Smithsonian | SCIENCE *for Computational Thinking*

A Weighty Problem

Grade 5

developed by

Smithsonian
Science Education Center

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A Weighty Problem
Teacher Guide

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Smithsonian Science Education Center

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

Smithsonian Institution

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

Smithsonian Science for Computational Thinking (SSfCT) is a freely available curriculum developed by the Smithsonian Science Education Center. This transdisciplinary curriculum integrates science, technology, engineering, and math (STEM) and computational thinking (CT). Using a phenomenon- and problem-driven pedagogy, students work to define and solve real-world problems and/or explain phenomena. This STEM+CT curriculum, which includes a literacy component, is aligned to the Next Generation Science Standards, the Computer Science Teachers Association K–12 Computer Science Standards, the ISTE Standards, and the Common Core Mathematics Standards.

Thank You for Your Support

This lesson plan was made possible through partnership with Department of Defense (DoD) STEM, whose mission is to inspire, cultivate, and develop exceptional STEM talent through a continuum of opportunities to enrich our current and future DoD workforce poised to tackle evolving defense technological challenges by a diverse and sustainable STEM talent pool ready to serve our Nation and extend the DoD's competitive edge. For more information, visit dodstem.us.

Smithsonian
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Dear Educator,

Thank you for using Smithsonian Science for Computational Thinking to integrate computational thinking into your science, technology, engineering, and math (STEM) classrooms.

Computational thinking is increasingly recognized as a fundamental approach to problem-solving that can be applied beyond computer science to other disciplines. This approach involves decomposing or breaking down a problem into parts; creating and using sequences of steps called algorithms; organizing and analyzing data to identify meaningful patterns; and developing and using models, including simulations, of natural and designed systems. Computers can do these things. But humans can as well.

Smithsonian Science for Computational Thinking provides opportunities for third- through fifth-grade students to develop and use computational thinking as part of three-dimensional phenomenon- or problem-driven learning experiences. The work students do is driven by explaining a phenomenon or defining and/or solving a problem. The use of phenomena and problems motivates students and leads to deeper and more transferable knowledge. Students who spend their time explaining phenomena and solving problems related to real-world situations also develop an understanding of the need for and value of science and engineering in their community. This is fundamental to STEM.

Making computational thinking an integral part of education is central to the federal STEM Strategic Plan. As the plan notes:

> *Although the concept was developed in computer science, computational thinking is increasingly seen as a set of broadly valuable thinking skills that helps people solve problems, design systems, and understand human behavior, and that can be learned at a very young age without involving computer coding. In an increasingly technological and complex global economy, computational thinking needs to be an integral element of all education, giving every learner the capacity to evaluate information, break down a problem, and develop a solution through the appropriate use of data and logic (1).*

Computational thinking is also an integral part of K–12 standards, including the K–12 Computer Science Framework, the National Educational Technology Standards, the Next Generation Science Standards (NGSS), and other state standards based on *A Framework for K–12 Science Education* (2). Using mathematics and computational thinking is one of eight essential science and engineering practices in NGSS. Additionally, aspects of computational thinking are integrated into the practices of designing and building models, planning and carrying out investigations, and analyzing and interpreting data, as well as the crosscutting concept of patterns.

Smithsonian Science for Computational Thinking takes a high-touch to high-tech approach to teaching computational thinking. It brings object-driven, phenomena-based, problem-based learning together with digital learning so they complement one another. Smithsonian Science for Computational Thinking integrates STEM and computational thinking (STEM+CT) so all students can improve their digital literacy—with and without access to computers and other high-tech devices.

I am immensely grateful to the Department of Defense STEM office for their support of this project. I am also grateful to my talented Smithsonian colleagues, Dr. Sarah Glassman, Melissa J. B. Rogers, and Hannah Osborn, who developed these units under the direction of Laurie Rosatone. I also want to thank the external subject matter experts who contributed to this guide for their perspectives and technical support in ensuring the information in this guide is accurate.

I hope your students enjoy engaging in the high-touch to high-tech lessons of Smithsonian Science for Computational Thinking. Thank you for all you do to advance STEM education.

Best,

Dr. Carol O'Donnell, Director
Smithsonian Science Education Center

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Series Pedagogy

Phenomenon- and Problem-Driven Learning

Phenomena are observable events in the universe, for example a fossil of an ocean organism is found on top of a mountain (3). An engineering problem is a situation people want or need to change, such as a town not having access to enough fresh water for both farmland and industry. Whether familiar or unfamiliar, all phenomena and problems allow students to draw on their prior knowledge and experiences to come up with an initial explanation or solution. Students can then complete a series of activities to collect evidence. As students collect evidence, they build on their initial ideas through an iterative process of critique and revision (4). This iterative sensemaking process leads to revised explanations of phenomena, definitions of problems, or solutions to problems (5).

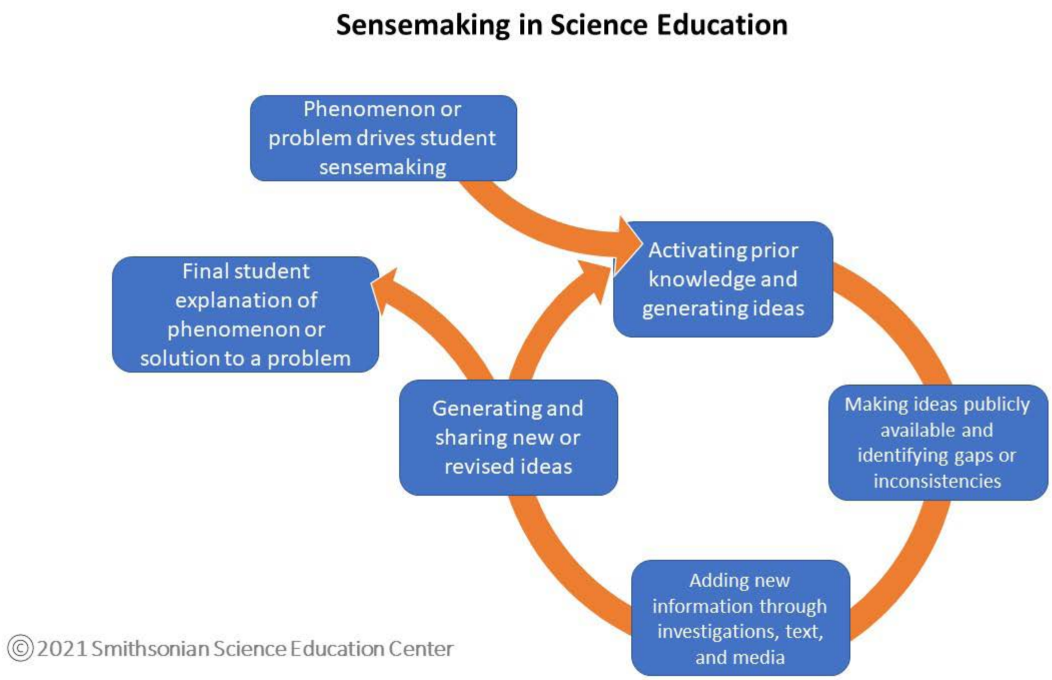


Figure 1: Students engage with new information through investigations, text, and media.

Computational Thinking

Computational thinking has been defined as a conceptual foundation that can be applied in practice to solve problems effectively and efficiently, with or without computers (6). Computational thinking includes (7, 8):

- Breaking down complex problems into more manageable subproblems (decomposition)
- Finding patterns within problems and solutions and reviewing how the solution can be transferred to similar problems (abstraction), which includes:
  - Data collection and analysis
  - Pattern recognition
  - Modeling
- Using a sequence of steps (algorithms) to solve problems
- Determining whether a computer can help us more efficiently solve those problems (automation)

There are parallels between the science and engineering practices and crosscutting concepts students develop as part of STEM learning and many aspects of computational thinking and foundational computer science knowledge. These include organizing and visualizing data to identify patterns to support claims and explanations; developing, testing, and improving procedures; working collaboratively and taking on specific and varied roles; and evaluating, ethically using, and communicating information.

Computational thinking as defined here is not described in one single set of standards (7, 8, 9). We have identified points within their learning where students are engaged in elements of the Next Generation Science Standards (NGSS) (10) and computational thinking practices described in the Computer Science Teachers Association Standards (CSTA) (11) and ISTE Standards for Students (12). The following chart shows how computational thinking overlaps across these standards.

Based on the amount of overlap between the science practices and computational thinking, STEM lessons are a great place to incorporate computational thinking into an already full instructional day.

CSTA 1B (grades 3–5)	**ISTE Standards for Students**	**NGSS (grades 3–5)**
Data and Analysis	1.5a Computational Thinker 1.5b Computational Thinker	Planning and Carrying Out Investigations (SEP) Data Analysis and Interpretation (SEP) Using Mathematics and Computational Thinking (SEP) Engaging in Argument from Evidence (SEP) Patterns (CCC) Cause and Effect (CCC)
Algorithms and Programming	1.4c Innovative Designer 1.5a Computational Thinker	Defining Problems (SEP) Developing and Using Models (SEP) Planning and Carrying Out Investigations (SEP) Using Mathematics and Computational Thinking (SEP) Constructing Explanations and Designing Solutions (SEP) Engaging in Argument from Evidence (SEP) Obtaining, Evaluating, and Communicating Information (SEP)
	1.3b Knowledge Constructor	Obtaining, Evaluating, and Communicating Information (SEP)
	1.5c Computational Thinker	Defining Problems (SEP) Developing and Using Models (SEP) Systems and System Models (CCC)

Figure 2: Computational thinking practices appear in CSTA, ISTE, and NGSS standards.

Unit Overview

Unit Storyline

Problem and proposed solution: You are collecting things to take on a hike. You want to minimize the weight in your pack. Can dissolving some of your drink powder into your water before you go solve your problem?

How students work toward solving the problem:

Task	Time
Task 1: Initial Ideas Students share their initial ideas about the solution of combining powder and water to lighten the load.	20 minutes
Task 2: Initial Investigation Planning Students consider an investigation question related to the proposed solution and identify key elements of an investigation: the materials, data, and data analysis.	20 minutes
Task 3: Writing the Investigation Procedure Student groups write a procedure for an investigation (algorithm), keeping in mind the materials they have available to them and the data they will need to serve as evidence to answer the investigation question.	30 minutes
Task 4: Investigation Procedure Test Run Student groups carry out the investigation using a peer group's procedure. Students identify problematic steps and document how they think they should fix the procedure at each trouble spot (test and debug).	20 minutes
Task 5: Revising the Procedure The class discusses common features of the procedures and differences among procedures. They discuss problems they encountered while conducting the investigation. Each group finalizes their procedure based on the debugging from the previous task and class discussion.	30 minutes
Task 6: Drink Mix Investigation Each group runs multiple trials of the investigation. They analyze their own data, looking for patterns. Students make a claim addressing the question.	30 minutes
Task 7: Revised Ideas Groups compile their data in a class bar graph and look for patterns. Groups make claims to address the question and the class reaches consensus that the weight of the powder did not disappear.	30 minutes

Task	Time
Task 8: Sharing the Story—Storyboard Students identify and discuss benefits and drawbacks of different ways to communicate ideas, such as the idea that the weight of the powdered drink mix does not disappear when it is added to water. They create a storyboard (visual outline) about their investigation.	40 minutes
Task 9: Introduction to Computer Algorithms Students identify examples of programming concepts (sequences, events, conditionals, and loops) in their drink mix investigation. They explore ways to use these structures in a computer program that creates an animation.	30 minutes
Task 10: Sharing the Story—Animation Students write a computer program (algorithm) to create an animated version of a story about their investigation. They identify where in the program they use events, sequences, loops, and conditionals.	40 minutes

Unit Alignment to Standards

Students develop and use part or all of the following standards in this unit. The standards students use are called out at point of use throughout the tasks.

