Between a Rock and a Dark Place

Science Focus: Investigating the relationship of Sound and Light

Lesson #	Lesson Title	Suggested Time
1	Down in the Drift	55 minutes
2	Can You See Me Now?	55 minutes
3	Making Sense of Sound	55 minutes
4	Here Comes the Train!	55 minutes
5	Helping Jessie	55 minutes

Phenomenon: Students imagine themselves in an underground drift at the Sanford Lab as they listen to a story about Jessie. Students ask questions and use a model drift to conduct investigations about light and sound. (Lessons 1-4).

Design Problem: Students must devise a way to use light and sound to help Jessie to communicate at a distance in a long, dark drift at the 4850 ft. level of the underground laboratory (Lesson 5).

Between a Rock and a Dark Place

Storyline:

Students in early elementary grades are exploring the world around them, and asking questions like, “What can I see in the dark?” and “What makes a sound?” and “How can I use technology to communicate?” As students explore their own five senses, they learn about seeing and hearing and connect those senses with light and sound.

In the first lesson, students meet Jessie, a biology student collecting samples at the Sanford Underground Lab. While Jessie was collecting samples, she stumbles, twists her ankle, and breaks her headlamp. Students will gather evidence that objects need to be illuminated by light to be seen. (1-PS4-2)

Jessie realizes that a train is approaching when she sees a light. She pulls a variety of materials out of her bag and must select something which will increase her visibility! Students investigate the effect of placing different materials in the path of a beam of light. (1-PS4-3) Students will test, classify, and compare different materials as they look for those best suited for working in a dark place like the underground drifts of Sanford Lab. (2-PS-1-1, 2-PS-1-2)

As Jessie is working, she feels movement underneath her and she hears a low humming. Could it be caused by the train? Students will make observations that lead to sense-making that vibrating materials cause sound and that sound causes materials to vibrate. (1-PS-4-1)

Jessie notices that a nearby puddle she is rippling. Could that be caused by the approaching train? Students plan and conduct an investigation with materials that are similar to what would be in the underground drift. (2-PS-1-1) Using their observations, they will construct an evidence-based explanation of what could be causing the ripples in the puddle. (2-PS-1-2)

In the final lesson, students will design and build a device that uses light or sound to help Jessie solve the problem of communicating over a distance. (1-PS4-4) Students will use their device to create a code that uses light or sound to signal, “Come toward me” and “Stop”, which are the common safety signals used in underground settings.

Throughout the unit, students are planning and carrying out investigations about both sound and light. (SEP 3) Students explore cause and effect by probing connections between light and the sense of seeing and the vibration of objects and the sense of hearing. (CCC: Cause/Effect) By testing different materials (CCC: Patterns), students will analyze and interpret their own data to construct explanations about the phenomena of light and sound. (SEP 4, SEP 6) Students use the Engineering Design Process to design and build a device that can solve a communication problem. This device can be considered a “technology” because it uses scientific information applied to a practical problem. (CCC: Technology)

Standards Addressed in the Unit		Lessons
1-PS4-1	Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (SEP: 3; DCI: PS4.A; CCC: Cause/Effect)	3, 4
1-PS4-2	Construct an evidence-based account for how objects can be seen only when illuminated. (SEP: 6; DCI: PS4.B; CCC: Cause/Effect)	1
1-PS4-3	Plan and carry out an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. (SEP: 3; DCI: PS4.B; CCC: Cause/Effect)	2
1-PS4-4	Design and build a device that uses light or sound to solve the problem of communicating over a distance. (SEP: 6; DCI: PS4.C; CCC: Tech)	5
2-PS1-1	Plan and carry out an investigation to describe and classify different kinds of materials by their observable properties. (SEP: 3; DCI: PS1.A; CCC: Patterns)	2, 4
2-PS1-2	Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. (SEP: 4; DCI: PS1.A; CCC: Cause/Effect, Technology)	2, 4
K-2-ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.	5

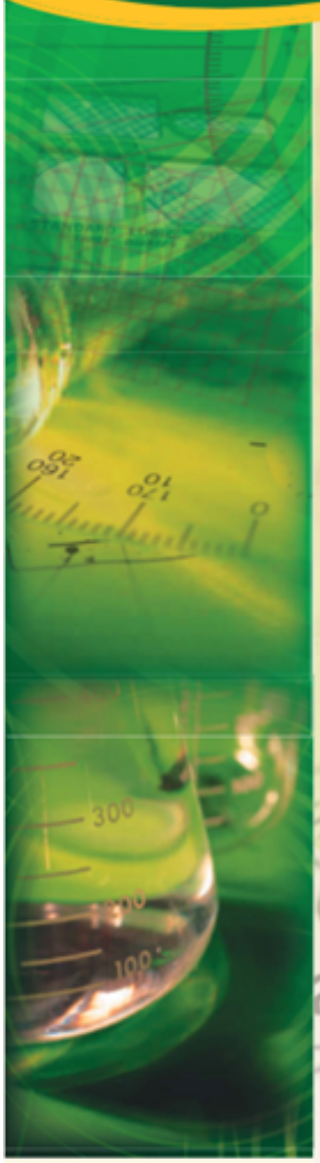
For more information on the South Dakota Science Standards, please visit the South Dakota Department of Education website .

SPECIAL NOTE TO TEACHERS:

A storybook was created to accompany this unit, featuring a science student named Jessie. This fictional scenario depicts Jessie stumbling while working in the dark, underground drifts.
Safety protocols in place at the lab would make this scenario very unlikely---Jessie would have been with other co-workers and accompanied by a trained, underground guide.

As you read the book to your students, each section ends with a page containing the phrases, “Let’s Help Jessie!” and “It’s time to investigate!”

Science and Engineering Practices



1. Asking questions (science) and defining problems (engineering).
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematics and computational thinking.
6. Constructing explanations (science) and designing solutions (engineering).
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information.

