EDUCATOR'S GUIDE

Release #2

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Section 1: Overview

1.1 PURPOSE

To support the Santa Fe Public Schools (SFPS) as they moved to a remote learning model, the Santa Fe Alliance for Science (SFAFS) agreed to develop a series of learning videos. Though they were originally developed in support of our Adopt-A-School partner, the videos will be made widely available to any SFPS teacher.

1.2 SUBJECT AREAS

Video content is created for these subject areas:

- Computer Science
- Earth & Environmental Sciences
- Life & Health Sciences
- Mathematics & Engineering
- Physical Sciences
- Astronomy
- STEM Fair Preparation

SFAFS embraces the concept of STEM Literacy. Activities that support this are embedded within each subject area, and are highlighted.

1.3 HOW TO USE THIS GUIDE

Within each subject area, there will be a description of the video.

LEARNING OBJECTIVES FOR STUDENTS are highlighted.
Linkage to EDUCATIONAL STANDARDS (e.g., NGSS) are also noted.

Where applicable, we also provide some suggestions for supplemental discussion topics that go deeper into some of the concepts that were introduced in the video.

All of the sessions can be jointly taught by an SFAFS Facilitator joining a teacher in *live-stream sessions*. Depending on the subject, we may run the presentation in real-time instead of playing the video. If the teacher wishes the SFAFS Facilitator to go deeper into a topic, or participate in a discussion on the suggested add-ons, this is possible with advance notice.

Some sessions will include "The Extra Mile."
This will give you some ideas on additional units of study to build on the content and concepts provided in the video. The units of study may be in the same subject area, or in other subject areas.

Section 2: Computer Science

2.1 SECRETS IN CODE

ABOUT THE SERIES

This series of videos introduces the science of cryptography. The videos should be viewed in the sequence listed. We will teach students the fundamentals of cryptography, showcase several methods, then give them hands-on experiences in coding secret messages.

➢Learning Objectives for the series:

After completing the modules in the series, students will have practiced and/or gained exposure to:

1. Basics of cryptography
2. Prime examples of cryptography applied in history
3. Problem solving skills
4. Communication skills

➢Applicable Education Standards:

ISTE	5- Computational Thinking (5a, 5b, 5c)
CSTA	1B-DA-06 Collection Visualization & Transformation

Session #1: Introduction (Runtime 7:06)

(Note: this video is also available in Spanish)

Discuss a few examples from history where codes were used.
Explain the coding process.

Supplemental Discussion Ideas	
Morse Code	• Who was Samuel Morse? • Why was Morse Code invented? • How was it used? Is it still used?
Navajo Code Talkers	• Explore the Navajo language • Study the biographies of some of the men who served in this capacity. • The Navajo language today (importance of preserving culture)

Exercise: Morse Code (Runtime 9:26)

Reinforces concepts discussed in Session #1 with hands-on exercises.
The video will tell you where to pause playing to allow the students time to figure out the solutions to the exercises.

Session #2: Caesar Cipher (Runtime 10:08)

This introduces the concept of shift ciphers: where a letter in the alphabet is represented by another letter (shifting a certain number of letters) or is represented by a number. Both methods utilize code wheels. The method was first used by Julius Caesar.

Because we know that code wheels may not be readily available in the students' homes, we also introduce the "linear code table" which is easily replicated at home if pencil and paper are available.

Supplemental Discussion Ideas	
Julius Caesar	• Study his biography, in particular his role as a military leader that led to the creation of the Caesar Cipher.
BC vs AD	• The discussion mentions "BC" in the discussion of Caesar.
Thomas Jefferson	• He embraced the Caesar Cipher methodology and invented an early version of a code wheel.

Exercise: How to Make Your Own Cipher Wheel (Runtime 8:48)

This is a "how to video" that shows step by step how you can make your own reusable version of a cipher wheel – using letters or numbers – at home. The materials used are: scissors, measuring instrument, pencil, scissors, and a fastening method (glue, staple, tape, paperclip, hair pin).

Session #3: Symbol Ciphers (Runtime 7:59)

Another method for representing messages is by substituting letters with symbols. We will discuss languages that are based on symbols or characters (e.g., hieroglyphs). Examples where symbols were used for sending secret messages will be discussed.

Supplemental Discussion Ideas	
Hieroglyphics	• Discuss the Egyptian culture • Dive deeper into hieroglyphics
Modern languages	• Many modern languages do not use what we refer to as the "western" or "roman" alphabet. Talk about a few of them and go through examples.
Sherlock Holmes	• Who was Sherlock Holmes? • The story of "The Dancing Men" used symbols as a secret code that Sherlock had to decode in order to solve a case.

Exercise: Using Symbol Ciphers (Runtime 7:16)

Reinforces concepts discussed in Session #3 with hands-on exercises.
The video will tell you where to pause playing to allow the students time to figure out the solutions to the exercises.

2.2 COMPUTATIONAL THINKING

ABOUT THE SERIES

This is a series of videos that discusses the different methods of thinking and reasoning that are used in computer science.

Video sessions 1 through 4 and associated exercises can be done in any order. But all of them should be completed before starting Session #5.

