whole group. This will also help learners decide what words to share in their native languages.

Grouping learners by **culture** can allow them to work through things in ways that are familiar and valued at home before sharing with the larger group. For instance, Indigenous learners might benefit from being grouped together and working by consensus rather than by having a leader. Or they may decide to communicate their final challenge on posters during a gallery walk, rather than by presenting publicly.

Similarly, if learners are grouped by **shared interests or hobbies**, they may start to interpret the learning in the context of what they know, which is fantastic! For example, "We mitigate hazards when biking all the time by slowing down, wearing helmets, and not biking when it's dark outside."

The number of learners in a group

Groups of 2: If students are sharing personal information or stories, working in pairs first gives learners an opportunity to hear other ideas and rehearse their own ideas before sharing with the whole group. Pairing up is especially helpful for multilingual learners.

Groups of 4: Use groups of four when learners would benefit from lots of perspectives or ideas.

Please note, *these activities are not designed for groups of five or more. A group of five would likely have an outlier with not enough to contribute.*

Engineering Pathway Storyline

Engineering Activities 2–5
Learners gain experience with concepts, materials, and techniques they will use in the final design challenge.

Engineering Activities 6–9
Learners apply what they have learned in the previous activities to design, test, improve, and communicate about their own water reuse processes.

CONTEXT

CONTEXT SETTING ACTIVITY – *Ready, S.E.T., Go!*

ACTIVITY SNAPSHOT
Learners investigate water. As scientists, they figure out where water is located. As engineers, they design a technology to get the water.

Prep Snapshot

Prep Time: 90 min

- Read unit.
- Print Notebooks.
- Prepare containers.
- Make an *Our Ideas* poster.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection
- Critical Thinking

Habits of Mind
- Use a structured problem-solving process

Science Practices
- Planning and Conducting Investigations

Connecting Across Activities

Today, learners start exploring water. As scientists, they figure out where water is located. As engineers, they design a technology to get the water.

Next time, learners will share experiences with, and stories about, water.

1

ENGINEERING ACTIVITY 1 – *Water Stories: Sharing Experiences*

ACTIVITY SNAPSHOT
Learners share experiences with, and stories about, water.

Prep Snapshot

Prep Time: 30 min

- Set up Materials Table.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection
- Communication

Habits of Mind
- Communicate effectively

Connecting Across Activities

Last time, learners started exploring water. As scientists, they figured out where water was located. As engineers, they designed a technology to get the water.

Today, learners share experiences with, and stories about, water.

Next time, learners will consider who uses water in their community and how, and they will make water samples.

2

ENGINEERING ACTIVITY 2 – *Close to Home: Water Where We Are From*

ACTIVITY SNAPSHOT

Learners consider who uses water in their community and how, and they make water samples.

Prep Snapshot

Prep Time: 15 min

- Set up Materials Table.
- Print handouts.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Habits of Mind

- Consider problems in context

Connecting Across Activities

Last time, learners shared experiences with, and stories about, water.

Today, learners consider who uses water in their community and how, and they make water samples.

Next time, learners will measure the water quality of the samples they have made.

3

ENGINEERING ACTIVITY 3 – *Measure Up: Investigating Water Quality*

ACTIVITY SNAPSHOT

Learners measure the water quality of the samples they have made.

Prep Snapshot

Prep Time: 15 min

- Set up Materials Table.
- Print handouts.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Habits of Mind

- Investigate features and uses of tools

Connecting Across Activities

Last time, learners considered who uses water in their community and how, and they made water samples.

Today, learners measure the water quality of the samples they have made

Next time, learners will investigate the ability of various filter materials to remove contaminants from a water sample.

4

ENGINEERING ACTIVITY 4 – *Block It Out: Investigating Filters*

ACTIVITY SNAPSHOT

Learners investigate the ability of various filter materials to remove contaminants from a water sample.

Prep Snapshot

Prep Time: 40 min

- Make Filter Bases.
- Set up Materials Table.
- Create chart.
- Prep charcoal filter.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Habits of Mind

- Investigate properties and uses of materials

Connecting Across Activities

Last time, learners measured the water quality of the samples they had made.

Today, learners investigate the ability of various filter materials to remove contaminants from a water sample.

Next time, learners will apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

5

ENGINEERING ACTIVITY 5 – *Order Up!: Investigating Reuse Process*

ACTIVITY SNAPSHOT

Learners apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

Prep Snapshot

Prep Time: 60 min

- Print and assemble handouts.
- Prepare Filter Bases for Activity 6.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking
- Collaboration

Habits of Mind

- Use systems thinking

Connecting Across Activities

Last time, learners investigated the ability of various filter materials to remove contaminants from a water sample.

Today, learners apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

Next time, learners will work in groups to plan, create, and test a water reuse process.

6

ENGINEERING ACTIVITY 6 – *Reuse in Action: Create a Process*

ACTIVITY SNAPSHOT

Learners work in groups to plan, create, and test a water reuse process for an extreme environment.

Prep Snapshot

Prep time: 45 min

- Create Filter Bases.
- Set up Materials Store.
- Print handouts.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking
- Collaboration
- Creativity

Habits of Mind

- Envision multiple solutions

Connecting Across Activities

Last time, learners applied what they learned about water quality to reconfigure a model building to reuse as much water as possible.

Today, learners work in groups to plan, create, and test a water reuse process.

Next time, learners will improve their water reuse processes to better meet the criteria for their group's environment.

7

ENGINEERING ACTIVITY 7 – *The Final Test: Improve a Process*

ACTIVITY SNAPSHOT

Learners improve their water reuse processes to better meet the criteria for their environment.

Prep Snapshot

Prep time: 20 min

- Set up Materials Store.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking
- Collaboration

Habits of Mind

- Persist and learn from failure
- Innovate processes, methods, and designs

Connecting Across Activities

Last time, learners worked in groups to plan, create, and test a water reuse process.

Today, learners improve their water reuse processes to better meet the criteria for their group's environment.

Next time, learners will prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

8

ENGINEERING ACTIVITY 8 – *Spread the Word: Preparing for the Engineering Share-Out*

ACTIVITY SNAPSHOT

Learners prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Prep Snapshot

Prep Time: 15 min

- Set up Materials Table.
- Invite people to Share-Out.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Collaboration
- Communication

Habits of Mind

- Make evidence-based decisions
- Communicate effectively

Connecting Across Activities

Last time, learners improved their water reuse processes to better meet the criteria for their environment.

Today, learners prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Next time, learners will communicate their ideas about designing a water reuse process in the Engineering Share-Out.

9

ENGINEERING ACTIVITY 9 – *Sum It Up: Engineering Share-Out*

ACTIVITY SNAPSHOT

Learners communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Prep Snapshot

Prep Time: 15 min

- Set up Materials Table.
- Invite people to Share-Out.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Collaboration
- Communication

Habits of Mind

- Communicate effectively

Connecting Across Activities

Last time, learners prepared to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Today, learners communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Next time, learners will experience the science of this topic in the Water in Extreme Environments Science Pathway (optional).

Engineering Pathway Vocabulary

This list is included to provide an overview of the content of this pathway. Note that you should not pre-teach it to learners before the activities–terms are introduced after learners have direct experience with the materials and processes to which those terms are connected.

Ready, S.E.T., Go!

- **Engineer:** A person who designs things to solve problems
- **Engineering Design Process:** A set of phases that engineers use to design technologies to solve a problem
- **Scientist:** A person who asks questions and gathers evidence to answer the questions
- **Technology:** Any object, system, or process designed by people to solve a problem
- **Water scarcity:** When people do not have enough water to complete all the tasks they need to live

Engineering Activity 3

- **Clarity:** How clear water is
- **Clean water:** Water that is safe enough to drink and wash with
- **Contaminant:** A substance that makes water dirty or unsafe to drink
- **pH:** How acidic or basic a sample is
- **Somewhat contaminated water:** Water that has been used at least once and can be used again
- **Texture:** The way something feels
- **Very contaminated water:** Water that is too dirty to be used again
- **Water quality:** The characteristics that let us know if water is safe to use

Engineering Activity 4

- **Filter:** A technology that removes some kinds of contaminants from water

Engineering Activity 5

- **Constraints:** Limits on a design
- **Criteria:** Things your design needs to do
- **Process:** A series of actions or steps leading to a result or goal

Teaching Tip

No new vocabulary terms are introduced to learners in Engineering Activities 1, 2, and 6–9.

Engineering Materials List

The quantities below are for one group of 24 learners. Follow this weblink to calculate the amount of materials you'll need for your number of learners.

Non-Consumable Items

Quantity	Material
1	*Optional:* computer and projector or another way of viewing short videos
1	container with lid, clear plastic, 8 oz.
1	measuring cup, 1/4 cup
1	strainer
1	utility knife
4	tablespoons
4	teaspoons
4	rulers
6	measuring cup, 1 cup
6 pairs	scissors
7	trays, foil, 12" × 12"
8	containers with lids, clear, 1/2 gallon

Consumable Items

Quantity	Material
1	bottle, 2-liter (cap not needed)
1 pad	chart paper and markers
1 bottle	scented liquid Choose from the following options: diffuser oils, scented teas, extracts, essential oils, or other scented liquids that differ from hand soap and detergent that align with your program's budget and learners sensory sensitivities.
1 vial	food coloring, yellow
2 Tbsp	detergent, powder
6 bottles	glue
1 roll	plastic wrap
1 bottle	soap
1 pad	sticky notes
1 roll	tape, masking
1 spool	thread
1 tube	toothpaste, travel size
1 bottle	vinegar, white
2 packages	modeling clay, 1 lb.
2 rolls	paper towels
2 cups	soil
3 cups	charcoal, activated
3 cups	limestone gravel
4 rolls	tape, painter's
5 sheets	cardstock
6	tea bags, black tea
6	to-go coffee cups

Quantity	Material
8	markers, black, permanent
8 packets	pH strips
8 cups	sand
38 pieces	cheesecloth, 12" × 12" Learners use cheesecloth in their water filter technologies in Activities 5, 6, and 7. Consider cutting squares in advance.
42	rubber bands
40	straws, jumbo, color 1
40	straws, jumbo, color 2
70	straws, jumbo, 3 different colors (see tip on pg. 67 for alternative to color)
60	craft sticks
60 sheets	copy paper
120	cups, plastic, clear, 8 oz.
150	cotton balls
150	index cards, 3" × 5"
	building supplies (such as clay, sticks, or blocks)
	coffee grounds
	drawing supplies (such as pencils, crayons, markers)
	natural materials (soil, sticks, grass, pebbles)
18	sheet protectors (optional)
	towels or disposable tablecloths (optional)

Quantity (Per Group of 4)	Material
1	to-go coffee cup
2	bottles, 2-liter (caps not needed)

Quantity (Per Learner)	Material
1	pencil
1	*Engineering Notebook*
1 set	safety gloves and goggles (optional)

Engineering Advance Preparation

You can complete much of the preparation for the Engineering activities ahead of time. Follow the steps below.

Educator Background

1. Read through the entire PLANETS Engineering Pathway Educator Guide Introduction, pgs. iii–xxvi, to learn more about the engineering content in this unit.
2. View the following video playlists:
   - How to prepare and teach with the materials
   - Background science and engineering content
   - How to support learner differences
3. Read the Educator Engineering Background (PDF) for context about the engineering in the unit.
4. Print and laminate any pages you want available for easy reference. The Inclusion Activities, pg. xx-xxi, Intentional Grouping Strategies, pg. xxii, and Pathway Storyline, pgs. xxiii–xxvi, are especially useful.
5. Review the Level Up activities throughout the pathway, decide which ones you might use, and plan accordingly.
6. Print your own copy of the Engineering Notebook (PDF) for reference.
7. Reflect on the learners who will engage in the pathway and identify ways to create an inclusive and collaborative learning environment (see pgs, viii–xviii).

For the Whole Group

1. Invite staff, family, and community members to attend the Engineering Share-Out in Activity 9. Make copies of the Engineering Activity 8 Share-Out Invitation (PDF) to distribute to family and friends.
2. Prepare an *Our Ideas* poster by following the Prep & Setup Guide (PDF).
3. Download and prepare to share the Ready, S.E.T., Go! slides (PPTX) and Engineering Activity 2 Extreme Environments slides (PPTX). If you cannot project them, print copies for each group instead.
4. Set up a device with a projector and internet access, then test the video Recycling Water on Space Station (1:32, optional).

Level Up!

Get families or a community member involved to share relevant stories of engineering in your community. Download customizable flyers and get ideas on the Water in Extreme Environments Family and Community Connections (weblink). (45 min.)

For Each Group of Learners

1. Print 1 copy of each of the following handouts for each group of 4 learners:
   - Engineering Activity 2 Water in Our Community Handout, pgs. 33–34
   - Engineering Activity 2 Water Sample Recipes Handout, pgs. 35–37
   - Engineering Activity 3 How to Test Water Quality Handout, pgs. 47–51
   - Engineering Activity 3 How Clean Does It Need to Be? Handout, pgs. 52–53
   - Engineering Activity 4 Testing Materials for Cleaning Handout, pgs. 63-64
   - Engineering Activity 5 Mapping Water Reuse Handout, pgs. 75-76
   - Engineering Activity 5 Made to Order Handout, pg. 77
   - Engineering Activity 6 Choose an Environment Handout, pgs. 89-92
   - Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94
     - If it is useful to your learners, print this page on swell paper or attach materials such as wiki sticks so learners can feel what is on each strip of paper.

For Each Learner

1. Print and staple one Engineering Notebook (PDF) for each learner, in color if possible.

Teaching Tip

If internet access may be a problem, consider downloading videos ahead of time. If it would benefit your learners, you can adjust the video playback speed. Note that video links may change over time; if a link does not work, try searching the title of the video.

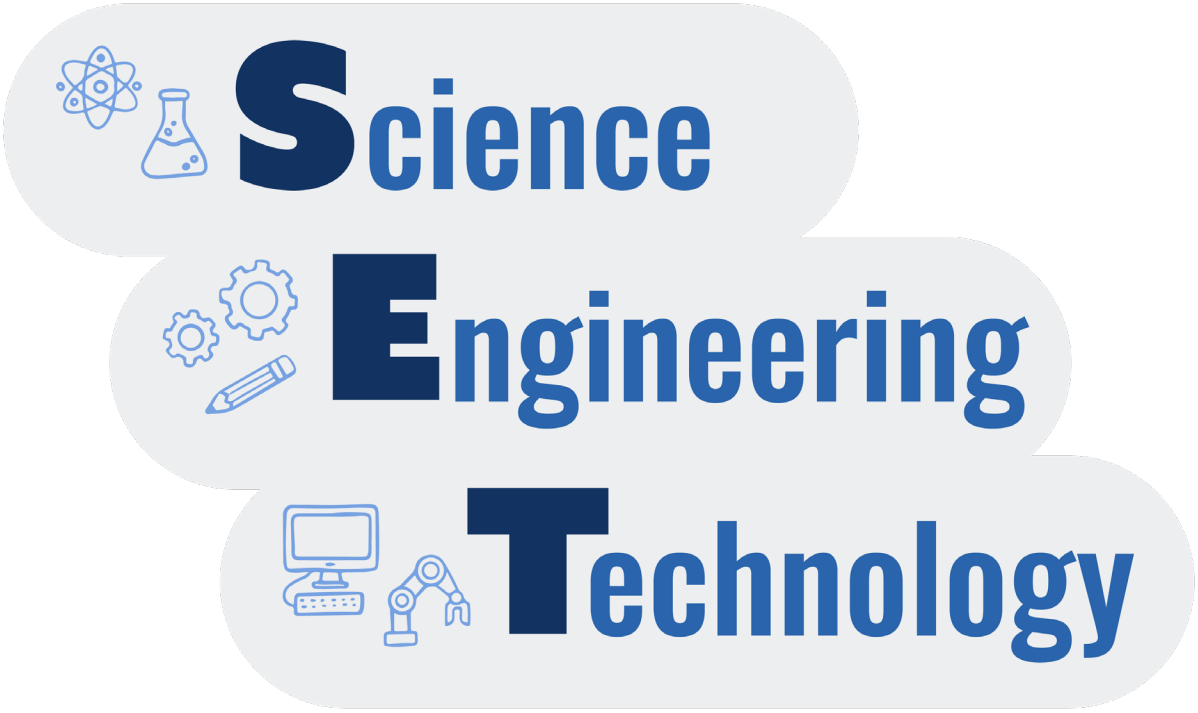
Support Learner Differences

All videos in this unit include captions. As needed, these captions can be translated by online video platforms.

Teaching Tip

If you think learners will benefit from having more space in the Notebook, print one-sided or add sheets of blank paper as you make the Notebooks.

Ready, S.E.T. (Science, Engineering, Technology), Go!



Educator Preview

Activity Snapshot

Learners investigate water. As scientists, they figure out where water is located. As engineers, they design a technology to get the water.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Plan & Create (S.E.T.)	25 min.
Reflect (Go!)	10 min.
Total	**45 min.**
Level Up Activities	5–30 min. each

Prep Snapshot*

Prep Time 90 min.

- Space Need: Sink
- Read unit.
- Print Notebooks.
- Prepare containers.
- Make *Our Ideas* poster.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Use a structured problem-solving process.

Science Practices

- Planning and Conducting Investigations

Guiding Question

How can we identify where there is water? How can we get it?

Learners Will Do

As scientists, identify which containers hold water. As engineers, design a way to get the water out.

Learners Will Know

Water is a limited natural resource, but scientists can figure out where water is, and work with engineers to get it and use it.

Connecting Across Activities

Ready, S.E.T., Go!	Activity 1: Sharing Experiences
Today, learners start exploring water. As scientists, they figure out where water is located. As engineers, they design a technology to get the water.	**Next time**, learners will share experiences with, and stories about, water.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/9b4fc726

Materials and Preparation

Materials

For the educator

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF)
  Examples & Template
  - index cards
  - markers
  - scissors
  - tape

For each learner

- Engineering Notebook (PDF)
- safety gloves and goggles (optional)

For the whole group

- 1 cup sand
- 1 permanent marker
- 6 to-go coffee cups (or other opaque containers) with lids
- 21 felt dots (or other raised adhesive objects for labeling containers), optional
- soda water (or water and non-medicated seltzer tablets)
- vinegar (or strongly scented juice, or essential oils)
- water
- additional substance such as water ice, dirt, or rocks
- Disinfecting wipes (to clean lids)

For each group of 4

- 1 to-go coffee cup (or other opaque container) with lid
- 1 cup, does not need to be opaque
- 1 square foot of aluminum foil
- 1 square foot of plastic wrap
- 5 cotton balls
- 5 craft sticks
- 5 feet of string
- 5 index cards
- 5 paper clips
- 5 straws

Ready, S.E.T., Go! Materials Preparation (90 min.)

Ahead of Time

1. Read through the PLANETS Engineering Pathway Educator Guide Introduction, pgs. iii–xxvi, to learn more about the engineering content in this unit.
2. Print and staple one Engineering Notebook (PDF) for each learner, in color if possible. As needed, prepare to share the Notebook digitally.
3. Print your own copy of the Notebook for reference.

Teaching Tip

This activity is the same in both the Science and Engineering Pathways. If your learners have already done this activity in one pathway, you do not need to repeat it.

This activity can stand alone as a brief single-session program.

If you think learners will benefit from having more space in the Notebook, print one-sided or add sheets of blank paper as you make the Notebooks.

Support Learner Differences

The Engineering Notebook (PDF) can be printed in large font and you can share a digital version that will work with screen readers. The Notebook is written in English, but you can translate the instructions into other languages; see translation guidance in our Translatable Glossary (DOCX).

