Integrated STEM Unit Planner

Grade 5 Science

Filter the Water

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PreK-12STEM
Community Training & Assistance Center (CTAC)
Tracy Unified School District

About the Integrated STEM Units

The integrated STEM units are a product of the partnership between Community Training and Assistance Center (CTAC) and Tracy Unified School District (TUSD) in California, funded in part through the Education Innovation and Research (EIR) program of the U.S. Department of Education in 2018. Teacher leaders came together to develop innovative units that align to STEM standards for student learning—namely the Next Generation Science Standards (NGSS) for California Public Schools, the Computer Science Content Standards derived from the national K-12 Computer Science Framework, and the California Common Core State Standards.

Each integrated unit brings together the following:

- an engineering design challenge
- one or more computational artifacts
- core science and math content
- language building opportunities
- engagement supports

Students in each grade level, pre-kindergarten through twelve, engage with the unit for about one or two months as part of their required coursework. The units are integrated and self-contained as a means to provide all students with equitable STEM experiences.

About the Partners

Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading teachers from the district contributed to the development of the units. Computer Science integrations resulted with support from the San Joaquin County Office of Education and Bootstrap of Brown University.

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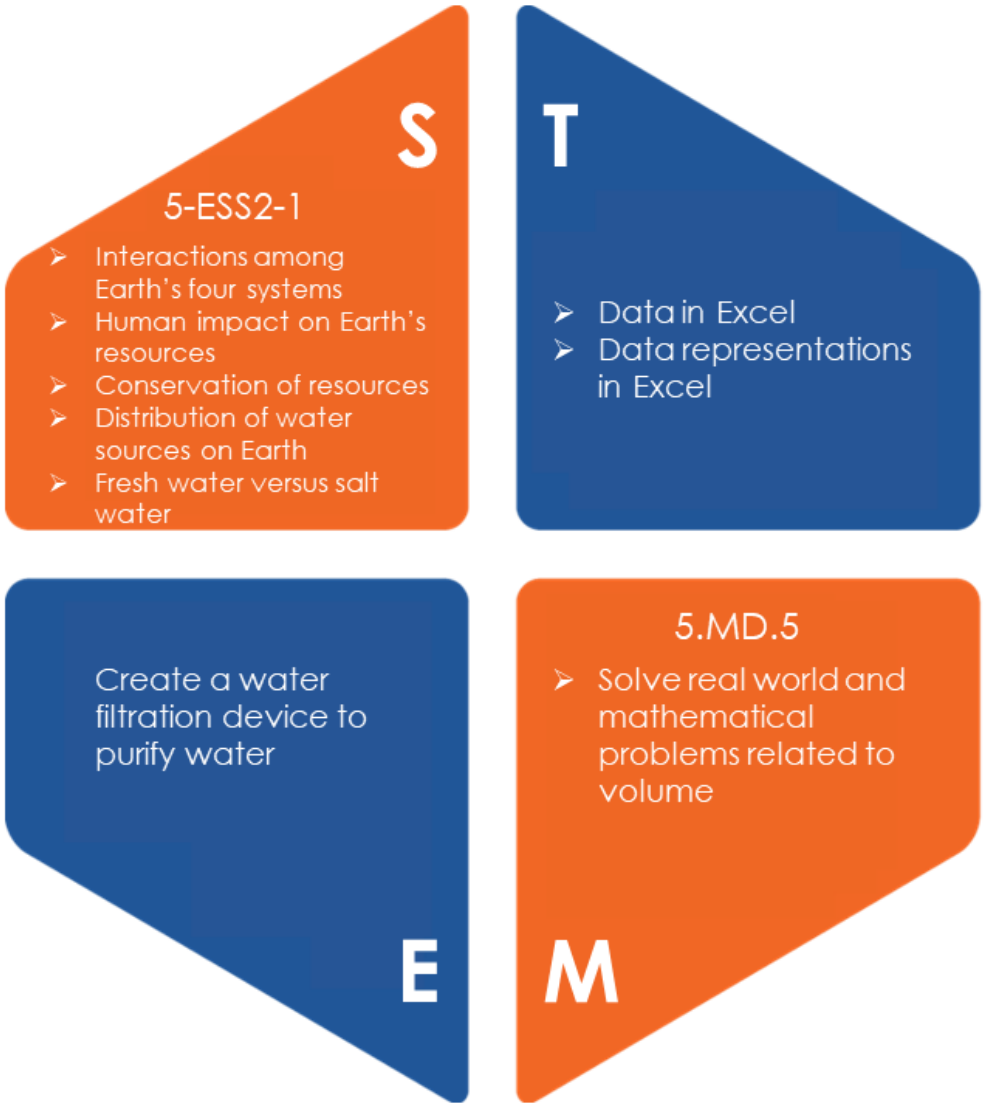
Contents