➢Learning Objectives for the series:

After completing the modules in the series, students will have practiced and/or gained exposure to:

1. Logical reasoning
2. Problem solving skills
3. Communication skills

➢Applicable Education Standards:

ISTE	5- Computational Thinking (5a, 5b, 5c)
CSTA	1B-DA-06 Collection Visualization & Transformation 1B-AP-08 Algorithms

Session #1: Logical Reasoning (Runtime 9:30)

We explain what logical reasoning is, then walk through examples that demonstrate three types of reasoning: classification, analogies and fact analysis.

	Supplemental Discussion Ideas
Classification	• Talk about how this is used in biology (e.g., kingdom, class, genus, species)

Exercise: Analogies (Runtime 4:45)

Exercise: Fact Analysis (Runtime 9:10)

Both exercises reinforce concepts discussed in Session #1 with hands-on exercises. The video will tell you where to pause playing to allow the students time to figure out the solutions to the exercises.

2.2 COMPUTATIONAL THINKING, continued

Session #2: Visual Pattern Recognition (Runtime 6:25)

We teach students a simple approach to looking for patterns. This session addresses visual patterns (e.g., shapes, colors, etc.).

Exercise: Practicing Visual Pattern Recognition (Runtime 8:31)

Students can practice visual pattern recognition through a set of puzzles.

Section 3: Earth & Environmental Sciences

3.1: WATER CYCLE (Runtime 11:35)

This is an early elementary overview of the earth's water cycle.

The video includes an activity to simulate the effect of the water cycle. Materials needed are listed and are easily obtainable with substitutions for home use.

➢Learning Objectives for Students:

1. Learn key terms: evaporation, condensation, precipitation, etc.
2. Understand how the water cycle relates to weather (snow, rain, ice)
3. Be able to describe what is occurring in each phase of the water cycle

	Supplemental Discussion Ideas
Precipitation	• Discuss the types of precipitation (e.g., snow – ice patterns, geometry of snowflakes, etc.) • Suggested books: *The Story of Snow: The Science of Winter's Wonder*, Mark Cassino and Jon Nelson (2009) *Snowflake Bentley,* Jacqueline Briggs Martin (1998)
Condensation	• Matter changing from a liquid to a solid

➢Applicable Education Standards:

NGSS	2-ESS2-3 Earth's Systems

THE EXTRA MILE: Water Pollution

Where does it come from? How does it affect the water cycle?

Water Purification

Make a small purification system to see if some dirty water can be cleaned. Please refer to: https://kids.nationalgeographic.com/explore/books/how-things-work/water-wonders/

Water Conservation

Think about saving water around your own house.

This is a good animated video on saving water (not affiliated with the Alliance): https://www.youtube.com/watch?v=rl0YiZjTqpw&feature=youtu.be

Additional Resources:
https://thewaterproject.org/resources/the_water_cycle/
The Magic School Bus At The Waterworks by Joanna Cole

3.2: EARTH & MAPPING

ABOUT THE SERIES

Where are we on earth? This series is an introduction to the Earth, its place in the solar system, and how we find our location on the planet earth.

➢Learning Objectives for Students:

1. Learn key terms: continents, countries, cardinal directions, N & S poles, lines of latitude and longitude, etc.
2. Students will be able to describe where they find ourselves on the earth: from the perspective of the solar system down to a specific location on a continent, country, state and actual location
3. Be able to describe the importance/use of degrees of latitude and longitude in relation to the equator and prime meridian.
4. Understand the cardinal directions and the role they play in our day-to-day lives

➢Applicable Education Standards:

NGSS	2-ESS2-2 Earth's Systems

Session #1: Introduction to the Earth (Runtime 10:54)

Introduces the concepts and vocabulary for the Earth's location in our solar system, how the Earth is described geographically and the terms used.

	Supplemental Discussion Ideas
Solar System	The Earth is only one of the planets in the solar system. What are the other planets and bodies that make up our solar system?
Geography	• Why is it important to know where things are? • What are some examples from history as to why this is important? • How did these concepts come into play as America was discovered?

Section 4: Life & Health Sciences

4.1 HOW WE MOVE

ABOUT THE SERIES

Students are introduced to basic concepts of kinesiology. Interspersed in each session are some movements that students can practice.

➢**Learning Objectives for Students:**

1. Understand the basic mechanics of body movement.
2. Learn key physiological terms, e.g., kinesiology, neurons, cortex, .

➢**Applicable Education Standards:**

NGSS	LS1A Structures and Function LS1D Information Processing

Session #1: The Role of the Brain in Movement (Runtime 9:32)

Session #2: Balance (Runtime 8:57)

Session #3: The Role of Eyes and Ears (Runtime 11:20)

Session #4: The Voice (Runtime 11:06)

4.2 HUMANE EDUCATION

ABOUT THE SERIES

This series is created in partnership with the Santa Fe Animal Shelter.

➢Learning Objectives for Students:

1. Develop empathy, compassion and respect for all living beings.
2. Increase understanding of personal responsibility for animals.
3. Awareness of the interconnectedness of issues pertaining to humans and animals.

➢Applicable Education Standards:

ISTE	3a- Citizen, exhibit empathetic behaviors
NGSS	LS 1, 2, 3, 4

Virtual Field Trip of the Santa Fe Animal Shelter (Runtime 11:16)

We recommend that this video be viewed before the rest of the Humane Education videos.

Session #1: Overpopulation (Runtime 11:35)

Discusses overpopulation as a social issue and how it negatively impacts animals. Parallels are drawn between the consequences to animals and similar impacts to humans (e.g., homelessness, hunger). We introduce the concepts of spaying and neutering, but do not go into details.