4. Download and prepare to share the Ready, S.E.T, Go! slides (PPTX). If you cannot project them, print a copy for each group instead.
5. Prepare an *Our Ideas* poster by following the online Prep & Setup Guide (PDF). See Our Ideas Poster examples here (PDF). Add the Guiding Question "How can we identify where there is water? How can we get it?" so learners can refer to it throughout the activity.
6. Assemble one set of materials for each group (cup, plastic wrap, cotton balls, string, index cards, paperclips). You can store each group's materials in a bag for easy distribution.
7. Label six coffee cups with the numbers 1 to 6. Optional: Attach the listed number of felt dots to each cup (1 felt dot on cup 1, 2 felt dots on cup 2, etc.).

Teaching Tip

You can begin the *Our Ideas* poster with several standard 23" × 32" pieces of chart paper. You may fill them up before the end of the pathway, in which case you can add more pieces as needed.

The *Our Ideas* posters capture students' authentic language and ideas as they emerge in real-time discussions. The posters are not meant to simply display and front-load vocabulary. The posters develop over time as the educator listens for and adds the language that learners use in the moment, thus validating their ideas, providing feedback, and supporting sensemaking and language development.

Support Learner Differences

Different learners have different needs. Choose from the following tips to best support your learners:

- View the Translanguaging Video to support learners who speak multiple languages.
- For those with low vision: add tactile elements, such as three-dimensional representations and Braille. Prepare a shared digital document all learners can access, ensuring that it supports text-to-speech for your learners.
- Add learner questions to the *Our Ideas* poster to foster an interest-led approach.

Adding felt dots to the cups allows all learners to refer to them by number (for example, "Container 2"), even if they cannot see the written labels. Using stickers or squares of tape, or punching through the back of a sticky note with a pen-tip to make raised hole punches, can also work.

In Your Space

8. Place the *Our Ideas* poster in a location all learners can access. Make a plan to store it between activities.
9. Fill one unnumbered coffee cup with water for each group.
10. Fill Cup 1 with water. Put on the lid.
11. Fill Cup 2 with sand. Measure or feel to ensure its weight is roughly the same as Cup 1. Put on the lid.
12. Fill Cup 3 with water and add roughly a teaspoon of vinegar. Measure or feel to ensure its weight is roughly the same as Cup 1. Put on the lid.
13. Leave Cup 4 empty. Put on the lid.
14. Fill Cup 5 with soda water (or water and non-medicated seltzer tablets). Measure or feel to ensure its weight is roughly the same as Cup 1. Put on the lid.
15. Fill Cup 6 with the non-liquid-water choice most appropriate for your site. Measure or feel to ensure its weight is roughly the same as Cup 1. Put on the lid.
    - Filling a cup with water and freezing it overnight into solid ice can spark conversations around the differences of water in solid form and what it would take to convert it to liquid.
    - Filling the cup with another material–such as beads, rocks, dirt, or marbles–can result in a distinct sound or odor distinguishable from water.
16. Set out the six numbered cups at six different stations.

Teaching Tips

- Lead this activity in a room with a sink for easy setup. Otherwise, bring a half-gallon of water.
- You will need to make clear that learners should **NOT** drink out of any of the cups. Consider marking the cups to indicate that they are not for drinking. You can also tape over the holes in the coffee cup lids, although this will make the contents more difficult to smell.

Activity Guide

Get Ready & Team Up (10 min.)

1. Organize learners into groups of four.
2. Say: **NASA is sending spacecraft to explore many planets, moons, and asteroids around the solar system. One of the things NASA is searching for is water. Water is fundamental for life. Human explorers will need clean water to survive, and we might find other living things in water around the solar system. Today, we're going to explore two problems that NASA is facing.** Share the Guiding Question with learners aloud and in writing (using multiple languages as needed): **How can we identify where there is water? How can we get it?**

Support Learner Differences

If learners are new to you or each other, have them share their names, name pronunciations, and other important parts of their identities. These introductions are important for all learners and can be especially relevant for Indigenous learners, multilingual learners, and learners with different physical abilities. You can also distribute index cards and have learners write anything they want you to know but do not want to share with the whole group, such as resources that will help them learn. If everyone knows each other's names, ask if anyone has a middle name or nickname you could learn to pronounce. Invite them to share about it.

For more strategies to engage learners, refer to Designing Instruction to Reach Diverse Learners, pgs. x-xvi.

Check out the Intentional Grouping Strategies, pg. xxii.

Teaching Tip

Throughout this guide, information for you to say to students appears in **bold**. You can say the bold sentences exactly as they are written or paraphrase them.

Plan & Create (S.E.T.) (25 min.)

Science: Find the Water

3. Display *Ready, SET, Go* slide 1: *Searching for Water*. Have learners discuss in their groups: **What do you notice about these images?** *(They all show ways of finding water: watching for birds who hunt fish; cattails grow by water; smooth stones often show up in riverbeds and dry washes; people dig wells to find water; satellites can identify where there is water.)*
4. Say: **Many times, people can't see the water they are searching for, so they have to detect it in other ways, such as by using the things you just talked about.**
5. Say: **Today, we're going to use more methods to figure out where there is water.** Have learners discuss in their groups: **What are other ways that people are able to find water without seeing it?**
6. Give each learner an Engineering Notebook. Say: **This Notebook is a place to record your observations and ideas.**

7. Have learners turn to *Find the Water*, pg. 2 in their Engineering Notebook. Say: **This page gives instructions to help you identify where there is clean, liquid water. As a group, you will go to six different stations. You will have about two minutes at each station. You cannot open or look into the containers, but you can use hearing, smell, and the way each container feels to gather data about them. Do NOT drink or eat anything from the containers.** Demonstrate how to "waft" the scent from the container with your hand to your nose, and warn learners about smelling the containers too deeply or closely.
8. Allow each group to go to a station and begin examining the container there. As needed, offer clarifications and explain that learners are trying to determine whether each container has water and/or something else inside without opening it.
9. Every 1–2 minutes, have each group switch to the next station.
10. After learners have finished their final stations, revisit the first part of the Guiding Question: **How can we figure out where there is water?** *(We can make observations by sound, smell, and feeling. We can use what we know about water and other substances.)* Have groups pair up to discuss or record their ideas on the *Our Ideas* poster. Say: **We will keep gathering ideas on this poster.**

Teaching Tips

- Consider ways to help learners remember not to look in the containers, such as by having them close their eyes.
- If you have safety gloves and goggles, have learners put them on.
- Ensure there is a quiet space to listen for bubbles. You may need to refresh bubbles between groups.

Support Learner Differences

- Recording learners' ideas using words, diagrams, and pictures on the *Our Ideas* poster or shared digital document throughout the activities allows them to refer to the poster to remember words and build on past ideas. You can refer to an "In-Use Example" in the *Our Ideas* poster Prep & Setup Guide (PDF).
- If you have learners who speak multiple languages, encourage them to share in their preferred languages.

11. Open the numbered containers and tell learners what was in each of them. Discuss the differences among the clean liquid water, water mixed with other substances (vinegar, bubbles), and (if you included it) ice.
12. Point to a container that most learners thought did not have water. Ask: **Why did you think there was not water in this container?** *(Because it was too heavy; because it didn't sound like water.)* Explain that learners used these observations to make hypotheses.

13. Display the *Searching for Water* slide again. Say: **Humans often need to find water that we can't see directly. Throughout history, people have done this in many ways, from studying local animals and plants, to digging holes and wells, to analyzing types of rocks, to measuring how light reflects from other planetary objects in space. Like these people, you have been using some practices of scientists. There are many other things scientists do that we did not have time to do today, such as choosing a question and analyzing our results.** Write the word *scientist* on the *Our Ideas* poster. Have learners come up with a description of scientists together and record it on the poster. (For example: Scientists ask questions, test things out, make observations and measurements, and gather evidence to answer the questions.) You can have learners add translations, drawings, or related images to the poster as well.

Engineering: Access the Water

14. Ask: **When people figure out how to find water they can't see, what kinds of things do they do next?** *Drill a well, get it out, use it.*
15. Say: **Now that you have identified where water is, you will design something to get it out of the container. You can use a variety of different materials: plastic wrap, cotton balls, string, index cards, and paper clips. You can't move the container because it represents a natural water source, like a lake, that can't be moved.**
16. Have learners turn to *Collect the Water*, pgs. 3-5 in their Engineering Notebook. Say: **This page gives you instructions to figure out how to collect the water. As a group, you will have about 10 minutes to follow the instructions.**
17. Give each group one coffee cup with water, one other cup, and the materials you listed.
18. Give groups 10 minutes to follow the instructions. As needed, offer clarifications and explain that learners are moving water from the container to the cup using the materials provided, without touching the cup directly. Say: **Try to move at least a few tablespoons of water.**
19. After about 10 minutes, revisit the second part of the Guiding Question: **How can we get water?** *(We can design devices that help us collect it.)* Have groups pair up to demonstrate their devices, discuss, or record their ideas on the *Our Ideas* poster.

Level Up!

- NASA has used satellite data to create a map of where water can likely be found near the surface of Mars. This map could be used by future astronauts to find drinking water on Mars! Read more here: https://www.nasa.gov/solar-system/nasas-treasure-map-for-water-ice-on-mars/ (5 min.)
- For an additional challenge, learners can attempt to move the water using only index cards.

Support Thinking

To help learners understand what they will be doing during this activity, play the translatable video Water in Extreme Environments Read Aloud.

Support Learner Differences

Give learners time to examine the materials before they begin the challenge.

20. Display *Ready, SET, Go* slide 2: *Water Technologies.* Say: **Humans often need to move water from one place to another. Throughout history, people have done this in many ways, from the shadoof in Egypt to stepwells in India, to water storage systems in the Southwest and water redirection systems in Central America. Like these people, you have been using the practices of engineers.** Write the word *engineer* on the *Our Ideas* poster. Have learners come up with a description of engineers together and record it on the poster. (For example: Engineers design things to solve problems.). You can have learners add translations, drawings, or related images to the poster as well.

21. Say: **Scientists often start with a question and work to answer it. Engineers start with a problem and work to solve it. The objects, systems, and processes engineers design to solve problems are *technology*; for example, your designs to move and collect water are technologies. Engineers often design technologies that help scientists answer their questions. They depend on each other.** Write the word *technology* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well.

22. Have learners refer to *Collect the Water*, pgs. 3-5 in their Engineering Notebook. Say: **Engineers record how the technologies they design work and find ways to improve them. As a group, you have about five minutes to record how your water collection technologies worked and think of ways you could improve them if you had other materials.**

Level Up!

- Learners may believe that *technology* refers only to devices powered by electricity. Explain that anything designed by people to solve a problem is technology. Have learners identify non-electrical technologies around them. (10 min.)
- Have learners think about how their technologies would function if they were larger and used in a different setting, such as a river next to a farm field. What would have to change to make sure the technologies kept working as intended? (5 min.)
- Have learners create portrayals–through drawing, acting, or some other method of their choice–of scientists and engineers working together to identify and get water. (30 min.)

Reflect (Go!) (10 min.)

23. Have learners discuss the following questions in their small groups: **Where on Earth do you think it is easier or harder to get water? Why? What about other places in the solar system?**

24. Say: **You will be acting as engineers to help solve more problems in space. These problems will involve designing technologies to use water. You will think about the phases you used to solve the problem of getting the water so you can use those phases again later with other problems.**

25. Have learners turn to *Our Engineering Design Process*, pg. 6 in their Engineering Notebook. Say: **There are many different processes that engineers use to design things to solve problems. You will be using these seven phases as your Engineering Design Process: Frame, Investigate, Brainstorm, Plan, Create, Test, and Evaluate. Then you go through the cycle again, or Iterate, to improve your design.** Ask: **How did you use this Engineering Design Process when getting water?** *(We framed the problem of getting water out of the container, investigated the materials we had and what we were trying to do, brainstormed ways to get the water, planned and created a process, tested it on the container, evaluated the results, and iterated as necessary.)*

Level Up!

Instead of using the premade Engineering Design Process, you can have learners make their own. If you do so, skip the next step and refer to the tip at the end of this section instead.

26. Say: **Next time, we will think about what we already know about water and why it is important.**

Level Up!

If time permits, have learners create their own engineering design processes:

1. Give each group index cards, markers, and one set of cards from Ready, S.E.T., Go! Phase Cards Handout (PDF). Explain that they should choose the phases they used to solve the trash problem. They can choose some or all of the phase cards, and they can write or draw their own cards (one phase per card). They should put the phases in the order they used them. (Note that the options shown on the phase cards are intentionally different from the phases of the EDP in the Engineering Notebook (PDF), to avoid implying that the EDP in the Notebook is the "correct" answer.)
2. When writing their own phases, learners may describe specific actions, such as "We folded the index cards." Through discussion, encourage learners to come up with terms to describe each phase of the process more generally, such as "We talked about it" and "We tested the materials." If learners speak multiple languages, encourage them to discuss in their preferred languages.
3. Give groups copies of the Ready, S.E.T., Go! Engineering Design Process Example Handout (PDF) for inspiration.
4. Gather the group and compare processes. Organize all the cards in groups on a poster to create a whole-group engineering design process of between three and ten phases. (For example: ask, imagine, plan, create, test, improve.) Save this *Engineering Design Process* poster for use in future activities.
5. Say: **You have just designed a set of phases like the ones engineers use to solve problems: an engineering design process**.

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for use in Activity 1.
   - Collect all materials and containers. Where possible, save the materials and substances for reuse.
   - Keep the cups for Activities 2 and 3.
2. Have learners invite people from the community, including their families and friends to the Engineering Share-Out in Activity 9.
3. Plan ahead for Activity 1. See Activity 1 Preparation on pgs. 20-21.
4. Take time to reflect on the following educator prompt. **How did you create continuity between the science and engineering portions of the activity?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Engineering Activity 1: Water Stories: Sharing Experiences

Educator Preview

Activity Snapshot

Learners share experiences with, and stories about, water.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Storytelling	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–60 min. each

Prep Snapshot*

Prep Time 30 min.

- Set up Materials Table.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Communication

Habits of Mind

- Communicate effectively.

Guiding Question

Why is water important?

Learners Will Do

Share a story or experience about water.

Learners Will Know

Water is essential for life.

Connecting Across Activities

Ready, S.E.T., Go!	Activity 1: Sharing Experiences	Activity 2: Water Where We Are From
Last time, learners started exploring water. As scientists, they figured out where water was located. As engineers, they designed a technology to get the water.	**Today**, learners share experiences with, and stories about, water.	**Next time**, learners will consider who uses water in their community and how, and they will make water samples.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/4f755d4d

Materials and Preparation

Materials

For the educator

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
  - index cards
  - markers
  - scissors
  - tape

For the Materials Table

- drawing supplies (such as pencils, crayons, markers)
- building supplies (such as clay, Legos, beads, natural materials)

For each learner

- Engineering Notebook (PDF)

Activity 1 Materials Preparation (30 min.)

Ahead of Time

1. If you did not do so before the Ready, S.E.T., Go activity, prepare an *Our Ideas* poster by following the Prep & Setup Guide (PDF). Add the Guiding Question "Why is water important?" so learners can refer to it throughout the activity.

Teaching Tip

This activity is the same in both the Science and Engineering Pathways. If your learners have already done this activity in one pathway, you do not need to repeat it.

2. Learn about local water, reasons why it is important in local communities and cultures, and the history of its use in your area. This information will help you understand learners' stories, and you can use it to provide examples and prompt learners' thinking.

3. Learn about or reflect on the storytelling styles of learners' communities. Think about the kinds of stories learners might tell and how you can structure the activity to support them.

Support Learner Differences

This is an opportunity to celebrate cultural stories about water. As appropriate, share one yourself, invite a community member to share, or suggest learners can share any they know.

Watch the video Working with Indigenous Learners.

In Your Space

4. Place the *Our Ideas* poster in a location all learners can access. Make a plan to store it between activities.
5. Set up a Materials Table with the items listed in the Materials section.
6. Optional: Set the mood for the activity by playing music or water sounds.

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(As scientists, we figured out which container had water. As engineers, we designed a technology to get the water out.)*
2. Say: **Our ultimate goal is to design a technology to reuse water, which will help people live in a place where water is hard to get. To start figuring this out, we're going to share what we know about why water is important.** Share the Guiding Question with learners aloud and in writing (using multiple languages as needed): **Why is water important?**
3. Organize learners into groups of four.

Support Learner Differences

If learners are new to you or each other, have them share their names, name pronunciations, and other important parts of their identities. These introductions are important for all learners and can be especially relevant for Indigenous learners, multilingual learners, and learners with different physical abilities. You can also distribute index cards and have learners write anything they want you to know but do not want to share with the whole group, such as resources that will help them learn. Lead an inclusion activity (pgs. xx-xxi) that is appropriate for your group (a list of possible activities is available on p. xvii). This tip is repeated because you may have new learners joining you in this and future sessions. Whenever you have new learners, repeat this strategy.

For more strategies to engage learners, refer to Designing Instruction to Reach Diverse Learners, pgs. x-xvi.

If you have learners who speak multiple languages, consider pairing learners with the same preferred language so they can share with each other in that language. Check out the Intentional Grouping Strategies, pg. xxii.

Storytelling (25 min.)

4. Say: **We all have stories. They can be stories we've heard from other people, stories we've watched or read about, or stories about things we have experienced ourselves. We experience stories**

every day in conversations, art, traditional craft, and online videos. Today, we're going to share stories about why water is important. These stories could be about why water is important for life, how water connects different parts of the world, how water has spiritual significance to many communities, how caring for water is an important responsibility, and how some communities have more reliable access to clean water than others.

5. Have learners turn to *My Water Story*, pg. 7 in their Engineering Notebook. Say: **To start, everyone will have 15 minutes to think about a story to tell that shows why water is important. Create some art that tells your story. You can write it down or write a poem that tells it, draw it, record it on a device, create a performance about it, or build something to demonstrate it.** Note that there are drawing and building materials on the Materials Table. During this time, check in with each group. If learners are struggling, consider sharing your own short story about water to spark ideas.

6. After 15 minutes, say: **Now, everyone in your group will take a few minutes to share their stories. If your story is long, you can choose one or two minutes of it to share so there is time for everyone.**

7. Allow learners to share their stories for 10 minutes. Remind them to switch so that everyone has time to share. Visit each group and listen to learners' perspectives on water.

Support Thinking

Learners may want to make up their own stories. Bear in mind that the goal of the activity is to identify why water is important to learners and communities they belong to, which made-up stories may or may not do.

Support Learner Differences

- If you have learners who speak multiple languages, have them discuss words for "water" in their preferred languages and notice similarities between languages. If you can, provide an example from a language you know. Take time to learn learners' words and use them throughout the activities.
- It is possible that stories about the importance of water may bring up trauma related to the lack of access to clean safe water (e.g., the water crisis in Flint, Michigan; lack of running water in certain Indigenous communities). If you notice this, ask the learner privately what they might need at that moment. If they do not know, you can offer some ideas from the Arizona Adverse Childhood Experiences Consortium Resource Library.
- In this activity, you will need to strike a balance between allowing learners to share complete stories and ensuring there is enough time for everyone to share. Different cultures have different conventions for storytelling, which may involve very long stories with many parts, the significance of which is not immediately apparent. Consider the best way to approach time management, which may involve dedicating multiple sessions to this activity.

  You can use storytelling as an opportunity for learners to practice social skills such as taking turns and showing respect for other people's experiences.

Reflect (10 min.)