Big Picture

Unit Emblem



Focal Standard

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact [Clarification Statement: The geosphere, hydrosphere (including ice), atmosphere, and biosphere are each a system and each system is a part of the whole Earth System (CA). Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time*.]

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by showing the video of clean water that has been contaminated (see news report on how fires in Paradise, CA contaminated drinking water)(Associated Press, 2019[i]). It will begin with the phenomenon of clean water versus dirty water and how water contamination affects all of us. During the entry event, teachers present the driving essential question: How can we protect Earth's resources? This question connects all learning experiences and learning targets.

The design challenge will be introduced: to create a water filtration device designed to purify water. Students will brainstorm initial ways to meet the design challenge in their sense-making notebooks. They will begin to ***ask*** questions about the challenge presented: How does water get dirty? How might water get cleaned in nature? How can we protect Earth's resources? What are ways of cleaning our dirty particles from water?

Students will participate in learning experiences that will help them explore and explain the four interacting spheres of Earth (5-ESS2-1).

Sequence 2: Students will expand their learning about the Earth's four spheres and how they interact to influence our resources. Students will also learn about fresh water and salt water on earth, emphasizing the distribution of and percentages of each type across the Earth.

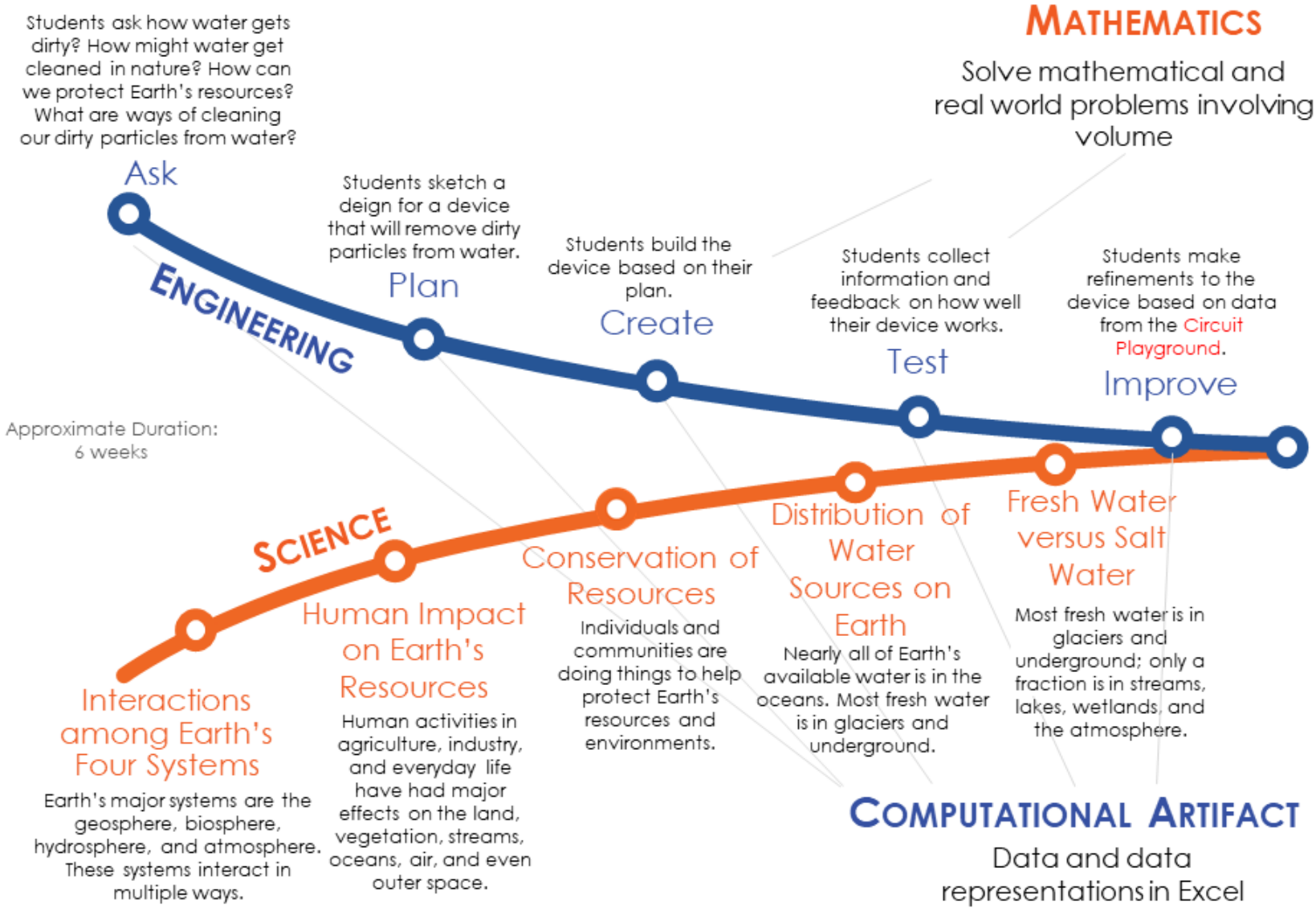
At the same time, students will begin to ***plan*** and sketch a design for a device that will remove dirty particles from water.

Sequence 3: Students will work in groups to ***create*** their water filtration device based on the plan.