Session #2: Adoptions (Runtime 11:33)

Explains how the pet adoption process works at the Shelter.

Session #3: What Animals Need (Runtime 10:57)

This session encourages interactive involvement by the students to think about all of the things that animals need to thrive. Together we come to the conclusion that most of the things that animals need to be happy and healthy are the same things that humans need.

Session #4: Safety Around Dogs (Runtime 11:28)

Students will learn that dogs have feelings – just like humans. And just as we have good and bad days that affect our behaviors and mood, so do dogs. We teach them to recognize some basic signs that tell us when a dog does not want interaction. They will also learn to play the SAFE game – to help them be safe when they encounter a strange dog.

Session #5: How Dogs "See" (Runtime 12:13)

Learn why a dog's sense of smell is so much better than humans.

4.3 HOW THE EYE WORKS

Students are introduced to the humane eye using a model that demonstrates how the eye processes information.

➢Learning Objectives for Students

1. Learn about the different parts of the eye.
2. Participate in activities that demonstrate how the parts work.

➢Applicable Education Standards:

NGSS	4-LS1-1; 4-LS1-2; 4-PS4-2 CCs: Cause and Effect, Systems and System Models SEPs: 2, 7

Section 5: Mathematics & Engineering

5.1 CALCULATING AVERAGES (Run time: 4:46)

This video teaches students what an average of numbers is, and how to calculate it.
(Note: this video is also available in Spanish)

➢Learning Objectives for Students:

1. Be able to calculate averages on a series of numbers.
2. Following directions.

➢Applicable Education Standards:

NGSS	SE Practices 5 and 8
CCSS	3.OA.C.7; NBTA.A.2; 3MD.B.3; 4.OA.A.2, 3; 4.NBT.B.5, 6; 6.SP.B.5c MPs 1, 2, 3, 6

THE EXTRA MILE: And The Beat Goes On

This lesson provides an opportunity to apply averaging and graphing skills without materials. The investigation can be done with small groups as well as with the whole class. The sheet can be sent electronically to students for them to use, and data can be shared with all students at the end of the activity.

➢Learning Objectives for Students:

1. Determine what type of exercise increases heart rates.
2. Collecting data in real time (as they undergo the activities)

➢Applicable Education Standards:

NGSS	LS1; LS2; LS3; SEPs 1,3,5,8

How to run the exercise:

A. Ask the **question:** What is the relationship between _____ and _____ ?

B. State your **hypothesis:** I think _____

C. Identify the **variables**

Independent Variables (IV)	Dependent Variables (DV)

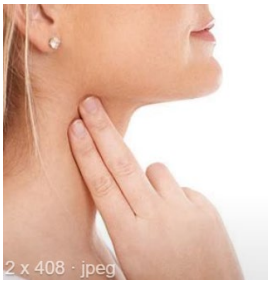
D. Materials required
> Watch with a second hand
> Copy of this data table.

Pulse per Activity	At Rest	After slow walking	After quick walking in place	After jogging in place
Heartbeats per minute	Trial #1= Trial #2= Trial #3= Average=	Trial #1= Trial #2= Trial #3= Average=	Trial #1= Trial #2= Trial #3= Average=	Trial #1= Trial #2= Trial #3= Average=

E. Exercise directions

1. Work with a partner.

2. You will take your pulse at your wrist or your throat.



3. Your partner will be the time keeper using the watch. Count the number of heartbeats for 1 minute after each activity.

4. Fill in the information on the table.

5. Graph the results by plotting the averages for each activity. Be sure to label the x-axis and the y-axis.

6. Describe the results:
   - Write (or orally share) what you did.
   - Look at the Graph, describe in writing (or orally) what it says; tell its story.
   - Describe what you found out about the relationship between ____ and ____.
   - Describe the relationship between IV and DV.

7. Write the conclusion.
   - Restate the question and describe the relationship between the IV and DV.
   - Restate the hypothesis and what was found.
   - Explain the outcome of the experiment

5.2 MATH RATIOS

ABOUT THE SERIES

Explain what math ratios are and how are they expressed. Students will see examples of relationships/proportions of things that constitute a ratio.

➢Learning Objectives for Students:

1. Be able to define the term "ratio" and give examples.
2. Be able to tell the three ways a ratio may be expressed, and explain each.
3. Students will learn notations to depict ratios: the word "to," using a colon, and in written form (e.g., three hummingbirds to two flowers).
4. Following directions.
5. Think creatively (e.g., substituting materials in the exercise)

➢Applicable Education Standards:

CCSS	6.RP.A1; 6.RP.A.2; 6.RP.A.3 MPs 1,2,3
NGSS	MS-LS2-2

Session #1: Introduction to Math Ratios (Runtime 4:34)

Present the concept of math ratios (proportion/relationships) and how they are expressed both mathematically and in written language.

	Supplemental Discussion Ideas
Environment/ wildlife	• What is the current environmental status of hummingbirds globally? • Is extinction a concern? • What are some of the fascinating facts about hummingbirds (e.g., wing beat speed, size, migration distances) • What types of plants attract hummingbirds, and why? A good resource on hummingbirds: https://www.hummingbirdsociety.org/

Session #2: Math Ratio Exercise (Runtime 15:00)

Students will learn how to make a simple hummingbird feeder. They'll also learn to make the food to go into the feeder, which will demonstrate the concept of a ratio.