8. Say: **Thank you for sharing your stories. They gave us great reasons why water is important.** Point out common themes you noticed among stories. Emphasize the importance of water for life. Ask: **Is there anything else you want to share to answer the Guiding Question?** Revisit the Guiding Question: **Why is water important?**

9. Have learners record answers to the Guiding Question near it on the *Our Ideas* poster. You can
   - have each group designate a member to record responses on the *Our Ideas* poster.
   - have each learner write or draw something on a (physical or digital) index card and add it to the *Our Ideas* poster.

10. Say: **Next time, we'll use the ideas we explored today to think about water in communities we belong to and the different groups that use it.**

Support Learner Differences

As needed, allow learners to choose other methods of sharing their ideas, such as audio recordings. Have them write the filename of each record on an index card and put the index cards on the Our Ideas poster. They will serve as placeholders. When necessary, you can ask, "Who has the idea named X?" and have the learner in question share the record.

Support Thinking

Learners may bring up ideas that will be relevant in future activities, such as water quality, water filtration, and order of water reuse. As appropriate, note that the group will return to these ideas.

Level Up!

- To explore why the chemistry of water makes it so important for life, show the video Properties of Water. (5 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We identified reasons why water is important.)* (5 min.)
- Check out some great examples of the more than 2,000 NASA spin-off technologies that enrich our lives–and keep water clean and usable–thanks to space exploration. (5 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We shared stories about why water is important." (5 min.)
- Read the book We Are Water Protectors, which tells a story about people fighting to keep water clean. Although this is a picture book, it has a message that is important for all ages. (60 min.)

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 2.
   - If learners created objects related to their stories, save those objects for reference in future activities.
2. Plan for Engineering Activity 2. See the Activity 2 Preparation on pg. 27.
3. Take time to reflect on the following educator prompt. **What strategies helped learners feel comfortable sharing stories?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Engineering Activity 2: Close to Home: Water Where We Are From

Educator Preview

Activity Snapshot

Learners consider who uses water in their community and how, and they make water samples.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Water in Our Community	10 min.
Water Samples	15 min.
Reflect	10 min.
Total	**45 min.**
Level Up Activities	5–20 min. each

Prep Snapshot*

Prep Time 15 min.

- Set up Materials Table.
- Print handouts.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Consider problems in context.

Guiding Question

Who uses water in our community, and how do they use it?

Learners Will Do

Identify multiple groups that use water and the kind of water each needs.

Learners Will Know

Different types of water can be used in different ways.

Connecting Across Activities

Activity 1: Sharing Experiences	Activity 2: Water Where We Are From	Activity 3: Investigating Water Quality
Last time, learners shared experiences with, and stories about, water.	**Today**, learners consider who uses water in their community and how, and they make water samples.	**Next time**, learners will measure the water quality of the samples they have made.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/e3c34ea8

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- 1 permanent marker
- 1 roll of masking tape
- 1 roll of paper towels
- 2 pairs of scissors
- 4 tablespoons
- 4 teaspoons
- 4 rulers
- 5 sheets of cardstock

For each learner

- 3 index cards
- Engineering Notebook (PDF)

For the Materials Table

- 1 bottle of scented liquid
- 1 bottle of soap
- 1 bottle of white vinegar
- 1 spool of thread
- 1 Tbsp of detergent
- 1 tube of toothpaste, travel size
- 1 vial of food coloring, yellow
- 2 sticks modeling clay
- 4 Tbsp of soil
- 4 tea bags, black tea
- coffee grounds
- natural materials (such as soil, sticks, grass, sand)

Teaching Tip

For the scented liquid, choose from the following options: diffuser oils, scented teas, extracts, essential oils, or other scented liquids that differ from hand soap and detergent that align with your program's budget and learners sensory sensitivities.

For each group of 4

- 1 craft stick
- 1 container, 1/2 gallon, filled with water
- Engineering Activity 2 Water Sample Recipes Handout, pgs. 35–37

Activity 2 Materials Preparation (15 min.)

Ahead of Time

1. Watch the video Engineering How to Part 1 (0:00–0:53) to learn about what happens in this activity.
2. Make one copy of Engineering Activity 2 Water in Our Community Handout, pgs. 33–34, for each group.
3. Make one copy of Engineering Activity 2 Water Sample Recipes Handout, pgs. 35–37, for each group.
4. Review the "In-Use Example" in the Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity. Add the questions "Who uses water in our community?" and "How do they use water?" so learners can refer to them throughout the activity.
5. Download and prepare to share the Engineering Activity 2 Extreme Environments slides (PPTX). If you cannot project them, print them instead.

In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

7. Arrange the materials (contaminants) listed above on the Materials Table for learners to access throughout the activity. Place the teaspoons, tablespoons, and scissors on the Materials Table for learners to share. Label each material with its name (for example, on an index card) to support learners identifying and talking about the materials.
8. Set up a device with a projector and internet access, then test the video Recycling Water on Space Station (1:32, optional).

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We told stories about why water is important, which helped us understand why it's important to solve problems about water.)* Draw learners' attention to their work on the *Our Ideas* poster about how water is important for humans and other living things.

2. Say: **Since water is so important, as engineers, our ultimate goal will be to design a technology to reuse water in a place where water is hard to get. The International Space Station is one place where it is important to reuse water. Let's watch a video about it.** Show the video Recycling Water on Space Station (1:32).

3. Say: **As engineers, we are going to answer the same big question as the engineers who designed the International Space Station: How can we reuse water in a place where water is hard to get?** Write the question on the *Our Ideas* poster. Ask: **What smaller questions will we need to answer in order to answer this question?** Allow learners to think of questions in pairs, then share them with the whole group. Record their questions on the *Our Ideas* poster in related categories. Possible categories of questions include:
   - **Environments**: Where is water hard to get? Who uses the water? How do people use water in different places? (answered in Activity 2)
   - **Measurement**: How can we tell if water is safe to reuse? How can we measure contamination in water? What can we measure and what can't we measure? (answered in Activity 3)
   - **Filtering**: How can we clean water? How can we remove contaminants from water? Can we turn contaminated water back into clean water? (answered in Activity 4)
   - **Reuse**: How clean does the water need to be for reuse? How can groups in the community reuse water? How many times can water be reused?

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

Teaching Tips

- If you cannot show the video, tell learners that, because water is so hard to get in space, astronauts on the International Space Station recycle the water in their urine.
- Each activity in this pathway has a suggested Guiding Question. As much as possible, replace these questions with similar ones from the list of questions learners have thought of. Using learners' questions will increase their engagement. There will likely be questions you do not answer in the pathway. When you can, mention these questions and have learners think about ways to answer them in the future.

4. Point out questions about users of water and say: **Today, we'll be investigating our questions about how different groups use water and what they use it for.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **Who uses water in our community, and how do they use it?**

5. Organize learners into groups of four.

Water in Our Community (10 min.)

6. Give each group a copy of *Engineering Activity 2 Water in Our Community Handout*, pgs. 33–34. Give each learner 3 index cards. Say: **You are going to be thinking about different groups in a community you belong to that use water. You have about five minutes to follow the instructions on the sheet.**

7. After about five minutes, say: **Now, you will take all your index cards that name groups and add them to the *Our Ideas* poster.** Have one learner from each group bring up those index cards and tape them to the poster around the question "Who uses water in our community?"

8. Say: **Now, you will take the rest of your index cards and add them to the poster in two categories: uses that need clean water and uses that do not.** Near the question "How do they use water?", write "Needs Clean Water" and "Does Not Need Clean Water." Have one learner from each group bring up the rest of the index cards and tape them to the poster in the appropriate categories.

Support Learner Differences

Although this activity uses the term *community*, learners can think about places they are from or have a connection to but do not currently live. Make sure to inform them of this option. If appropriate, you can use different terms, such as *homeland* or *home community*.

Support Thinking

- Following the instructions on Engineering Activity 2 Water in Our Community Handout, pgs. 33–34, learners will be identifying groups in the community that use water and what they use water for. Provide examples as needed to prompt learner thinking. For example, farmers use water to irrigate crops and water livestock, gardeners use it for plants, and wild animals and plants use it to live and as a habitat. Many people use water for laundry, sinks and showers, toilets, cooking, and drinking. (Make clear that learners should not actually drink any of the water they work with in this activity.)
- Learners may draw connections between water in their communities and social, environmental, and health issues, such as pollution, disease, and the availability of running water. Find ways to encourage conversation around these topics as appropriate.

Support Learner Differences

As needed, allow learners to choose other methods of sharing their ideas, such as audio recordings or Braille. Post index cards with filenames on them so the record can be referenced later.

Water Samples (15 min.)

9. Give each group a copy of *Engineering Activity 2 Water Sample Recipes Handout*, pgs. 35–37. Say: **One of the problems people face is that, once clean water is used for something, it is no longer clean. To learn about this problem, we're going to make water samples that are like water after it has been used. You have about ten minutes to follow the instructions on the sheet.**

10. Give each group one container of water, and draw learners' attention to the substances on the Materials Table. Give groups 10 minutes to create their water samples.

11. After learners make their water samples, have groups pair up and share their samples. Ask: **What do you notice about your water samples? What is similar? What is different? What substances do you think these materials represent? Are you surprised by any of them?** As learners share, capture the vocabulary they use, such as *dirt*, *murky*, *soap*, *yellow*, *contaminated*, and add these words to the *Our Ideas* poster.

Teaching Tip

Encourage different small groups to choose different samples so that the group as a whole has a variety of samples to compare.

Support Learner Differences

Give learners time to examine the materials on the Materials Table before they begin making their samples.

12. Say: **Things that make water dirty are called *contaminants*. The substances you added, like toothpaste, dirt, and soap, are all examples of contaminants. Water with contaminants in it is called *contaminated*.** Add the words *contaminants* and *contaminated* to the *Our Ideas* poster. Let learners discuss in groups words that they know related to these words. If appropriate, they can make up sounds or movements to help remember the words.

13. Ask: **Why can contaminants in water be a problem?** Have learners discuss in their groups. *(Contaminants can make water unsafe to drink; they can make people and animals sick; they can make it so the water can't clean things.)* As needed, share examples of problems caused by contaminated water. Discuss how different types of contamination can cause different problems. For example, fertilizer in water may make it unsafe to drink, but it can make plants grow better. Salty water might make some animals and plants sick, but other organisms can only survive in salt water.

Reflect (10 min.)

14. Revisit the Guiding Question on the *Our Ideas* poster: **Who uses water in our community, and how do they use it?** Say: **Now that we've thought about different groups and the ways they use water, we can understand the problem: water is important, but it gets contaminated when it is used. Your challenge is to learn more about how to reuse contaminated water, then engineer a water reuse system for a particular community.** Remind learners of the words *contaminant* and *contaminated*.

15. Display the *Engineering Activity 2 Extreme Environments* slides and move through them as you read the following list. **There will be four communities you can choose to help:**
    - An off-the-grid farmhouse in the Southwest United States
    - Astronauts on a future exploration of Mars
    - Scientists on a research ship at sea
    - Astronauts on the International Space Station
16. Say: **Next time, we will think about how to make water samples less contaminated.**
17. Using the permanent marker and masking tape, have learners label the water samples they made (Farm Field, Bathroom Sink, Laundry, Shower, or Toilet) and save them for use in the next activity.

Support Thinking

Show the video Water Reuse in Extreme Environments: Human Technology to emphasize how people can design ways to reuse water in places where water is scarce.

Level Up!

- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We framed the question of groups that use water and investigated how they use it and how it becomes contaminated.)* (5 min.)
- Ask this story prompt question: **Can you tell a story about contaminated water, either that you've experienced directly or learned about?** *(Possible responses include finding contaminated water, witnessing the effects of contaminated water, and helping to clean contaminated water.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We explored who in our community uses water and how." (5 min.)

Support Learner Differences

It is possible that stories about contaminated water may bring up trauma related to the lack of access to clean safe water (e.g., the water crisis in Flint, Michigan; lack of running water in certain Indigenous communities). If you notice this, ask the learner privately what they might need at that moment. If they do not know, you can offer some ideas from the Arizona Adverse Childhood Experiences Consortium Resource Library

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for use in Activity 3.
   - Save the water samples for use in Activity 3. Decide if you need to make more.
2. Plan for Engineering Activity 3. See the Activity 3 Preparation on pg. 42.
3. Take time to reflect on the following educator prompt. **How did focusing on communities support learner engagement?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Water in Our Community

Groups That Use Water

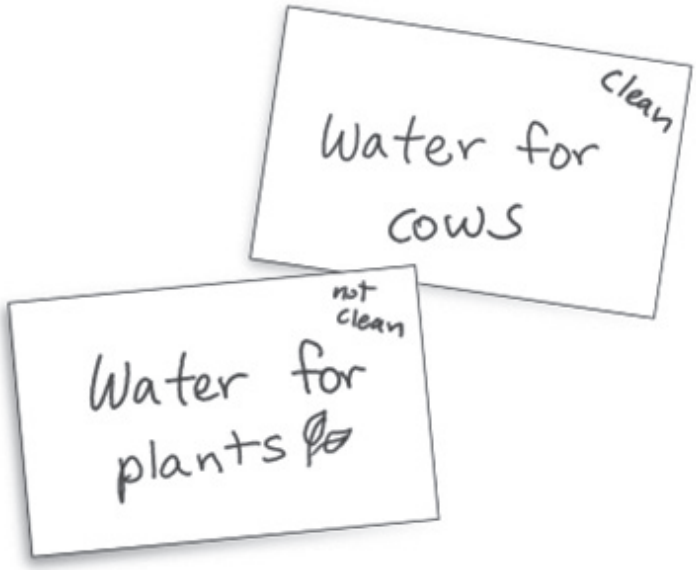
1. Think about groups in a community you belong to that use water. Write the name of one of these groups on an index card.

Ways of Using Water

2. Think about the group you chose. Write two ways that group uses water on your other two index cards.

Does It Need to Be Clean?

3. Think about the ways of using water you chose. Is it ok for the water to be contaminated? What types of contamination (if any) are ok? Indicate this in the corner of each index card.



Water Sample Recipes

As a group, choose one of the water samples listed below and make it.

Farm Field Water Sample

- 1/2 container of water
- 1/2 tsp scented liquid
- 1 Tbsp loose soil
- 2 Tbsp vinegar

Add scented liquid to water and mix. Then mix the other ingredients and add them to the water.

Bathroom Sink Water Sample

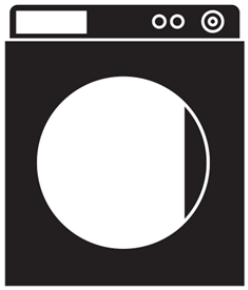
- 1/2 gallon container of water
- 1/2 tsp scented liquid
- 1 tsp soap
- 2 pea-sized blobs of toothpaste

Add scented liquid to water and mix. Then mix the other ingredients and add them to the water.

Laundry Water Sample

- 1/2 gallon container of water
- 1/2 tsp scented liquid
- 1 tsp tea leaves
- 1 Tbsp detergent
- 2 tsp soil

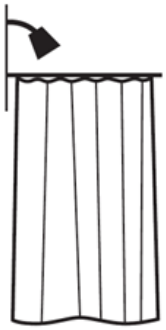
Add scented liquid to water and mix. Then mix the other ingredients and add them to the water.



Shower Water Sample

- 1/2 gallon container of water
- 1/2 tsp scented liquid
- 1 tsp soap
- 1 tsp soil
- 2 Tbsp vinegar
- 30 pieces of thread, approx. 3–5" long

Add scented liquid to water and mix. Then mix the other ingredients and add them to the water.



Toilet Water Sample

- 1/2 gallon container of water
- 1/2 tsp scented liquid
- 1 tsp soap
- 1 tsp tea leaves
- 1 Tbsp soil
- 2 drops yellow food coloring

Add scented liquid to water and mix. Then mix the other ingredients and add them to the water.

Engineering Activity 3: Measure Up: Investigating Water Quality

Educator Preview

Activity Snapshot

Learners measure the water quality of the samples they have made.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Water Quality	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–20 min. each

Prep Snapshot*

Prep Time 15 min.

- Space Need: Sink
- Set up Materials Table.
- Print handouts.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Investigate features and uses of tools.

Guiding Question

How can we tell if water is safe to reuse?

Learners Will Do

Test for at least one level of water quality.

Learners Will Know

Engineers gather data to understand problems.

Connecting Across Activities

Activity 2: Water Where We Are From	Activity 3: Investigating Water Quality	Activity 4: Investigating Filters
Last time, learners considered who uses water in their community and how, and they made water samples.	**Today**, learners measure the water quality of the samples they have made.	**Next time**, learners will investigate the ability of various filter materials to remove contaminants from a water sample.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/f72a8d8f

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- water
- towels or disposable tablecloths (optional)

For each learner

- Engineering Notebook (PDF)

For each group of 4

- water sample from Activity 2
- 1 coffee filter
- 1 flashlight
- 1 packet of pH strips
- 1 piece of construction paper (the same color for all groups)
- 1 plastic cup
- Engineering Activity 3 How to Test Water Quality Handout, pgs. 47–51
- Engineering Activity 3 How Clean Does It Need to Be? Handout, pgs. 52–53

Teaching Tip

Instead of pH strips, you can use alternative methods to measure pH, such as goldenrod paper or red cabbage juice.

Support Learner Differences

It may be helpful for your learners to use light meter and color meter apps for measurement. These apps are useful for two reasons: First, they allow learners who are blind or low-vision to make water quality measurements. Second, they quantify features of water quality, making the measurements more exact.

Various **light meter apps** are available for free download. These apps measure camera images in lux, a unit describing how much an area is illuminated. For example, a light meter app may give a reading of 20 lux for a water sample, which means that very little light is passing through the water because it is so cloudy. By giving numbers, the app allows for accurate comparisons of water clarity. Make sure learners orient devices so the cameras are down as close to the tabletop as possible.

Because measurements of light meter apps can vary depending on lighting and background, it's important to make the measurement of a cup of clear water first. Comparing the measurement of the clear water to the measurement of the water sample can help learners decide how clear the sample is. For consistency, it's also important to continue using the same app throughout the activity.

Various **color meter apps** are available for free download. These apps measure the color of part of an image, allowing for non-visual color assessments and measurements of pH strip results. For example, a color meter app may identify the color of a pH strip as R:62, G:171, B:159, which allows easy comparison to the reference colors on a pH scale.

If necessary for your learners, make sure the devices you are using for these apps have a read-aloud function enabled for using the apps (e.g., TalkBack for Android, VoiceOver for iOS).

If you have some devices available, but not enough for every group to have one, you can set up stations where groups can use devices as needed to measure their samples.

Activity 3 Materials Preparation (15 min.)

Ahead of Time

1. Watch the video Engineering How to Part 1 (0:53–2:55) to learn about what happens in this activity.
2. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
3. Review instructions on Engineering Activity 3 How to Test Water Quality Handout, pgs. 47–51. Make one copy for each group.
4. Make one copy of Engineering Activity 3 How Clean Does It Need to Be? Handout, pgs. 52–53, for each group.

In Your Space

5. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
6. Fill up one cup of clean water for each group.

Teaching Tip

Lead this activity in a room with a sink for easy setup. Organize group materials in bags for easy distribution.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We thought about how groups in communities we belong to use water and how water gets contaminated. We made water samples for different sources. This helped us get ready to think about cleaning the water.)* Draw learners' attention to their work on the *Our Ideas* poster about community water users, water uses, and sources of contamination.
2. Say: **Our challenge is to find ways to help people reuse water in a place where water is hard to get.** Show the *Engineering Activity 2 Extreme Environments* slides to remind learners of possible locations (desert Southwest, Mars, research boat, or the International Space Station**)**.
3. Say: **Today, we're going to start by investigating our questions about measurement of how clean water is.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can we tell if water is safe to reuse?**
4. Organize learners into groups of four and distribute Engineering Notebooks.