Orange text indicates an NGSS disciplinary core idea, green text indicates an NGSS crosscutting concept, blue text indicates an NGSS science and engineering practice, **bolded black text** indicates a CSTA or ISTE standard, and plain black text indicates Common Core Mathematics Standards.

Next Generation Science Standards Elements

Disciplinary Core Ideas

PS1.A Structure and Properties of Matter

E2 The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

Crosscutting Concepts

Patterns

E3 Patterns can be used as evidence to support an explanation.

Cause and effect

E1 Cause and effect relationships are routinely identified, tested, and used to explain change.

Scale, proportion, and quantity

E2 Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Science and Engineering Practices

Planning and carrying out investigations

E1 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.

Engaging in argument from evidence

E4 Construct and/or support an argument with evidence, data, and/or a model.

E5 Use data to evaluate claims about cause and effect.

Obtaining, evaluating, and communicating information

E5 Communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.

Computer Science Teachers Association K–12 Computer Science Standards

Data and Analysis

CSTA 1B-DA-06 Organize and present collected data visually to highlight relationships and support a claim.

Algorithms and Programming

CSTA 1B-AP-10 Create programs that include sequences, events, loops, and conditionals.

CSTA 1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

ISTE Student Standards

Computational Thinker

ISTE 1.5c Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.

ISTE 1.5d Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Creative Communicator

ISTE 1.6c Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Common Core Standards for Mathematical Practice

Number & Operations in Base Ten

CCSS.MATH.CONTENT.5.NBT.A.3.B Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.

CCSS.MATH.CONTENT.5.NBT.A.4 Use place value understanding to round decimals to any place.

CCSS.MATH.CONTENT.5.NBT.B.7 Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

CCSS.MATH.CONTENT.5.G.A.1 Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).

Assessment Map

Multiple moments have been identified within this unit during which student learning can be assessed. For each moment, we have identified the assessment as a pre-assessment or a formative assessment.

During pre-assessments students have an opportunity to provide their initial explanation of a phenomenon or their initial definition of or solution to a problem. The phenomena and problems in each unit are purposefully chosen because students need to understand key concepts in order to explain or solve them. Reading, viewing, and/or hearing students' initial ideas provides an opportunity to understand what students already know about these concepts.

Following the pre-assessment, subsequent tasks require students to develop and use their skills and knowledge in progressively complex ways. Each identified task incorporates at least two NGSS, CSTA, or ISTE standards. Teachers are provided with a table of tasks and indicators they can refer to as they assess students. Teachers can use this table to identify the extent to which students are meeting the lesson objectives and areas where they need additional support. Analysis of student work using these indicators can be used to inform future lesson planning as well as to provide specific, actionable feedback for students. For some assessable moments, suggestions for supporting all students are provided within the table and/or at point of use within the task.

Assessable Moment and Objectives	Evaluating this Assessable Moment
Task 1: Initial Ideas	
Initial Ideas About Drink Mixes sheet Discussion Drink Mix Ideas chart **Objective** Construct an initial argument using evidence from prior experiences about the effect of mixing water and powder on the weight of the materials. **Standards** NGSS PS1.A E2 NGSS Cause and effect E1 NGSS Engaging in argument from evidence E4	Pre-assessment Students' initial ideas are a pre-assessment. It is an opportunity to learn what students might already know about conservation of mass. Make note of different ideas about the weights before and after mixing, looking for ideas that were not shared during class discussion. These can be incorporated into discussions in subsequent tasks. Make note of the evidence students use to support their ideas, including prior experiences in and out of school. Integrating students' prior experiences into discussions as the unit progresses may help students remain engaged in and take more control of their learning. **Naive concepts** Elementary students may think that when matter, such as powdered drink mix, dissolves in water, it vanishes and therefore no longer contributes to the weight of the beverage. They may also think the powdered mix is absorbed into the water in such a way that the weight of the resultant beverage is greater than the sum of the mix and water weights (13, 14, 15, 16). Students may refer to the mixing of the powder and the water as a chemical reaction (17). This naive idea is not addressed in this unit but should be noted as a starting point for other learning activities.

Assessable Moment and Objectives	Evaluating this Assessable Moment
Task 3: Writing the Investigation Procedure	
Discussion Written investigation procedure **Objective** **Use algorithmic thinking** to write an investigation procedure about whether the weight of a powder disappears when mixed into water, taking into account the need to collect and record data in units that are consistent throughout the investigation. **Standards** NGSS Scale, proportion, and quantity E2 NGSS Planning and carrying out investigations E1 **ISTE 1.5d**	Formative assessment Students should **write clear steps that others could follow** to conduct the investigation, which should include collecting and recording data. Look for evidence that students are using the need to know about the weight of the prepared drink versus the weight of the drink parts to guide their planning of an investigation procedure and that they are taking into account the need for standard units of weight across all parts of the investigation.
Task 4: Debugging the Investigation Procedure	
Investigation Procedure Test Run sheet Discussion **Objective** **Identify and suggest how to fix errors** in a procedure so that it can be used to collect data as evidence to respond to a claim about whether the weight of powder disappears when it is mixed into water. **Standards** **CSTA 1B-AP-15** **ISTE 1.5d**	Formative assessment Students should be able to **identify missing steps** ("but we never weighed the mix container") and recognize when the procedure falters due to **lack of clarity**. Students may find it easier to identify unclear or problematic steps in the investigation procedure than to fix the steps. Encourage students to use gestures and/or materials to demonstrate what needs to happen and have others in the group suggest language to describe the action. If a procedure did not identify a way to record all the data needed as evidence, have groups determine whether the data sheet they drafted earlier could be used to record data with appropriate units of measure.

Assessable Moment and Objectives	Evaluating this Assessable Moment
Task 7: Revised Ideas	
Our Claim About Drink Mix Weight sheet Drink Mix Bar Graph Discussion **Objective** Use patterns from a **visual representation** of class data as evidence to support a claim that the weight of the powder does not disappear when mixed into water. **Standards** NGSS PS1.A E2 NGSS Patterns E3 NGSS Engaging in argument from evidence E5 **CSTA 1B-DA-06** **ISTE 1.6c**	Formative assessment Students should explain that the weight of a prepared drink is the same as the total weight of the water and powdered mix that went into it. The weight of the powder does not disappear when it is dissolved in the water. They may be unsure about this when looking at just their group's data at the start of the task. Once they have access to all groups' data **represented on a bar graph**, they should be able to use the pattern that all groups may have worked with different quantities of water and powder, but there is not a significant difference in any group's before and after weights. They use this pattern as evidence to support a claim about the effect on weight of mixing the water and powder.
Task 8: Sharing the Story—Storyboard	
Important Parts of the Story sheet Storyboards **Objective** **Identify the important parts of the story** of their investigation so that the story can be communicated to others. **Standards** NGSS Obtaining, evaluating, and communicating information E5 **ISTE 1.5c**	Formative assessment Students **identify the important elements of the story** of their learning as they prepare to communicate to others that the weight of a prepared drink is the same as the total weight of its parts.

Assessable Moment and Objectives	Evaluating this Assessable Moment
Task 10: Sharing the Story—Animation	
Group animations **Objective** **Create and debug an animation that uses events, sequences, loops, and/or conditionals** to communicate how students learned that the weight of a prepared drink is the same as the total weight of its parts. **Standards** NGSS PS1.A E2 NGSS Obtaining, evaluating, and communicating information E5 **CSTA 1B-AP-10** **CSTA 1B-AP-15** **ISTE 1.5d**	Formative assessment Students **create and debug** an animation that communicates how they learned that the weight of a prepared drink is the same as the total weight of its parts. They use the pattern within the class data as evidence to support their claim.

Materials Management and Safety

Materials

In this unit, students will be comparing the weights of water and powdered drink mix before and after mixing them together. This unit is written so that students work in groups of four. Group size should be modified to fit your classroom and students.

In the unit, each group of four students will use a reusable drink container. The groups do not need to have identical containers. Small (150–400 ml) plastic containers work well. When gathering containers, make sure the weight of a container half-filled with prepared drink mix is not too heavy for the scales students will use. Transparent containers are better than opaque ones so students can see that the drink mix has dissolved in the water. Bottles sold for juicing and for use by runners are particularly light.

Powdered drink mix that contains sugar weighs more per volume than sugar-free drink mixes. The preparation directions in the unit were written using drink mix containing sugar. Mix that comes in a tub is more economical and, in areas where plastic recycling is possible, results in less waste than single-drink packets.

Students will need digital scales with at least 500 g capacity and readability of 0.1 g or 0.01 g. Scales with 1 g readability will work fine for the science content of the unit, but will not offer the opportunity for students to add, subtract, compare, and round decimals. It is best if each group of students has their own scale, but groups can share scales if needed.

Groups of two students will create computer programs in the final two tasks of the unit. For these tasks, student pairs (or larger groups) need access to laptop or desktop computers. Tablet or mobile devices with the Scratch app installed, although less optimal, will suffice. Modify group size based on the availability of computers and your students' experiences with programming while keeping the group size as small as possible. Scratch does not support shared editing, and research indicates that when working in groups one student may do the majority of the programming while others watch (18).

Materials, in Order of Use	**How Many?**
Powdered drink mix	140 g per group of four students plus 200 g for the teacher
Small containers with lids such as take-out salad dressing tubs	7 per group of four students plus 4 for the teacher
Digital scales	1 per group of four students
Plastic drink containers with lids	1 per group of four students plus 4 for the teacher
Water	
Backpack	1
Cell phone (optional)	1
Snack (optional)	1
Hiking trail map (optional)	1
Bird or plant identification book (optional)	1

Materials, in Order of Use	How Many?
Chart paper	
Large sticky notes	1 pack per group of four students
Safety goggles	1 per student
Funnels	1 per group of four students
Pitchers students can use to pour water into their drink containers	4 for the class
Large containers for collecting liquids	4 for the class or classroom sink
Materials for cleaning spills	
Writing paper	
Computer or tablet with Internet access	1 for the teacher 1 per group of two students (optional)
Projector for digital media	1

Student Sheet Guidance

Distribution information for sheets students will need access to during the unit.