	Supplemental Discussion Ideas
Chemistry	Talk about solutions, relating the discussion to the mixing of sugar and water from the exercise.

THE EXTRA MILE:

Check out these ratio practice sheets at https://www.mathworksheetsland.com/6/

5.3 FIBONACCI NUMBERS

ABOUT THE SERIES

The Fibonacci number series is a simple arithmetic series with connections to nature, history and architecture. In addition Fibonacci introduced to Europe our current number system

➢Learning Objectives for Students:

After going through the series, students will have basic understanding of:

1. number series,
2. ratios,
3. measuring rectangular objects,
4. and making graphs.

➢Applicable Education Standards:

NGSS	CCs: Patterns, LS, PS, ESS, Grades K-8
CCSS.	6.RPA.1; 6.RPA.2; 6.RPA.3; 7.RPA.A.1; 7.RPA.2; MP's 1, 2, 4, 8 *(for Roman numerals):* 4.NBT.A.2; 5.NBT.A.1

Session #1: Fibonacci Number Series (Runtime 9:56)

Introduces the Fibonacci number series, and shows where to find these numbers in Nature, from pineapples to pinecones.

Session #2: Fibonacci Number Series and The Golden Ratio (Runtime 11:17)

We look at the ratios between adjacent Fibonacci numbers, and that these approach the Golden Ratio, and the Golden Ratio in Greek and Roman architecture. You will get to measure ratios of rectangular objects around the house.

Session #3: Fibonacci and the Number Zero (Runtime 16:52)

Fibonacci encounters Arabic math in North Africa. He realizes that it is superior to Roman numerals, and introduces it to Europe. Learn about different number systems (Roman, Arabic, base-10, binary).

Supplemental Discussion Ideas	
History	Fibonacci lived about 800 years ago in Pisa. What was life like then in Pisa, in Europe, in North Africa, and here in the American Southwest? Find images of Greek and Roman buildings, and measure their proportions. Are these close to the Golden Ratio? What about other famous buildings?
Geography	Where is Pisa, Italy? How close is it to North Africa, Greece, Spain and Egypt?
Math	What other number sequences can you make up? What if you start with a Fibonacci sequence with different starting numbers (instead of 1 and 1)?
Suggested References	*Wild Fibonacci: Nature's Secret Code Revealed* by Joy Hulme 2005) *Blockhead: The Life of Fibonacci* by Joseph D'Agnese (2010) https://coe.hawaii.edu/ethnomath/wp-content/uploads/sites/12/2019/10/Fibonacci-Sequence-in-Nature.pdf

Section 6: Physical Sciences

6.1 ENERGY

ABOUT THE SERIES

Explore energy and forces in our lives.

➢Applicable Education Standards:

NGSS	K-PS2-1 Motion and Stability: Forces and Interactions 3-PS2 4-Ps3-2 Energy 5-PS2 Disciplinary Core Idea: PS3A: Definitions of Energy PS3C: Relationship Between Energy and Forces

Session #1: Types of Energy (Runtime 12:04)

This is an introduction to the types of energy and the forces (e.g., wind, heat, light, sun). The video includes an activity to demonstrate forces and motion. Materials can be found in the home to replicate the activity.

➢Learning Objectives for Students:

1. Learn key terms: energy, force, sources of energy
2. Understand that objects in motion are a result of energy forces
3. Understand that energy is neither created or destroyed but only moves from one place to another

Other references that you may wish to refer to:

- *Energy Makes Things Happen*, Kimberly Bradley (2002)
- The book is read aloud by Peggy Ringgenberg (not affiliated with the Alliance for Science) in this video: https://www.youtube.com/watch?v=_YOSy2ZTASE

Supplemental Discussion Ideas	
Energy Transfer	Explore types of energy transfer, such as windmills, hydroelectric dams, solar power, etc.
Forces	How does the strength of forces affect the transfer of energy?

Session #2: Energy- Force and Motion (Runtime 10:32)

This is an introduction to the types of energy and the forces (e.g., wind, heat, light, sun). The video includes an activity to demonstrate forces and motion. Materials can be found in the home to replicate the activity.

This session uses the book, *Duck in the Truck*, by Jez Alborough.

(View a reading of this book recorded by "Once Upon A Tome" – not affiliated with the Alliance for Science)
https://www.youtube.com/watch?v=pEEjSXyk7jI

➢Learning Objectives for Students:

1. How different forces (push and pull, balanced and unbalanced force) create motion and affect the position of an object.
2. How force and direction of force affect the position of an object.
3. Language objectives: students will be asked in the video to respond in writing (and orally if video is shown interactively), to various questions posed throughout the video.
4. Rolling object activity will reinforce the concept of varying amounts of force and how it influences an object's movement.
5. Math tasks include: measurement, graphing and the use of Venn Diagrams (although the term is used in the video)

NOTE:
For the three rolling objects activity, the students should kneel down to blow the objects at the object level whether on a floor or table. The other two trials are done with a flicking motion of one and then two fingers to make the object move. (the premise is that two fingers provides a greater force than one finger).

Supplemental Discussion Ideas	
Force and motion- building the Pyramids	Ask students heavy objects were moved in the past. How did the Egyptians move the heavy pyramid stones?