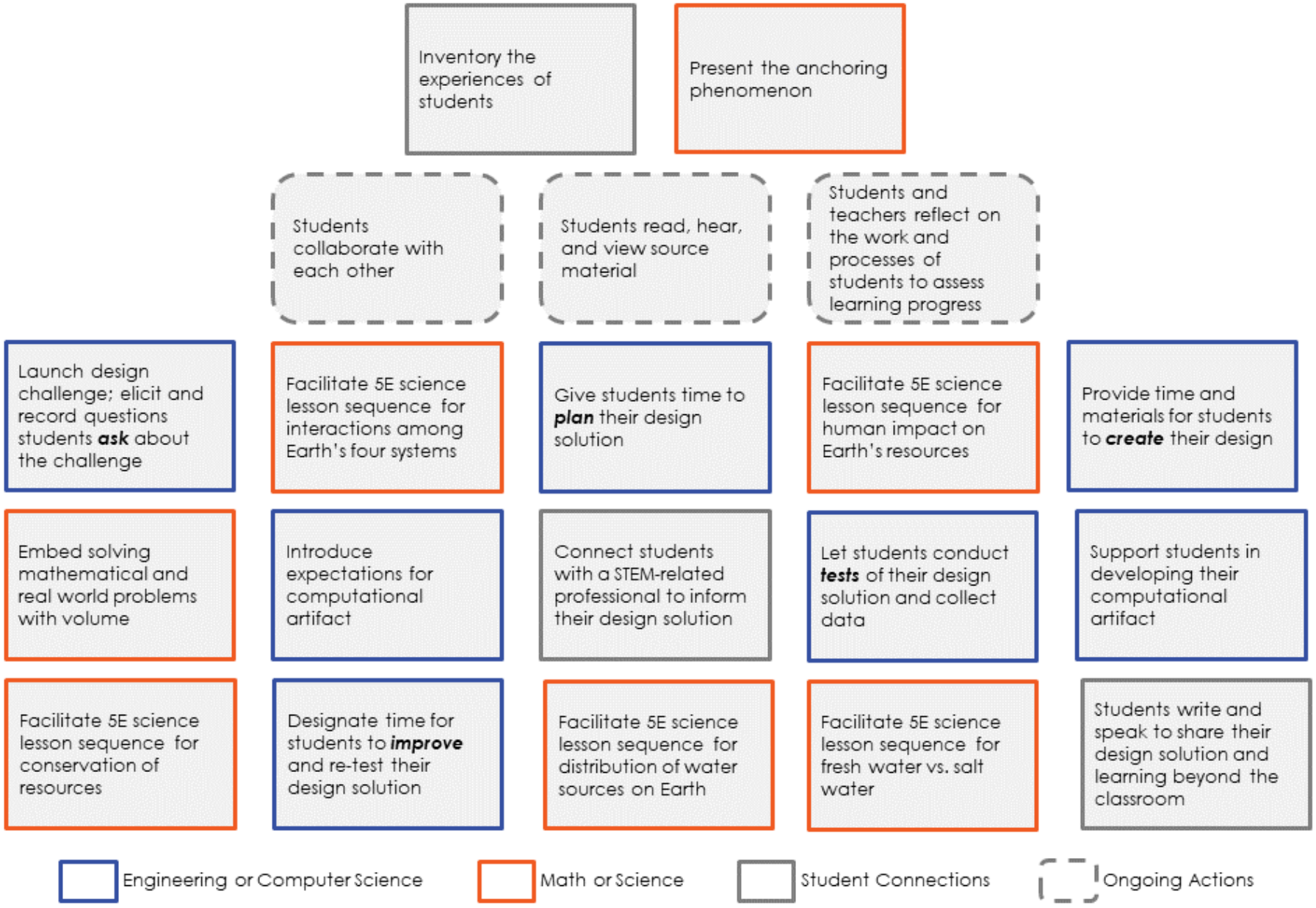
Sequence 4: Students then begin to ***test*** their prototype, collecting data to determine how close their model filters the water. Data will be recorded in Excel and appropriate graphs made.

Sequence 5: Students reflect on their data and revise the plan to ***improve*** their model and then conduct follow-up tests on their improved water filters. Students will complete an online blog about the design and improvement process, sharing details of the process they followed in their oral presentations.

Integrated Unit Storyline



Integrated Unit Wayfinder



STEM Dive

Engineering

Design Challenge: Create a water filtration device designed to purify water

Type of Engineering: Environmental Engineering

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *How does water get dirty? How might water get cleaned in nature? How can we protect Earth's resources? What are ways of cleaning our dirty particles from water?*	**3-5-ETS1-1.** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)
Plan *Sketch a design for a device that will remove dirty particles from water.*	**3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
Create *Build the device based on their plan.*	
Test *Collect information and feedback on how well their device works.*	**3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)
Improve *Make refinements to the device based on data from the Circuit Playground.*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Students collect and display their data in Microsoft Excel.

Computational Artifact

Definition: Anything created by a human using a computational thinking process and a computing device. A computational artifact can be, but is not limited to, a program, image, audio, video, presentation, or web page file. (Source: College Board, 2016)

- Data and data representations in Microsoft Excel

Hardware

Definition: The physical components that make up a computing system, computer, or computing device. (Source: MDESE, 2016)

- Computer

Software (includes programs, applications, websites, etc.)

Definition: Programs that run on a computing system, computer, or other computing device. (Source: k12cs.org)

- Microsoft Excel for students to record data and create graphs

Standards

- **3-5.CS.2** Demonstrate how computer hardware and software work together as a system to accomplish tasks.
- **3-5.CS.3** Determine potential solutions to solve simple hardware and software problems using common troubleshooting strategies.
- **3-5.IC.21** Propose ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.