Sheet Name	Number of Copies
Initial Ideas About Drink Mixes	1 per student
Our Drink Mix Investigation Ideas	1 per group of four students
Investigation Procedure Test Run	1 per group of four students
My Claim About Drink Mix Weight	1 per student
Our Claim About Drink Mix Weight	1 per group of four students
Important Parts of the Story	1 per student
Storyboard Frame 1	Multiple per student
Storyboard Frame 2	Multiple per student
Storyboard Peer Review (optional)	1 per student
Animation Program Planning	1 per student

Safety

Review drink mix labeling for allergy information.

Students should wear safety goggles when handling the powdered mix. Tell students that in the science setting they should not taste the powdered drink mix or the combined mix and water. Caution students to not touch their face with their hands while working with the powder or mixed beverages. Tell students to let you know if they get any of the powder in their eyes, nose, or mouth.

Task 1: Initial Ideas 20 minutes

Task 1

Background Information

The law of conservation of mass is a fundamental law of science. This law was independently described by Mikhail Lomonosov in 1756 and Antoine Lavoisier in 1789. In its simplest form it states that matter cannot be created or destroyed. Students may find this a difficult concept, as they are used to seeing things "disappear." For example, water in a puddle evaporates and sugar vanishes when it is stirred into tea. However, matter hasn't been destroyed in these situations.

In the first case, it has changed into a gas, which has become part of the air. If the system was closed so nothing was able to escape, it would be found that the total weight of water in the system would remain the same. In the second case, the sugar dissolves but does not vanish.

When materials are mixed together, the weight of the materials is conserved. That is, the weight of the mixture is equal to the sum of the weights of the separate materials before mixing. In this unit, students investigate what happens to the weight of two materials when they combine a powdered drink mix with water. The unit is written to test powdered drink mixes. Students may be interested in investigating liquid drink mixes as well. In this task, students are introduced to the idea of mixing a powder and water as a possible solution to a heavy backpack problem. They share their initial ideas, and support their ideas with their prior knowledge and experiences.

Supporting claims with evidence is an aspect of argumentation. Claims about the best explanation or the best solution are put to the test through argumentation with peers who analyze the relevance and sufficiency of the evidence being used to support the claims. If the evidence is found to be lacking, alternative claims are proposed. Throughout the unit, students will design, write, and conduct an investigation to gather evidence they can use to develop a claim about the drink mix weight.

The drink mix situation involves a cause-and-effect relationship. An effect is something that has happened, and the cause is the event that made it happen. Investigations often help students identify and test a possible cause-and-effect relationship. Students are likely to encounter cause-and-effect relationships in their daily lives and will probably have identified them in language arts and social studies classes as well as STEM class.

Figure 1.1: Does the weight of the powder disappear when it is added to water?

Preparation

1. Using a scale to measure the weight, pour about 20 g of powdered drink mix each into three tubs. Secure the lids on the tubs.
2. Using a scale to measure the weight, pour about 40 g of powdered drink mix into a fourth tub. Secure the lid on this tub.

Teacher Tip

Use distinguishing language when talking about the containers within which students will mix the water and powder (drink container) and the containers that will hold the powdered drink mix (tubs).

Task 1

Figure 1.2: Some scales have a zero or tare function to account for the weight of a container. Put a tub on the scale and push the zero/tare button. The scale reading will change to zero. As powder is added, only the weight of the powder will be displayed.

Figure 1.3: Prepared materials to pass around during class.

3. Prepare four drink containers.
   - Fill four drink containers about three-fourths full of water. Secure the lids on three of the containers.
   - Pour the mix from one of the tubs of 20 g of powdered mix into the open drink container, secure the lid, and shake to help dissolve the powder.
   - Put the tub with 40 g of mix and one container of water in the backpack. You will mix half of this powder into the water in the drink container as a demonstration for students.
   - Set aside the other prepared drink containers and powder tubs for use during the activity.

4. Put a few other hiking items in the backpack such as a cell phone, a snack, a trail map, and a bird or plant identification book. This is optional.
5. Prepare a Drink Mix Ideas chart that can be made accessible to all students during the activity (see Figure 1.4). Students will need access to this chart throughout the unit and you will add to it in later tasks.
6. Make one copy of the Initial Ideas About Drink Mixes sheet for each student.
7. Gather large sticky notes that groups can use to document and post ideas.

Drink Mix Ideas		
Will mixing some of my drink mix into my water affect the weight of my pack?		
Yes	Maybe	No

Figure 1.4: Student groups will post their ideas on the Drink Mix Ideas chart.

Procedure

1. Tell the class that you have a problem you would like them to help you with. It involves the weight of a backpack for a hiking trip. Have students turn to a shoulder partner and discuss experiences they have had with hiking and packing. If students do not have hiking experiences to share, ask them to think about other experiences where they need to think about how much weight to carry, such as to and from school, when visiting friends or family, or carrying groceries home from a store.
2. Introduce students to the problem. Share that you are collecting things to take on a hike and don't want to carry too much weight in your pack.
3. Take the tub of drink mix and the drink container out of the pack. Ask the class if mixing some of the drink mix into the water might help. Have them think about this quietly.

4. Remove the lids. Pour about half of the drink mix into the water in the drink container. Replace the lids. Shake the drink container to mix in the powder. Put the tub and drink container back in the pack.
5. Have students pass around or otherwise observe the backpack and the other prepared containers of water, powdered drink mix, and premixed beverages.
6. Give each student an Initial Ideas About Drink Mixes sheet. Tell the class that you would like to learn what each of them thinks about what you just demonstrated for them. Ask them to record their ideas on the sheet. Tell students that they can use both writing and drawing to express their ideas. As students answer these pre-assessment prompts, encourage students to use relevant vocabulary they have learned in class or outside of class. Review the individual sheets after this class period to learn more about students' early ideas about conservation of mass, which can be built upon throughout the unit.
7. As students finish responding to the prompts individually, have them form small groups and discuss their answers. Ask students to share their experiences with mixing together drinks and how these experiences influenced their thinking. Encourage them to discuss whether they think their ideas are true for all drink mixes.
8. During this small-group discussion, make the Drink Mix Ideas chart accessible to all students. Give each group a few large sticky notes. Ask group members to share their ideas and work together to record their thinking on the sticky notes. Encourage groups to use writing and sketches to represent their ideas. Have groups post their ideas in the appropriate section of the Drink Mix Ideas chart. Tell the students that there are no right or wrong answers right now; this is just an opportunity for them the share their initial ideas.

PS1.A Students record their initial ideas about how combining water and powdered drink mix affects the weight of the mixture.

Cause and effect Students incorporate a cause-and-effect relationship into their initial argument about what effect mixing two substances together will have on the final weight of the new substance.

Engaging in argument from evidence Students use evidence from prior experiences to support their initial ideas about the drink mix weight.

Teacher Tip

Empty and clean the bottles between class periods or store them in a refrigerator to minimize mold and mildew growth. If you empty and clean the containers, you will need to refill them for Tasks 2 and 3.

Task 2: Initial Investigation Planning 20 minutes

Background Information

In this task, students are given an investigation question that will likely represent some of their initial ideas about the drink mix question. If powdered mix is combined with water, does the powder still have weight? They plan how to collect evidence to support a claim that answers this question.

NGSS PS1.A states: "The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish." As students plan an investigation, look for evidence that this disciplinary core idea, as well as the need to gather evidence to support a claim about cause and effect, is guiding their efforts. If you choose to have students ask their own investigation questions based on the drink mix scenario, make sure students will be able to encounter the common naive concepts cited in the Assessment Map and gather evidence that supports their understanding of the disciplinary core idea.

Planning and carrying out investigations can include selecting or developing ways to measure outcomes, conducting a fair test, developing and following procedures, and making and recording observations and data. It also usually involves collaborating with others, exchanging ideas, setting roles, and pooling data.

In this unit, students are given a significant amount of structure and time to plan an investigation. This structure provides an introduction to several computational thinking practices, including abstraction and decomposition. One aspect of abstraction is foregrounding the factors that are key to the situation under study—in this case, measuring and comparing weights. Abstraction is useful because it helps students eliminate unrelated details for the given context (for example, shape of the container, flavor of the drink mix, weight of the backpack) and focus on the key factors. Decomposition means breaking a problem down into smaller parts that are easier to tackle. In this task, students begin decomposing the investigation into the materials, the data, and ways to record and analyze the data. In this way, the investigation becomes more manageable to plan and conduct.

Preparation

1. Prepare a chart with the title Building an Investigation Plan that can be made accessible to all students and added to during the activity. Add the investigation question under the title: "If powdered drink mix is combined with water, does the powder still have weight?" Students will need access to this chart throughout the unit.
2. Prepare one drink mix tub for each group of four students. Using a scale to measure the weight, pour about 20 g of powdered drink mix into each tub. Secure a lid on each tub.
3. Prepare one drink container for each group of four students. Fill each drink container about three-fourths full of water. Secure a lid on each container.

4. If you emptied and cleaned the demonstration containers following Task 1, prepare one set of containers for student reference, using the directions in steps 2 and 3. Use the directions in Task 1, step 3, to prepare a drink in another drink container.
5. Place sets of materials for groups of four in a location that will be accessible to all students during the task. Each set of materials should contain:
   - 1 drink container of water
   - 1 powdered mix tub
   - 1 funnel
   - 1 digital scale
6. If groups will need to share scales, develop guidelines to ensure equitable access.
7. Make one copy of the Our Drink Mix Investigation Ideas sheet for each group of four students.
8. Make sure the Drink Mix Ideas chart is accessible to all students.

Task 2

Procedure

1. Show students a tub of drink mix, a bottle with water in it, and a container of prepared drink. Remind students of the demonstration you did in the previous class and have them review what groups posted on the Drink Mix Ideas chart.
2. Ask students if they have any new ideas to add to the chart, and record any ideas that are shared.
3. Tell the class that, based on their discussions at the end of the last class, it sounds like it would be a good idea to investigate what happens when you combine powdered drink mix and water.
4. Post the Building an Investigation Plan chart and read the question aloud: "If powdered drink mix is combined with water, does the powder still have weight?" Give students time to identify ideas on the Drink Mix Ideas chart or their own Initial Ideas About Drink Mixes sheets that relate to this question. As needed, explain that some of the posted ideas said the weight of the powder disappears when it is mixed into the water.
5. Have students help you identify the possible cause-and-effect relationship in the question. For example, the cause is mixing water and powder together and the possible effect is the disappearance of the weight of the powder.
6. Explain to the class that an investigation will give them data they can use to evaluate whether or not this cause-and-effect relationship is accurate.

Teacher Tip

Some students might suggest that powdered drink mix doesn't weigh much, so even if the weight of the powder disappears the pack wouldn't be much lighter. Explain that every bit of weight savings can be important when trying to lighten a load.