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC 2011)

Three Dimensional Learning Matrix

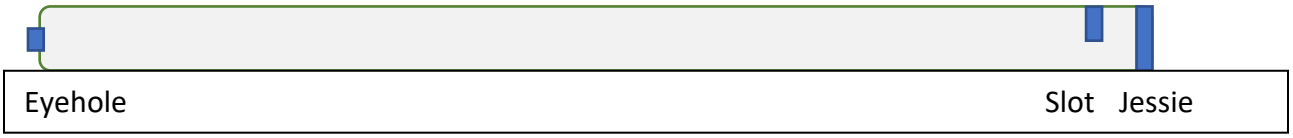
Lesson	Disciplinary Core Idea	Science and Engineering Practice	Crosscutting Concept
1 "Down in the Drift"	Objects can be seen if light is available to illuminate them or if they give off their own light. (1-PS4-2)	SEP 6: Constructing Explanations	Cause and Effect
2 "Can You See Me, Now?"	Some materials allow light to pass through them, others allow only some light to pass through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (1-PS4-3)	SEP 3: Planning and Carrying Out Investigations	Cause and Effect
	Matter can be described and classified by its observable properties. (2-PS1-1)	SEP 3: Planning and Carrying Out Investigations	Patterns
	Different properties are suited to different purposes. (2-PS1-2)	SEP 4: Analyzing and Interpreting Data	Cause and Effect
3 "Making Sense of Sound"	Sound can make matter vibrate and vibrating matter can make sound. (1-PS4-1)	SEP 3: Planning and Carrying Out Investigations	Cause and Effect
4 "Here Comes the Train"	Sound can make matter vibrate and vibrating matter can make sound. (1-PS4-1)	SEP 3: Planning and Carrying Out Investigations	Cause and Effect
	Matter can be described and classified by its observable properties. (2-PS1-1)	SEP 3: Planning and Carrying Out Investigations	Patterns
	Different properties are suited to different purposes. (2-PS1-2)	SEP 4: Analyzing and Interpreting Data	Cause and Effect
5 "Helping Jessie"	People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	SEP 6: Designing Solutions	Influence of Engineering, Technology and Science on Society and the Natural World
	A situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	SEP 1: Asking Questions and Defining Problems	

Materials List

For Unit	✓ *Between a Rock and a Dark Place* Storybook ✓ "Helping Jessie" Science Notebook, for each student (print master) ✓ Model drift (mailing tube) *, for each pair of students

***NOTE TO TEACHERS:** Each pair of students will be given a tube representing a drift (tunnel) in the Sanford Underground Research Facility with two endcaps – one containing an eye hole and the other with a cutout picture of Jessie, the science student. Use in all lessons, except for Lesson 3.

Model Drift Diagram:



- For **Lesson 1&2**, both end caps will be on the tube. Students will use the flap over the slot to either block light or to let light into the tube (Lesson 1), and testing materials (Lesson 2).
- For **Lesson 4**, both end caps will be off the tube. Students will be able to see the train tracks and other parts of the underground drift inside.
- For **Lesson 5**, both end caps will be off the tube but end caps are available if students need to darken it for testing.

Lesson	Kit Materials Provided (14 sets)
1	• Flashlight
2	• "Light Materials" (mounted on stick, 5 each set) • Flashlight
3	• "Sound Materials" (12 inch length, 5 each set) • Rock • Comb (one for EACH student) • Wax Paper
4	• "Sound Materials" from Lesson 3 • Tub half filled with water
5	• "Light Materials" from Lesson 2 • "Sound Materials" from Lesson 3 • Rock • Flashlight

Adjusting Modules to Accommodate Your Classroom Needs

Timing

The education team at Sanford Lab has done its best to develop curriculum modules that are flexible and incorporate both facilitator and student supports. As you explore this module with your students, please keep in mind that these curriculum modules are grade banded. If your students are at the lower end of the grade band, or if they come to you with limited experiences in science, you should fully expect the module to take more time than designated in the facilitator's guide. This is especially true if you teach very young students.

As an effective educator, you will know how to adjust the timing of these lessons to best fit your classroom and students. Please feel free to break any of the lessons into shorter segments, over multiple days, to accommodate the learners in your classroom.

Follow-up/Practice

Lessons in this unit include 'Follow-up/Practice' sections. These are useful (optional) resources proposed to enrich classroom practices for diverse learners. These resources are not included in the time designations of the unit; if you feel your students will benefit by pursuing these resources, please plan for additional time.

Design Principles

Effective educators alter, adjust, and change their instruction depending on who is in the classroom and the extent to which those students are succeeding. Frequently, educators will augment curriculum with additions of instructional strategies. However, please keep in mind that best practices in science education have shifted from merely *learning about* to *figuring out.* These units are designed to provide opportunities for students to figure out phenomena and design solutions to problems.

This emphasis on *figuring out* represents a revolution in how we teach science at all grade levels. In their learning, students must use all three dimensions of the science standards—crosscutting concepts (CCCs), disciplinary core ideas (DCIs), and science and engineering practices (SEPs)—in an integrated fashion in order to make sense of phenomena or design solutions to problems.

Classrooms incorporating three-dimensional learning will have students build models, design investigations, share ideas, develop explanations, and argue using evidence. All of which allow students to develop important 21st century skills such as problem solving, critical thinking, communication, collaboration, and self-management. Three-dimensional learning also helps students apply new knowledge to other situations. Every student will benefit from this instructional approach.

Important Note

Science Notebooks	**You may wish to have students set up their Science Notebooks prior to the first lesson.** Science notebooks are an important part of solidifying your students' learning. Student scientists record their observations, questions, evidence, and ideas in a running record of their thinking. Science notebooks are also a great way to practice writing skills! As students develop their understanding of science concepts, they may use drawings and other illustrations- such as charts, tables, models, and graphs. The science notebook can be used by the teacher to assess the development of student understanding. Science notebooks may be a printed booklet prepared by the teacher, a bound composition, or a spiral notebook. A printable science notebook specific to this unit is available in the print masters section.