THE EXTRA MILE: The Movement of Objects

Investigating Forces and Analyzing the Movement of Objects 5E (**E**ngage, **Ex**plore, **E**xplain, **E**laborate, **E**valuate) lessons offer opportunities to extend students' STEM experiences and embed literacy activities. Each lesson is self-contained and includes science and language objectives, instructional procedures as well as a link to the book, Move It!

Learning Objectives for Students:

For the following science objectives, students will be able to:

- explain how a push or pull affects how an object moves,
- explain the difference between a push and pull,
- explain the way to change how something is moving when pushed or pulled,
- analyze changes in the movement of objects, and
- respond to the questions "Is it a push?" or "Is it a pull?" for the alpha-boxes.

For these language objectives, students will:

- Orally retell the story,
- respond orally to the "Is it a pull or push? questions, and
- read the information in the pull and push alpha-boxes.

The Science Focus

A. When a force is exerted, things move. Students may be unaware that a force affects the motion of an object.
B. A force has a direction. A direction may be back and forth, straight, fast or slow, or in a circle, zigzag, or curve.
C. By pushing or pulling, an object moves.

Materials

✓ Books: *Duck in the Truck* by J. Alborough or *Push and Pull* by H. J. Endres.
✓ Paper for the anchor chart and different color markers. (First use one color, then change the color of the marker for new information; for corrections, add a third color.)
✓ Chart paper for two alpha-boxes (one for push and one for pull).

Engage

1. Read *Duck in the Truck* or *Push and Pull*, by Nelson or Endres to stimulate interest in the topic.
2. Ask students questions as you read to get them to think about the topic of forces.
3. To build on prior science knowledge of force and motion, have objects to jog their memories about ramps, marbles, trucks, cars, etc.
4. In groups, students retell the story that was just read to them, either orally or in writing in their science notebooks.

Explore

1. Point to a truck or another object and ask *What is a push?* and *What is a pull?* Have these objects available for students to use.
2. Follow up if students are having difficulty and continue to brainstorm answers to these questions. They should understand that pushes and pulls are ways to use force to move an object. During this discussion, record what the students say on an anchor chart.
3. Continue the discussion by focusing on the amount of force that is needed to move different objects.
4. Ask the students, *Did you use push or pull forces when you got up off the floor to stand? Are there other ways to use your bodies to push or pull?*

Explain

1. Construct two alpha-boxes on chart paper. Each should look like the following. Be sure to have two charts. Use the alpha-boxes when students respond to the questions *Is it a push?* or *Is it a pull?*
2. Ask students to think of things that can be pushed. When they mention something, write its name in the alpha-box that begins with the same letter. See the chart below for an example. This activity can continue for several days, serving to activate prior knowledge when students read the words on the chart, but also to introduce new ones.

Push Words

a	bike	c	d
e	f	g	h
i	j	k	l
m	n	o	p
q	remote	swing	t
u	v	w/x	y/z

Pull Words

a	b	c	d
e	f	g	handle
i	j	knob	l
m	n	o	p
q	Rope	s	t
u	v	w/x	y/z

Elaborate

1. The students return to the alpha charts once there are examples in the boxes.
2. After the students have generated a variety of words that have been placed in the boxes, they read the words.
3. Students in groups to ensure that the words are in the correct boxes use a variety of materials to test their ideas.
4. Students use the claims and evidence scaffold to support their reasons for any changes that are made.

Evaluate

1. Students come together and the recorder reporters from the groups take turns to share the changes, if any, that their group made in the alpha-boxes.
2. They share their reasons (claims and evidence) if they think a word was not in the correct box; the teacher draws a line through the word and adds it to the appropriate box with a different color.

Source: Adapted and modified from Let's Use Force, by M. L. Damjanovich, 2011. Used with permission. Retrieved from the companion website for Growing Language Through Science, K–5: Strategies That Work by Judy Reinhartz. Figure 6.4. Thousand Oaks, CA: Corwin, www.corwin.com.

THE EXTRA MILE: Pushing and Pulling

Learning Objectives for Students:

For the following science objectives, students will:

- move objects in as many different ways as possible by pushing and pulling them, and
- use science terms that will demonstrate when they share and report out in writing that they understand force.

For these language objectives, students will:

- orally describe what happens when the teacher uses a ramp and drops a ball from the top, and when they push or pull different object,
- complete in writing the sentence frames on the Make it Move sheet twice,
- share orally with group members what they observed and did to get the objects to move, and
- use words and phrases on index cards and construct a sentence using science information from the lesson.

The Science Focus

A. *Force* is a *push* or *pull* that produces a change in the motion of an object.
B. The position and motion of objects can change by pushing or pulling them.
C. An unbalanced force makes a resting object move, brings the moving object to rest, or changes its direction.
D. Changing the surface on which an object moves can make it easier or harder for the object to move because of *friction*, a force that acts when two surfaces rub against each other.
E. The steepness of a ramp affects how far a ball rolls.

Materials

- ✓ Assortment of objects: balls, cardboard tubes, ramps, blocks. (This exercise could take place in the block center so students can investigate using these materials.)
- ✓ Meter sticks (you can put them end to end and count the number of meter sticks the object rolled).
- ✓ Chart paper and book, *Move It!* https://www.youtube.com/watch?v=l1cKYR-T1v8
- ✓ 2 copies of the Make It Move sheet for each group.