7. Ask students to quietly imagine what an investigation will involve. Encourage them to think about what data they would need to use as evidence to answer the question and what materials they could use in an investigation.
8. Divide the class into groups of four students. Students will work in these groups through Task 7. Give each group access to an Our Drink Mix Investigation Ideas sheet. Have students share their investigation ideas within their group and answer the first prompt on the sheet. Encourage them to use sketches as well as written words to help all students express their ideas.
9. Ask students to share what materials they suggest for an investigation. Record these ideas on the Building an Investigation Plan chart.
10. Once groups have shared their materials suggestions, let the class know what materials you have available for them. If students suggested other materials that you have access to, gather these for the groups to use. Have each group pick up one prepared set of materials for their group. Tell them that they can use these materials as they complete their Our Drink Mix Investigation Ideas sheet, but that they should not mix drink powder and water together at this time.
11. If groups will need to share materials, provide guidelines to ensure equitable access.

PS1.A Students are building toward an understanding of this concept. They keep in mind the need to compare weights before and after mixing substances as they begin to plan an investigation.

Engaging in argument from evidence Students are preparing to construct and support an argument with evidence. They identify ways to collect data to be used as evidence to construct an argument about drink mix weight.

ISTE 1.5c Students identify important aspects of an investigation of the drink mix question: required materials, data to be collected, and proposed data analysis.

Teacher Tip

Students may suggest they need to know the weight of the backpack. Record this on the chart but discuss that while the weight of the pack may be relevant to the overall scenario, it likely does not have a role in the investigation. As groups continue to plan the investigation, this will become more apparent.

12. When groups have completed their sheets, facilitate a class discussion about investigation data, using prompts such as those below. Record students' ideas as they are shared on the Building an Investigation Plan chart (see Figure 2.1). Ask students who used drawings to explain their ideas

Task 2

to add sketches to the chart. Encourage students to explain why their groups decided certain data were important.

- What data do we need to get from the investigation so that we can answer our question? *(We need to know the weights of the water and however much drink mix we would use for a drink. We need to know the weight of the drink after it's been mixed together. Maybe we need to know the weight of the drink container and tub the powder is in, because those were in the pack.)*
- How should we keep track of the weight data? When each group does the investigation, what should they do with the data? *(Each group should write the weights down on a piece of paper. We should make a class chart of all the groups' weights.)*
- When we do an investigation, we need to analyze the data. What do we need to do with the data so that we can answer the question? *(We need to compare the water weight and powder weight added together to the weight of the mixed drink to see if the weight of the powder went away.)*

Building an Investigation Plan

If powdered drink mix is combined with water, does the powder still have weight?

Materials

water
powder
scale or something to weigh with (grams? ounces?)
water bottle or cup
funnel, or make a paper cone
backpack?

Data to collect

weights: bottle, water, powder, drink
size?
volume?
data for each trial

Record and analyze data

data table
compare weights (< > =)
subtract container weights
graph: what kind?

Figure 2.1: Students' ideas will vary based on their experiences planning investigations.

13. Have groups use their Our Drink Mix Investigation Ideas sheet to draft a data table they think they could use for the investigation.

Teacher Tip

Students will likely not identify all the data they will want to collect and a complete analysis plan at this time. See Figure 2.2 for a list of data students may eventually decide to collect and mathematical analysis that will lead to weight comparisons.

14. If students use appropriate weight units when discussing how to record and analyze weight data, acknowledge their use of this important concept. Regardless of whether students brought up units on their own, ask students to refer to their sheets and their draft data table and explain which unit of weight they should use. Ask students to explain the role of units when recording or discussing data and why groups should all use the same units. Remind students that they can refer to the scales they will be using to support this discussion.

Scale, proportion, and quantity Students explain what standard units they should use when measuring, recording, and analyzing weight data.

Possible Data Table Headings
Drink container with lid weight
Water and container with lid weight
Water only weight
Small tub with lid weight
Powder and small tub with lid weight
Powder mixed into water in container with lid weight
Powder only weight
Water + powder weight
Powder mixed into water weight (no container)

Figure 2.2: Students may collect data differently if they use a zero/tare function on their scale.

Teacher Tip

Groups will use the tubs of drink mix and empty drink containers in the next task. Groups will need access to their Our Drink Mix Investigation Ideas sheets in the next task.

Task 3: Writing the Investigation Procedure 30 minutes

Background Information

Some students may have experience with writing steps for tasks such as making a sandwich or washing their hands during COVID-19. These sets of steps are sometimes called algorithms. There is some debate within the computer science and computational thinking worlds about whether any sequence of steps can be called an algorithm, or if that term should be reserved for steps written to be performed by a machine (19). Students may not have experience writing detailed investigation procedures or otherwise writing a sequential set of steps within a STEM context.

In this task, students continue to develop computational thinking practices by developing a procedure that can be used by a human to investigate the drink mix weight question. Consider what level of detail you can expect from your students. While the goal is to have a procedure that anyone can follow, you may want to allow students to provide less detailed steps, such as "weigh the container," that make sense to everyone in the classroom.

Preparation

1. @ Navigate to **ScienceEducation.si.edu/drinkweight**. Open and review the Weighing Detailed Procedure file. This file contains detailed procedure steps for part of the investigation. Use this as a starting point if you need to provide your students with a sample procedure with a high level of detail.
2. Make sure both charts from Tasks 1 and 2 are accessible to all students.
3. If you emptied and cleaned the tubs following Task 2, prepare one powdered drink mix tub for each group of four students. Using a scale to measure the weight, pour about 20 g of powdered drink mix into each tub. Secure a lid on each tub.
4. Place sets of materials for groups of four in a location that will be accessible to all students during the task. Each set should contain:
   - 1 empty drink container with lid
   - 1 powdered mix tub with lid
   - 1 funnel
   - 1 digital scale
   - Other materials identified by the class in Task 2
5. Decide how groups will record their investigation procedure. In the next task, groups will switch procedures with another group and use the peer group's procedure to conduct the

Task 3

investigation. As groups conduct the investigation, they will need to mark trouble spots in the procedure. Figure 3.1 shows a procedure written on chart paper with subsequent comments placed using sticky notes.

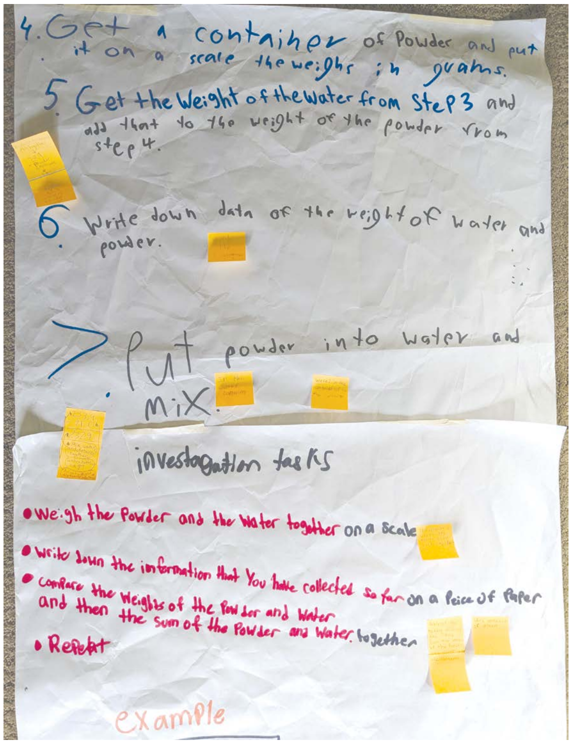


Figure 3.1: Groups could use blank paper, chart paper, or computers to record and share their procedure.

Teacher Tip

If students will be writing their procedures electronically, consider taking pictures of each material to be used in the investigation. Share the photo files with students so they can use them in writing their procedures.

6. Fill several large pitchers or similar containers with water. Secure lids on the pitchers, if possible. Place the pitchers in locations around the room for students to access during the activity. Place materials for cleaning spills in the same locations.
7. Place large containers in accessible locations for collecting liquids after the activity or make sure students can access a classroom sink for liquid disposal.
8. Have additional empty tubs with lids available for student use.

Task 3

Procedure

1. Have students rejoin their groups from Task 2. Make sure each group has their copy of the Our Drink Mix Investigation Ideas sheet.
2. Tell the class that they will use their sheets and the posted charts as guidance as they develop a procedure for an investigation. Ask students to think of times when they followed directions that were either very clear or were hard to understand. Use questions such as the following to access student thinking and to introduce the importance of clarity in procedures.
   - Did you think of any times when a procedure was poorly written? What makes you say that?
   - Did you think of any times when a procedure was well written? What makes you say that?
   - Why does it make a difference if an investigation procedure is well written?
3. Remind the class that the investigation will give them data they can use as evidence to make a claim about the cause-and-effect question on the Building an Investigation Plan chart. They will also have the chance to reevaluate the ideas that are posted on the Drink Mix Ideas chart.
4. Ask students to summarize the class's ideas for what data to collect. Have students share how that data will help them evaluate the cause-and-effect relationship.
5. If you expect students need additional support writing a procedure or if you see groups having difficulty once they start, share a general list of tasks that groups can build from. Figure 3.2 provides an example.

Investigation Outline
Identify and gather materials/supplies
Weigh empty containers
Weigh containers with water and powder in them
Mix the water and powder
Weigh container with drink in it
Compare weights

Figure 3.2: If needed, provide students with an investigation outline. Provide detail based on your students' needs.

6. Have groups take investigation materials to their work areas. If groups will need to share materials, provide guidelines to ensure equitable access.
7. Give groups time to write their investigation procedure steps, including sketches if students find this helpful. Encourage them to use the materials as they work. Groups may choose to consult with or collaborate with other groups. When you see this happening, acknowledge that such consultation and collaboration is an important aspect of STEM work.

8. When a group has completed their procedure, have them check their procedure against the draft data table they created in Task 2. Give them additional time to revise their table or procedure if they think it is necessary.

Find the weight of the water
Step 1: Zero your scale.
Step 2: Place your empty drink bottle on the scale.
Step 3: Record the weight of the bottle.
Step 4: Zero the scale again to account for the weight of the bottle.
Step 5: Pour water into the bottle.
Step 6: Record the weight of the water in the bottle.

Figure 3.3: An example of steps a group may write for weighing water. These students are familiar with and chose to use the zero/tare function on their scale. Groups' procedures may be less detailed than this.

PS1.A Students plan procedures that will enable them to collect data to use as evidence to support their understanding of this concept, comparing the weights of a prepared drink and of the water and powdered mix that went into it.

Scale, proportion, and quantity Students incorporate the appropriate units for weight into their investigation procedure and/or data table.

Planning and carrying out investigations Students collaboratively write procedures for an investigation that will provide evidence to evaluate a claim about drink mix weight.

