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What's in Your Water?

NGSS EARLY IMPLEMENTERS
WestEd

A Collaboration of the K–12 Alliance @ WestEd,
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Introduction

The California K–8 NGSS Early Implementation Initiative was developed by the K-12 Alliance at WestEd with close collaborative input on its design and objectives from the California State Board of Education, the California Department of Education, and Achieve. This project was designed to build local education agency (LEA) capacity to fully implement the Next Generation Science Standards (NGSS) as a core subject in the elementary grades (K–5) and as the SBE's preferred integrated model in grades 6–8.

The six-year Initiative provided teachers and administrators with in-depth, content-rich professional development to build leadership capacity and teacher acumen to deliver high-quality 3-dimensional learning for K–8 students. In addition, through collaborations among the K-12 Alliance, Achieve, and others, the LEAs in the Collaborative had opportunities to pilot test new NGSS-aligned tools, processes, assessment item prototypes, and digital and other instructional materials. The LEAs continue to serve as resources for NGSS implementation across California, and in other NGSS-adopting states as well.

This resource presents the conceptual storyline for a unit of instruction at a specific grade level, then focuses on a portion of the storyline called a learning sequence. The learning sequence uses the three dimensions of the NGSS (disciplinary core ideas—DCI; science and engineering practices—SEP; and crosscutting concepts—CCC) to build and deepen student understanding of natural phenomena and design challenges.

Participants in the CA NGSS K–8 Early Implementation Initiative developed and field-tested the lessons in the learning sequence.

Overview

This engineering design learning sequence is built on the anchoring phenomenon: Sewage water is consumed by people, but they do not get sick. Students are introduced to town water samples that have been gathered from a local town. The town hires the students to find out what is in the water and tell the town how to clean it. Students explore matter and its properties and discover that matter can be identified and grouped by its properties. Properties include size, shape, color, magnetism, conductivity, and solubility. They investigate quantifying matter by weight and volume. Using their understanding of physical properties, students design a solution to determine what is in the town water samples.

This unit builds towards these Performance Standards:

PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating and cooling, or mixing substances, the total weight of matter is conserved.

PS1-3	Make observations and measurements to identify materials based on their properties.
3-5-ETS1-1	Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.
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 a problem.

Learning Sequence Narrative

The Learning Sequence Narrative briefly describes what students do in each lesson and links the learning between the lessons as a conceptual storyline. As students progress through the learning sequence, they are making sense of designing a solution to the problem.

The identified problem for this learning sequence is: Water collected from a town may be contaminated. The town officials are requesting help to design a process that will identify the particles in the water and then clean the water. Students begin thinking about a solution to the problem by developing models of the town water samples and exploring the properties of the observable and unobservable matter in those samples. The properties students explore include magnetism, conducting electricity, solubility, and the quantities of matter in terms of weight and volume. Students then design a solution and evaluate the efficiency of processes to clean the water samples.

Students figure out this phenomenon by:

Science and Engineering Practices (SEPs)

Asking Questions and Defining Problems

- Ask questions that can be investigated and predict reasonable outcomes based on patterns ~~such as cause and effect relationships~~.
- Define a simple design problem that can be solved through the development of ~~an object, tool,~~ process, or system and includes criteria for success and constraints on materials, time, or cost.
- Use prior knowledge to describe problems that can be solved.

Developing and Using Models

- Develop and/or use models to describe ~~and/or predict~~ phenomena.
- Identify limitations of a model.
- Collaboratively develop and/or revise a model based on evidence that shows the relationships ~~among variables for frequent and regular occurring events~~.

Planning and Carrying Out Investigations

- ~~Plan and~~ conduct an investigation collaboratively to produce data to serve as the basis for evidence, ~~using fair tests in which variables are controlled and the number of trials considered~~.
- Evaluate appropriate methods and/or tools for collecting data.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- Test two different models of the same proposed object, tool or process to determine which better meets criteria for success.

Analyzing and Interpreting Data

- Analyze and interpret data to make sense of phenomenon, using logical reasoning mathematics, and/or computation.
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
- Represent data in tables and/or various graphical displays ~~(bar graphs, pictographs and/or pie charts)~~ to reveal patterns that indicate relationships.

~~Constructing Explanations and~~ Designing Solutions

- Apply scientific ideas to solve problems.
- Use evidence (e.g., measurements, observations, patterns) to construct of support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points to an explanation.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

Engaging in Argument from Evidence

- Compare and refine arguments based on an evaluation of the evidence presented.
- Construct and/or support an argument with evidence, data, and/or a model.
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Obtaining, Evaluating, and Communicating Information

- Read and comprehend grade-appropriate complex text and/or other media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

Disciplinary Core Ideas (DCIs)

PS1.A: Structure and Properties of Matter

- Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means.
- Measurements of a variety of properties can be used to identify materials.
- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

ETS1.A: Defining and Delimiting Engineering Problems

- 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.

ETS1.B: Developing Possible Solutions

- 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.