Water Quality (25 min.)

5. Have learners discuss in their groups: **What are some ways we can measure how clean or contaminated water is?** *(We can measure how clear it is, if there are things in it, if it smells bad, if it has chemicals in it, what color it is.)* Record ideas on the *Our Ideas* poster.
6. Give each group its water sample from the previous activity, 1 cup of clean water, 1 coffee filter, 1 flashlight, 1 packet of pH strips, and 1 piece of construction paper.
7. Give each group a copy of *Engineering Activity 3 How to Test Water Quality Handout*, pgs. 47-51. Say: **This sheet has tests to measure water quality. As a group, you will have about 15 minutes to try three to five of these tests on your water samples, then record your results on *Our First Water Sample,* pg. 8 in your Notebook.**

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

Support Learner Differences

As needed, provide groups with a tub or other container to hold their materials. Give learners time to examine the materials before they begin testing.

Support Thinking

To help learners understand what they will be doing during this activity, play the translatable videos from the How to Prepare and Teach playlist.

8. Say: **To get used to testing, we will start by doing one test all together.** Read the instructions for the "How Clear Is It?" test aloud one step at a time, and have learners follow them using their cups of clean water. This will give them a measurement for how much light passes through clean water.
9. Have learners repeat the test with their water samples and compare their results to the results for the clean water. Have each group record its results. Make sure learners do not contaminate the clean water by using tools that were previously in contaminated water.
10. Give groups 15 minutes to perform additional tests on their water samples. As needed, offer clarifications and explain testing instructions.
11. After about 15 minutes, have learners stop testing. If groups did not have a chance to perform all the tests, have each group pair up with another that performed different tests and share their results.

Level Up!

Cut out the circles on Engineering Activity 3 Secchi Disks Handout (PDF) and give one to each group. Explain that these disks are tools used by environmental professionals to measure water quality. Learners can hold the disks in place of the construction paper as they determine water clarity.

Support Thinking

Remind learners that *clear* and *colorless* do not mean the same thing. Give an example, like apple juice, that is clear but has a yellow color.

Teaching Tips

The pH strips may stain the tabletop, so have learners place their used strips on a paper towel. Placing samples on white paper makes them easier to see.

Support Learner Differences

Allow blind and low vision learners time to touch and orient themselves with materials before starting the testing time.

Level Up!

- Pass out the Engineering Activity 3 Acidity Chart Handout (PDF) so learners can compare the acidity of their water samples to the common contaminants on the chart. A Braille version of the chart is available online. (5 min.)
- Have the entire group decide on one additional observable feature to determine water quality. Have learners add it to the testing directions on Engineering Activity 3 How to Test Water Quality Handout, pgs. 47–51. (20 min.)

12. Connect learners' experience to vocabulary by saying: **Good job testing your water samples! To make it easy to talk about these sorts of tests, scientists and engineers use certain words.**
13. Say: **What words would you use to describe what you measured in the "How Clear Is It?" test?** *(Clearness, transparency, translucency, opacity, clarity.)* Write the terms learners suggest on the *Our Ideas* poster. Say: **How clear the water is can be called *clarity*.** Write *clarity* on the *Our Ideas* poster.
14. Say: **What words would you use to describe what you measured in the "How Acidic Is It?" test?** *(Acid, acidic, base, basic, neutral, pH.)* Write the terms learners suggest on the *Our Ideas* poster. Say: ***pH* is how acidic or basic a sample is. *pH strips* are tools that measure pH.** Write *pH* on the *Our Ideas* poster.
15. Say: **How clean or contaminated a water sample is, is called *water quality*. Clarity, color, pH, smell, and texture are ways to figure out water quality. How water can be reused depends on its quality.** Write *water quality* on the *Our Ideas* poster. You can have learners add translations of terms, drawings, or related images to the poster as well.

Support Learner Differences

If you have learners who speak multiple languages, have them discuss words for "clarity," "color," "pH," "smell," "texture," and "quality" in their preferred languages and notice similarities between languages. If you can, provide an example from a language you know. Take time to learn learners' words and use them throughout the activities.

Support Thinking

Have learners discuss different reasons why contaminated water is bad to reuse. *It can make you sick; it is gross to drink water with chunks in it; really acidic water can hurt you.*

Teaching Tip

Learners may note, or you may want to point out, that water quality involves other features beyond the five measured in these tests. For example, water containing pathogens may seem clean but be unsafe to drink. As a result, learners should never drink water samples they create, even if they seem clean.

Level Up!

- In addition to water quality, you can have learners think about water accessibility. Have them consider places where water may not be easy to get, such as communities without running water, and how this lack of accessibility affects people in those areas. (10 min.)
- NASA uses satellite missions to look for water on Earth. Learn more about how they are working on solving water problems on Earth at https://earthobservatory.nasa.gov/images/151134/water-tracking-satellite-reveals-first-views. (5 min.)

16. Give each group a copy of *Engineering Activity 3 How Clean Does It Need to Be? Handout*, pgs. 52–53. Say: **This page gives instructions on how to figure out water quality using the measurements you took. Figure out the quality of your sample as a group and record it on *Our First Water Sample*.** Give groups a few minutes to determine the quality of their water samples.

Reflect (10 min.)

17. Have learners revisit the Guiding Question in their small groups: **How can we tell if water is safe enough to reuse?** *(We can measure clarity, color, pH, smell, and texture. Water with bad quality is probably not safe to reuse.)* As needed, refer to terms on the *Our Ideas* poster.

18. Say: **Next time, you will use what you learned about water quality to design ways to remove contaminants from water.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for use in Activity 4.
   - Dispose of used pH strips and coffee filters.
   - Save the water samples and measurement supplies for use in Activity 4. Decide if you need to make more.
   - Collect the handouts.
2. Plan for Engineering Activity 4. See the Activity 4 Preparation on pg. 57.
3. Take time to reflect on the following educator prompt. **How did you connect learners' observations to new vocabulary?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

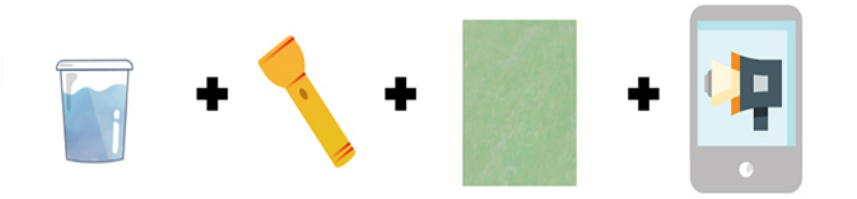
Level Up!

- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We investigated how water quality is measured.)* (5 min.)
- Ask this story prompt question: **Can you tell a story about a time when you've had to observe water closely, either out in a natural setting or somewhere else?** *(Possible responses include while boating, fishing, or cooking.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We explored water quality and how to measure it." (5 min.)
- You can introduce learners to the industry terms *potable water*, *greywater*, and *wastewater*. Potable water is clean water that people can drink safely. Greywater is somewhat contaminated water, which has been used once and can be used again for some purposes. Wastewater is very contaminated water, which cannot be reused for most tasks before its quality is improved. (5 min.)

How to Test Water Quality

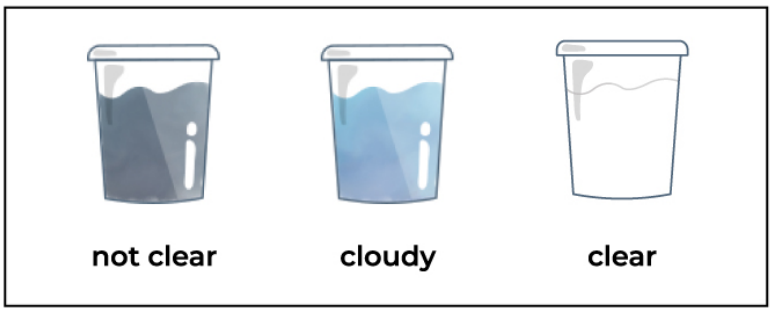
Use 3 to 5 of these tests on your sample.

How Clear Is It?



1. Have one person hold the construction paper behind the water sample.
2. Have another person shine a flashlight down onto the sample from above.

3. Have a third person look at the sample. Figure out how clear the water is.
   - **not clear** (no light goes through)
   - **cloudy** (some light goes through)
   - **clear** (all light goes through)



Do the whole test twice: once with clean water, so you know how much light goes through it, and once with your water sample.

What Is the Color?

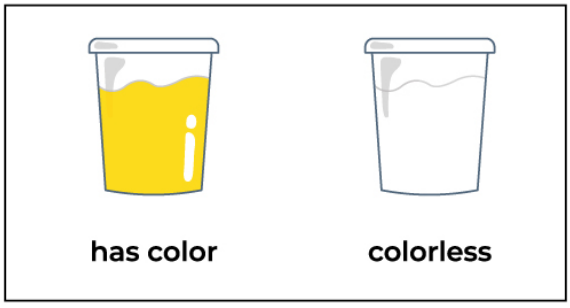
cup with water sample

observer or meter app

1. Look at the water sample.

2. Score the color.

- **has color**
- **colorless**



How Acidic Is It?

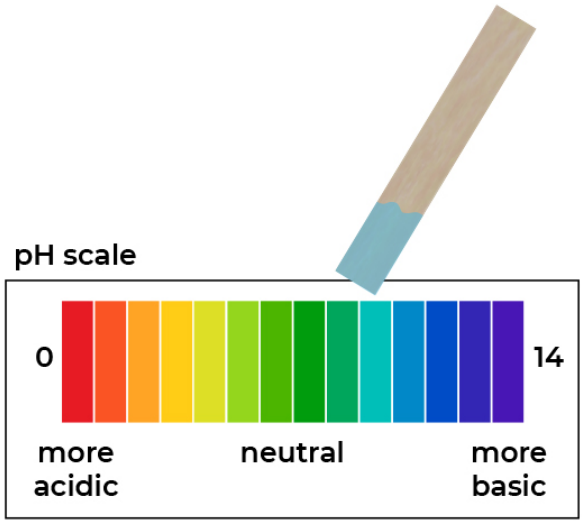
cup with water sample

pH strips

Use a testing strip:

1. Dip the end of the strip into the water sample.
2. The strip will turn a color. Compare it with the color scale on the packet that came with the strip.

3. Score the acidity.
   - **acidic**: 0–5
   - **neutral**: 6–8
   - **basic**: 9–14



What Does It Smell Like?

cup with water sample

1. Smell the sample.

2. Rate the smell.

- **strong smell**
- **weak smell**
- **no smell**

What Is the Texture?

1. Set up the clear plastic cup.
2. Havve one person hold the coffee filter over the top of the cup.
3. Have another person pour about 1 tablespoon of water from the container through the coffee filter into the cup.

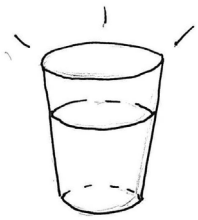
4. Feel the coffee filter. Score the texture.
   - **gritty texture** (you can feel objects)
   - **smooth texture** (you just feel the filter)

How Clean Does It Need to Be?

We will categorize our water in three ways: clean water, somewhat contaminated water, and very contaminated water. Use the key below to see how clean water needs to be for each category.

Clean Water

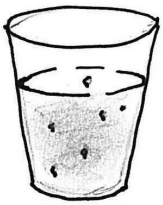
- Clear
- Colorless
- Neutral pH (6–8)
- No smell
- Smooth texture



Can be used at ***any*** location

Somewhat Contaminated Water

- Clear or cloudy
- Colorless
- pH 5–9
- No smell or weak smell
- Smooth texture



Can be used for

- Toilet 
- Watering Edible Plants 
- Watering Landscape Plants 

Very Contaminated Water

- Not clear
- Has color
- pH 0–4 or 10–14
- Strong smell
- Gritty texture

Can be used for

Watering Landscape Plants 

Educator Guide

Engineering Activity 4: Block It Out: Investigating Filters

Educator Preview

Activity Snapshot

Learners investigate the ability of various filter materials to remove contaminants from a water sample.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Investigate	25 min.
Reflect	10 min.
Total	45 min.

Level Up Activities 5–20 min. each

Prep Snapshot*

Prep Time 40 min.

- Space Need: Sink
- Make Filter Bases.
- Set up Materials Table.
- Create chart.
- Prep charcoal filter.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Investigate properties and uses of materials.

Guiding Question

How can we improve water quality?

Learners Will Do

Test the effectiveness of at least one filter material for cleaning water.

Learners Will Know

Engineers investigate how well materials filter contaminants from water so they can design solutions for places with limited water.

Connecting Across Activities

Activity 3: Investigating Water Quality	Activity 4: Investigating Filters	Activity 5: Investigating Reuse Process
Last time, learners measured the water quality of the samples they had made.	**Today**, learners investigate the ability of various filter materials to remove contaminants from a water sample.	**Next time**, learners will apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/f804712f

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- chart paper and markers
- 1 foil tray, 12" × 12"
- 1 plastic container with lid, 8 oz.
- 1 roll of paper towels
- 1 roll of painter's tape
- 2 rubber bands
- 1 safety glove
- 1 strainer
- 1 utility knife
- 1 vial of food coloring, yellow
- 2 Tbsp of activated charcoal
- 2 pieces of cheesecloth, 12" × 12"
- 7 two-liter bottles
- towels or disposable tablecloths (optional)

For the Materials Table

- 1 measuring cup, 1/4 cup
- 1 cup of limestone gravel
- 2 cups of sand
- 2 tablespoons
- 8 half-sheets of paper towel
- 18 pieces of cheesecloth, 12" × 12"
- 20 rubber bands
- 40 cotton balls
- 60 plastic cups, 8 oz. (optional)

For each learner

- Engineering Notebook (PDF)

For each group of 4

- 1 coffee filter
- 1 Filter Base, cut from Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94
- 1 flashlight
- 1 foil tray, 12" × 12"
- 1 measuring cup, 1 cup
- 1 packet of pH strips
- 1 piece of construction paper (the same color for all groups)
- 1 plastic cup
- 1 water sample from Activity 3
- sticky notes

Activity 4 Materials Preparation (40 min.)

Ahead of Time

1. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Make 7 Filter Bases using the Preparing Filter Bases Instructions, pg. 62.
3. Make one copy of Engineering Activity 4 Testing Materials for Cleaning Handout, pgs. 63-64, for each group.

In Your Space

4. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
5. Arrange materials on a Materials Table so learners can easily access them.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

6. Fill the 8 oz. plastic container halfway with water and add 1–2 drops of yellow food coloring.
7. Using the strainer, rinse the charcoal under running water for approximately 1 minute until the water runs clear. **Make sure to do this, or the charcoal will make the water quality worse.** Keep the strainer available for use during clean-up.
8. Create a charcoal filter by putting 2 Tbsp of pre-washed charcoal in a square of cheesecloth and tying it closed with a rubber band.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We calculated the quality of water after it has been used in different ways.)* As necessary, draw learners' attention to the *Our Ideas* poster and the terms *clarity*, *pH*, *texture*, and *water quality*.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. viii–xviii).

2. Ask: **What is the problem we are trying to solve?** *(We are trying to find ways to help people reuse water in places where water is hard to get.)* Show the *Engineering Activity 2 Extreme Environments* slides to remind learners of the locations.
3. Say: **Today we will investigate different materials that can improve the water quality of our samples so that they can be reused.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can we improve water quality?**
4. Organize learners into groups of four.

Investigate Filter Materials (25 min.)

5. Give each group a copy of *Engineering Activity 3 How Clean Does It Need to Be? Handout*, pgs. 52–53. While pointing to terms on the *Our Ideas* poster, remind learners: **This page explains the water quality that is needed for different uses. Your goal is to find ways to improve water quality by removing contaminants.** Note that there is a difference between somewhat contaminated water, which can be used again for several different purposes, and very contaminated water, which cannot be reused except to water plants no one is going to eat.
6. Say: **You will work in groups to test how well each material removes contaminants from one of the water samples.** Give each group a copy of *Engineering Activity 4 Testing Materials for Cleaning Handout*, pgs. 63-64, to review the testing instructions.

Teaching Tip

The use of "very contaminated water" has been simplified for this activity. In practice, whether very contaminated water can be reused depends on the type of contamination and how it is used. Water that has a very high or very low pH, for example, may be suitable for some plants but not others. Water with contaminants that should be kept out of soil and groundwater (for example, pesticides, motor oil) should not be reused even on landscaping plants.

Level Up!

Show the video The Water Cycle to explore how water is purified naturally as it moves between states of matter. (5 min.)

7. Ask while pointing to the terms for *contaminants*, *clarity*, *color*, and *pH* on the *Our Ideas* poster, ask: **Does everyone remember what contaminants are?** If needed, return to these terms and have learners discuss the terms and make drawings for them.

8. Make sure learners understand how they will test each filter material. Demonstrate with one filter base, a piece of cheesecloth, a rubber band, the yellow water you prepared, and a foil tray.
   - First, you will record the water quality (clarity, color, pH, smell, texture) of your sample in the "Before Filtering" section on *Cleaning Results*, pgs. 9-10 in their *Engineering Notebook*. (Remind the group that they have information about the water quality of their sample from the previous activity, and they can share it with teammates who were not present.)
   - Then, you will place a material on the top of the base. (Note that before placing any loose materials such as sand or limestone into the base, learners should first put down a piece of cheesecloth as a liner.) Demonstrate by attaching a piece of cheesecloth above the filter base with a rubber band.
   - You will pour 1/2 cup of your water sample over the material. Demonstrate by pouring yellow water over the cheesecloth.
   - You will measure and record the water quality of the sample in the base in the column for the material you used.
   - You will place used materials into the foil trays. Demonstrate by putting the cheesecloth and rubber band in a foil tray. Return the yellow water to its original container.

9. Give each group its water sample from Activity 3.

10. Invite groups up to the Materials Table to collect one base, a foil tray, and their materials. Encourage learners to examine the different materials they will be investigating (cheesecloth, cotton balls, limestone, paper towels, and sand) with sight and feeling before testing.

11. Remind learners that they will test each material separately, so they should pour only 1/2 cup of the polluted water sample through the material for each test.

12. As learners are working, ask: **How is this material affecting the quality of the water? Does it improve the clarity, color, pH, smell, or texture? Which material removes contaminants best?** Have learners fill out *Cleaning Results*, pgs. 9-10 in their *Engineering Notebook*.

Support Learner Differences

As needed, provide groups with a tub or other container to hold their materials.

Teaching Tips

- Learners can use rubber bands to secure filter materials in the base.
- Have learners use plastic cups to save cleaned water samples for comparison to the original. It helps to look at these samples against white paper.
- Between smell tests, learners may need to smell something cleansing, such as peppermint, in order to notice if the smell is different.

13. Write the names of the filter materials on the *Our Ideas* poster. After learners are finished testing, say: **Now we will gather information as a group about the materials we tested. You will write the type of sample or contaminants you had on sticky notes, then you will put the sticky notes on the *Our Ideas* poster next to the names of the material that removed contaminants the best.** Give learners several minutes to do this. Have learners examine the results and talk in their groups about what patterns they notice.

14. After learners are finished testing, ask: **How would you describe what the materials you tested are doing to the water?** *(Cleaning, treating, purifying, filtering.)* Say: **One word engineers use for materials like these is *filter*.** Have learners come up with a definition for the word *filter* together and record it on the poster. (For example: a technology that removes some kinds of contaminants from water.) You can have learners add translations and related images to the poster as well.

15. Explain that some filters need more time to treat the water. Bring out the plastic container of yellow water and the charcoal filter bag. Let learners know that there is charcoal inside the cheesecloth bag. Place the charcoal filter bag into the yellow water and explain that they will check on this filter at the end of the next activity. Save some of the yellow water in a container with no charcoal, so that you can compare the results in Activity 5.