Science

Focal Standard

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: The geosphere, hydrosphere (including ice), atmosphere, and biosphere are each a system and each system is a part of the whole Earth System (CA). Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time*.]

Related Content Standards

5-ESS2-2 Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. [*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere*.]

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing the video of clean water that has been contaminated (see news report on how fires in Paradise, CA contaminated drinking water). Let students brainstorm initial ways to meet the design challenge in their sense-making notebooks.

Content Outline

Below is a content outline for the science content in this unit. It includes the key concepts within the unit along with an approximate number of days it would take to facilitate a sufficient amount of student learning experiences. For each key concept, key learnings appear, which come from the grade band endpoints in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (source: https://www.nextgenscience.org/framework-k-12-science-education). The storyline begins with an anchoring phenomenon.

Key Concept	Key Learnings	# of Days
Interactions among Earth's Four Systems	• Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living	

Key Concept	Key Learnings	# of Days
	things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)	
Human Impact on Earth's Resources	• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	
Conservation of Resources	• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	
Distribution of Water Sources on Earth	• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	
Fresh Water versus Sea Water	• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	

Science and Engineering Practices	Crosscutting Concepts
1. Asking questions and defining problems **2. Developing and using models** 3. Planning and carrying out investigations 4. Analyzing and interpreting data **5. Using mathematics and computational thinking** **6. Constructing explanations and designing solutions** 7. Engaging in argument from evidence **8. Obtaining, evaluating, and communicating information**	1. Patterns **2. Cause and effect** **3. Scale, proportion, and quantity** **4. Systems and system models** 5. Energy and matter 6. Structure and function **7. Stability and change**

Note. Bolded items are called out specifically in the standards cluster for this unit.

Mathematics

Description of Student Engagement

Students will collect data regarding the effectiveness of their water filter prototype. They will represent the data using various graphs, interpret the data.

Standards for Mathematical Content

5.MD.5 Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.

5.MD.2 Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots.

5.NF.2 Solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators, e.g., by using visual fraction models or equations to represent the problem. Use benchmark fractions and number sense of fractions to estimate mentally and assess the reasonableness of answers.

5.NF.5.a Interpret multiplication as scaling (resizing), by: Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication.

Standards for Mathematical Practice

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

MP.6 Attend to precision.

MP.7 Look for and make use of structure.

MP.8 Look for and express regularity in repeated reasoning.

Note. Bolded items are emphasized in this unit.

English Language Arts and Development

Reading Standard: Integration of Knowledge and Ideas

RI.5.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

Writing Standard: Text Types and Purposes

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

- **W.5.1.A** Introduce a topic or text clearly, state opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.
- **W.5.1.B** Provide logically ordered reasons that are supported by facts and details.
- **W.5.1.C** Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).
- **W.5.1.D.** Provide a concluding statement or section related to the opinion presented.

W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

- **W.5.2.D** Use precise language and domain-specific vocabulary to inform about or explain the topic.

Writing Standard: Research to Build and Present Knowledge

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Speaking and Listening Standard: Comprehension and Collaboration

SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.

- **SL.5.1.A** Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- **SL.5.1.B** Follow agreed-upon rules for discussions and carry out assigned roles.
- **SL.5.1.C** Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- **SL.5.1.D** Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

Unit Vocabulary

The following terms reflect the core vocabulary students should understand and use in this unit.