Crosscutting Concepts (CCCs)

Scale, Proportion, and Quantity

- Natural objects and/or observable phenomena exist from the very small to the ~~immensely~~ large ~~or from very short to very long time periods~~.
- Standard units are used to measure and describe physical quantities such as weight, ~~time, temperature~~, and volume.

Patterns

- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rate of change for natural phenomena and designed products.
- Identify patterns related to time, including simple rates of change and cycles and use these patterns to make predictions.

- Identify similarities and differences in order to sort and classify natural objects and designed products.
- Matter is made of particles and that energy can be transferred in various ways and between objects.

Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change.

System and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.

Influence of Engineering, Technology, and Science on Society and the Natural World

- People's needs and wants change over time, as do their demands for new and improved technologies.

Throughout the sequence, students drive the learning and are expected to be the architects of their own sensemaking. The teacher facilitates this process by offering opportunities for questions, supporting, and redirecting when necessary.

Throughout the sequence, a flag (▶) denotes formative assessment opportunities where instruction may change in response to students' level of understanding and making sense of the problem. The sequence also provides direction when summative assessment opportunities arise.

Each individual lesson's narrative is based on the conceptual flow found at the end of this section.

Identified Problem: Water collected from a town may be contaminated. The town officials are requesting help to design a process that will identify the particles in the water and then clean the water.

Lesson 1: Town Water Samples

This lesson is the first in the sequence and is designed to engage students' prior experience with contaminated water, elicit their questions about contamination from observations of a video and actual water samples, and generate investigation questions that will drive their learning through the next set of lessons. This lesson introduces the identified problem: Water collected from a town may be contaminated. The town officials are requesting help to design a process that will identify the particles in the water and then clean the water. In order to do this throughout the learning sequence, students will build on their prior knowledge that matter is made of particles too small to be seen, but even then, the matter still exists and can be detected by other means.

Lesson 2: Finding Impurities in Water

In this lesson, students use their investigation questions to identify the presence and amount of contamination, reinforcing the idea that particles that are too small to be seen still exist in the water. They continue to revise models and create new ones to explain their understanding. Students also review and add to their design questions to clean the water.

Lesson 3: Properties of Matter

This lesson centers on students' understanding that properties such as magnetism and solubility of matter can be used to identify unknown matter, and those properties can be useful in solving problems such as separating matter into categories for identification. They look for patterns, group the matter based on those patterns, and categorize the matter based on its properties. By using the properties of matter, students can begin to plan a design to solve the problem of separating and identifying the matter in the town water samples.

Lesson 4: Cleaning Water

This lesson centers on students investigating new properties of matter (evaporation and filtration) to gather data and evidence. They strengthen their understanding that properties of matter can be useful in solving problems such as separating a mixture into its component parts. They use this evidence to plan a design solution for identifying and removing the unwanted materials from the town water samples. Students define criteria and constraints of the water problem as part of the engineering design.

Lesson 5: Separating Mixtures

This lesson centers on students using all the information they have gathered regarding the properties of matter to design a process or system to separate and identify the materials in the town water samples. Students will also evaluate their processes for success in meeting the criteria and constraints and compare their results to the results of other teams' processes. By the end of this lesson, students will be closer to understanding the anchoring phenomenon that sewage water can be processed so that it is drinkable.

Learning Sequence 3-Dimensional Progressions

SEP PROGRESSION	
Asking Questions and Defining Problems	
Lesson 1	Students ask questions based on observation, then ask questions that can be investigated. They begin the Class Question Board and the Design Solutions Question Board.
Lesson 2	Students continue to add and refine questions for the Class Question Board and the Design Solutions Question Board.
Lesson 3	Students continue to add and refine questions for the Class Question Board and the Design Solutions Question Board.
Lesson 4	Students continue to add and refine questions for the Class Question Board and the Design Solutions Question Board. They begin to develop solutions to the problem using their Environmental Engineering Design Plan, identifying criteria and constraints.
Lesson 5	Students continue to add and refine questions for the Class Question Board and the Design Solutions Question Board. They modify their questions based on their engineering plan and the results of their prototype.
Developing and Using Models	
Lesson 1	Students develop initial models to describe the town water samples.
Lesson 2	After using indicators, students refine their town water samples models to include observable and unobservable components.
Planning and Carrying Out Investigations	
Lesson 2	Student conduct an investigation of the idea that matter may exist in particles too small to be seen. Using indicators, they observe that there are "invisible" particles in the water.
Lesson 3	Students conduct an investigation to learn more about the properties of matter. They explore magnetism, weight/volume, and solubility as properties of matter. In addition, they test matter for its ability to conduct electricity.
Lesson 4	Students conduct an investigation using solubility as a property that can allow filtration to separate a mixture.
Lesson 5	Students test their prototype filtration design and compare their process with other groups to determine which best meets criteria for success.