Lesson 1	Down in the Drift

Three Dimensional Teaching and Learning	**Overview:** *Students hear a story about Jessie, a biology student who is working in the Sanford Underground Research Facility. Jessie finds herself between a rock and a dark place when she stumbles in the drift, twisting her ankle and breaking her headlamp! What can she see in the dark? Students will look at objects, with and without illumination, to record their observations. They will use evidence to show that objects can only be seen when illuminated.* **Performance Expectation:** **1-PS4-2** Construct an evidence-based account for how objects can be seen only when illuminated. **Science and Engineering Practice:** **SEP 6**: Constructing Explanations **Crosscutting Concept:** Cause and Effect **Objectives:** Students will • make observations about an object's visibility with and without illumination • draw a picture or write a description using evidence to support the statements: ✓ "I can see objects with light." ✓ "I cannot see objects without light."
Background Information	Students gain valuable information about light and its behavior in the early elementary grades. The idea that objects can only be seen when light shines on them is an important foundation to future explorations with light. Some students may mistakenly think that they can see objects without light, based on previous experiences in dimly lit rooms or spaces.
Materials	For the classroom: *Between a Rock and a Dark Place* storybook For each pair of students: ✓ model drift with both end-caps ✓ flashlight For each student: "Helping Jessie" Science Notebook
Prior Knowledge	Using a science notebook may be a new experience for students in early elementary. Emphasize that there are many ways to input information into a science notebook. Each student's notebook can be unique, personalized for the individual learning style. The performance expectations for this lesson require students to demonstrate grade-level proficiency in constructing explanations to communicate their observations about light. The "Helping Jessie" Science Notebook includes space for students to draw or write their explanations. Sentence-stems support students with the emerging skill of connecting their scientific observations with a scientific explanation.
Launch (10-15 minutes)	

Engagement and Communication of Student Expectations	1. Begin by asking students to imagine an underground cave or tunnel with no light. It would be completely dark. Ask students to think about ways to make the classroom as dark as an underground cave. Is it possible? Continue to darken the room (using the student's suggestions), until it is as dark as you can reasonably make it. Ask the students, "What can you see?" Is there still light in the room? 2. Read the first part of the *Between a Rock and a Dark Place* storybook. When students learn about Jessie's collection of bacteria samples, stop, and ask students what kind of life Jessie might be looking for by going deep underground? How would she get there? Would you like to visit a laboratory deep underground? Continue reading the "Let's Help Jessie" page.
Explore (30 minutes)	
Procedure	1. After you have finished reading the storybook portion for Lesson 1, distribute the Science Notebook to each student. 2. Students **make predictions** about what could be seen with light and without light in the underground drift. 3. Distribute one *model drift* and a flashlight to each pair of students. Both end caps should be on each mailing tube. 4. Ask students to try to see Jessie in the model drift using a small amount of light coming in from the slit. NOTE: students may need to hold the slit up to the classroom overhead light, window or use the flashlight near the slit to see Jessie. 5. Next, ask student to try to see the photo of Jessie *with no light coming into the drift.* NOTE: Encourage students to explore different ways to ensure that there is no light in the model drift. 6. Students will record their observations in their "Helping Jessie" Science Notebook. 7. Complete the Lesson 1 pages in the "Helping Jessie" Science Notebook including the "Answer the Question" section.
Questions	**Driving Question:** "What evidence do I have that objects can only be seen with light?" **Probing Questions:** • How can you be sure that there is no light in the model drift? • What do you see when you look into the model drift with no light? • What do you see when you look into the model drift with light coming in through the slit in the tube?

	• What is the least amount of light that will allow you to see Jessie?
Summarize (10 minutes)	
Communicate	Students can share their evidence that allows them to know that objects can only be seen with light. Ask for several pieces of evidence (such as, "We cannot see the photo of Jessie with no light in the drift" or "When we use the flashlight, we can see Jessie") Work with students to brainstorm different ways that Jessie could find a light: for instance, her cell phone, a pen light in her backpack, or repairing her headlamp. If there is sufficient time, allow students to color sources of light in their science notebooks. Tell students that the story of Jessie in the underground drift will continue during the next lesson.
Terminology and Concepts to Solidify	**Drift** --underground tunnels that connect the science lab spaces at the Sanford Underground Research Facility. The term *drift* is used more generally in mining operations to mean a horizontal passage which follows the vein of ore. Sanford Lab has nearly 400 miles of *drifts* formerly used by the Homestake Gold Mine. **Light—** *Light* makes vision possible. **Illuminate—**to make something brighter by increasing the amount of light. **Dark—**the absence of light. **Evidence—**measurements, data or observations used to support or refute a scientific claim.
Connection to Big Ideas (Phenomena)	Objects can be seen only if light is available to illuminate them or if they give off their own light. This is a good example of cause (light) and effect (the ability to be seen). The underground drift is a very dark place in which Jessie can see only if she can find a source of light.
Follow Up/Practice	Students may ask additional questions about darkness and light. It is possible that some students will not readily accept that objects cannot be seen in the dark. Students may need to think about the difference between objects that can be seen because light shines on them, compared to objects that generate their own light.
Assessment	Students who reach this performance expectation will use evidence from their investigation to support their observations that objects can only be seen in the presence of light. In early elementary, this evidence may be a sketch or a simple picture, using symbols to describe their observations. Students may also be able to complete sentence starters in the "Helping Jessie" Science Notebook. For example, "I know that I can see objects with light because…" and "I know that I cannot see objects without light because…."

	As students make a scientific claim, they support their claim with evidence from the investigation. For example, a student might write "*I know that objects cannot be seen without light because I could not see anything in the drift when there was no light in the drift.*"

Lesson 2	**Can you See Me, Now?**
Three Dimensional Teaching and Learning	**Overview:** *Jessie sees the drift ahead of her getting a little lighter - a train is nearing the corner. With the dim light from the train, Jessie searches her backpack. She needs to find something that will make her visible to people on the approaching train. She tests a variety of materials from her backpack. Students will plan and*

	conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. **Performance Expectations:** **1-PS4-3** Plan and carry out an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. **2-PS1-1** Plan and carry out an investigation to describe and classify different kinds of materials by their observable properties. **2-PS1-2** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. **Science and Engineering Practices:** **SEP 3**: Planning and Carrying Out Investigations **SEP 4**: Analyzing and Interpreting Data **Crosscutting Concepts:** Cause and Effect, Patterns **Objectives:** Students will • test a variety of fabrics and materials by placing them in a beam of light • describe and classify the materials based on the effects of placing them in the path of light. • choose the material that they observe to be the most visible in the beam of light.
Background Information for performance expectation	As students test various materials by placing them in the path of a beam of light, they will develop an understanding that light can travel from place to place. Student will observe that some materials reflect light, some allow light to pass through and some materials block light. The vocabulary words for this lesson are introduced after the investigation, to allow students an opportunity to explore.
Materials	For the classroom: *Between a Rock and a Dark Place* storybook For each pair of students:

	✓ model drift with one end cap (with a photo of Jessie) ✓ flashlight ✓ A set of five materials to test in the light
Prior Knowledge	In Lesson 1, students gathered evidence that light must be present in order to see an object. In this lesson, they will investigate how light interacts with materials in order to select one that will help Jessie to be more easily seen in the dimly-lit drift. Planning and carrying out an investigation to answer questions or testing solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. Simple investigations are designed to gather evidence to support or refute student ideas about cause and effect.
Launch (10-15 minutes)	
Engagement and Communication of Student Expectations	Read the *Between a Rock and a Dark Place* storybook portion for Lesson 2 stopping after the second "Let's help Jessie" page. In the story, Jessie searches thru materials in her backpack to select one that helps her to be seen by the people on the train. Students will plan and conduct an investigation to determine which material will help Jessie to be more visible in the light of the oncoming train.
Explore (30 minutes)	
Procedure	1. Distribute the "Light Materials" set to each pair of students. 2. Help students to make predictions in the Helping Jessie science journal about the effect of placing each material into the path of a beam of light. 3. *After students have completed their predictions*, distribute a model drift and a flashlight to each pair of students. 4. Allow students time to plan an investigation to determine what material will be best for Jessie to be seen. They should write down their materials and plan before they start testing materials. 5. Following their plan, each group will test each material in the path of a beam of light. Encourage students to think about what effect the

	material has on the light. Does the light pass through or bounce back? Does the material block all or part of the light? 6. Allow students to conduct their own investigation. Note to teachers: *Some students may need help in placing the materials into the opening on the top of the model drift, in front of the photo of Jessie. You may want to suggest that students shine the light on each material, and record their observations in their "Helping Jessie" Science Journal. Students may also want to shine the light at the slit on the top of the model drift*. 7. After completing their investigation, each group select one material that they think will help Jessie to be easily seen. Note: there is more than one good choice. Encourage students to use evidence and reasoning when making their choice.
Questions	**Driving Question:** "Which material would help Jessie to be easily seen by the person on the train?" **Probing Questions:** 1. How will you record your observations about each material? 2. What are some words to describe what you are seeing? 3. How will you decide which type of material will be best to help Jessie be easily seen by the person on the train?
Summarize (10 minutes)	
Communicate	Ask students, "What have we learned from our investigation?" and "How will Jessie cause herself to be more visible to the people on the train?" The science journal introduces the terms reflective, transparent, translucent and opaque. Ask students if they can think of items that Jessie might have in her backpack that would fit into the categories: reflective, transparent, translucent or opaque. Students can share their observations about the various materials that they tested. Encourage students to use evidence to support their decision about which material they have discovered to be the most visible to the person on the approaching train. As the students share their observations, reinforce the vocabulary terms on the board. Each of the materials fits into one of these categories: reflective

	(mirror, vest stripes), transparent (plastic "raincoat"), opaque (colored paper), translucent (wax paper).
Terminology and Concepts to Solidify	**Reflective –**light is redirected by a reflective material. Examples include mirrors, safety vest strips, aluminum foil. **Transparent—**light can pass through a transparent material. Examples include plastic, glass. **Translucent—**some (but not all) light can pass through the material. Examples include wax paper, and frosted windows. **Opaque—**no light can pass through the material. A shadow results. Examples include cardboard or wood.
Connection to Big Ideas (DCI)	Matter can be described using a wide variety of physical and chemical characteristics. In this lesson, students will focus on the property of a material's interaction with light. Students are testing materials with a specific purpose in mind (helping Jessie to be visible in the light on the train). Students may choose a material that is reflective or brightly colored. Students will gather evidence that different properties of materials make them best suited for different purposes.
Follow Up/Practice	Students may want to shine the flashlight on other materials in the room in order to continue to classify them into different groups. You may want to ensure that students will be able to find materials that are reflective, transparent, translucent and opaque in your classroom.
Assessment	Students will use their "Helping Jessie" Science Journal to draw pictures and use words to describe what they see while shining the light on different materials. Student who demonstrate proficiency on these performance expectations will be able to *use evidence* to support their choice of a material to help Jessie be more visible to the people on the on-coming train. In the science journal, teachers should look for evidence and reasoning that students use to support their claim. For instance, a student might write, *"I chose the reflective mirror as the best material to help Jessie to be seen, because when I shine the light on it, it shines brightly back to me and I can see it clearly."*

Lesson 3	Making Sense of Sound
Three Dimensional Teaching and Learning	**Overview.** *Jessie is still wondering what to do about her sticky situation when she notices something. The train tracks beneath her are moving slightly. She hears what sounds like a very faint humming. What is happening? Jessie realizes that the vibrations and sounds she is feeling and hearing are coming from the approaching train. Students will make observations that lead to sense-making that sound causes materials to vibrate, and that vibrating materials produce a sound.* **Performance Expectations** **1-PS4-1.** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

	Science and Engineering Practice: **SEP1 :** Asking Questions and Defining Problems **SEP 3:** Planning and Carrying Out Investigations **Crosscutting Concept:** Cause and Effect **Objectives:** Students will ✓ Test materials according to their ability to make sound ✓ Investigate the relationship between sound and vibration, using various materials
Background Information	Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. Simple tests can be designed to gather evidence to support or refute student ideas about causes and effects. Students will learn that sound is caused by objects vibrating and sound can cause objects to vibrate. They will investigate material that can be used to make sound and make observations to construct an evidence-based explanation for a phenomenon. **Instructions for the Comb Kazoo:** Cut out a piece of wax paper to encircle the small comb. Tell students to place their lips on the wax paper (with the comb inside) and hum or buzz into the paper to cause a vibration. NOTE: each student has his/her own comb, and they should not be shared.
Materials	For the classroom: *Between a Rock and a Dark Place* storybook For each pair of students: ✓ Model drift, end caps removed ✓ "Sound Materials" (5 each, numbered) ✓ A rock For each student: ✓ Comb