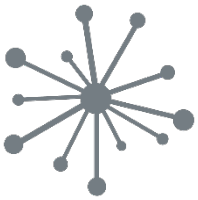
- **aquifers**: An aquifer is an area of porous rock or sediment that contains water gathered from precipitation seeping through the soil. (Source: adapted from USGS[1]: https://on.doi.gov/3yZ8z2G)
- **atmosphere**: The atmosphere is the gas that surrounds a planet or star. The Earth's atmosphere is made up of mostly nitrogen, while the Sun's atmosphere consists of mostly hydrogen (Sourced from NASA: https://go.nasa.gov/3trlyJp)
- **biosphere**: All living things are part of a complex, often delicately balanced network called the biosphere. The earth's biosphere, in turn, is composed of countless ecosystems, which include plants and animals and their physical environments.(Sourced from FWS[2]: https://bit.ly/3zYaNAD)
- **climate**: Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean [average] and variability of relevant quantities over a period of time ranging from months to thousands of years. The classical period is 3 decades, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. (Sourced from the EPA[3]: https://bit.ly/3jX4li6)
- **earth materials**: Earth materials include minerals, sediments, rocks, ores, and petroleum products. They form over very long time periods and are not alive. (Sourced from USGS: https://on.doi.gov/2Vzfy4M)
- **earth systems**: Earth is also made up of five major parts or subsystems: the Atmosphere, Hydrosphere, Biosphere, Cryosphere, and Geosphere. Each major part is connected to the other parts in a complex web of processes. (Sourced from NASA: https://go.nasa.gov/3C0de66)
- **environment**: The environment is the complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival. (Source: https://www.merriam-webster.com/dictionary/environment)
- **filtration**: Filtration is the act or process of removing something unwanted from a liquid, gas, etc., by using a filter. (Source: https://www.merriam-webster.com/dictionary/filtration)

[1] USGS = U.S. Geological Survey
[2] FWS = U.S. Fish and Wildlife Services
[3] EPA = Environmental Protection Agency

- **geosphere**: The geosphere includes the soils, sediments, and rock layers of the Earth's crust, both continental and beneath the ocean floors. (Sourced from EPA: https://bit.ly/38Wrkch)
- **human impact**: Humans impact the environment in a variety of ways. Too many people in a location can deplete resources. Pollution can make natural resources like water and air unusable or dangerous. Burning fuel sources can pollute the air. Removing trees and other foliage can cause a loss of habitat for some species and erosion of the soil.
- **hydrosphere**: The hydrosphere is the component of the climate system comprising liquid surface and subterranean water, such as: oceans, seas, rivers, fresh water lakes, underground water etc. (Sourced from EPA: https://bit.ly/2X3DSfw)
- **interact**: To interact is to come together and have an effect on each other. (Source: https://www.merriam-webster.com/dictionary/interact)
- **landforms**: Land surfaces are sculpted into a wide diversity of shapes and arrangements, called landforms. The bedrock subsurface of an area plays an important role in determining the shape of the land, but it is not the only factor. It is the geologic processes that shape Earth's landforms over vast periods of time through the actions of water, wind, ice, and gravity, as well as internal tectonic and volcanic activity. (Sourced from the NPS[4]: https://www.nps.gov/subjects/geology/landforms.htm)
- **pollutant**: Pollution is the introduction of harmful materials into the environment. These harmful materials are called pollutants. (Source: https://www.nationalgeographic.org/encyclopedia/pollution/)
- **purification**: The process of removing particles or pollutants from water and other substances. When water is purified, attempts are made to remove contaminants and dissolved particles from the water.
- **reservoir**: A reservoir is an artificial lake where water is collected and kept in quantity for use. (Source: https://www.merriam-webster.com/dictionary/reservoir)
- **resources**: A natural resources is something (as water, a mineral, forest, or kind of animal) that is found in nature and is valuable to humans. (Source: https://www.merriam-webster.com/dictionary/natural%20resource)
- **society**: A society is an enduring and cooperating social group whose members have developed organized patterns of relationships through interaction with one another. A society is also thought of as a community, nation, or broad grouping of people having common traditions, institutions, and collective activities and interests. (Source: https://www.merriam-webster.com/dictionary/society)

[4] NPS = National Park Service

Assessment Tools



Student Experience Inventory

Teachers can use the following prompts with students prior to the beginning of the unit or early in the unit in order to learn about students' experiences that relate to the unit. Teachers can make informed instructional decisions based on this learning, enabling tailored opportunities for students to make their own meaning.