Learning Sequence 3-Dimensional Progressions (continued)

SEP PROGRESSION (continued)	
Analyzing and Interpreting Data	
Lesson 2	Students analyze their observational data to determine that jars #1, #2, and #3 have "invisible" components while jar #4 does not. They look for patterns in the data from other groups.
Lesson 3	Student use scientific data to think about a design solution. They compare and contrast their ideas with other groups.
Lesson 4	Student use scientific data to think about a design solution. They compare and contrast their filtration ideas with other groups.
Lesson 5	Student test their prototypes and gather data for its re-design.
Engaging in Argument from Evidence	
Lesson 2	Students use evidence to support their recommendation for treatment of water at the various schools.
Obtaining, Evaluating, and Communicating Information	
Lesson 2	Students obtain information from text and media and communicate how this information supports their claims in their presentations to the school board.
Lesson 3	Students use a Frayer Model to communicate their understanding of magnetism and solubility.
Constructing Explanations and Designing Solutions	
Lesson 4	Students apply scientific ideas to their engineering design plan, which is based on their evidence about the properties of matter.
Lesson 5	Students test their prototypes that were designed on scientific ideas and evidence from prior investigations. They examine and compare multiple solutions to the problem based on how well they meet the criteria and constraints of the design solution.

DCI PROGRESSION	
Lesson 1	Students define a simple design problem (how to clean contaminated water) that can be solved through the development of a process or system (a filtering system for the water) based on the idea that matter of any type can be subdivided into particles that are too small to seen, but the matter still exists and can be detected by other means.
Lesson 2	Students explore matter that is too small to be seen but can be detected by other means (e.g., using indicators) by engaging in a "parts per billion" investigation.

Learning Sequence 3-Dimensional Progressions (continued)

DCI PROGRESSION (continued)	
Lesson 3	Students explore measurements of a variety of properties (including magnetism and solubility) that can be used to identify materials. They learn that matter can be described and classified by its observable properties. Students discover that the amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (mixtures and solutions).
Lesson 4	Students define criteria and constraints of the town water samples problem (that matter can be too small to be seen but still exist) to design a process using the engineering design core idea. The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions are compared on the basis of how well each one meets the specific criteria for success or how well each takes the constraints into account.
Lesson 5	Students learn that possible solutions to a problem are limited due to 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. Students test different solutions in order to determine which of them best solves the problem within the criteria and constraints. At every stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

CCC PROGRESSION	
Scale, Proportion, and Quantity	
Lesson 1	Students consider scale as they explore that matter is made of particles too small to be seen.
Lesson 2	Students consider scale as they explore that matter is made of particles too small to be seen. They consider proportion and quantity as they investigate parts per billion.
Lesson 3	Students explore the idea that standards units are used to measure weight and volume.
Lesson 4	Students apply scale, proportion, and quantity to their criteria and constraints lists.
Patterns	
Lesson 2	Students look for patterns using indicators and refine their models based on new information.
Lesson 3	Given many different types of matter, students share and discuss similarities and differences in patterns that can be used to sort and communicate information about matter.
Lesson 4	Students use patterns to begin to design solutions.
Lesson 5	Students identify patterns in successful prototypes.

Learning Sequence 3-Dimensional Progressions (continued)

CCC PROGRESSION (continued)	
Cause and Effect	
Lesson 2	Students learn about cause and effect in understanding parts per billion.
Energy and Matter	
Lesson 2	The entire learning sequence is about the idea that matter is made of particles. Students confirm this with data obtained through indicator tests.
Systems and System Models	
Lesson 5	Students develop their solution by designing a system that is composed of parts (e.g., separation by magnetism, filtration, and evaporation).

References

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. DOI: https://doi.org/10.17226/13165. National Research Council; Division of Behavioral and Social Sciences and Education; Board on Science Education; Committee on a Conceptual Framework for New K–12 Science Education Standards. National Academies Press, Washington, DC.

Grade 5 What's in Your Water? Conceptual Flow

Anchoring Phenomenon

Sewage water is consumed by people, but they do not get sick.

Matter can be subdivided into particles too small to be seen, but it still exists.

Identified Problem

Water collected from a town may be contaminated. The town officials are requesting help to design a process that will identify the particles in the water and then clean the water.

PS1.A	PS1.A	PS1.A	PS1.A	PS1.A
Water is a substance that may contain particles of other matter that are dissolved in it.	Matter can be identified and grouped by its properties.	Magnetism is a property that can help identify matter. Solubility is a property of matter in which a substance dissolves in liquid. Not all matter is soluble in water.	Filtration is the process of separating particles from a fluid using a filter. Evaporation is the process by which a liquid vaporizes.	Mixtures can be separated by physical processes based on the properties of its components.
			ETS1.A, ETS1.B	ETS1.A, ETS1.B

Asking questions and defining problems

Developing and using models

Constructing explanations and designing solutions

Analyzing and interpreting data

Planning and carrying out investigations

Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information

Engaging in argument from evidence

Scale, Proportion, and Quantity

Patterns

Cause and Effect

System and System Models

Energy and Matter