ISTE 1.5d Students write investigation procedure steps that are clear and complete enough for another person to follow and that accomplish the goals of the investigation.

Task 4: Investigation Procedure Test Run 20 minutes

Task 4

Background Information

Debugging, or identifying and fixing errors in an algorithm, is another aspect of computational thinking and computer programming. Research into the use of computational thinking in support of student metacognition indicates that "as teachers engage students in debugging practice it shifts the culture of learning in the classroom as students do not get discouraged when their strategies do not work and are willing to try new strategies" (20).

In this task, each group exchanges procedures with a peer group and uses the procedure they receive to conduct the investigation. Team members record trouble spots within the procedure during an initial testing-and-debugging run. Members of the group record their ideas for how to edit the procedure so the investigation can be conducted as intended to gather evidence they can use to support a claim about the drink mix weight.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Review the procedures groups wrote in Task 3. If you think groups will have too much difficulty debugging the procedures, prepare a demonstration of the procedure the class can debug together.
    - Compile segments of multiple procedures into a single investigation procedure.
    - Identify a location where you can conduct the investigation as a demonstration.
    - Prepare a place to record data from the compiled investigation procedure.
    - Gather one set of materials, including a pitcher of water, an empty drink container with lid, a tub of powdered mix with lid, an empty tub with lid, a digital scale, a funnel, and cleaning supplies.
    - Have extra drink containers, powdered drink mix, and tubs for weighing the mix available.
3. Make one copy of the Investigation Procedure Test Run sheet for each group of four students. If groups will be testing the procedure on their own, in addition to this sheet consider giving each group sticky notes they can use to mark problematic steps in the procedure they are using. Groups can also use this sheet to record issues if you conduct the investigation as a demonstration.
4. Prepare one powdered mix tub for each group of four students. Using a scale to measure the weight, pour about 20 g of powdered drink mix into each tub. Secure a lid on each tub. If there is more than one type of drink mix, mark the lids with different symbols and record a symbol key for reference.

5. Place sets of materials for groups of four in a location that will be accessible to all students during the task. Each set should contain:
   - 1 empty drink container with lid
   - 1 powdered mix tub with lid
   - 1 empty powdered mix tub with lid
   - 1 funnel
   - 1 digital scale
   - Other materials identified by the class in Task 2
6. Fill several large pitchers or similar containers with water. Secure lids on the pitchers, if possible. Place the pitchers in locations around the room for students to access during the activity. Place materials for cleaning spills in the same locations.
7. Place large containers in accessible locations for collecting liquids after the activity or make sure students can access a classroom sink for liquid disposal.
8. Have additional drink mix and empty tubs with lids available that groups can use if needed.

Procedure

1. Ask the class to share what they thought about writing their own investigation procedures. Explain to students that writing clear procedures is an important part of science and engineering. Clear procedures are needed for science investigations and for testing engineering designs. Procedures need to be well written so the original user can understand them, but also so that others who want to repeat or do a similar investigation can use the procedure.
2. Continue to explain that one way researchers ensure their procedures are clear is to conduct a test run. During such a test, they identify steps or sections that are hard to follow and then revise those sections. This helps everyone who will use the procedure.
3. Tell the class that their groups will do this type of test run using another group's procedure.
4. Have students rejoin their groups. Give each group a copy of another team's investigation procedure. Give each group a copy of the Investigation Procedure Test Run sheet or an alternative way to mark trouble spots.
5. Tell students where they can get materials. If groups will need to share materials, remind them of the guidelines to ensure equitable access.
6. Give groups time to complete one trial of the investigation. If the class is using more than one type of drink mix, have groups write the symbol from their powder container next to their weight data.
7. Remind students to use the first two columns of the Investigation Procedure Test Run sheet to record problem spots as they work through the procedure. Tell the class that they will have time to suggest fixes when they have completed the investigation test run.

8. When groups finish their test run, have them discuss the problems they encountered and record their suggested fixes. Tell them that they will have additional time to revise the procedure in the next task, after the whole class has discussed their test runs.

CSTA 1B-AP-15 / ISTE 1.5d Students complete or observe a test run of an investigation procedure. They appropriately identify trouble spots in the procedure (not just differences in how they would write the investigation) and suggest ways to fix errors so that the procedure runs as intended.

Task 5: Revising the Procedure 30 minutes

Background Information

In this task, the groups share with the class the problems they encountered while conducting the investigation. The class identifies common problems, such as lack of specific language and missing directions. Students have the opportunity to suggest alternative approaches to solve common problems. Each group finalizes their procedure based on notes from their Investigation Procedure Test Run sheet and this class discussion.

Figure 5.1: Students revise their procedure for weighing powdered drink mix.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Place empty drink containers with lids and empty powder mix tubs with lids as well as other investigation materials in a location accessible to all students.

Procedure

1. Have students rejoin their groups. Ask groups to review their completed Investigation Procedure Test Run sheets.
2. Ask the class questions such as the following to help draw attention to problem spots in the procedures and to allow them to celebrate successes.
   - Did you successfully find the weight of the water or the drink mix?
   - How did you account for the weight of the containers?
   - Did you find the combined weight of the water and drink mix?

3. As part of the class discussion, ask groups to use their Investigation Procedure Test Run sheets to share details about problems they encountered while conducting the investigation. Encourage the use of "me too" gestures so the class gets a sense of common issues such as lack of clarity in the language or steps that were missing.

Teacher Tip

Encourage students to access materials to demonstrate the problem they encountered or possible ways to fix a problem.

4. Give students the opportunity to work together to brainstorm changes to language that might benefit their own and/or other groups.
5. Have groups record new suggested fixes on their Investigation Procedure Test Run sheet.
6. Following the class discussion, give groups time to revise their procedure. Let them know that they will run the investigation again. Have groups access and use materials as needed and record their procedure changes in such a way that their final procedure will be usable by their group in the next task.

CSTA 1B-AP-15 / ISTE 1.5d Students complete the debugging of their investigation procedure. They incorporate ideas from peers to improve the procedure so it can be used to collect data that can be used as evidence to answer the class question about what happens to the weight of a powder when it is dissolved in water.

Task 6: Drink Mix Investigation 30 minutes

Background Information

In this task, groups of students use the procedures they tested and debugged to conduct an investigation. If the importance of running multiple trials of the investigation has not yet come up in class discussions, this practice should be introduced for discussion as part of this task. Scientists do multiple trials of investigations to increase their confidence in the results. If different drink mixes are available to students, they should mark their data appropriately so that these different trials are apparent when the data is analyzed. Having investigation results for different drink mixes will enable students to generalize their conclusions beyond a single powdered drink mix.

At the end of the task, groups analyze their own data and students independently make and support a claim in response to the investigation question. Analyzing the weights involves adding, subtracting, and comparing multidigit numbers, including decimals. Students should also be given the opportunity to round their weights to the units place before making final comparisons and in preparation for graphing in Task 7.

Figure 6.1: A student group prepares to perform an investigation to collect evidence to evaluate a claim.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Make a copy of the My Claim About Drink Mix Weight sheet for each student.
3. Using a scale to measure the weight, pour about 40 g of powdered drink mix into a tub. Secure the lid on the tub.

4. Fill one drink container about three-fourths full of water. Secure the lid on the container.
5. Put the tub with 40 g of mix and the container of water in the backpack.
6. Prepare three drink mix tubs for each group of four students. Using a scale to measure the weight, pour about 20 g of powdered drink mix into each tub. Secure a lid on each tub. If there is more than one type of drink mix, mark the lids with different symbols and record a symbol key for reference.
7. Place sets of materials for groups of four in a location that will be accessible to all students during the task. Each set should include:
   - 1 empty drink container with lid
   - 1 empty powdered mix tub with lid
   - 1 powdered mix tub with lid
   - 1 funnel
   - 1 digital scale
   - Other materials identified by the class in Task 2
8. Set aside the extra filled powder tubs (prepared in step 6).
9. Fill several large pitchers or similar containers with water. Secure lids on the pitchers, if possible. Place the pitchers in locations around the room for students to access during the activity. Place materials for cleaning spills in the same locations.
10. Place large containers in accessible locations for collecting liquids after the activity or make sure students can access a classroom sink for liquid disposal.
11. Have additional drink mix and empty tubs with lids available that groups can use if needed.

Task 6

Procedure

1. Ask students to reflect on the problem you shared at the beginning of the unit and the demonstration you did. Repeat the demonstration of mixing powder and water from your backpack and returning the powder container and mixed drink to the backpack.
2. Invite students to review the ideas they recorded on their Initial Ideas About Drink Mixes sheet and the Drink Mix Ideas chart.
3. Invite students to share how they think the investigation they have designed will address their ideas and the question posted on the Building an Investigation Plan chart.
4. Have students rejoin their groups and access their final investigation procedures.
5. Give groups time to complete one trial of the investigation.

6. As they are working, have groups discuss how their observations relate to the question they are investigating.
7. Circulate among the groups and take note of the range of before and after weights, which will be used in Task 7.

Teacher Tip

If students need support adding, subtracting, and/or rounding their weight data, consider working through some examples in small groups or as a whole class.

8. If the class has already discussed the need for multiple trials in this investigation, have them continue to conduct at least three trials. If trials have not been discussed, have groups stop work after one run through the investigation. For groups that need to wait for others to finish, have them record any difficulties they encountered with the procedure.
9. Have the groups discuss any problems they encountered during the investigation. Ask them to discuss if these were issues with the procedure or with how they conducted the procedure. Have students point out issues they may have encountered, such as some powder sticking to the tubs or funnels. Have them consider how the problems may have affected their results and if conducting additional trials would help them be more confident in their results.
10. Tell groups where they can access additional drink mix tubs and have groups complete two more investigation trials. Tell students to use the large container or a classroom sink to dispose of prepared drinks after each trial.
11. Have groups discuss their investigation data and how it applies to the question.
12. Give each student a copy of the My Claim About Drink Mix Weight sheet and have them complete the sheet independently.

Teacher Tip

Students will need access to their investigation procedures in Tasks 8 through 10.

Cause and effect Students conduct an investigation to test their ideas about a cause-and-effect relationship related to powdered drink mix weight.

Scale, proportion, and quantity Students set the scale to measure in the appropriate units and record their weight data using the appropriate units.

Planning and carrying out investigations Students conduct an investigation to gather evidence to be used to evaluate a proposed cause-and-effect relationship. They identify issues that may affect their confidence in the investigation data and conduct multiple trials to increase their confidence.

Engaging in argument from evidence Students use evidence from their group's investigation data to evaluate the cause-and-effect claim within their investigation question and to support their claim about what happens to the drink mix weight.

CCSS.MATH.CONTENT.5.NBT.A.3.B / 5.NBT.A.4 / 5.NBT.B.7 Students add, subtract, compare, and round multidigit numbers, including decimals, as part of their weight data analysis.