Reflect (10 min.)

16. Have groups pair up and discuss the Guiding Question on the *Our Ideas* poster: **How can we improve water quality?** *(Different filter materials can remove different types of contaminants from water.)* **Which materials could you combine to improve water quality even more?**

Support Learner Differences

Consider attaching small pieces of each material to the *Our Ideas* poster. You can leave space on the chart for learners to write the names of materials in their preferred languages.

Teaching Tips

Successful filters make the water quality better (high clarity, colorless, neutral pH, no smell, no texture). Different filter materials have different expected results:

- Limestone balances an acidic pH.
- Cheesecloth, cotton balls, paper towel, and sand all remove particles and may slightly improve color.

The charcoal filter may take 24–48 hours to remove color from the water.

Consider having learners populate a Water Quality chart using their data from *Our First Water Sample*, pg. 8 in their Engineering Notebook (PDF) or record this on the *Our Ideas* poster so they can reference it in Activity 5. See Step 3 of Activity 5 Materials Preparation on pgs. 67-70.

17. Say: **Next time, you will use your knowledge of water quality and filtering to think about how contaminated water can be reused multiple times in different locations.**

Level Up!

- Ask this story prompt question: **Can you tell a story about a kind of filter you've used in the past, for water or for something else?** *(Possible responses include stories about water filters, air filters, and filters for photographs.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We explored how filters can improve water quality." (5 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We investigated different filter materials.)* (5 min.)

After the Activity

1. Clean up (watch the video Engineering How to Part 1 (2:55–3:35) for details):
   - Discard the remaining used filter materials.
   - Save the yellow water and charcoal filter for use in Activity 5.
   - Save the sample of yellow water with no charcoal for use in Activity 5.
   - Discard the water samples from Activity 3, using the strainer to prevent any contaminants from going down the drain.
   - Wipe out any remaining contaminants from the inside of the Filter Bases and rinse them in the sink.
   - Rinse the limestone with the strainer and set it aside for later.
   - Save the Filter Bases, aluminum trays, clean filter materials, and *Our Ideas* poster for Activity 5.
   - Collect all handouts.
2. Plan for Engineering Activity 5. See Engineering Activity 5 Preparation on pgs. 67-70.
3. Take time to reflect on the following educator prompt. **How did learners describe their results? How did their descriptions connect to vocabulary introduced in the previous activity?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

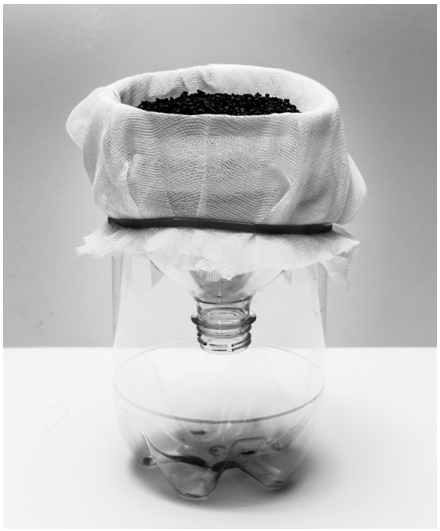
Preparing Filter Bases Instructions

1. Wearing a safety glove, cut a bottle in half with a utility knife.
2. Place painters' tape over cut edges.
3. Remove cap.
4. Save the bottom for catching water.

5. Stack the top of the bottle upside-down inside the bottom of the bottle. This is the Filter Base.

Testing Materials for Cleaning

1. Place material inside the top of the base. (In this example, cheesecloth is used to keep the charcoal from falling through the funnel.)



2. Pour a dirty water sample into the open top of the base.

3. Water flows through the filter material into the bottom of the bottle.

4. Remove the top of the base and place used materials in the foil trays.

5. Measure the quality of the water sample in the bottom of the bottle using 3 to 5 of the same water quality tests as before.

6. Repeat with each material by pouring a new sample of dirty water through each material.

Engineering Activity 5: Order Up!: Investigating a Reuse Process

Educator Preview

Activity Snapshot

Learners apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.

Timing | 45 minutes

Get Ready & Team Up	10 min.
A Reuse Process	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–25 min. each

Prep Snapshot*

Prep Time 60 min.

- Space Need: Sink
- Print and assemble handouts.
- Prepare Filter Bases for Activity 6, as noted in Materials & Preparation.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking
- Collaboration

Habits of Mind

- Use systems thinking.

Guiding Question

In what orders can water be reused?

Learners Will Do

Reconfigure the pipes in a model building.

Learners Will Know

Engineers can design processes to solve problems.

Connecting Across Activities

Activity 4: Investigating Filters	Activity 5: Investigating Reuse Process	Activity 6: Create a Process
Last time, learners investigated the ability of various filter materials to remove contaminants from a water sample.	**Today**, learners apply what they learned about water quality to reconfigure a model building to reuse as much water as possible.	**Next time**, learners will work in groups to plan, create, and test a water reuse process.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/58aebdd3

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- plastic container with lid, 8 oz., with yellow water and charcoal filter from Activity 4
- sample of yellow water with no charcoal from Activity 4
- 4 rolls of painter's tape
- 16 sheets of copy paper
- 40 straws, color 1
- 40 straws, color 2
- 40 straws, color 3
- other long items, such as craft sticks or pencils (optional)
- towels or disposable tablecloths (optional)

For each group of 4

- Engineering Activity 3 How Clean Does It Need to Be? Handout, pgs. 52–53
- Engineering Activity 5 Mapping Water Reuse Handout, pgs. 75–76
  - cups
  - yarn to outline locations in home
  - glue to attach yarn
- 1/2 stick of modeling clay
- 1 pair of scissors
- 2 sheet protectors (optional)

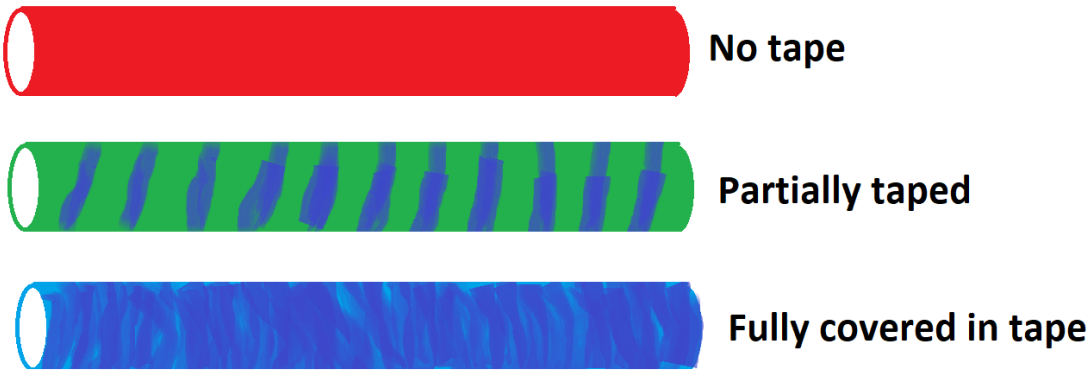
For each learner

- Engineering Notebook (PDF)

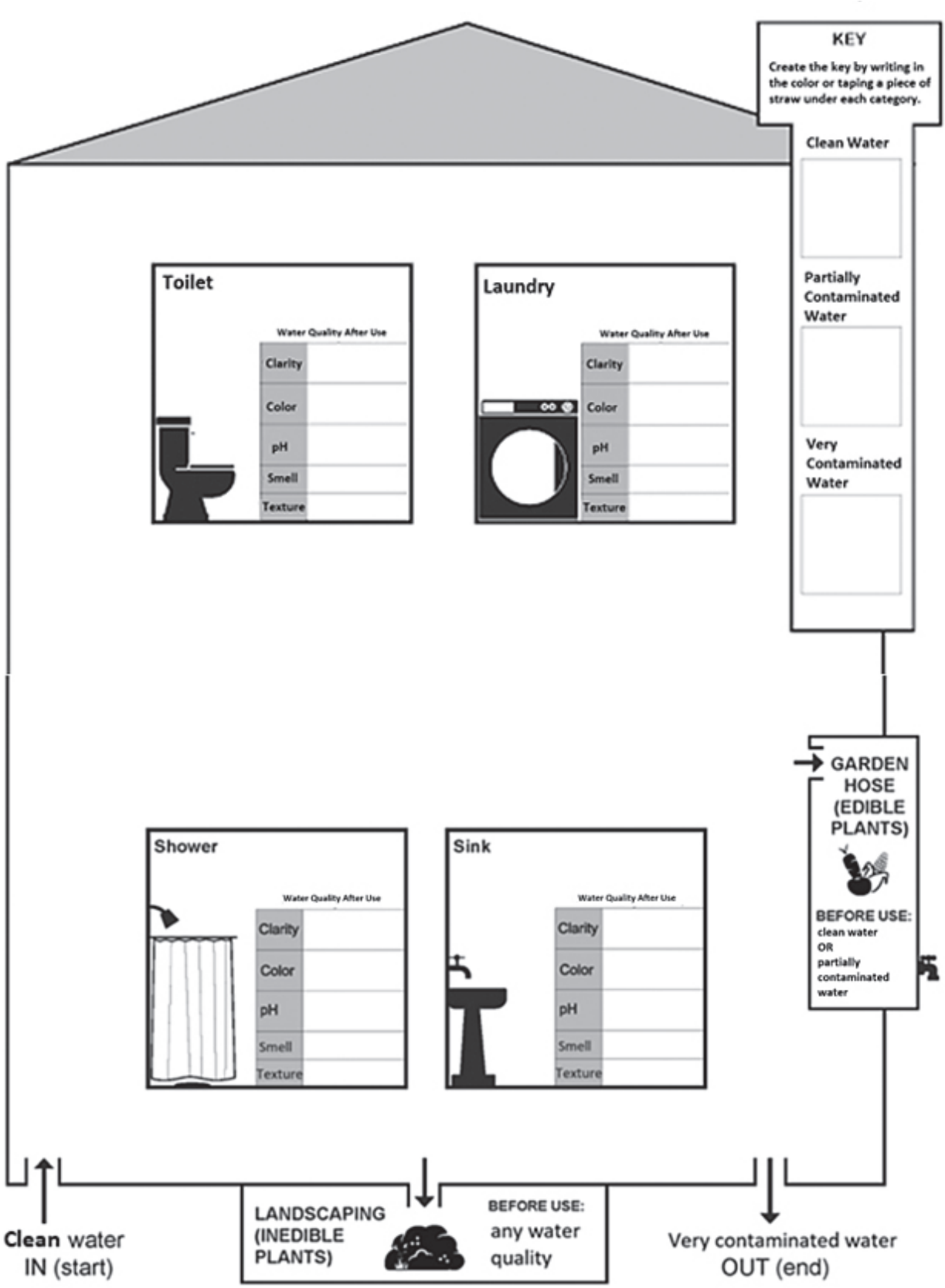
Activity 5 Materials Preparation (60 min.)

Ahead of Time

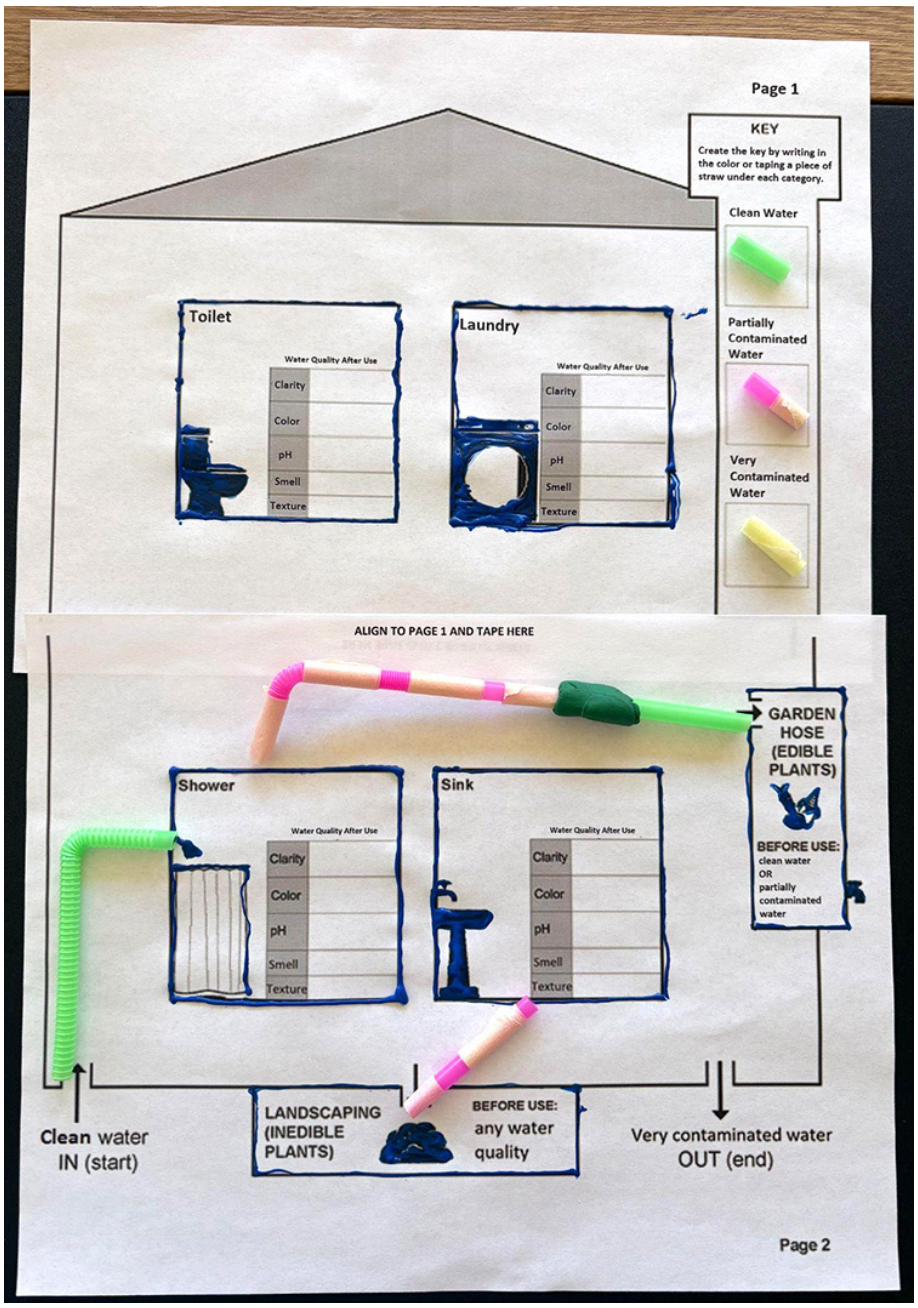
1. Watch the video Engineering How to Part 2 (0:00–1:08) to learn about what happens in this activity.
2. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
3. For each group, make copies of both pages of *Engineering Activity 5 Mapping Water Reuse Handout* and tape the two pages together to make one larger sheet for each group (see pgs. 75-76).
4. Fill in the "After Use" water quality sections on the *Engineering Activity 5 Mapping Water Reuse Handout* pages by using learners' data from *Our First Water Sample*, pg. 8 in their Engineering Notebook (PDF).
5. Optional: Glue pieces of yarn to the outlines of the toilet, washing machine, shower, and sink so they can be identified by feel as well as by sight. Attach one cup to each room. Use cups of different materials or cut them to different sizes to make them easy to distinguish for learners who are blind or low vision. (You can also use puff paint or Wikki Stix.)
6. Decide how to make the three kinds of connectors accessible by feel as well as sight. You can
   - Attach intermittent bands of painter's tape to each of the Color 2 straws. Cover the Color 3 straws entirely with painter's tape.



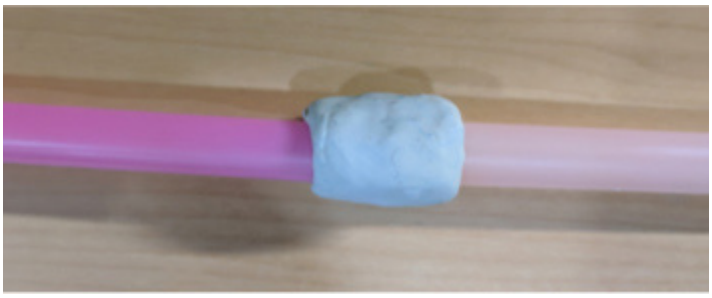
   - Use straws and two other kinds of long items (such as craft sticks and pencils).
7. Make one copy of Engineering Activity 5 Made to Order Handout, pg. 77, for each group.



Mapping Water Reuse Handout pages taped together.



Part of a process is shown on ***Engineering Activity 5 Mapping Water Reuse Handout.***



Modeling clay represents the location of a filter.

In Your Space

8. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Activity 6 Pre-Preparation (15 min.)

Learners will need a total of 12 Filter Bases over the course of this unit (only 6 are needed for Activity 5, but 12 are needed for Activities 6–9). Making Filter Bases can be time consuming, so consider preparing them ahead of time. Follow the Preparing Filter Bases Instructions, pg. 62.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We investigated how different filter materials can improve water quality in different ways.)* Indicate the word *filter* on the *Our Ideas* poster.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

2. Ask: **What is the problem we are trying to solve?** *(We are trying to find ways to help people reuse water in places where water is hard to get.)* Show the *Engineering Activity 2 Extreme Environments* slides to remind learners of the locations.
3. Draw learners' attention to the section of the *Our Ideas* poster that describes clean and contaminated water. Say: **One of the problems with very contaminated water is that it cannot be reused as is. However, if it is filtered and its water quality improves, then it can be reused for some purposes.**
   - Make sure to be clear that in a real building, very contaminated water such as sewage must be treated before it can be reused. Simple filters like the ones used in this activity are not sufficient.
4. Say: **In addition to using water for one purpose, engineers design larger systems in which water is used for multiple purposes. Like these engineers, we are going to imagine we are redesigning a building in our community to reuse more water. We will use what we learned about water quality to change the flow of water so it can be reused.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **In what orders can water be reused?**
5. Organize learners into groups of four.

A Reuse Process (25 min.)

6. Give each group a copy of *Engineering Activity 5 Made to Order Handout*, pg. 77, to review the challenge. Explain that things your design needs to do are called ***criteria***, and limits on a design are called ***constraints***. Have learners write these words after their definitions on the page, and add them to the *Our Ideas* poster.

Support Learner Differences

To increase learner engagement, you can tell learners they are redesigning a specific building in your community (possibly the building in which you are running the activity or a building they discussed during Activity 2). If your community does not have running water, consider choosing a specific building learners are familiar with elsewhere that would be appropriate to redesign.

Support Thinking

Consider bringing learners to an area where exposed pipes are connected to a sink or toilet.

7. Pass out a taped set of *Engineering Activity 5 Mapping Water Reuse Handout*, pgs. 75–76, to each group. Allow learners to examine the pages. Hold up the items as you explain that they will use straws (or other objects) as model pipes and they will use clay to represent the location of filters (see images in *Materials and Preparation*, pgs. 68-69). They will not be putting water into the straws.

8. Assign one straw color and tape pattern (or one type of object) to indicate each water quality (clean, somewhat contaminated, and very contaminated) and instruct learners to record these colors or patterns on the Key on the first page of the *Engineering Activity 5 Mapping Water Reuse Handout,* pgs. 75–76. Review what these terms mean. Ask: **What is the difference between clean, somewhat contaminated, and very contaminated water?** *(Clean water has the fewest contaminants and can be used anywhere. Somewhat contaminated water has some contaminants and can be used in the toilet and for plants. Very contaminated water has the most contaminants and cannot be used until it is treated.)* Give each group a copy of *Engineering Activity 3 How Clean Does It Need to Be? Handout*, pgs. 52–53, to review the requirements for the different levels of water quality.