	✓ Wax paper
Prior Knowledge	Students use their five senses to experience the world around them. In Lesson 1 they explored light and the sense of seeing. In this lesson, they explore sound and the sense of hearing by planning and carrying out a simple investigation about sound. Students may not be familiar with the term 'vibration'. The term is intentionally introduced at the end of the lesson, during the summary.
Launch (10 minutes)	
Engagement and Communication of Student Expectations	1. Remind students of Jessie's dilemma. Ask students, "if you woke up in total darkness – so dark you couldn't see your hand in front of your face - how would you know anything about where you were?" "Can you make observations without seeing?" As students suggest ways they can observe *without seeing*, write them down on the board. Then, discuss what they are using for the observation – ears, nose, skin, etc. They can divide their tools into the four remaining senses – hearing, touch, taste, smell. 2. Read the next part of the story to see what happens to Jessie. 3. In order to make sense of what Jessie is hearing and feeling, we are going to explore sound. Have students open their Helping Jessie Science Journal to Lesson 3 and write or draw what they see or hear as the teacher thumps the ruler on the edge of the desk, first at 3" and then at 6". Demonstrate several times at each distance while students fill in their journals.
Explore (30 minutes)	
Procedure	1. Distribute a "Sound Materials" and the rock to each pair of students. For each material, students will make observations as they thump it, then explore other ways they can make sounds with it. Optional: students may explore ways to make sound with the rock. 2. Support students in making a connection between the movements of a material and the sound(s) it produces. 3. Students should complete the observation table in their Helping Jessie Science Journal.
Questions	**Driving Question:** "Can sound be caused by a movement? Can a movement make a sound?" **Probing Questions:** ✓ How can you use the materials to make a sound? ✓ Can you change the sound you are hearing with a given material?

	✓ What do you observe happening physically to the material when sound is produced?
Summarize (10 minutes)	
Communicate	1. Once groups are finished with their observations, introduce the word 'vibration.' A vibration is a quick, back-and-forth movement. Did students see vibrations when they made sounds with the materials? Have them answer the questions in the journal. 2. Distribute a comb and piece of wax paper to each student. Show students how they can make a kazoo (see instructions in *Prior Knowledge* section). Students can take home their kazoos (have them keep them at school until unit is completed).
Terminology and Concepts to Solidify	**Vibration** – a rapid, back-and-forth movement **Sound**—vibrations that travel through the air and can be heard when they reach a person's ear.
Connection to Big Ideas	Students will begin to make a clear connection between the **cause and effect** relationship between sound and vibration. Students will explore a variety of materials and find evidence that some materials can produce sound more readily than others, depending upon their physical characteristics (flexibility, rigidity, etc). This observation will help students to recognize **patterns** in the properties of materials and their ability to produce sounds and vibrations.
Follow Up/Practice	As students plan and conduct their investigation about sound, they will observe that some materials (for instance, the brass and the metallic rod) produce sound more readily than others (like the wooden dowel or rod). Some students may want to try to produce sound with other objects in the room, like strings, rubber-bands, notebooks, or plastics. In each case, challenge students to observe that sounds cause vibrations, and that vibrations cause sounds.
Assessment	Students will observe the cause and effect relationship between sound and vibration. Each material in the "Sound Materials" kit can create sound and vibrating. However, some materials are much easier to use for making sound than others. Teachers may need to support students in making this connection by showing students how to make a high-pitched or low-pitched sound by changing the way the materials vibrate. In Lesson Four, students will plan and conduct their own investigation about vibration and sound as the assessment for this performance expectation.

Lesson 4	Here Comes the Train
Three Dimensional Teaching and Learning	**Overview** *By the dim light of the approaching train, Jessie notices that a nearby puddle of water is rippling. How strange! What could be causing that? Could it be caused by the train in the distance, around the corner? Students will plan and conduct an investigation to determine if the train could be causing something in the drift to vibrate and cause the ripples in the puddle.* **Performance Expectations** **1-PS4-1.** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. **2-PS1-1.** Plan and carry out an investigation to describe and classify different kinds of materials by their observable properties. **2-PS1-2.** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. **Science and Engineering Practice:** **SEP 3:** Planning and Carrying Out Investigations **SEP 4:** Analyzing and Interpreting Data **Crosscutting Concept:** Cause and Effect; Patterns **Objectives:** Students will ✓ Describe materials according to their ability to make sound ✓ Investigate the relationship between sound and vibrations using various materials
Background Information	Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. Simple tests can be designed to gather evidence to support or refute student ideas about causes and effects. Students will learn that sound is caused by objects vibrating and sound can cause objects to vibrate. They will investigate materials that could be used to make sound and make observations to construct an evidence-based explanation for a phenomenon (the rippling puddle).
Materials	For the classroom: *Between a Rock and a Dark Place* storybook

	For each pair of students: ✓ The model drift, end caps removed ✓ The bag of "Sound Materials", used in Lesson 3 ✓ A rock ✓ Plastic container with water
Prior Knowledge	In the previous lesson, students made observations about the properties of materials and their abilities to make sound through vibration, and to cause vibrations using sound. Students should be able to clearly connect the cause and effect relationship between sounds they can hear and vibrations that they can see or feel.
Launch (10 minutes)	
Engagement and Communication of Student Expectations	1. Recap what students learned about sound in Lesson 3. How does it relate to the humming and vibrations Jessie was hearing and feeling? Brainstorm specific ways that the sound and the vibration from the train reaches Jessie through the drift. (Ideas might include: through the air, through the train tracks, through the rocks, etc) 2. Read the next section of *Between a Rock and a Dark Place.* As the light from the train gets a little brighter, Jessie notices ripples in a puddle next to where she is sitting. What is causing that phenomenon? 3. Ask students what could be causing the ripples. Could the rippling water be caused by the distant train? How? How could they get evidence to support their claims? 4. Distribute the model drifts, with endcaps removed. Tell each pair of students to observe the drift and write or draw three things that could transfer sound and vibration from the train to cause ripples in the puddle. (Lesson 4 of Helping Jessie Science Journal). Tell students to make predictions about what is causing the ripples.
Explore (40 minutes)	
Procedure	1. Distribute the "Sound Materials" to each pair of students. Are there things in the bag that are like the materials in the drift? Have students choose three materials that closely match the items they noted in their observations of the drift. Students will use these three materials in their investigation. 2. Tell students that each pair will get a tub of water to use in their investigation. Before they get it, they need to develop a plan for an investigation, write it in their journal and show it to the teacher. **NOTE to TEACHERS**: students will need to experiment with the materials to find a way to create ripples in the tub of water (without spilling!). The most effective way we have found is to place the tub on top of the material, and "thump" over the edge of the desk as in Lesson 3. Students can be creative here!