Task 7: Revised Ideas 30 minutes

Background Information

When data are collected in an investigation or test, they are usually in a relatively raw format. For data to be helpful, they usually must be organized and visualized by creating tables, graphs, or other visuals. This helps scientists and engineers identify patterns in data. Identifying patterns is useful as they work to connect results to possible causes. Data collection and analysis and pattern recognition are considered to be computational thinking practices.

In this task, students expand upon their analysis of their own group's data and analyze all groups' data to support their argument about drink mix weight. Students should be able to support a claim that the weight of the mix does not disappear when it is dissolved in water. They should recognize that the total weight of the prepared drink is comparable to the sum of the initial weights of the water and powder.

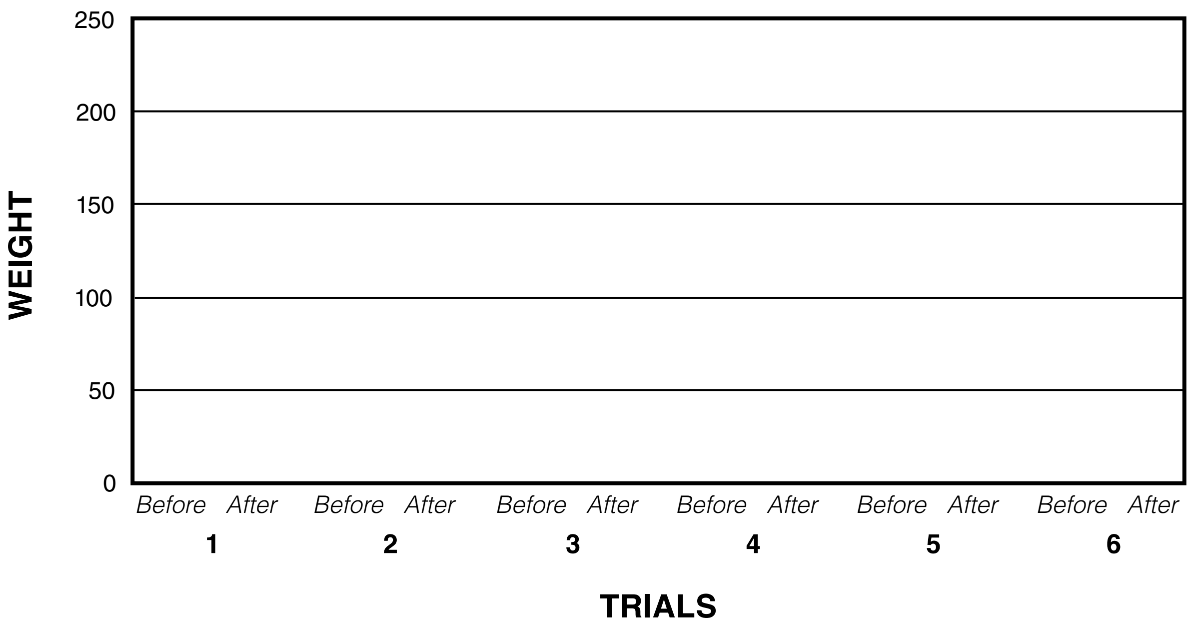


Figure 7.1: Prepare a grid for a bar graph showing all groups' data.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Use the data groups collected in the previous task to identify the range of weight values to be represented on a bar graph. Prepare a grid on which all groups can plot before and after weights. Include number labels on the vertical grid, but do not include weight units at this time. Use Figure 7.1 for guidance.

Task 7

3. Have at least one classroom scale and prepared containers of water, powdered drink mix, and a premixed beverage available for use during class discussion.
4. Make one copy of the Our Claim About Drink Mix Weight sheet for each group of four students.

Procedure

1. Remind the class of the posted Drink Mix Ideas chart and their investigation question.
2. Have students rejoin their groups and share the claims they made on the My Claim About Drink Mix Weight sheets. Even if all group members have similar claims, sharing their evidence and discussing how the evidence supports their claim is important scientific argument experience.
3. Remind the class that scientists look for patterns in data when they are figuring out what investigation results mean. Raw data usually needs to be organized in a way that reveals patterns and relationships. Facilitate a class discussion about how groups organized and analyzed their data and to introduce the idea of using bar graphs to look for patterns across all the groups' data.
   - Do you think you can see any patterns in your group's weight data? Why or why not? *(We only had time to do the investigation once, so you can't see a pattern with just one set of measurements. We did three trials and the results are all about the same. The total weights before and after the powder was mixed into the water are the same. We think that's a pattern.)*
   - What could we do to help us use patterns in data to support our claims? *(We could look at all the groups' data at one time. I think we could graph all the data. We didn't all use the same amounts of water or mix, so I'm not sure we can look at what every group did together; the numbers will all be different. I think we can tell if the comparison for each group is the same. I think we could tell if the weight of the mix went away.)*

Teacher Tip

If you have time and space, allow groups to graph all their data. Alternatively, have groups choose one data set they think best represents their trials and graph those data. Ask them to be prepared to explain why that data set best represents all their trials.

4. Show the class the grid for the bar graph you prepared. Explain that looking at data using graphs is one way scientists look for patterns. Tell the class that you put weight labels on the graph, but you didn't put units on it yet. Ask the class what the units label should be. Ask students to explain what would have happened if not all groups measured and recorded the weights using the same units.

Teacher Tip

Have students round the weights they will graph to the units place.

5. Have a representative from each group draw bars representing before and after mixing weights on the grid. If groups used different types of drink mixes, ask them to put the symbol for their mix in their bars, for example the Ls and Ks in Figure 7.2.

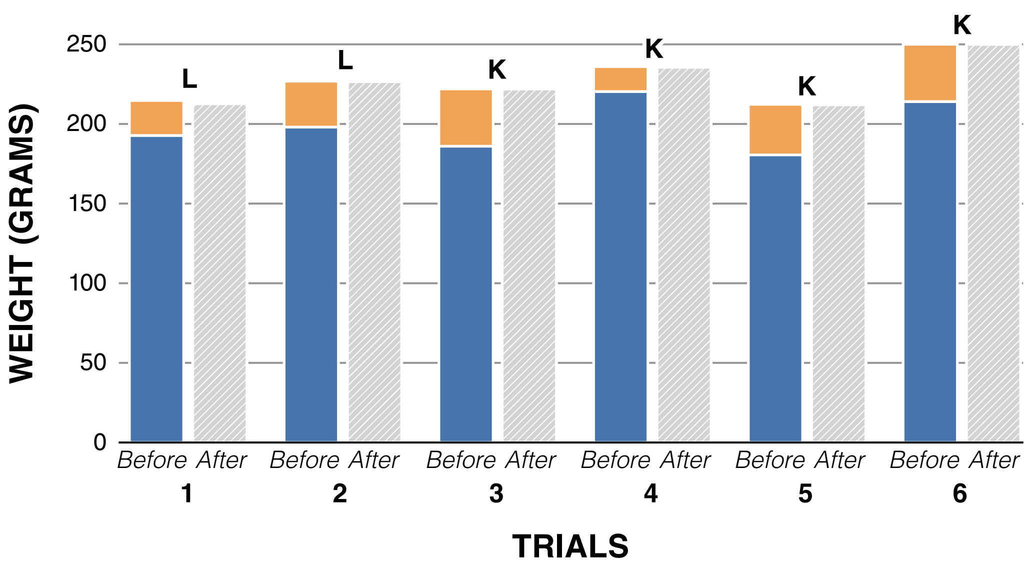


Figure 7.2: This sample class bar graph of investigation data shows weight in grams of the water (bottom/blue), the drink mix powder (top/orange), and the two mixed together (gray).

6. As the bars are being drawn, encourage groups to discuss the class data, looking for patterns. Give each group an Our Claim About Drink Mix Weight sheet.
7. When all the bars are added to the graph, ask groups to again review their individual claims and the graph of class data. Have students argue in support of a group claim and record it on their Our Claim About Drink Mix Weight sheet.
8. Have groups share their claims and evidence with the class. The class should reach consensus that the weight of the powdered mix does not disappear when it is added to water, even though the powder dissolves.

Teacher Tip

Some groups may observe that the weight of the drink mixture is not exactly the same as the sum of the initial water and powder weights, although the difference is not enough to argue that the entire weight of the powder disappeared. Use this as a starting point for a discussion of possible errors or inconsistencies in measurements.

9. Write and attach a final class claim to the Building an Investigation Plan chart near the investigation question. Have students guide you in listing the evidence that supports their response.
10. Have students review the Drink Mix Ideas chart again. Remind them that scientists often change their ideas when they encounter new evidence. That is how scientists learn new things about the world. Have students reflect on how any of their ideas about the weight of the powder or the drink mix weights changed and why.
11. Ask the students for ideas of other types of drink mixes or other powders they could investigate using the same procedures they wrote and tested. Do they think they would observe the same effect if other mixes were combined with water?
12. Encourage students to identify other ideas on the chart to which their data may apply and to think of additional questions they could investigate or learn more about through other types of research.

Teacher Tip

Students may be interested in others who experience the problem of a heavy pack. @ Navigate to **ScienceEducation.si.edu/drinkweight**. Open and copy the optional reading *Lighten the Load*. Have pairs of students read the story together. Give them time to discuss the problems caused by carrying a heavy load and different ways to solve the problems.

PS1.A Students explain that the weight of a prepared drink is the same as the total weight of the water and the powdered drink mix that went into it. The weight of the powder did not disappear when the powder dissolved in water.

Patterns Students identify a pattern that holds for all groups' data and use it as evidence to support their argument.

Engaging in argument from evidence Students use evidence from all groups' investigation data to evaluate the cause-and-effect claim within their investigation question and to support their claim about the drink mix weight.

CSTA 1B-DA-06 / ISTE 1.6c Students prepare a visual representation of all groups' weight data to help them respond to the drink mix question.

Task 8: Sharing the Story—Storyboard 40 minutes

Background Information

Scientists and engineers need to communicate information about their research. They must be in constant communication with peers to stay up to date and learn from the findings of others. They also must address other audiences, such as potential funders or the public, and understand the needs of those audiences. In all cases, they need to clearly explain the motivation for their work and what they did, including evidence they collected, problems they encountered, and conclusions they formed, which must be supported by their evidence.

In the final tasks of this unit, students tell the story of their drink mix research. In this task, they identify and discuss benefits and drawbacks of different ways to communicate ideas. They then create a storyboard or visual outline about their investigation.

Based on your classroom access to the Internet, your students' experience can end following this task and a modified version of Task 9, or can continue with them creating an animation that tells their story using Scratch. For Task 8, consider collaborating with an art or language arts teacher if you are not in a self-contained classroom. For Tasks 9 and 10, consider collaborating with a computer or technology teacher in your school or district, if this resource is available.