Student Prompts

1. Tell a few sentences about a time you had fun with water. Be sure to include where you were and where the water came from.

2. What are some of the ways you use water? Where does the water come from?

3. Have you seen water in other places outside of Tracy? If so, where was the water and what was it like?

4. What are some of the ways you interact with the natural things on Earth (environment)?

5. What are some of the ways you have noticed the natural things on Earth interacting with each other?

Aligned Learnings

1. Responses to this item provide insight into students' experiences with water and water sources. 5-ESS2-2, 5-ESS3-1

2. Responses to this item provide insight into students' experiences with water and water sources. 5-ESS2-2, 5-ESS3-1

3. Responses to this item provide insight into students' experiences with global sources of water. 5-ESS2-2

4. Responses to this item provide insight into students' interactions with the environment. 5-ESS3-1

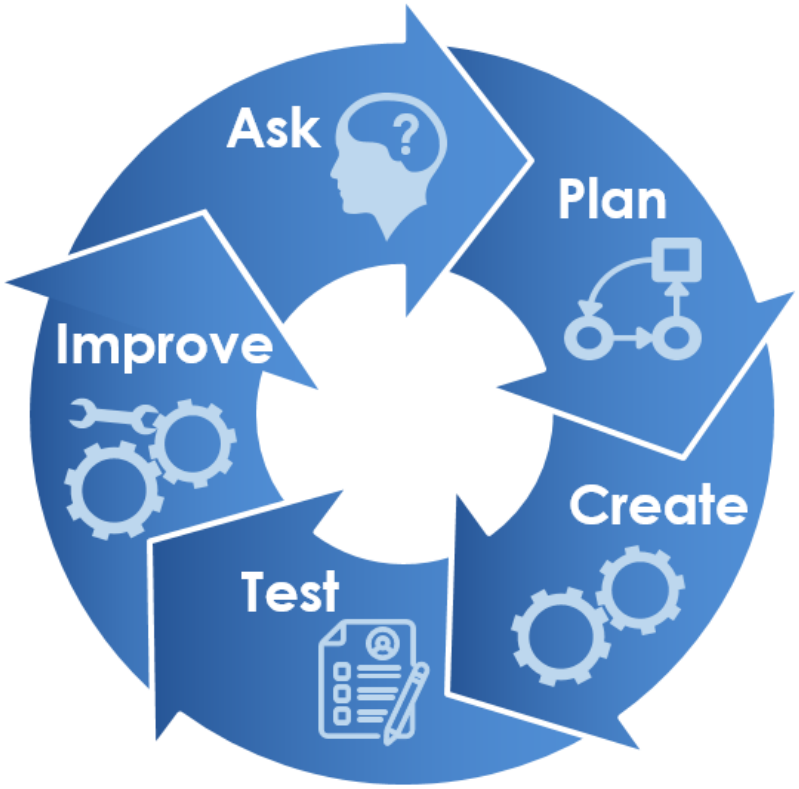
5. Responses to this item provides insight into students' experiences with or knowledge of interactions among Earth's four major systems. 5-ESS2-1

Student Self-Assessment of Engineering

Improve:
Here is what would make my design better and why…

Ask:
Here is what I am wondering about before I plan my design…

Plan:
Here are my design ideas for the project…



Test:
Here are the data I collected…

Create:
Here is what I think about what I made compared to what I planned, and here is what I think will happen when I test it…

I am doing the work of an environmental engineer

One-Point Design Challenge Rubric

Criteria serve as a primary reference point throughout the engineering design process. Teachers use the criteria **to communicate expectations** and **to guide students**. With teacher guidance, students use the criteria to inform and reflect on their work.