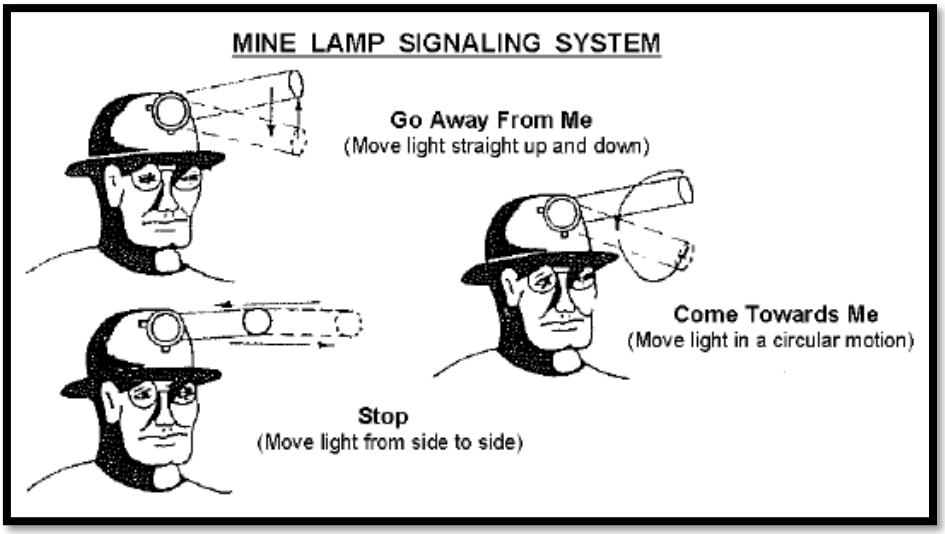
	3. Students will conduct their investigations, collect evidence and then answer the question, "What is causing the ripples in the puddle of water?" 4. Ask student to reflect on their answers. Did it match their prediction? What did they learn?
Questions	**Driving Question:** "Could the train at the other end of the drift cause ripples in a puddle of water?" **Probing Questions:** ✓ How can vibrations or sound be transferred from one kind of material to another? ✓ Do some materials cause vibrations more easily than others? ✓ Can you use sound to cause vibrations in the water? ✓ Is it important how you handle the materials?
Summarize (10 minutes)	
Communicate	1. Facilitate student discourse about their investigations. Did everyone reach the same conclusion? Could there be more than one thing that causes the water to ripple? 2. Finish the discussion of sound by reinforcing the connection between sound and vibration. Students should be able to use evidence to show that vibrating materials produce a sound, and that sound causes materials to vibrate. 3. Students have gathered evidence that different materials transfer sound and vibration differently.
Terminology and Concepts to Solidify	**Vibration** – a rapid back-and-forth movement **Ripple**—physical evidence of a vibration in the water **Sound**—vibrations that travel through air and can be heard when they reach a person's ear.
Connection to Big Ideas	Teachers should help students to make a clear connection between the cause of the sound (the approaching train) and the effect (vibrations on the train track). The cause/effect connection is further emphasized as students understand that the vibrating train track results in ripples or vibrations in the puddle of water.
Follow Up/Practice	Students may begin to ask questions about how people hear sounds. It may be helpful to encourage students to wonder about sound as a vibration in the air. The human ear senses vibrations which move through the air. Ask students, "Can you hear underwater?" Students may wonder if the human ear can sense vibrations in water. (Answer---yes! Humans can hear underwater, as vibrations can move through solids, liquids or gases)

Assessment	Students will use their "Helping Jessie" Science Journals to draw pictures and use words to describe their sound investigations, data and observations as well as conclusions for Lesson 3 and Lesson 4. Success in meeting the performance expectation will be evidenced by the collaboratively developed investigation plan and results. Students should be able to identify and describe the materials to be used, how the materials will be made to vibrate in order to make ripples in the water, and how the resulting ripples will be observed and described. Some students may also include a way to measure or determine that a material is vibrating when a sound is heard and a ripple in the water is observed. Students in early elementary will find it challenging to identify a measure only a single variable during an investigation. For instance, as the students test various materials, they should hold other variable constant (position under the water in the container, length of the stick under the container, degree of movement, etc). In experimental design, holding other variable constant while testing is an important consideration.

Lesson 5	Helping Jessie
Three Dimensional Teaching and Learning	**Overview:** *The train has made it around the corner, and the engineer can see Jessie, but does not know that she needs help. Jessie needs to communicate with the person on the train, using sound or light to make a signal. Students will design and build a communication tool using light or sound to signal two different messages: "Stop" and "Come toward me" across a distance.* **Performance Expectations:** **1-PS4-4** Design and build a device that uses light or sound to solve the problem of communicating over a distance. **K-2-ETS1-1** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. **Science and Engineering Practices:** **SEP 6:** Designing Solutions **SEP 1:** Asking Questions and Defining Problems **Crosscutting Concept:** Technology **Objectives:** Students will • design a tool or device which will use light or sound to communicate over a distance • create their own code or signal (using light or sound) to communicate two different messages: "Stop" And "Come toward me." • use their device or tool to communicate with each other or with other students using the model drift.
Background Information	The performance expectation for this lesson integrates traditional science content with engineering, requiring students to solve a specific problem (communicating over a distance with light or sound). Students may ask questions like "What is an engineer?" "What do engineers do?" and "How do engineers approach problems and design solutions?" It is important to remember that engineering is an *applied* science. Engineers focus on real problems and processes.