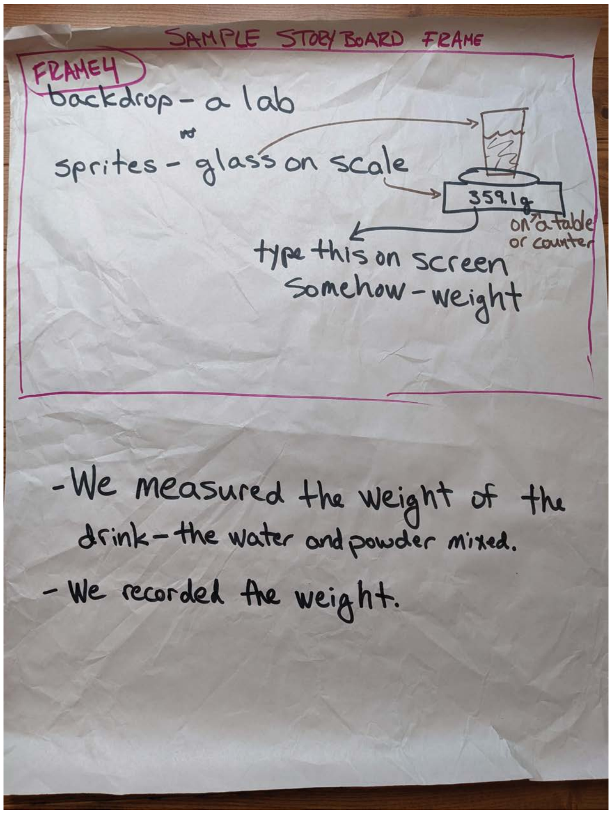


Figure 8.1: A storyboard identifies the elements of the story, including visuals and explanations of what happens in each scene.

Task 8

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Prepare a Ways to Learn About Drink Mix Weights chart with the headings shown in Figure 8.2. The chart will be made accessible to all students and added to during the activity.
3. @ Navigate to **ScienceEducation.si.edu/drinkweight**. Open the Animation Scenes file and have it ready to share with the whole class.
4. Post copies of all the groups' investigation procedures so students can refer to them during Tasks 8 through 10.
5. Make one copy of the Important Parts of the Story sheet for each student.
6. Make copies of one or both of the Storyboard Frame sheets or a storyboarding or comic strip template your students are familiar with. Plan for about six frames per student.
7. If students will peer review each other's storyboards, make one copy of the Storyboard Peer Review sheet for each student.

Procedure

1. Have students review the investigation question and class claim recorded on the Building an Investigation Plan chart. Invite shoulder partners to discuss other ways they could have learned about the results of mixing powder and water besides investigating it themselves. Have them discuss benefits and drawbacks of the different approaches they think of.
2. Ask students to share their ideas. Record these on the Ways to Learn About Drink Mix Weights chart so they are accessible to all students. Include doing an investigation on the list. Possible student ideas are shown in Figure 8.2.

Ways to Learn About Drink Mix Weights	Benefits	Drawbacks
Plan and perform an investigation	Gather our own evidence	Need materials; takes a lot of time
Teacher or someone could just tell us	Fast; don't need any materials or computer	Boring; don't see evidence
We could look it up and read about it online or in a book	Might be fast; might have a book already in the classroom or library	Might need computer and Internet; need to find site/ book we can trust; might be boring
We could do a computer simulation	Might be fast; fun; can kind of see evidence being collected	Need computer and Internet; need to find simulation we can trust
We could watch a video or animation	Fast, except maybe finding a good video; might be able to see evidence being collected	Need computer and Internet; need to find video we can trust; might be boring

Figure 8.2: Examples of what students might say about different ways information can be accessed and communicated.

3. Ask students which of the ideas they shared are ones they could do. How could they create something to communicate what they did and teach others that the weight of powder doesn't disappear when it is mixed into water?
4. Tell the class that you thought of two approaches they could take to create a way for others to learn about drink mix weight. One is to create a story in some format that can be shared in print. The other is to create an animation that can be shared electronically. Ask students to share their experiences telling stories in different ways.
5. Explain that before the students start creating a story or an animation, they need to think about what information is most important to share. Tell students that identifying the most important aspects of the story and deciding what parts to leave out is similar to outlining, which they may have done when starting on writing projects, and is an example of a skill called abstraction. They also used abstraction when they initially identified the materials, data, and type of data analysis that were important for their investigation.
6. Tell students where they can access the investigation procedures they used so they can refer to them.
7. Give each student a copy of an Important Parts of the Story sheet and time to record their ideas about the aspects of the drink mix investigation story they think would be important to share

with others. Once students have had time to record their individual ideas using written words and sketches, gather ideas from the class. Encourage students to add ideas that came up in the class discussion to their sheets.

- What are the important parts of the story? *(You didn't want your backpack to weigh a lot on a hike. You mixed some of your drink powder into your water bottle to try to reduce the weight. How we investigated, all our data, our answer to the investigation question or what we learned.)*

8. Introduce the idea of storyboarding to students. Storyboarding is often done before creating something like a video or an animation. It is like creating an outline before writing something, but storyboards include visual aspects of the story, too, like scenes and characters. They can create a storyboard and it can communicate their story. They can use their storyboard to guide the creation of their animation. They could also use their storyboard as the basis for other ways to tell the story, such as writing a print story or creating a video.

Teacher Tip

If your students will not be creating an animation, using the backdrops and sprites shown in the Animation Scenes file can be optional.

9. Explain that the programming environment students will use to build an animation in the next two tasks is set up with specific scenes and characters. They will use Scratch to write their animation. In Scratch, the scenes are called backdrops and characters and objects are called sprites.
10. Project the Animation Scenes file so the information is accessible to all students. Tell the class that these are the backdrops and sprites that have been built into Scratch for their use. They should create their initial storyboards with these in mind.
11. Tell the class that they do not need to use all the backdrops and sprites in their storyboard or animation, but they should include at least one character and that character needs to move at least once during the story.
12. Provide students with the Storyboard Frame sheets. Explain that they should number their frames sequentially. They should use the box to identify visual elements of each part of the story. They can do this by listing the backdrop and sprites they want to use and by drawing or describing additional visual elements. For visual ideas, encourage students to refer to sketches they or their classmates included earlier on charts or within procedures. They should use the lines to write out the action that takes place within the frame. Figure 8.1 shows an example of one storyboard frame.

13. If students will not be continuing on to Tasks 9 and 10, have students share their storyboards within small groups or with the entire class.

Teacher Tip

Give students the opportunity to have a peer review their storyboard. Give each student a copy of the Storyboard Peer Review sheet and ask them to complete it during the review of another student's storyboard. Give students time to read the peer review comments before starting the animation project.

PS1.A Students communicate their claim that the weight of drink mix powder does not disappear when mixed into water and/or that the weight of a prepared drink is the same as the total weight of the water and the powdered mix that went into it.

Patterns Students refer to a pattern that held for all groups' data and use it as evidence to communicate their claim.

Scale, proportion, and quantity Students consistently use appropriate units when communicating about weight data.

Obtaining, evaluating, and communicating information Students create a storyboard that accurately communicates how they learned that the weight of a prepared drink is the same as the total weights of its parts.

CSTA 1B-DA-06 Students use a visual representation of all groups' weight data to help them communicate the drink mix story.

ISTE 1.5c Students identify major elements they need to communicate in order to explain how they learned that the weight of a prepared drink is the same as the total weights of its parts.

Task 9: Introduction to Computer Algorithms 30 minutes

Task 9

Background Information

Computer programs are examples of algorithms. Like the investigation procedures students wrote, these algorithms must be written clearly. In the case of computer programs, the computer will perform steps exactly as written; it cannot interpret what a peer meant, as students may have done during their investigation.

Computer programs are written using special languages or may be constructed using graphical elements. In either case, certain structures are common in computer programs, such as sequences, events, conditionals, and loops. Instructions are written and performed in a specific order or sequence. Events within programs are actions that cause a portion of a program to run. An event students may be familiar with is clicking an on-screen button to start a video playing or to select a feature in a game. Conditional structures check to determine if a condition is true and then initiate a portion of code in a program based on that result. In a loop, a sequence of code is repeated multiple times.

In this task, students are introduced to these programming concepts. They identify examples of sequences, events, loops, and conditionals in their drink mix investigation procedure. Students can complete these parts of the task (through step 7) without access to Scratch. Students are then introduced to the Scratch programming environment; explore ways to program sequences, events, loops, and conditionals; and consider ways to use these concepts to program an animation.

Teacher Tip

Groups of two students will create programs in Scratch. Each pair (or larger groups, if necessary) needs access to a laptop or desktop computer. Tablets or mobile devices with the Scratch app installed, although less optimal, will also work. Students will need Scratch accounts to be able to save their projects. Alternatively, they can download/upload their Scratch projects as .sb3 files to save their projects without the need for Scratch accounts.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. Make sure copies of all the groups' investigation procedures are accessible so students can refer to them during Tasks 9 and 10.
3. Prepare a Programming Concept Examples chart that students can access during the task. See Figure 9.1 for possible examples. Students will need access to the chart through the end of the unit.

Programming Concept Examples
Event: An action triggers another action. When it is 7 a.m. the alarm goes off.
Sequence: Ordered steps. You get out of bed before brushing your teeth.
Conditional: If something is true, it triggers an action. Is it a weekday? If yes, pack lunch for school.
Loop: An action that is repeated some number of times. Put three squirts of ketchup on your fries.

Figure 9.1: Share programming concept examples that your students will have experience with.

4. @ Navigate to **ScienceEducation.si.edu/drinkweight**. Access and review the Drink Mix Animation Scratch Project and the Drink Mix Animation Scratch Tutorial file. Set up a way for pairs of students to access Scratch and the tutorial on their computers.
5. Make one copy of the Animation Program Planning sheet for each student.

Procedure

1. Remind students that they have the opportunity to tell their investigation story through an animation they will create. Explain that they will create their animations using a programming environment called Scratch.
2. Invite students to share their experiences using Scratch or other computer programming languages or environments.
3. Tell the class that a computer program is a list of instructions or an algorithm, just like their investigation procedure. A big difference from their investigation procedure is that the computer cannot interpret the instructions.
4. Make the Programming Concept Examples chart accessible to all students. Use the information in the Background Information at the beginning of this task to introduce your students to sequences, events, conditionals, and loops.
5. Have students think of and share other examples of each of these programming concepts.

6. Divide the class into groups of four students. Assign each group to one of the posted investigation procedures used in Task 6.
7. Give groups time to review the procedure and to identify an example of a sequence, event, conditional, and loop that appears in the procedure. If students cannot find an example for a programming concept, have them suggest a way that the missing concept(s) could be incorporated into the procedure. See Figure 9.2 for some possible examples.

Programming Concepts in Investigation Procedures

Event: Once we had our materials gathered, we were able to weigh the containers.

Sequence: Mixing together powder and water has to come before weighing the mixture.

Conditional: Does the scale have a tare or zero function? If yes, push the button to zero out the weight of the drink container.

Loop: Shake the container five times to mix the powder. Or repeat the entire procedure three times for additional trials.