Engage

1. Review the previous day's work by having students observe as some of the balls and other materials are pushed and pulled.
2. Students describe orally what they think (predict) will happen when the teacher uses a ramp and drops the ball from the top.
3. Read the beginning of the book, *Move It!* (2005) by A. Mason, to get students interested.

Explore

1. Each group has an assortment of balls, cardboard tubes, ramps, blocks, and meter sticks.
2. Students explore as many different ways as possible to make a marble (object) move from one place to another.
3. Give groups of students the Make It Move sheet with sentence frames like the ones below.

   They respond orally or in writing:
   1. *I used* _____ *object.*
   2. *I made the object move by* _____.
   3. *Another way I made it move:* _____.

Explain

1. Have students share with group members what they did and observed before working with the whole class.
2. Bring the students together to brainstorm what they discovered and learned about pushing and pulling during their investigations.
3. Use an anchor chart to record the group ideas/comments. To get the brainstorming started, here are some questions to ask:
   - *What objects rolled?*
   - *What do these objects have in common?*
   - *How did you get an object to roll?*
   - *Did you stop an object from rolling? How did you stop it?*

4. What questions can we ask to guide our investigations?
5. Continue to read the book *Move It!* to add to the discussion on force.

Elaborate

1. Return to the anchor chart, where group comments were recorded.
2. Have students ask questions before they continue to investigate.
3. Have each group try out the ideas from another group to see if they get the same results.
4. Have each group complete a *new* Make It Move sheet.
5. Have each group report out again and with a different color pen; the teacher records their responses on the anchor chart.

Evaluation

1. Take the pushing and pulling ideas from the anchor chart.
2. Have the students pick out words (adjectives, nouns, verbs) and phrases and write (draw) them on 5 × 7 index cards or cut sentence strips.
3. In working in groups, students use a chart like the one below and put the cards in the appropriate column. (Previously, teachers worked with students on adjectives, nouns, verbs, and phrases, and used a chart like the following.)
4. Once students have placed the cards in the specific column, they are ready to construct sentences using the information from the chart. They read their sentences to the whole class. Then the whole class reads the sentence composed by each group.

Adjectives	Nouns	Verbs	Phrases
round	marble	rolled	down the ramp
rubber	ball	bounced	on the floor

Section 7: Astronomy

7.1 Investigating Moon Craters (Run time: 5:00)

This module is intended for Grades 2-3.
Students conduct an investigation with materials readily available at home to study how moon craters form. They use sand and different sized rocks to form the craters. Students document their observations throughout the investigation and come together in a meaning making circle to answer the questions:

- Is there a pattern to how craters form?
- Do larger objects make deeper craters?
- Do smaller objects make craters that are shallower?
- How did the craters on the Moon form?

Learning Objectives for Students

1. Be able to identify craters on the surface of the Moon.
2. Be able to describe craters and explain how they form.
3. Be able to explain that the Moon has many more craters than Earth because it does not have an atmosphere.
4. Be able to identify and describe patterns in the crater formation process.

Applicable Education Standards

NGSS	**K-4 Benchmark I**: Know the structure of the solar system and the objects in the universe. **Grade 3 Performance Standards** 1. Describe the objects in the solar system (e.g., sun, Earth and other planets, moon) and their features (e.g., size, temperature). 2. Describe the relationships among the objects in the solar system (e.g., relative distances, orbital motions).

Supplemental Discussion Ideas	
Craters	• Are there craters on Earth? • Why does the Moon have many more craters than Earth? • How does a crater form? • Is there a pattern to how craters form? • Do larger objects result in deeper craters? • Do smaller objects form craters that are shallower?

THE EXTRA MILE: Learning About Space

This is a science inquiry unit of study, suitable for Grades 2 & 3.

It integrates science standards with both language arts and mathematics standards. All of the lessons are designed for to in classroom as well as online teaching. Students initially learn characteristics of the planets in our solar system and then progress to study phases of the Moon and formation of craters on the Moon. While learning about the Moon, students extend their learning beyond science concepts to learn about Moon folklore and go on to write their own legend. After learning about the Moon, students learn about stars and conduct an investigation to answer this focus question: Are stars moving? The unit culminates with a solar system project where students are presented with a variety of creative options to express their learning about the solar system.

Learning Objectives for Students:

- Describe the objects in the solar system (e.g., sun, Earth and other planets, moon) and their features (e.g., size, temperature).
- Describe the phases of the Moon and what causes them.
- Identify craters on the Moon and describe how they form.
- Explain that stars appear to move because the Earth rotates on its axis.

Discussion Questions:

1. How are stars and planets different?
2. Why does the shape of the Moon appear to change every night? What is a crater?
3. How do craters form?
4. Is there a pattern to the way craters form?
5. Are stars moving?

Applicable Standards:

NGSS	**K-4 Benchmark I**: Know the structure of the solar system and the objects in the universe. **Grade 2 Performance Standards** 1. Observe that the phase of the moon appears a little different every day but looks the same again after about four weeks. 2. Observe that some objects in the night sky are brighter than others. 3. Explain that the sun is a star. **Grade 3 Performance Standards** 1. Describe the objects in the solar system (e.g., sun, Earth and other planets, moon) and their features (e.g., size, temperature). 2. Describe the relationships among the objects in the solar system (e.g., relative distances, orbital motions).