9. Pass out a taped set of *Mapping Water Reuse* pages to each group. Have them discuss a plan for the order of water reuse.

10. Let learners gather their materials (straws or other objects, modeling clay, tape, and scissors) and begin designing the ways they will reuse water. They can cut straws and secure them in place with loops of painter's tape placed underneath the straws (make sure the securing tape does not interfere with the texture of other tape on the straws).

11. As groups are working, move around the room and ask: **Why is it important to know the water quality of the samples? How are you choosing an order for the steps to reuse water? In how many locations have you been able to reuse water? Can you think of other ways you could order the water flow?** Record the descriptive vocabulary used by learners, such as *cleaner*, *more contaminated*, *order*, *steps*, and *process* on the *Our Ideas* poster.

Support Learner Differences

- If learners are unfamiliar with the terms *edible* and *inedible*, have them think about plants they can and cannot eat. Explain that plants they can eat are edible and plants they cannot eat are inedible. Have learners give examples of edible and inedible plants in their communities. Note that edible plants become inedible when they are watered with very contaminated water, so it is important to know which plants will be used for food and which will be used for other purposes.
- As needed, provide groups with a tub or other container to hold their materials. Give learners time to examine the materials before they begin designing.

Support Thinking

Encourage groups to be creative with the way they sequence steps in the process. The steps can be arranged in a straight line, branches, or even a loop.

12. Say: **You have been developing a process for reusing water.** Write the word *process* on the *Our Ideas* poster. Ask: **What other processes do you use in your life?** *(Composting food to make soil to grow plants; recycling metal and glass; getting clothes, wearing them, and passing them on for others to use.)* Have learners come up with a definition for the word *process* together and record it on the poster (for example: a series of actions or steps leading to a result or goal.). You can have learners add translations and related images to the poster as well.
13. Bring out the plastic container of yellow water with the charcoal filter and the sample of yellow water with no charcoal. Ask: **What do you notice about the quality of the water now?** *(The water sample is less yellow than it was before.)* Ask: **How can you use this filter material in your water reuse process?** Make sure learners understand that some filters, like charcoal, take time to clean the water.

Reflect (10 min.)

14. Have groups pair up and discuss the Guiding Question: **In what orders can water be reused?** *(Water quality determines the order water can be reused for specific locations. Some locations require cleaner water than others, so a good order uses water at those locations first.).* As needed, remind learners of terms such as *process*, *criteria*, and *constraints* on the *Our Ideas* poster.
15. Ask: **What similarities do you notice between your processes? What differences do you notice? Is the process of reusing water a technology?** *(Yes. It solves the problem of not having enough water by ordering the flow of water so it can be reused.)*
16. Say: **Next time you will begin designing a process for reusing water in one of the four communities we have discussed: the desert Southwest, Mars, a research boat, or the International Space Station.**

Level Up!

- Learners may have questions about when "somewhat contaminated" water is used. Explain that its usage varies depending on the type of contamination, region, local regulations, plant species. Encourage them to look up or ask other learners or educators in your program how such water is used locally. (25 min.)
- Have learners think about the types of contamination astronauts have to deal with on the International Space Station. Would types of contamination be different on the Moon? Or on Mars? (10 min.)
- Ask this story prompt question: **Can you tell a story about a time when you've designed a process for other people to use, or followed a process someone else designed?** *(Possible responses include following a recipe, building something, or following directions.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We explored how the order of pipes between locations affects water reuse." (5 min.)
- Give each learner a copy of the Family Connection flyer (PDF) to share at home. (5 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We investigated why order is important; we planned how to order the flow of water; we created a process for reusing water in the home.)* (5 min.)

After the Activity

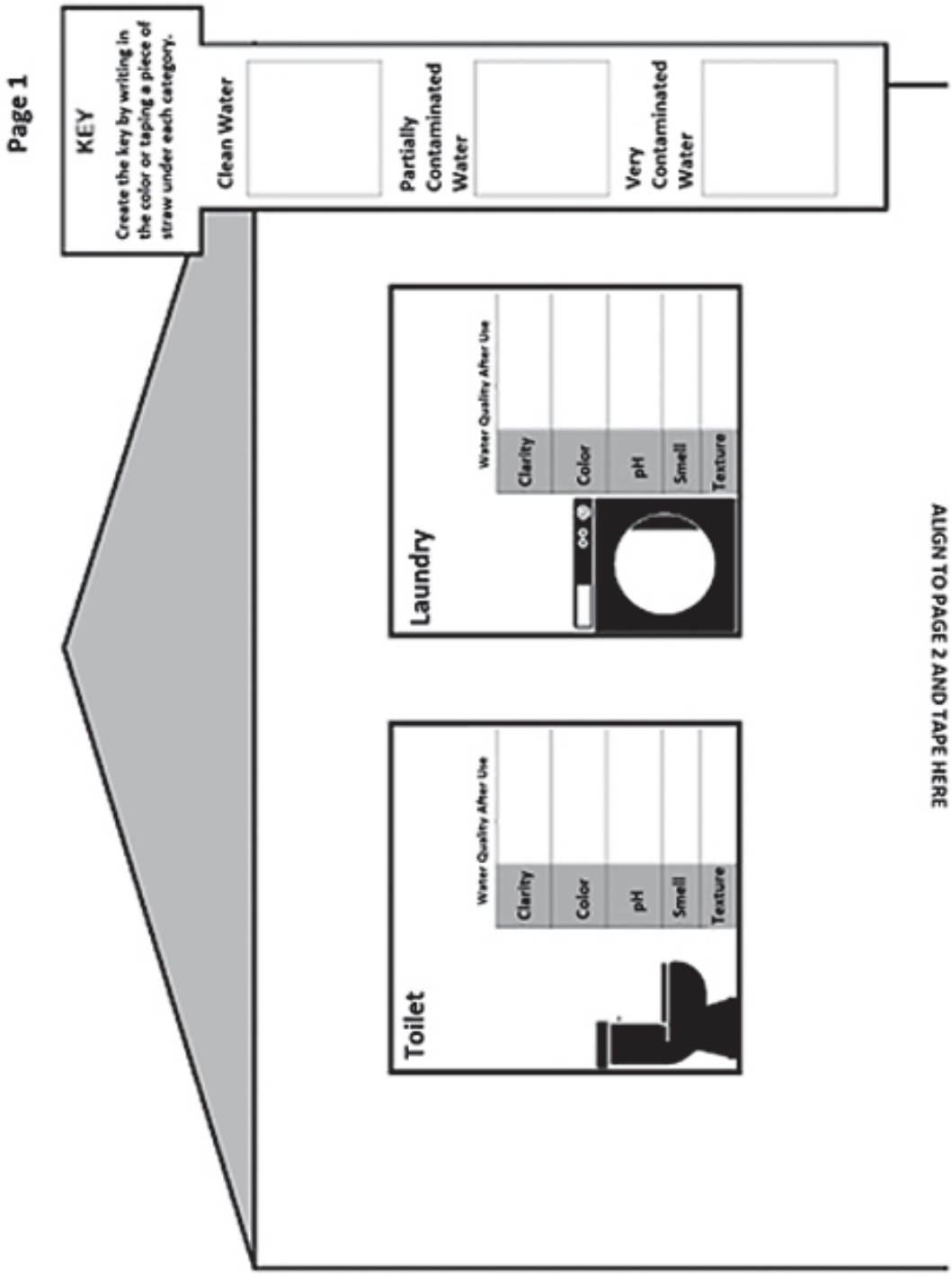
1. Clean up:
   - Save the *Our Ideas* poster for Activity 6.
   - Consider keeping the *Engineering Activity 5 Mapping Water Reuse Handout* pages with processes on them for reference in future activities.
2. Plan for Engineering Activity 6. See Engineering Activity 6 Preparation on pg. 81.
3. Take time to reflect on the following educator prompt. **How did learners demonstrate their understanding of the idea of a process?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Mapping Water Reuse



ALIGN TO PAGE 1 AND TAPE HERE
Clean water IN (start)
Shower
Water Quality After Use
Clarity
Color
pH
Smell
Texture
Sink
Water Quality After Use
Clarity
Color
pH
Smell
Texture
LANDSCAPING (INEDIBLE PLANTS)
BEFORE USE: any water quality
GARDEN HOSE (EDIBLE PLANTS)
BEFORE USE: clean water OR partially contaminated water
Very contaminated water OUT (end)
Page 2

Made to Order

We are reconfiguring a building to use less clean water.

Goal

Design a process for reusing water in the building.

Things your design needs to do (criteria)

- Each location must have water going in and coming out.
- Somewhat contaminated water must be used at one or more locations.
- You must represent filters with modeling clay.

Things you have to work with (constraints)

- You will have only five straws of each type and half a stick of modeling clay. (The water will not actually go through the straws.)
- One filter can improve water quality by only one level.
- You cannot reuse toilet water.

Engineering Activity 6: Reuse in Action: Create a Process

Educator Preview

Activity Snapshot

Learners work in groups to plan, create, and test a water reuse process for an extreme environment.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Plan, Create, and Test	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–45 min. each

Prep Snapshot*

Prep Time 45 min.

- Space Need: Sink
- Create Filter Bases.
- Set up Materials Store.
- Print handouts.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking
- Collaboration
- Creativity

Habits of Mind

- Envision multiple solutions.

Guiding Question

Does our final water reuse process meet our water quality goals?

Learners Will Do

Create and test a water reuse process.

Learners Will Know

Engineers apply what they learn from investigations to inform their design decisions.

Connecting Across Activities

Activity 5: Investigating Reuse Process	Activity 6: Create a Process	Activity 7: Improve a Process
Last time, learners applied what they learned about water quality to reconfigure a model building to reuse as much water as possible.	**Today**, learners work in groups to plan, create, and test a water reuse process.	**Next time**, learners will improve their water reuse processes to better meet the criteria for their group's environment.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/c2872316

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- 1 bottle of scented liquid
- 1 bottle of soap
- 1 bottle of vinegar
- 1 cup of soil
- 1 roll of masking tape
- 1 roll of paper towels
- 1 safety glove
- 1 spool of thread
- 1 strainer
- 1 Tbsp detergent
- 1 teaspoon
- 1 tube of toothpaste, travel size
- 1 utility knife
- 1 vial of food coloring, yellow
- 1 learners-made water reuse process, from Activity 5
- 2 tablespoons
- 2 tea bags, black tea
- 6 two-liter bottles
- 8 containers, 1/2 gallon
- 8 sheets of copy paper
- coffee grounds
- natural materials (such as sticks, grass, sand)
- 1 roll of plastic wrap (optional)
- towels or disposable tablecloths (optional)

For each learner

- Engineering Notebook (PDF)

For the Materials Store

- 1 measuring cup, 1/4 cup
- 2 cups of activated charcoal
- 2 cups of limestone gravel
- 4 cups of sand
- 8 craft sticks
- 18 pieces of cheesecloth, 12" × 12"
- 18 half-sheets of paper towel
- 20 rubber bands
- 60 plastic cups, 8 oz.
- 80 cotton balls

For each group of 4

- 1 flashlight
- 1 foil tray, 12" × 12"
- 1 measuring cup, 1 cup
- 1 packet of pH strips
- 1 pair of scissors
- 1 permanent marker
- 1 piece of construction paper (the same color for all groups)
- 2 Filter Bases
  - Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94

Activity 6 Materials Preparation (45 min.)

Ahead of Time

1. Watch the video Engineering How to Part 2 (1:08–2:35) to learn about what happens in this activity.
2. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
3. Follow the Preparing Filter Bases Instructions, pg. 62 to make 6 more Filter Bases (for a total of 12) if not previously assembled.
4. Make one copy of Engineering Activity 6 Choose an Environment Handout, pgs. 89-92, for each group.
5. Make one copy of Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94, for each group, and cut out the cards. If it is useful to your learners, print these pages on swell paper or attach materials such as wiki sticks so learners can feel what is on each strip of paper.

In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
7. Prepare new water samples using the recipes on *Water Samples for Final Challenge Recipes*, pgs. 87-88, in this guide. Use the masking tape and a permanent marker to label them.
8. Using the strainer, rinse the charcoal under running water until the water runs clear (approximately 1 minute).
9. Arrange the water samples and the materials on a table to make a Materials Store. Place the tablespoons with the limestone and charcoal and the 1/4 cup with the sand on the table.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Place *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards* in bags or envelopes for easy distribution.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We investigated how different processes allow water to be reused.)*

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

2. Draw learners' attention to three major concepts on the *Our Ideas* poster: water quality, filters, and reuse processes. Check for understanding of these concepts. If needed, return to these terms and have learners discuss the terms and make drawings for them. Say: **You will now use all the ideas you have explored so far: water quality, filters, and reuse processes.**
3. Say: **Today we will start the final design challenge: designing a process to reuse water, including actual filters and the order in which they are used. Last time, we thought about a building in our community. Now, you will be able to choose one of the four locations we've talked about to design for.** Share the Guiding Question with learners aloud and in writing on the *Our Ideas* poster (using multiple languages as needed): **Does our final water reuse process meet our water quality goals?**
4. Organize learners into groups of four.

Plan, Create, and Test (25 min.)

5. Give each group a copy of *Engineering Activity 6 Choose an Environment Handout*, pgs. 89-92, and have them review the environments they can choose from. Indicate the words *criteria* and *constraints* on the *Our Ideas* poster to remind them about the meaning of those terms. If needed, have learners discuss the terms and make drawings for them.
6. Give each group 5 minutes to choose one of the environments. When they make a decision, have learners write their environment, water sources, and goal on *Planning a Process*, pgs. 11-12 in their Engineering Notebooks.

Level Up!

- Have learners build a model of the environment they choose (using craft supplies, Legos, etc.) to help them think about how the parts of that environment might be connected. (30 min.)
- Have learners research a real-world context where water filtration and reuse is important. It can be a location on Earth, like a community they belong to or a community with limited or contaminated water, or another NASA mission, such as Artemis. (30 min.)

Teaching Tip

Make clear that learners cannot use their systems to create drinkable water, and they **should not** drink the water they have filtered, no matter how clean it appears to be.

7. Allow learners to examine the containers with the water samples you prepared. Explain that they will be ordering and filtering the water from up to four sources: bathroom sink, shower, laundry, and space toilet. (Groups designing for the farmhouse environment can use a fifth source: farm field.)

8. Display one of the *Engineering Activity 5 Mapping Water Reuse Handout* pages with processes on them from Activity 5. Remind learners that both the filter materials and the order of the filters matter in producing water that is clean enough to reuse.

9. Hold up *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards,* pgs. 93-94, as you explain that learners will create a model process showing how water is used in one location, is filtered to a new level of quality, and then is reused in another location. They can arrange the water locations in any order, but their process must meet the criteria listed for their environment. Ask: **How can we test if the water is clean enough to reuse?** *(We can observe clarity, color, pH, smell, and texture.)* **How will we know where the water can be reused?** *(We can test the sample and check the* How Clean Does It Need to Be? *handout.)*

10. Remind learners that although they will have multiple water locations within their environment to think about, they will have only two Filter Bases. Learners can use multiple filter materials in each Filter Base and combine water from multiple locations to send through the Filter Bases.

Teaching Tip

A space toilet is different from a toilet on Earth because solid waste is disposed of separately, while liquid waste is collected for reuse.

Support Learner Differences

If learners have struggled with previous activities, consider starting them with the farmhouse. Once they are successful, they can select a more challenging environment. To discuss the different levels of difficulty, you can explain that sources of drinking water on Earth include rain, groundwater, lakes, rivers, and springs. Off-the-grid homes—even the ones in the driest deserts—don't have to be as efficient as NASA space missions because they can get more water from sources on Earth.

Level Up!

If learners want more information about the different environments, you can share the following:

- The surface of Mars is almost completely dry. There are reservoirs of water ice in the north and south polar caps and under the surface in some locations.
- Ocean water is not usable to sailors on most ships because it is too salty. The Navy is working with NASA to improve its ability to use and reuse ocean water for human activities. (5 min.)

11. Give each group a set of *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards,* pgs. 93-94, and let them order the cards on the table to plan their water reuse processes. Encourage them to record their ideas on *Planning a Process*, pgs. 11-12 in their Engineering Notebooks.

Support Thinking

Learners can place the Filter Bases directly on top of the Filter Base cards, if they choose.

Teaching Tip

If time is short, you can pause the activity here and finish it during another session.

12. After learners finish their plans, have them gather materials from the Materials Store and begin engineering their water reuse processes. Note that the order is not linear; in fact, sometimes two different water sources must go through the same filter. Have learners record the materials on *Planning a Process*, pgs. 11-12 in their *Engineering Notebook*.

13. When groups are ready to test their processes, have them label plastic cups with the name of each water location they will include, then come to the Materials Store. Stir the samples with a craft stick and then pour 1/2 cup of water into each labeled cup.

14. Give groups copies of *Engineering Activity 3 How Clean Does It Need to Be? Handout*, pgs. 52–53, to review the requirements for clean water, somewhat contaminated water, and very contaminated water. Have groups test their processes and record the quality of their final water sample on *Testing a Process*, pg. 14 in their Engineering Notebooks. Have them compare the result to the criteria and constraints for their environment to determine if their process has met their goals.

Teaching Tips

- The pH strips may stain the tabletop, so place used strips on a paper towel.
- Groups may want to use charcoal in their processes overnight. Label their designs, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

15. Let learners know when there are 10 and 5 minutes remaining.

Support Thinking

Learners may say that they have failed. Emphasize that engineers think about designs failing, not about people failing. Explain that failure is an important way in which engineers gather information to improve their designs. Ask: **What did you learn from the failure of this design?** *(We need to include a different material in the filter; the process needs to go in a different order.)*

Reflect (10 min.)

16. Have each group come up with an answer to the Guiding Question: **Does our final water reuse process meet our water quality goals?** Additionally, have them discuss the following questions: **How have you ordered your water locations? Is your process working like you thought it would? Are you meeting the criteria of your environment? How might you improve your process?** As needed, remind learners of terms on the *Our Ideas* poster.

17. Say: **Next time, you will improve your water reuse process. Later, you will share design recommendations for water reuse processes and demonstrate the importance of reusing water in environments on Earth and in space.**

18. Have learners clean up by

    - rinsing the charcoal and limestone with the strainer and setting them aside for use in later activities.
    - rinsing their Filter Bases and placing them in their tray with their Water Reuse Plan location cards.
    - labeling their trays for next time using a permanent marker and masking tape.

Level Up!

- Ask this story prompt question: **Can you tell a story about something you've designed in the past?** *(Possible responses include designing objects, systems, or processes.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We designed a process to filter and reuse water." (5 min.)
- Invite a family or community member to come in as a special guest and share their knowledge about water-related topics. (45 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We planned, created, and tested our processes for reusing water.)* (5 min.)