Figure 9.2: Students identify examples of programming concepts in their investigation algorithm.

8. Assign partners within each group of four students and have each pair access a computer.
9. Depending on your students' familiarity with Scratch, either project the main programming screen and use the Drink Mix Animation Scratch Tutorial file to introduce students to the programming environment, or have student pairs access Scratch on their computers.
10. Once students have some familiarity with the code blocks, explain that any time students put blocks together, they are creating a sequence. If the sequence doesn't make sense, the program won't run.
11. Give students time to explore the blocks and discuss with their partner and within their groups of four which code blocks might be useful to code events, conditionals, and loops and to use in their animation. Give each student a copy of the Animation Program Planning sheet and have them use it to record their ideas. See Figure 9.3 for some examples.

Teacher Tip

Consider reducing the programming requirements if students have difficulty identifying ways to use the programming concepts.

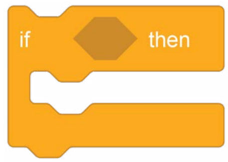
Programming Concept	Example	How It Could Be Used in Our Animation
Event		We can have the person watching the animation click on the water bottle sprite and that starts the part of the animation that tells about the investigation.
Conditional		We think we can use this when we are comparing the sum of the weight of the water and the weight of the powder to the weight of the mixed drink. Maybe we can make something happen if that is true.
Loop		We can make the sprite telling the story walk back and forth across the scene three times.

Figure 9.3: Examples of code blocks students may find to program events, conditionals, and loops.

CSTA 1B-AP-10 / ISTE 1.5d Students explore code blocks and identify examples of events, conditionals, and loops they could use to program their animation.

Task 10: Sharing the Story—Animation 40 minutes

Background Information

In this task, students use their storyboards, their ideas about code constructs from Task 9, and Scratch to create an animated version of the story about their investigation. To encourage students to use specific code structures, certain requirements are suggested for the animation project. These requirements include placing and directing the motion of a sprite. To accomplish this, students use ordered pairs in the coordinate system established within Scratch.

Preparation

1. Make sure all the charts from previous tasks are accessible to all students.
2. @ Navigate to **ScienceEducation.si.edu/drinkweight**. Access the Drink Mix Animation Scratch Project and the Drink Mix Animation Scratch Tutorial files listed in Task 9. Review the sample animation and prepare to share the sample animation with the class. Set up a way for pairs of students to access the Drink Mix Animation Scratch Project and the tutorial on their computers.

Teacher Tip

Modify the group size based on the availability of computers and your students' experiences with programming, while keeping the group size as small as possible. Scratch does not support shared editing, and research indicates that when working in groups one student may do the majority of the programming while others watch (18). During programming time, encourage students with more experience to assist their peers.

Procedure

1. Remind the class that they created storyboards to communicate information about the investigation they did, why they did it, and what they learned about what happens to the weight of a powdered drink mix when it is dissolved in water.
2. Explain to the class that they will use the storyboards to guide them as they work in pairs to write a computer program to create an animation that tells the same story. The program will direct characters' motion and speech.

3. Remind the class that they need to include at least one character in their animation and that the character needs to move at least once during the animation. Share the sample animation with the class so it is accessible to all students. Have them identify at least one character and one backdrop in the animation.
4. Tell the class that they will have to use at least three different programming concepts in their programs. Have students review the charts from Task 9 and their completed Animation Program Planning sheets. Consider reducing the programming requirements if you anticipate students will have difficulty identifying ways to use the specified concepts.
5. Divide the class into pairs and give students time to share their storyboards with each other and decide on the elements they want to include in their animation.
6. Have students work on their programming.
7. When students have completed their programming, allow time for all students to share their animations with the class.

PS1.A Students explain that the weight of a prepared drink is the same as the total weight of the water and powdered drink mix that went into it. The weight of the powder does not disappear.

Scale, proportion, and quantity Students consistently use appropriate units when communicating about weight data.

Obtaining, evaluating, and communicating information Students create an animation to communicate how they learned that the weight of a prepared drink is the same as the total weights of its parts.

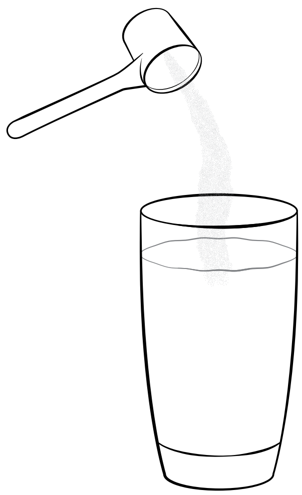
CSTA 1B-AP-10 / ISTE 1.5d / ISTE 1.6c Students create a program that uses events, sequences, loops, and/or conditionals to communicate the story of how they learned about the drink mix weights.

CSTA 1B-AP-15 / ISTE 1.5d Students test and debug the program as they write it so the program runs as intended.

CCSS.MATH.CONTENT.5.G.A.1 Students use the coordinate system within Scratch to place sprites and to direct a sprite’s motion between two points represented by ordered pairs.

Initial Ideas About Drink Mixes

1. How will adding powdered drink mix into water affect the weight your teacher carries on their hike?



2. Why do you think that?

3. What experiences have you had that support your thinking?

Student Sheets

Our Drink Mix Investigation Ideas

If powdered drink mix is combined with water, does the powder still have weight?

1. What materials do you need for the investigation?

2. What data should you collect?

3. How should you record and analyze the data?

Student Sheets

Investigation Procedure Test Run

1. Take notes on the drink mix investigation procedure as your group conducts the investigation. Did you have any problems using the procedure? Why?

Problem Spot	What Was the Problem?	Suggested Fix

My Claim About Drink Mix Weight

If powdered drink mix is combined with water, does the powder still have weight?

1. Write a claim that answers the investigation question.

2. What evidence from your investigation supports your answer?

3. How does your evidence back up your claim?

Student Sheets

Our Claim About Drink Mix Weight

If powdered drink mix is combined with water, does the powder still have weight?

1. Write a claim that answers the investigation question.

2. What evidence supports your group's answer?

3. How does your evidence back up your claim?

Important Parts of the Story

You need to communicate the story of why and how you investigated drink mixes in water and what you learned.

1. List the parts of the story you think are important to share.

Storyboard Frame 1

Storyboard Frame 2

Storyboard Peer Review

1. Does the storyboard explain why the class investigated drink mixes?
2. Does the storyboard include important parts of the investigation?
3. Does the storyboard explain what you learned about the weights?
4. Explain at least one thing you like about the storyboard.

5. Explain at least one thing you think could be improved.

Student Sheets

Animation Program Planning

1. Record at least one Scratch example of each programming concept. Explain how you could use that Scratch code in your animation program.

Programming Concept	Example	How It Could Be Used in Our Animation
Event		
Conditional		
Loop		

References

1. Committee on STEM Education of the National Science and Technology Council. 2018. *Charting a Course for Success: America's Strategy for STEM Education*. Office of Science and Technology Policy. Retrieved from https://www.energy.gov/sites/default/files/2019/05/f62/STEM-Education-Strategic-Plan-2018.pdf.
2. National Resource Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. Retrieved from https://doi.org/10.17226/13165.
3. Moulding, B., R. Bybee, and N. Paulson. 2015. *A Vision and Plan for Science Teaching and Learning: An Educator's Guide to a Framework for K–12 Science Education, Next Generation Science Standards, and State Standards*. Salt Lake City, UT: Essential Teaching and Learning PD, LLC.
4. Odden, T.O., and R. Russ. 2019. Defining Sensemaking: Bringing Clarity to a Fragmented Theoretical Construct. *Science Education* 103, no. 1: 187-205.
5. Short, M.E. 2021. *Making Sense of Student Sensemaking*. Retrieved from https://landing.carolina.com/smithsonian-students-sensemaking-whitepaper.
6. Wing, J.M. 2010. Research Notebook: Computational Thinking—What and Why? *The Link*. Carnegie Mellon University School of Computer Science. Retrieved from https://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-andwhy.
7. Shute, V.J., C. Sun, and J. Asbell-Clarke. 2017. Demystifying computational thinking. *Educational Research Review* 22: 142-58. Retrieved from https://doi.org/10.1016/j.edurev.2017.09.003.
8. Yadav, A., H. Hong, and C. Stephenson. 2016. Computational thinking for all: Pedagogical approaches to embedding 21st century problem solving in K–12 classrooms. *TechTrends* 60, no. 6: 565-568. Retrieved from https://doi.org/10.1007/s11528-016-0087-7.
9. Weintrop, D., E. Beheshti, M. Horn, K. Orton, K. Jona, L. Trouille, and U. Wilensky. 2016. Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology* 25: 127–47.
10. NGSS Lead States. 2013. *Next Generation Science Standards: For States, by States*. Washington, DC: The National Academies Press.
11. Computer Science Teachers Association. 2017. *CSTA K-12 Computer Science Standards.* Retrieved from https://www.doe.k12.de.us/cms/lib/DE01922744/Centricity/Domain/176/CSTA%20Computer%20Science%20Standards%20Revised%202017.pdf.
12. Brooks-Young, Susan. 2016. *ISTE Standards for Students: A Practical Guide for Learning with Technology.* Arlington, VA: International Society for Technology in Education.
13. Russell, T., W. Harlen, and D. Watt. 1989. Children's Ideas About Evaporation. *International Journal of Science Education* 11, Special Issue: 566-576.
14. Russell, T., and D. Watt. 1990. *Evaporation and Condensation*. Liverpool, UK: Liverpool University Press.
15. Smith, C., M. Wiser, C.W. Anderson, J. Krajcik, and B. Coppola. 2004. *Implications of Research on Children's Learning for Assessment: Matter and Atomic Molecular Theory.* Committee on Test Design for K-12 Science Achievement, Center for Education. Washington, DC: National Research Council.
16. Stavy, R. 1990. Pupils' Problems in Understanding Conservation of Matter. *International Journal of Science Education* 12, no. 5: 501-512.
17. Özmen, H., and A. Ayas. 2003. Students' Difficulties in Understanding of the Conservation of Matter in Open and Closed-System Chemical Reactions. *Chemistry Education Research and Practice* 4, no. 3: 279-290.
18. Cucinelli, G., A. Davidson, M. Romero, and T. Matheson. 2018. Intergenerational Learning Through a Participatory Video Game Design Workshop. *Journal of Intergenerational Relationships* 16, no. 1-2: 146-165. Retrieved from https://doi.org/10.1080/15350770.2018.1404855.
19. Caeli, E.N., and A. Yadav. 2020. Unplugged Approaches to Computational Thinking: A Historical Perspective. *TechTrends* 64: 29-36. Retrieved from https://doi.org/10.1007/s11528-019-00410-5.
20. Yadav, A., C. Ocak, and A. Oliver. 2022. Computational Thinking and Metacognition. *TechTrends* 66: 405-411. Retrieved from https://doi.org/10.1007/s11528-022-00695-z.