Approaches Expectations *Notes on how to improve the project*	**Meets Expectations** *Criteria indicating success*	**Exceeds Expectations** *Notes on how project goes beyond expectations*
	Engineering Students participate in the 5-part engineering design process, use data, and make thoughtful improvements to their design. (3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3)	
	Computer Science The computational artifact shows student success loading and representing data. (3-5.CS.2, 3-5.CS-3, 3-5.IC.21)	
	Collaboration Students contribute and support others with honesty and kindness (including feedback given and received on water filtration devices). (SL.5.1)	
	Communication Students speak and write using academic vocabulary to share thoughts and read and listen to learn from others. (W.5.2, W.5.2.D, W.7, SL.5.1)	
	Science Use knowledge of Earth's interacting systems to create a filtration system that cleans dirty water. (5-ESS2-1, 5-ESS2-2, 5-ESS3-1)	

Engagement

Community and Career Connections

During the unit, students engage with STEM professionals who can inform students' work at some point during the engineering design process. The interaction with STEM professionals serves a few purposes:

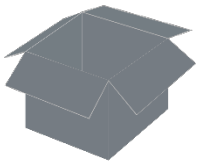
- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

Below are a few potential STEM-related professionals that align to one of California's 15 industry sectors for Career and Technical Education:

- **Local Utility Manager** (Water) (Energy, Environment, and Utilities)
- **Public health worker** (nurse, public health official, physician) (Health Science and Medical Technology)
- **Water treatment plant worker** (someone who tests the water) (Public Services)

The interactive experience will ideally be co-constructed by the teacher and professional. In coordinating with the professional, a few questions appear below that can be used to guide the planning and live interaction with students:

- **Local Utility Manager** (Water) (Energy, Environment, and Utilities)
  - How do you decide how many water pipes to lay in an area?
  - How is water pressure influenced by demand for water and the amount of available water?
  - Are there billing differences for water used for households, lawn and garden watering, and septic services? Are those items billed together or separately?
  - Have there been water restrictions around here? How often does that occur?
  - Who enforces water restrictions? How are they enforced? What happens to someone who violates the rules?
- **Public health worker** (nurse, public health official, physician) (Health Science and Medical Technology)
  - How important is clean and readily available water to the health of the public?
  - What kinds of diseases can be carried through water?
  - What is done to prevent the spread of diseases through the water?
  - Suppose there is an outbreak of some kind of disease, like a lot of people with the flu or diarrhea or some specific disease, how do you go about trying to figure out the cause of that outbreak?
- **Water treatment plant worker** (someone who tests the water) (Public Services)
  - What tools do you use to filter the water?
  - Do you add anything to the water? What is it and why is it added?
  - What would happen if the water treatment plant had equipment failure?
  - Where does the water in the plant originate? Are there problems with the availability of water for this area?



Materials List

The items in the materials list below reflect total quantities for a class of 32 students, allowing for 8 groups of 4 students.

Permanent Equipment (classroom totals):

- ☐ 32 (4.7 inch wide mouth) funnels

Consumable Equipment (classroom totals):

- ☐ 320 cotton balls
- ☐ 32 gauze
- ☐ 32 packs facial tissues
- ☐ 96 coffee filters
- ☐ 32 cups (1 gallon) sand
- ☐ 10 pounds of pea gravel
- ☐ 64 snack size zip bags
- ☐ 96 clear plastic cups

Distance Learning Modifications

In distance learning, the design challenge will be conducted by students individually at home. Student collaboration will need to occur remotely with a modified materials list.

Modified Materials List (student totals):

- ☐ 10 cotton balls
- ☐ 1 roll of gauze
- ☐ 1 pack of facial tissue
- ☐ 3 coffee filters
- ☐ ½ cup of sand
- ☐ 1/4 cup of gravel in a snack bag
- ☐ 1 funnel
- ☐ 3 clear plastic cups

Endnotes

[i] Associated Press. (2019, April 18). *Fire in Paradise, California, poisoned the water with a 'toxic cocktail'*. NBC News. *https://www.nbcnews.com/news/us-news/fire-paradise-california-poisoned-water-toxic-cocktail-n996136*