After the Activity

1. Clean up:
    - Discard the remaining used filter materials.
    - Save groups' design components in a safe location so learners can improve them in the next activity.
    - Save the containers with the water samples for the Share-Out. Be sure to label them, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill. (If you lack storage space, you can take pictures instead.)
    - Save the *Our Ideas* poster for use in Activity 7.
    - Collect all handouts.
2. Plan for Engineering Activity 7. See Engineering Activity 7 Preparation on pg. 97.
3. Take time to reflect on the following educator prompt. **Which environments did learners choose? Why do you think they chose those environments?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: **https://hov.to/7cb5c428**

Water Samples for Final Challenge Recipes

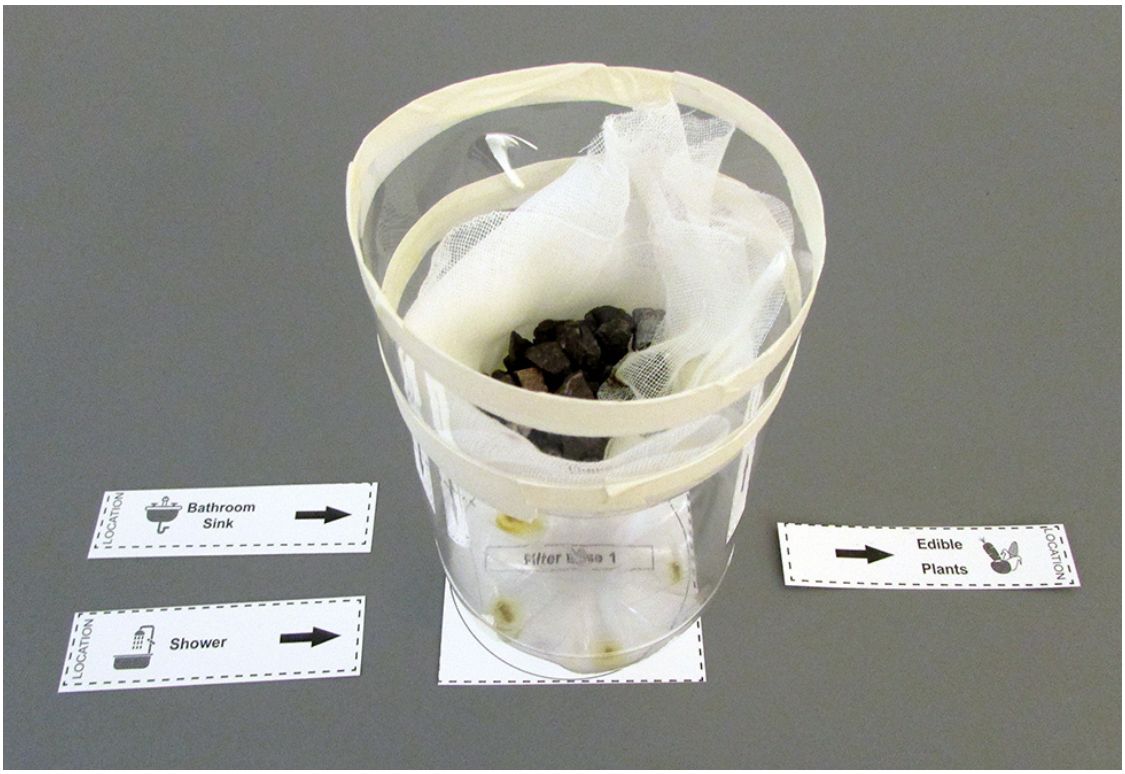
Groups will share these samples to test their water reuse process, 1/2 cup at a time.

Water Source	Mixtures
Farm Field	■ 1/2 gallon container of water ■ 1/2 tsp scented liquid ■ 1 Tbsp loose soil ■ 2 Tbsp vinegar
Space Toilet	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 2 drops yellow food coloring
Laundry	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 1 tsp soap ■ 1 tsp soil ■ 2 Tbsp vinegar ■ 30+ pieces of thread, 1–2" long
Shower	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 1 tsp detergent ■ 1 tsp tea leaves ■ 1 Tbsp soil
Bathroom Sink	■ 1/2 gallon water ■ 1/2 tsp scented liquid ■ 1 tsp soap ■ 2 blobs toothpaste, pea sized

1. Prepare two containers of each water mixture (or, if you are including the farm field sample, 1–2 containers of each mixture).
2. Prepare each mixture in a separate 1/2 gallon container.
3. Stir well before distributing.

Teaching Tip

There are 8 cups in a half gallon, so if several groups choose the same scenario, you may need to make an extra containers of the water samples listed in that scenario.



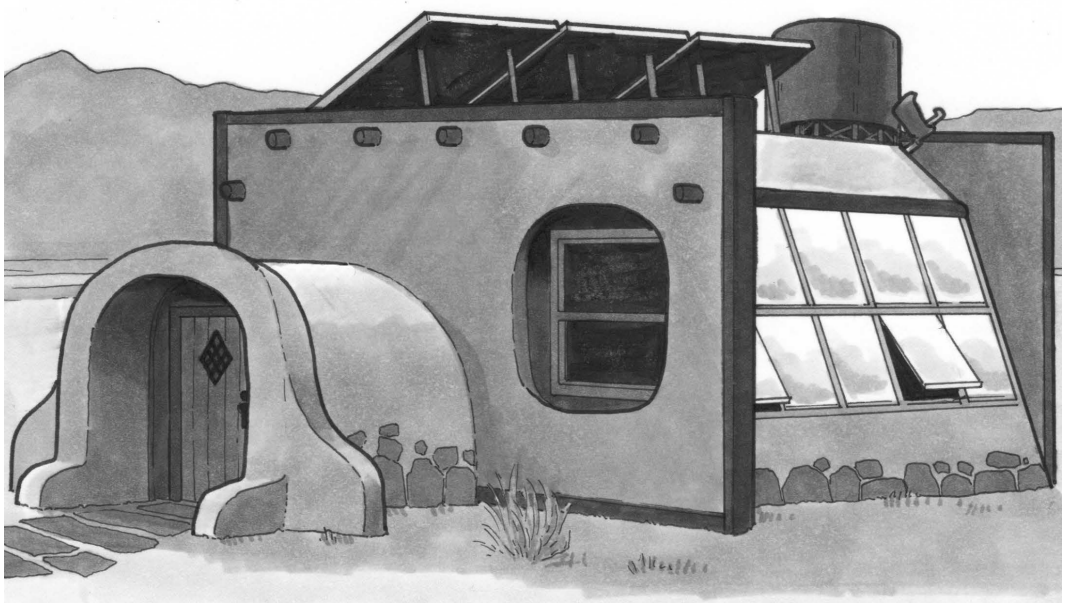
Example Water Reuse Process on Tabletop (step one of a process) with Location and Filter Base Cards.

Choose an Environment

Choose one of the four environments to design a process for.

Farmhouse

Your team is building an off-the-grid farmhouse in the American Southwest, which means all resources (water and electricity) will come from the environment. This home is specially designed to collect and reuse water. You will need to create a process that filters enough water to reuse in the vegetable garden.



Criteria

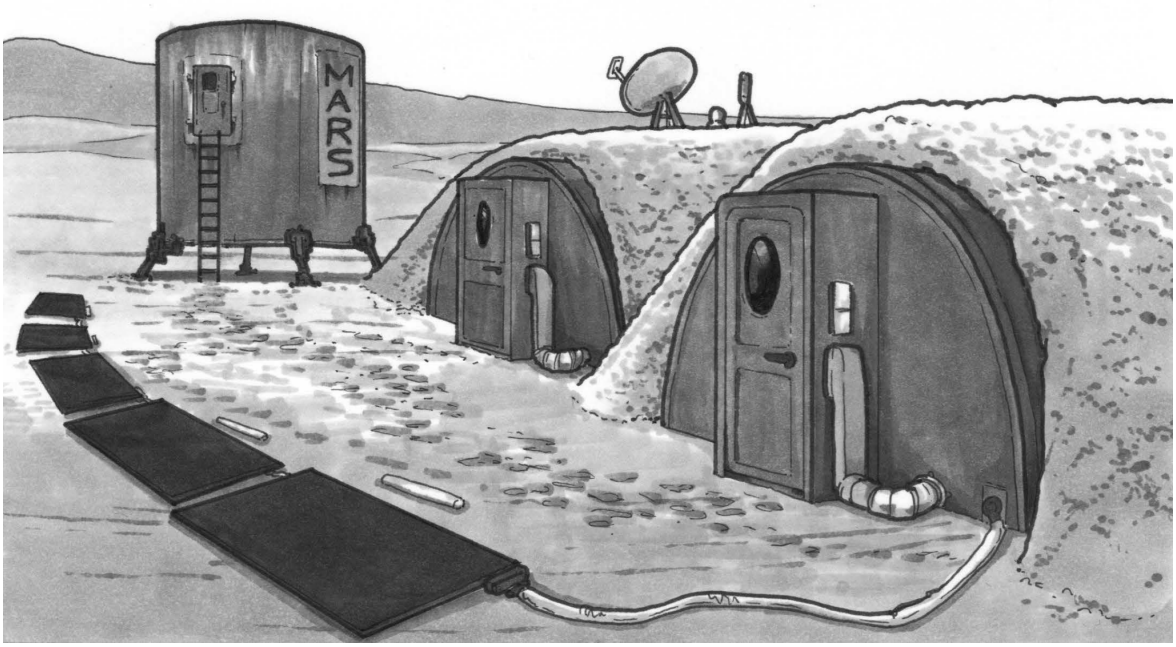
- Must filter water from each source:
  - bathroom sink
  - shower
- Must produce
  - clean or only somewhat contaminated water for watering edible plants

Constraints

- You can use two Filter Bases.

Mars Habitat

Your team is designing a process for reusing water on Mars. This process needs to reuse as much water as possible and still produce enough water for the plants in the greenhouse.



Criteria

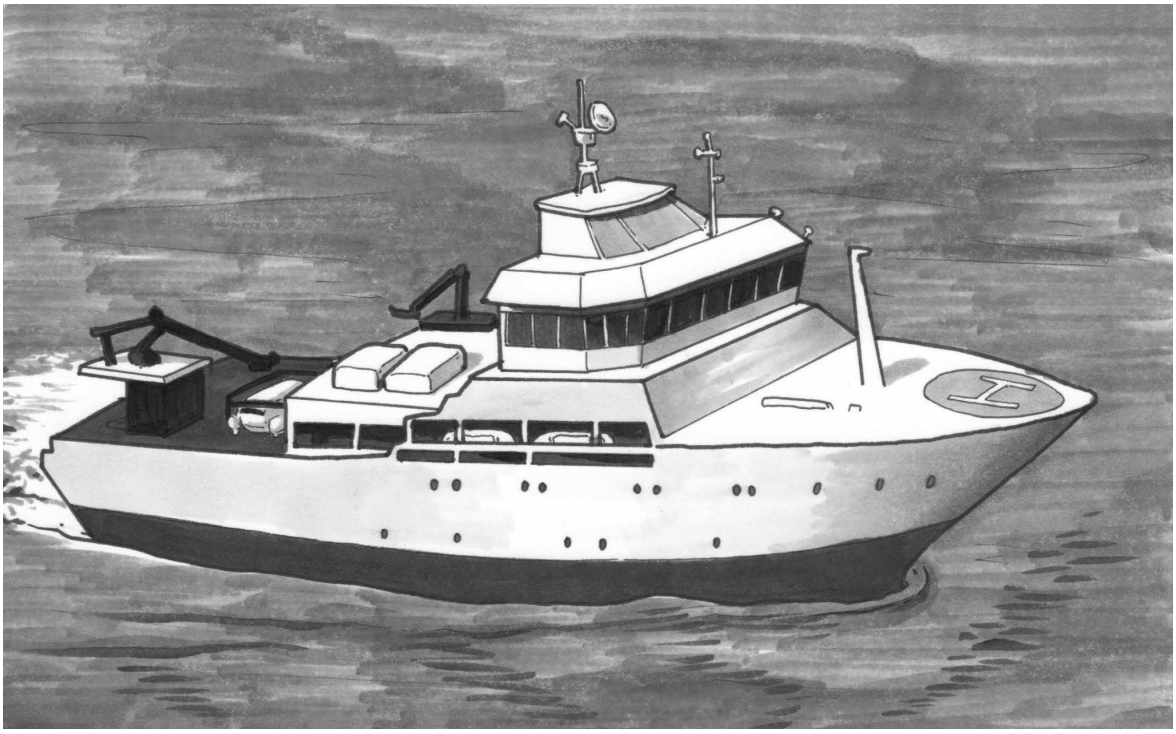
- Must filter water from each source:
  - laundry
  - shower
  - space toilet
- Must produce
  - clean or only somewhat contaminated water for watering edible plants

Constraints

- You can use two Filter Bases.

Floating Research Lab

Your team is living on a boat on the ocean, so no fresh water is available. You will have to filter and reuse as much water as you can onboard, or you'll risk polluting the surrounding waters.



Criteria

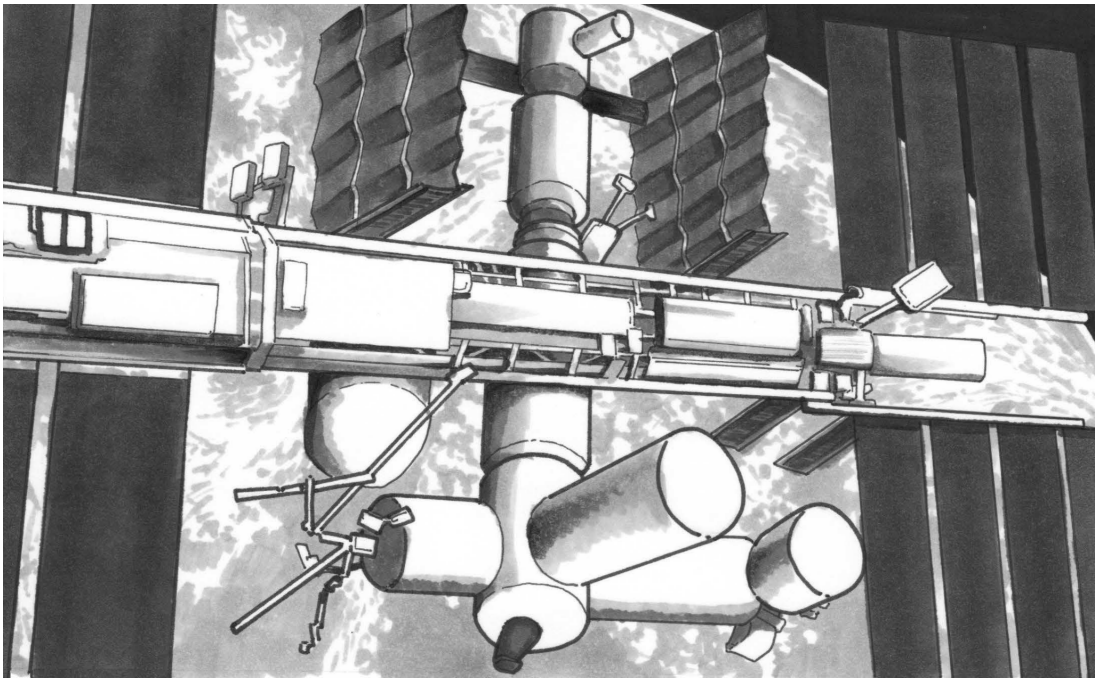
- Must filter water from each source:
  - bathroom sink
  - laundry
  - shower
- Must produce
  - clean or only somewhat contaminated water for toilet

Constraints

- You can use two Filter Bases.

International Space Station

Your team is creating a process for reusing water for the International Space Station. You need to reuse all the water you use on board. The next shipment of clean water won't arrive for another three months!



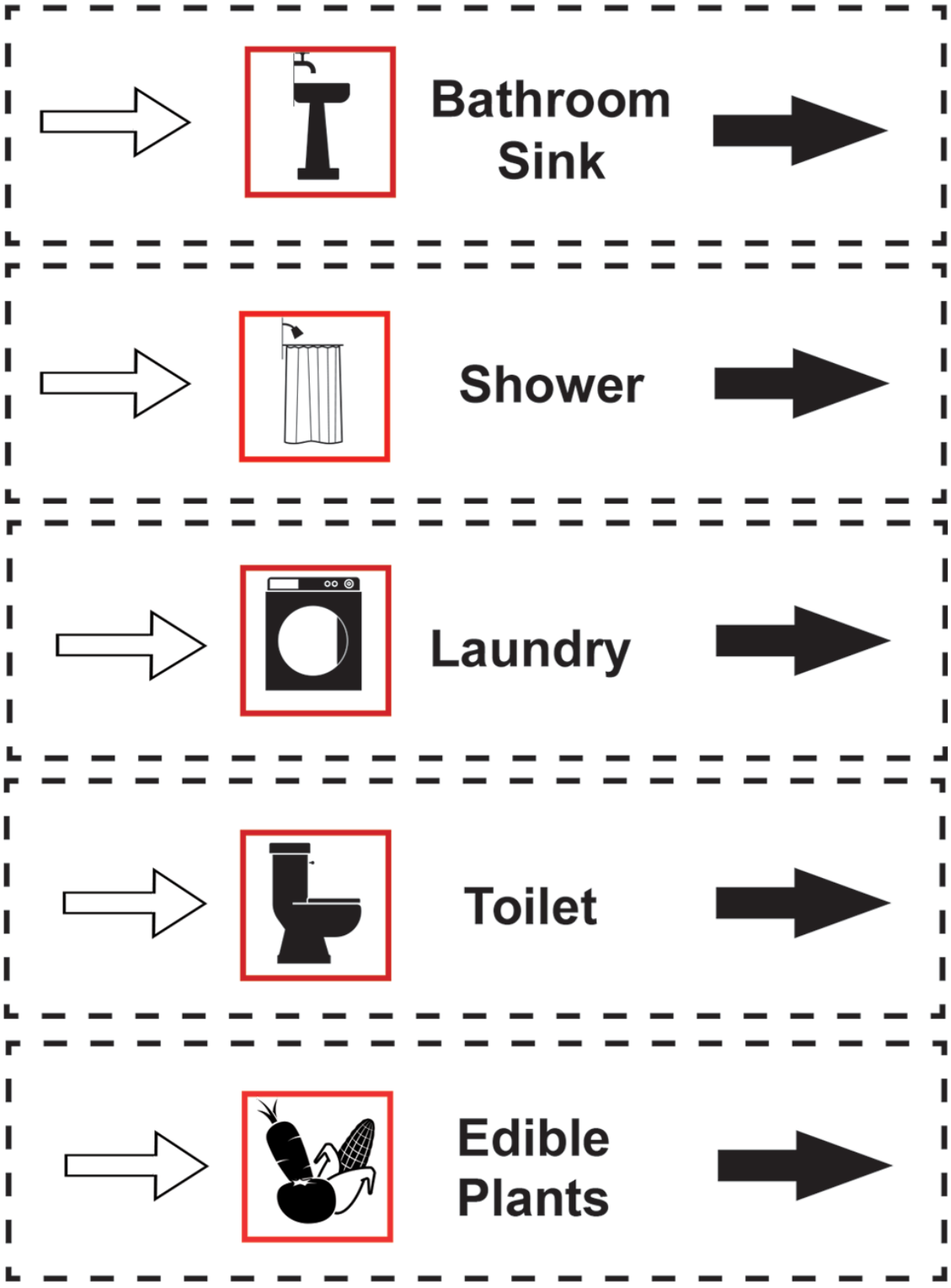
Criteria

- Must filter water from each source:
  - bathroom sink
  - laundry
  - shower
  - space toilet
- Must produce
  - somewhat contaminated water
  - clean water