A 13 day *Unit* about our solar system that is available upon request at info@sfafs.org.

The mentor texts are accessible to teachers and students in Epic!: https://www.getepic.com/sign-in

The texts *La luna en un mes y Cómo la luna recobró su forma* are also available in English. Digital access to the texts minimizes student sharing of materials and allows students to re-read the books at their own pace. Materials for the investigations are accessible to the teacher in a classroom and to students learning at home.

The student charts in this unit are provided in PDF format. They can be inserted into Seesaw assignments where students can write directly into the chart. They may also be printed and distributed to students in the classroom.

Section 8: STEM Fair Preparation

This is a series of videos that provides information and instructions to students should they wish to work on a project for presentation at a STEM Fair.

8.1 HOW TO DO STEM FAIR PROJECTS (Run time: 12:04)

Veteran science fair judges, Bruce Abell and Dean Gerber, share tips for planning and carrying out a science fair project. They present the key elements for making a project successful. Learn now to:

- turn a weak project into one that is much better developed
- do research on a topic,
- make measurements to collect data in a notebook,
- include variables in your experiment (i.e., changing only one thing at a time),
- draw a table, and
- report on the science project using a trifold board.

Learning Objectives for Students

1. Ask questions and define a problem.
2. Plan and carry out an investigation.
3. Collect, analyze, and compare data by completing a table to organize the information and develop a graph to describe results using evidence.
4. Communicate conclusions using the data collected and graphed.

Applicable Education Standards

NGSS	Science and Engineering Practices (1, 3, 4, 6, 8)

Supplemental Discussion Ideas	
The following Alliance videos address other subjects that are useful when doing STEM Fair projects.	
Science Journals	See 8.2 in this Guide
Calculating Averages	See 5.1 in this Guide

THE EXTRA MILE: Popcorn

Another way to get students to think about topics for a science fair project, is to consider things in their daily lives. This exercise outlines an investigation into different brands of popcorn.

Concept: Elaboration
Elaborate is the part of the science lesson where students come to know and understand the steps to an investigation. It starts with a question. In this experimental investigation, students use the question frame:

What is the relationship between ____ and ___ ?

First, the word relationship should be discussed and defined, and examples provided and placed on the science word/phrase wall. A graphic organizer is constructed with the word relationship in the center, with lines radiating from the word to demonstrate what the students think the "relationship" means.

Using this frame: *What is the relationship between ____ and ___ ?*
...opens the door to understanding *variables* (dependent and independent). For example:

What is the relationship between the brand of popcorn
and the number of kernels popped?

The BRAND of popcorn is the independent variable; the NUMBER OF KERNELS is the dependent variable.

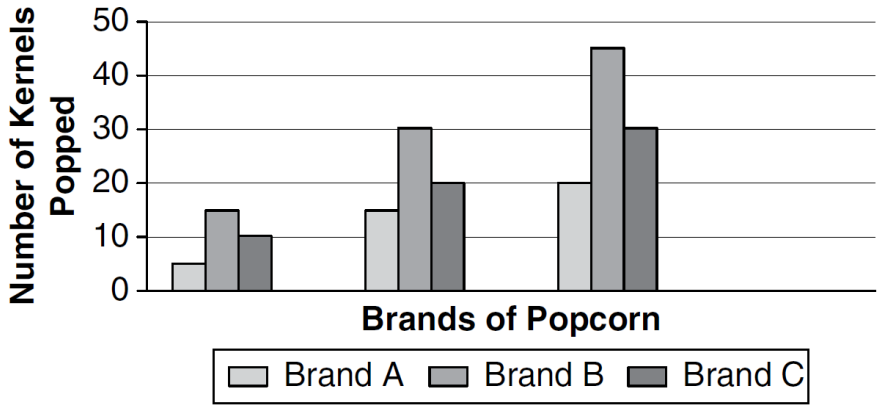
1. After coming up with a class question (using the question frame noted above), take a minute to analyze the question for cause-and-effect phrases. For example, in the popcorn question, the BRAND of popcorn is the *cause*; the NUMBER OF KERNALS popped is the *effect*.

2. Students then formulate a hypothesis that can be tested.

3. Students design and conduct an experiment, make observations, collect data, and record them on the "T" data table:

BRAND OF POPCORN *(the CAUSE, independent variable)*	# OF KERNELS POPPED *(the EFFECT, dependent variable*
Brand A	
Brand B	
Brand C	

4. Students *plot the data* from the data table to a graph (they can choose the type- bar, line, circle etc.), labeling each axis with the names of the variables.



5. Now the students are ready to *analyze the data* they have collected. One place to begin is to review the information plotted:
   - Which brand has the most kernels that popped,
   - the least that popped,
   - and somewhere in between.

   Looking at the graph, decide which brand is the best to buy, based on the evidence they uncovered in this experiment. Ask: *Why do you think so?*

   If they need support in coming up with answers, why do you think the Claims and Evidence Scaffold that follows may prove helpful?

   Students go back to the "T" table and the graph to fill in the Claims and Evidence Scaffold. They think about their "claims" or conclusions made about the popcorn brand (best, worse, in between). Once a *claim* has been identified, it must be supported with *evidence*.

The key question is: Is there evidence to support your claim of best, worst, in between? If the answer is "yes" students go on to the second claim, finding evidence in the data collected and plotted on a graph.