	An Engineering Design Challenge invites students to take an integrated approach to problem solving that incorporates not only science or math content knowledge but also creativity, critical thinking, problem solving and open-ended questioning. A well-constructed design challenge has multiple solutions, and encourages students to take risks with diverse approaches to the problem. The teacher sets the stage for the Engineering Design Challenge by helping students to ask questions and define the problem. The classroom culture should welcome brainstorming and exploration of solutions. An emphasis on the *process* rather than the *product* will keep students focused on their job as engineers who design solutions, rather than on competition or right/wrong answers to a problem. In this Engineering Design Challenge, students choose either light or sound to design a device that solves the problem of communicating over a distance. The concept of technology is emphasized as students realize that the tool or device that they build is technology, because it uses scientific understanding to address a practical, human problem or need.
Materials	For the classroom: *Between a Rock and a Dark Place* Storybook For each pair of students: ✓ model drift (no end caps) ✓ all materials from previous lessons For each student: "Helping Jessie" Science Journal
Prior Knowledge	Students should understand that communication is not always verbal. This will be reinforced in a class discussion at the beginning of this lesson. Students need to know that a *tool* or a *technology* can be broadly defined as any human solution to a problem. The device that will be used to solve this communication problem includes both *the materials* chosen by the student plus the idea of *a code or signal* created to communicate across a distance.
Launch (10 minutes)	
Engagement and Communication of Student Expectations	• Begin by reminding students of Jessie's plight. She can now be seen by the train, but she still needs to communicate that she needs help. Use the graphic organizer in the Science Journal to allow students time to think of ways people communicate **without using words.**

	• Read the next part of the *Between a Rock and a Dark Place* storybook to the students. Tell students, "The ending of the story is up to YOU!" How can Jessie communicate with her co-worker on the train? • Ask, "How will you use the materials to design a device that will help Jessie to use light or sound to signal to the people on the distant train?" You may need to give an example of a code or signal to help students get started.
Explore (30 minutes)	
Procedure	1. Distribute all lesson materials and the model drifts to each pair of students. 2. Tell students that today, they are engineers who will be using sound and light to communicate across a distance. 3. Students will use any of the materials to create a signal to communicate, using light or sound, two messages: ✓ "Stop." ✓ "Come toward me." 4. Ask students to write or draw their signals into their "Helping Jessie" Science Journals. 5. When students have determined their code, they should test their communication using the model drift. Can their partner correctly identify the message (either "Stop" or "Come here")? 6. Have students make improvements and draw their final design in their Science Journals. 7. If time allows, ask students to test signals with other groups.
Questions	**Driving Question:** "How can we use materials to design a tool or device to communicate over a distance, using light or sound?" **Probing Questions:** • How can you make the light or sound signals very clear? • How can you record your signals? • How can you work with your partner to check to see if you can use the code to communicate?
Summarize (10 minutes)	

Communicate	Finish reading the *Between a Rock and a Dark Place* storybook. Ask students to think about why communication in an underground drift at the Sanford Lab is so important to safety. Tell students that Sanford Lab has a code or signal using light to communicate over a distance. At Sanford Lab, everyone who visits the underground lab is trained on the following code: 1. "Stop." = headlamp moved side to side  2. "Move toward me." = headlamp moved in a circle 3. "Move away from me." = headlamp moved up and down. If time allows, you may want to share this Mining Safety Video with your students: Mindy Rocks Cap Lamp Signals
Terminology and Concepts to Solidify	**Engineer/Engineering-** An engineer designs solutions to human problems by creatively applying principles of science, mathematics or technology. **Engineering Design Process-** Engineers use an iterative cycle of steps to solve a human or societal problem. **Communicate—**the transmission of information by (in this case) mutually understood signals **Signal—**a gesture, sound or light pattern with an agreed-upon meaning that results in an action.
Connection to Big Ideas	**ASK-PLAN-BUILD-TEST-REFINE** Engineers use science and technology to solve problems and design solutions. The Engineering Design Process is cyclical and adaptable. Students are given a design challenge, and then begin to look for solutions by **asking questions**. Ideally,

	students will brainstorm with their teams and create detailed **plans**. As teams begin to **build** or create solutions, **testing** and **refining** begin. Students will naturally work toward a solution while utilizing multiple stages of the Engineering Design Process, often simultaneously.
Follow Up/Practice	Students can share their signal with other groups. Students can continue to test and refine their signal until it can be easily interpreted by other classmates.
Assessment	When assessing an Engineering Design Challenge, the focus is on the *process* rather than the *product*. Students should be encouraged to take risks with their ideas, to consider innovative solutions to the problem and to extend their exploration beyond the classroom setting. It is important to eliminate unnecessary judgements or comparisons of team's solutions to the problem. Skilled teachers find ways to affirm the *process* that a student has undertaken, even when the outcome doesn't "work" the way that a student may have wished. Students who demonstrate grade-level proficiency on the performance expectations for this lesson will ask questions, compare solutions and consider many different possible answers to the communication problem. Student lab journals should show clear evidence of the process by which they used materials to design a device to communicate using light or sound. In the "Helping Jessie" Science Journal, look for evidence of the Engineering Design Process (**ASK-PLAN-BUILD-TEST-REFINE**). You might see ✓ sketches or diagrams (ASK/PLAN/BUILD) ✓ erasure marks (TEST/REFINE) ✓ evidence statements supporting a proposed solution

Print Masters

Dear Student Scientist,

Scientists use notebooks, and you will too. This is a place to keep track of your work and your questions.

Here's where you'll record your measurements. Or you might make a drawing to show what you observed and add notes to it. You can explain your ideas here too.

Your notebook is for you, to help you remember what you were thinking, what you did, and what you found out. And it is for others who want to know what another scientist (you) was thinking.

When it's time for Science, open your notebook and fill it with your ideas, questions, drawings, and findings!

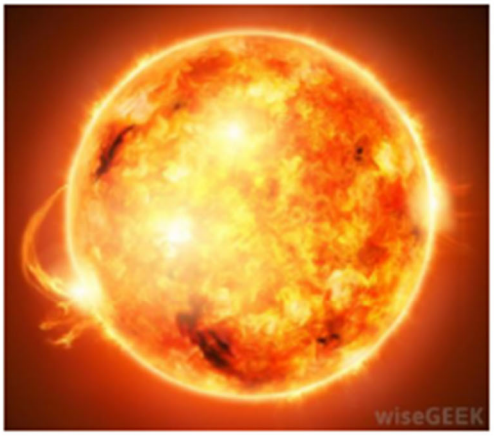
Between a Rock and a Dark Place

'Helping Jessie' Science Notebook

NAME

_____

About the Sanford Underground Research Facility

The Sanford Underground Research Facility is located in Lead, SD at the site of the former Homestake Gold Mine.	Large physics experiments located a mile underground are searching for particles that could explain mysteries of the universe.
	