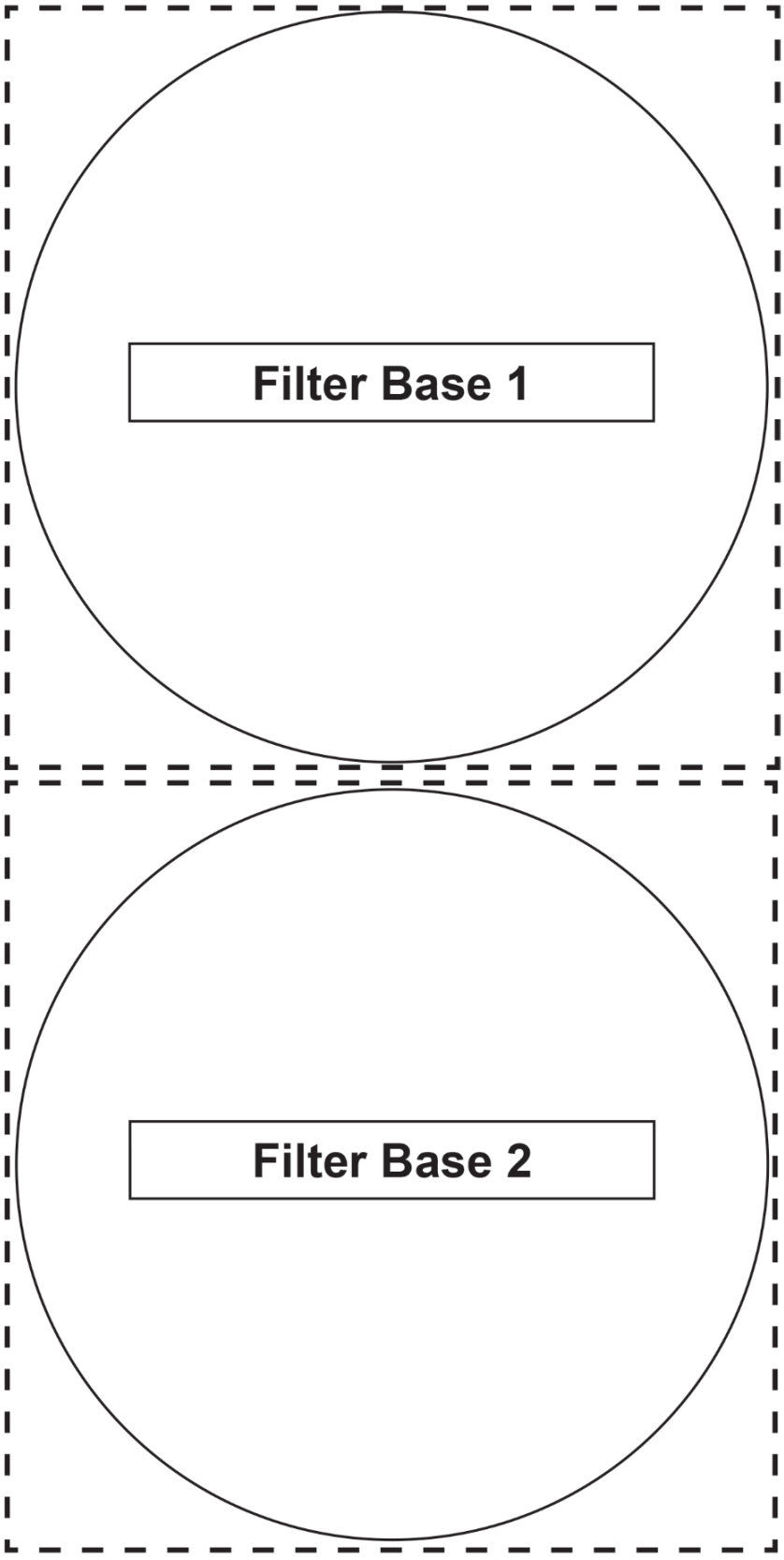
Constraints

- You can use two Filter Bases.

Water Reuse Plan Location and Filter Base Cards



Cut out the boxes and arrange these cards on the table to plan your water reuse process.



Engineering Activity 7: The Final Test: Improve a Process

Educator Preview

Activity Snapshot

Learners improve their water reuse processes to better meet the criteria for their environment.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Improve	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–20 min. each

Prep Snapshot*

Prep Time 20 min.

- Space Need: Sink
- Set up Materials Store.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking
- Collaboration

Habits of Mind

- Persist and learn from failure.
- Innovate processes, methods, and designs.

Guiding Question

How can we improve our water reuse processes?

Learners Will Do

Attempt to make their water reuse processes more effective.

Learners Will Know

Engineers reflect upon, change, and improve their designs.

Connecting Across Activities

Activity 6: Create a Process	Activity 7: Improve a Process	Activity 8: Preparing for the Engineering Share-Out
Last time, learners worked in groups to plan, create, and test a water reuse process.	**Today**, learners improve their water reuse processes to better meet the criteria for their group's environment.	**Next time**, learners will prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/f8463f44

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- Remaining materials from Activity 6
- 1 measuring cup, 1/4 cup
- 1 roll of masking tape
- 1 roll of paper towels
- 1 strainer
- 2 tablespoons
- 8 craft sticks
- 8 containers, 1/2 gallon, with water samples
- 35 sheets of copy paper
- 1 roll of plastic wrap (optional)
- towels or disposable tablecloths (optional)

For each group of 4

- 1 flashlight
- 1 foil tray, 12" × 12"
- 1 packet of pH strips
- 1 pair of scissors
- 1 permanent marker
- 1 piece of construction paper (the same color for all groups)
- 1 set of Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94
- 2 Filter Bases

For each learner

- Engineering Notebook (PDF)

Activity 7 Materials Preparation (20 min.)

Ahead of Time

1. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Optional: Make a new copy of the Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94, if the first copies were damaged by water.

In Your Space

3. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
4. Create a Materials Store with the materials remaining from Activity 6.
5. Optional: Prepare more water samples in the containers using the recipes on *Water Samples for Final Challenge Recipes*, pgs. 87-88, and other recipes from Activity 6.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We planned, created, and tested a water reuse process for an environment.)*

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

2. Say: **Today you will improve your water reuse process to make it more affordable and effective. You can improve by lowering the cost of the process, decreasing the amount of materials you use, or increasing the quality or amount of water your process produces.** Share the Guiding Question with learners aloud and in writing on the *Our Ideas* poster (using multiple languages as needed): **How can we improve our water reuse processes?**
3. Organize learners into their groups of four from the previous activity.

Improve (25 min.)

4. Remind learners that improving is an important part of the Engineering Design Process. It will help them understand what design principles work best for water reuse systems. Later, they will share their design recommendations with visitors in an Engineering Share-Out.
5. Have groups pair up and share their results, discuss problems, or give advice from the last activity. Ask: **Which environment did you choose? Did your design work the way you imagined it would? What worked well? What challenges did you encounter? How can you rearrange the process to get more water out of the process, or improve water quality?**
6. Say: **One way to improve your process is to make sure it is not too expensive. Each environment now includes a budget as an additional constraint.** Ask: **Which materials do you think will cost more? Why?** Say: **You can find your budget and the costs of materials on *Cost Sheet*, pg. 17 in your Engineering Notebook.**
7. Have learners calculate the cost of their previous filter using the materials listed on *Planning a Process*, pgs. 11-12 in their Engineering Notebook.
8. Say: **You will now plan improvements to your process for reusing water. You should use the data you gathered last time to choose at least one part of your process to improve. You also need to stay within your budget.**
9. Give groups five minutes to record their improved designs on *Improving a Process*, pg. 18 in their Engineering Notebook.
10. When groups complete their plans, have them collect materials from the Materials Store and begin improving.

Support Learner Differences

For some learners, the introduction of the budget may be distracting and too challenging. Encourage these learners to improve their designs in other ways, such as by improving the effectiveness of the filters or increasing the number of times water is reused.

11. Encourage groups to test their designs as they improve. Let groups know that they can record new testing data on *Improving a Process*, pg. 18 in their Engineering Notebook.

Support Thinking

If needed, distribute copies of Engineering Activity 3 How to Test Water Quality Handout, pgs. 47–51 and Engineering Activity 4 Testing Materials for Cleaning Handout, pgs. 63-64, to review the procedures for testing water quality and using a Filter Base.

Teaching Tips

The pH strips may stain the tabletop, so place used strips on a paper towel.

If learners have trouble improving their designs, encourage them to ask other groups for advice.

12. Let groups that are still working know when there are 10 and 5 minutes remaining. As learners finish testing and improving, congratulate them on their engineering work.

Teaching Tip

Some groups may want to use the charcoal in their processes and let the filter work overnight. Be sure to label their designs, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

Reflect (10 min.)

13. Have each group come up with an answer to the Guiding Question: **How can we improve our water reuse processes?** *(We can improve the filters and adjust the order to make the water reuse process better.)* Additionally, have them discuss the following questions: **Are your improvements working out the way you thought they would? What else can you do to improve your design?** As needed, remind learners of terms on the *Our Ideas* poster.

14. Say: **Next time, you will think about the design recommendations you would give to someone else designing a water reuse system.**

15. Have learners discard used filter materials (except charcoal, limestone and other reusable materials) and their final water samples, then rinse their Filter Bases and place them in their tray with their *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards*. Have groups re-label their trays if needed.

Level Up!

- Ask this story prompt question: **Can you tell a story about how you made changes to make something better?** *(Possible responses include stories about improving skills, technologies, ideas, or relationships.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We improved a process to filter and reuse water." (5 min.)
- Astronauts on the International Space Station have improved their systems enough that they are able to recover and reuse 98% of the water they use! Read more about the filters they use here NASA Achieves Water Recovery Milestone on International Space Station - NASA. (5 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We planned how we wanted to change our design; we created and tested improved designs.)* (5 min.)

After the Activity

1. Clean up:
   - Save the containers with the water samples and groups' design components in a safe location so learners can share them later.
   - Save the *Our Ideas* poster for Activity 8.
2. Plan for Engineering Activity 8. See Engineering Activity 8 Preparation on pg. 102.
3. Take time to reflect on the following educator prompt. **How did you support learners to persist through and learn from failure?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Engineering Activity 8: Spread the Word: Preparing for the Engineering Share-Out

Educator Preview

Activity Snapshot

Learners prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Preparing the Presentation	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 20–25 min. each

Prep Snapshot*

Prep Time 15 min.

- Space Need: Sink
- Set up Materials Table.
- Invite people to Share-Out.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Collaboration
- Communication

Habits of Mind

- Make evidence-based decisions.
- Communicate effectively

Guiding Question

What design recommendations do we have for water reuse processes?

Learners Will Do

Plan how to discuss what they have learned with members of their community.

Learners Will Know

Engineers have valuable knowledge to share about the problem they have solved.

Connecting Across Activities

Activity 7: Improve a Process	Activity 8: Preparing for the Engineering Share-Out	Activity 9: Engineering Share-Out
Last time, learners improved their water reuse processes to better meet the criteria for their environment.	**Today**, learners prepare to communicate their ideas about designing a water reuse process in the Engineering Share-Out.	**Next time**, learners will communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/95e4ce92

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- chart paper and markers
- remaining materials from Activity 7

For each group of 4

- designs from Activity 7

For each learner

- Engineering Notebook (PDF)

Activity 8 Materials Preparation (15 min.)

Ahead of Time

1. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Invite people from the community, including families and friends of learners, to the Engineering Share-Out.

In Your Space

3. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
4. Create a Materials Table with the materials remaining from Activity 7.
5. If needed, prepare more water samples in the containers using the recipes on *Water Samples for Final Challenge Recipes*, pgs. 87-88.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We improved our water reuse processes and tested them again.)* If learners describe specific improvements, you can note them on the *Our Ideas* poster.
2. Say: **You'll be sharing design recommendations for water reuse processes with others. This sharing will help them make their own reuse processes.** Share the Guiding Question with learners aloud and in writing on the *Our Ideas* poster (using multiple languages as needed): **What design recommendations do we have for water reuse processes?**
3. Organize learners into their groups of four from Activities 6 and 7.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

Preparing the Presentation (25 min.)

4. Give each group time to think about the following question: **What ideas do you think we should share?** *(Why water reuse is important; how we designed processes to reuse water; things other people should think about when designing water reuse processes.)* **How should we share them?** *(By talking, writing, drawing, discussing with others, and making records such as videos and audio recordings.)* When everyone is ready, discuss as a whole group.
5. The Share-Out is a chance for learners to explain their thinking and reflect on what they learned about water reuse throughout the unit. As a group, agree upon a structure for the Share-Out.

   Possible structures include the following:

   - Storytelling: Groups use the evidence they've collected to tell stories about water reuse and different environments. They can also tell their stories about water from Activity 1.
   - Gallery Walk: Groups host stations to explain their posters, graphs, maps, writings, drawings, or audio or videos on small devices.
   - Pair-Share: Groups pair off and share their choices with one another.
   - Screening: If time permits, groups make slideshows, animations, videos, or audio files. The whole group observes as these creations are screened.
   - Performance: Some people play scientists asking questions about learners' processes. You can develop script cards to include adults in the performance.
   - Discussion: Learners and community members share their knowledge. You can write discussion prompts to lead this discussion.

Support Learner Differences

Some learners may disengage if the Share-Out contains too much whole-group discussion. Think about what your learners need and ensure they choose an appropriate Share-Out structure.

6. Once learners have chosen a structure for the Share-Out, tell them they can prepare notes on *Communicate*, pg. 19 in their Engineering Notebook. Say: **Think about the languages spoken by your family and friends, and possible guests. Try to include those languages if you can.** Give groups time to reassemble their water reuse processes and make other preparations.
7. As groups are preparing, rotate among them and provide support.

Reflect (10 min.)

8. Have groups pair up and discuss the Guiding Question: **What design recommendations do we have for water reuse processes?**
9. Say: **Next time, you will share your designs with an audience. Communicating with others is an important part of an engineering design process.** Have each group discuss: **Why is it important to share what we have done and learned with others?** *(So others can build on our knowledge; so they don't make the same mistakes.)* Hand out copies of the Engineering Activity 8 Share-Out Invitation (PDF) for learners to give to caregivers, family, and friends.

Support Learner Differences

- If you have learners who speak multiple languages, encourage them to share in their preferred languages. Circulate and ask groups: **Where can you include your preferred language or other languages you know in your share-out?** Encourage learners to make welcome signs and present in different languages spoken by the audience.
- All learners should contribute to the Share-Out, but not everyone will feel comfortable presenting in the same style. Indigenous learners may feel it is inappropriate to present directly as the center of attention. Ensure nonverbal presentation methods are available, and encourage participation behind the scenes, not just in presenting in front of the class.

Level Up!

- Ask this story prompt question: **Can you tell a story about a previous time you've presented your ideas and how you did it?** *(Possible responses include stories about sharing ideas in school, family, and community settings.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We prepared to share about water reuse processes we designed." (5 min.)
- Invite family and community members to participate in the Engineering Share-Out by sharing their stories and expertise. (25 min.)

After the Activity

1. Clean up:
   - Save each group's design and presentation materials for the Engineering Share-Out.
   - Keep the *Our Ideas* poster for use in Activity 9.
2. Take time to reflect on the following educator prompt: **What methods did learners choose to present their designs? What did you learn from the methods they chose?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428

Engineering Share-Out Invitation

You're invited to the Engineering Share-Out

Come see your young engineer

showcase their water reuse process!

Date: _____

Time: _____

Location: _____

PLANETS

NASA Grantee

Educator Guide

Engineering Activity 9: Sum It Up: Engineering Share-Out

Educator Preview

Activity Snapshot

Learners communicate their ideas about designing a water reuse process in the Engineering Share-Out.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Engineering Share-Out	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5 min. each

Prep Snapshot*

Prep Time 15 min.

- Space Need: Sink
- Set up Materials Table.
- Invite people to Share-Out.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Collaboration
- Communication

Habits of Mind

- Communicate effectively.

Guiding Question

How can we share our water reuse process recommendations with others?

Learners Will Do

Share design recommendations for engineering a water reuse process.

Learners Will Know

Engineers have valuable knowledge to share about the problem they have solved.

Connecting Across Activities

Activity 8: Preparing for the Engineering Share-Out	Activity 9: Engineering Share-Out	Science Pathway
Last time, learners prepared to communicate their ideas about designing a water reuse process in the Engineering Share-Out.	**Today**, learners communicate their ideas about designing a water reuse process in the Engineering Share-Out.	**Next time**, learners will experience the science of this topic in the Water in Extreme Environments Science Pathway (optional).

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/f75ae3d6

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- chart paper and markers
- remaining materials from Activity 7
- 1 measuring cup, 1/4 cup
- 2 tablespoons
- 8 craft sticks
- 8 containers, 1/2 gallon, with water samples
- 60 plastic cups, 8 oz.
- all tactile, audio, and video resources needed for the Share-Out

For each group of 4

- 1 foil tray, 12" × 12"
- 1 measuring cup, 1 cup
- 1 packet of pH strips
- 1 pair of scissors
- 1 set of Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94
- 2 Filter Bases

For each learner

- Engineering Notebook (PDF)

Activity 9 Materials Preparation (15 min.)

Ahead of Time

1. Invite people from the community, including families and friends of learners, to the Engineering Share-Out using the Engineering Activity 8 Share-Out Invitation (PDF).
2. Decide what to do with learners' designs and presentation materials after the activity.

In Your Space

3. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
4. Create a Materials Table with the materials remaining from Activity 8.
5. If needed, prepare more water samples in the containers using Water Samples for Final Challenge Recipes, pgs. 87-88.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We prepared to share our water reuse processes at the Engineering Share-Out.)*

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

2. Share the Guiding Question with learners aloud and in writing on the *Our Ideas* poster (using multiple languages as needed): **How can we share our water reuse process recommendations with others?**
3. Organize learners into their groups of four from Activities 6–8.
4. Give learners five minutes to set up for the Share-Out so they can present in the ways that they have planned.

Engineering Share-Out (25 min.)

5. When learners are ready, invite guests into the room and explain how the Share-Out will proceed. Carry out the steps of the Share-Out as the group has planned.

Support Learner Differences

To ensure the Share-Out is accessible as possible, provide tactile, audio, and video resources from throughout the pathway to attendees as appropriate.

6. As they experience the Share-Out, invite families and other guests to think about their family, cultural, or other knowledge related to what they observe and share that knowledge with learners individually or the event as a whole.
7. Ask or encourage attendees to ask the following questions: **What are some things you investigated to help you solve this problem? What part of your process worked really well? What didn't work so well? How did the Engineering Design Process help you reach this final design? What suggestions do you have for other people designing water reuse processes?**
8. At the end of the Share-Out, congratulate your group on doing a great job communicating and being engineers. Have learners thank attendees before concluding.

Reflect (10 min.)

9. Have groups discuss the following questions: **What are you most proud of doing as part of this engineering group? Are there other water conservation problems you would like to solve as an engineer? Why do you consider yourself an engineer?**

10. Have learners discard used filter materials (except charcoal, limestone and other reusable materials) and their final water samples, then rinse their Filter Bases and place them in their trays.

Level Up!

- Tell learners, if anyone asks them what they did today, they can tell them "We shared design recommendations for water reuse processes." (5 min.)
- Ask: **Which engineering design process phases were most helpful to you? Can you imagine other problems you might solve using an engineering design process?** (5 min.)
- If your learners enjoyed this planetary engineering design challenge, they would also enjoy the Rover Observation and Discoveries in Space (ROADS) student challenges. Show your learners the NASA National Student Challenges. (15 min. to review weblink, 10–15 hours per challenge)

After the Activity

1. Clean up:
   - Collect the Engineering Notebooks.
   - Decide if you want to keep the *Our Ideas* poster.
   - Reset the space in which you held the Share-Out.
   - Consider saving materials for when you conduct this activity in the future. Rinse and set aside the limestone, charcoal, filter bases, and aluminum trays. Once dry, store any loose materials in airtight containers.
2. Take time to reflect on the following educator prompt. **How did learners use the *Our Ideas* poster throughout the pathway? If you taught the pathway again, would you use the poster differently?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/7cb5c428