CLAIMS	EVIDENCE

Taylor and Villanueva (2014) provide the following series of questions that teachers can ask to assist students in completing the Claims and Evidence Scaffold. The following questions and sentence frames provide a template for student responses.

a. What do you claim to be true from your investigation?

b. How can you prove your claim? (How can you back up your claim?)

c. With the whole class, ask *Who agrees with each group's claim?*
How many agree with ____ group's claim and evidence?
How many disagree with ___ group's claim and evidence?

Student response sentence frames might include:
I agree with ____ claim because ____.
I disagree with ___ claim because ___.

d. Finally, ask Which of the following claims is most like yours [state the claim]?
Students may respond: *My claim is…*
…similar to ___.
…somewhat similar to ___.
…completely different from my classmates.

6. Students in the upper grades will identify and then describe the variables in their investigation based on the question they posed and the data they collected.

7. In their science notebooks, students will do the following:
   - Write the question and make a hypothesis, which is an idea that can be tested by an experiment or observation *(Sciencesaurus, 2006).*
   - Sketch a "T" data table using the question and the variables they identified. Taking the popcorn question, *What is the relationship between the brand of the popcorn and the number of kernels popped?*
   - Summarize the findings, looking at the information in the "T" table and drawing conclusions byu using sentences following these frames: *In this investigation, I did ___ or learned that ___.*
   - They use the information from their Claims and Evidence Scaffold to respond. Emphasize that every claim must be supported by evidence.

THE EXTRA MILE: The Cat's Meow

This is a less formal method of exposing students to science investigations.

Learning Objectives for Students:

(Science objectives) Students will:

- carry out an investigation with group members,
- construct explanations for their observations,
- explain cause and effect events during the investigation.

(Language objectives) Students will:

- read or follow directions provided orally,
- explain orally to group members the results of the investigation,
- construct explanations in writing about their observations in their science notebooks.

Materials needed per group:

- ✓ *Whole* (i.e., full fat) milk in a beaker or container that has a spout
- ✓ Paper plate – strong dinner size
- ✓ 4 different containers of food coloring
- ✓ 1 toothpick
- ✓ Dish detergent in a small plastic container
- ✓ Science notebooks

Procedures

1. In your groups, decide who is going to be the
   PI (Principal Investigator)
   MM (Material Manager)
   MD (Material Director)
   RR (Reporter Recorder)
2. Pour the milk into the plate, covering the bottom.
3. Take 4 different containers of food coloring.
4. Add a drop of each color to the edge of the plate at the 3, 6, 8, 12 positions.
5. Dip the toothpick into the detergent.
6. Place the toothpick in the center of the plate and hold it for a moment. DO NOT press too hard because you do not want to make a hole in the paper plate.

Communicating what you observed

1. Talk/share/discuss with group members what you saw.
2. What do the changes look like to you? Do you see anu patterns? Draw and write what you saw or think happened in your science notebook.
3. What do you think is causing these patterns and/or changes? Write your ideas down in your science notebook.
4. Construct an explanation in your science notebook along with pitures based on their observations and discussions with group members.

Assessment

1. Monitor groups and listen to their interactions with group members. How are they describing what took place when they added food coloring and detergent to the milk?
2. Read their science notebook entries. Have they identified any patterns? How did they explain what took place?

8.2 WHAT IS A SCIENCE JOURNAL? (Run time: 3:35)

Scientists collect a lot of data! To help them remember everything about their experiments, they keep it organized and safe in a journal. This video will give you some tips for creating your own science journal.
(Note: this video is also available in Spanish)

Learning Objectives for Students

1. How to organize your thoughts.
2. How to record data following a scientific method.
3. Practice observation skills.

Applicable Education Standards

NGSS	Science and Engineering Practices • Asking questions and defining problems • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking • Constructing explanations and designing solutions • Obtaining, evaluating and communication information

8.3 GRAPHING & PRESENTING DATA (Run time: 7:05)

This video will teach you how to visually present the data that you collect for your STEM Fair project.

Learning Objectives for Students

1. Learn key terms: vertical and horizontal lines of a graph. Labeling a graph
2. How to plot data.
3. Relate changes in data to averages.
4. Show changes in time or other variables in an exploration.
5. Understand when to use a bar graph vs. a line graph.

Applicable Education Standards

CCSS	MPs: 1, 2, 3 2.MD.B.6; 2MD.D.9; 2MD.D.10 3.MD.B.3; 3MD.B.4 4.MD.B.4 5.G.A.2; 5.G.A. 3; 5.G.B.4 6.NS.C.8
NGSS	SEPs: Analyzing and interpreting data. Using mathematical an computational thinking.

Supplemental Discussion Ideas	
Variables	Understanding what a variable is in science exploration, and how to represent it visually.
Other observations	The video provides suggestions for other at-home activities for developing graphing skills.
The following Alliance videos address other subjects that are useful when doing STEM Fair projects.	
Science Journals	See 8.2 in this Guide (importance of recording your data)
Calculating Averages	See 5.1 in this Guide
Energy Part 1	See 6.1 in this Guide (provides other examples of graphing… e.g., energy use in the home)

Revision History

Version	Date	Name	Description
1.0	07Aug2020	Caren Shiozaki	First release issued
2.0	04Dec 2020	Caren Shiozaki	Second edition released