Other scientists are searching for life living inside the rock; if life can live there, maybe it can be found on other planets.	The experiments are underground to get away from radiation from the Sun that is constantly bombarding the Earth.
	

For more information, see www.sanfordlab.org.

Lesson 1. Down in the Drift

Jessie has stumbled in the dark drift, and her headlamp is broken. What can she see with no light?

Ask a Question

What evidence do I have that objects can only be seen with light?

Make a Prediction

With some light I will see...	With no light I will see...

Collect Evidence

With some light, I saw...	With no light, I saw...

I can make my model drift very dark by...

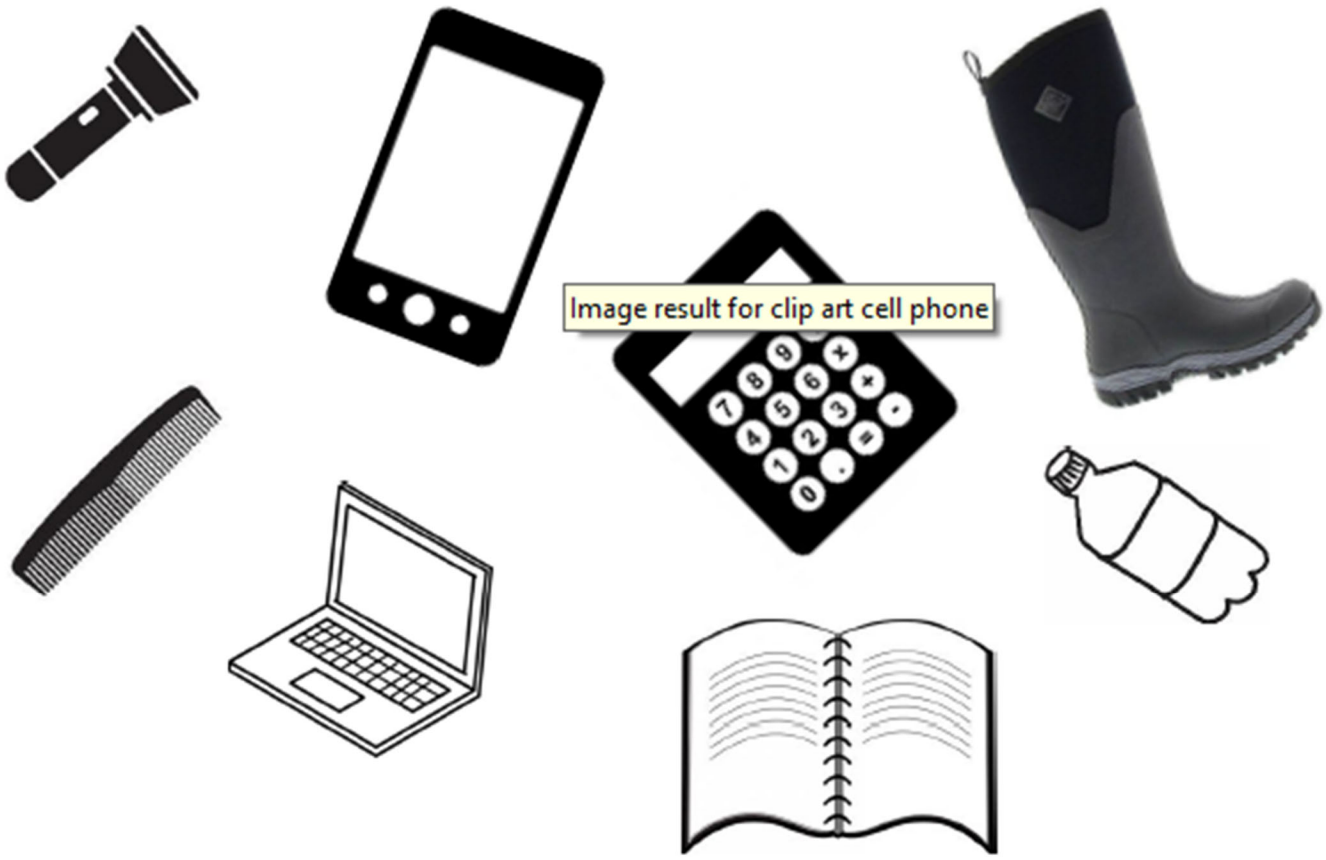
Lesson 1. Down in the Drift

Answer the Question

I know that I can see objects with light because…

I know that I cannot see objects with no light because…

Circle the objects that produce light.



Lesson 2. Can you See Me Now?

Using the dim light of the oncoming train, Jessie is able to see inside her backpack. Can she find something to make her visible to the train? She finds materials to test in the light.

Ask a Question

"Using the results of our investigation, which material would help Jessie to be easily seen by the person on the train?"

Make a Prediction (before the investigation)

Material Description	What will happen when we put the material in front of Jessie then shine light on it? Can you see Jessie through the material?
Mirror	
Colored Paper	
Wax Paper	
Clear Plastic	
Metallic Paper	

Lesson 2. Can you See Me Now?

Plan and Conduct an Investigation

Think of a way to decide which material will help Jessie to be easily seen by the person on the train.

Materials:	Plan:
We will use…	We will…

Collect Evidence

Material Description	What happens when we put the material in front of Jessie then shine light on it? Can you see Jessie through the material?
Mirror	
Colored Paper	
Wax Paper	
Clear Plastic	
Metallic Paper	

Lesson 2. Can you See Me Now?

Answer the Question

We think that the best material to help Jessie to be seen by the person on the train is...

We think this because...

Using your flashlight, shine light on different objects in the room. Find materials that are transparent, translucent, opaque or reflective.

Transparent	**Translucent**
I can see Jessie clearly through the material. 	I can see Jessie, but she is blurry. 
Opaque	**Reflective**
I cannot see Jessie through the material. 	I cannot see Jessie, but I can see myself! 

Lesson 3. Making Sense of Sound

Jessie is hearing noises and feeling movement from the approaching train. Are the sounds and movements connected to each other?

Ask a Question

Can sound be caused by a movement?
Can a movement make a sound?

Make Observations

When my teacher holds the ruler at 3" then thumps it,		When my teacher holds the ruler at 6" then thumps it,	
I can see...	I can hear...	I can see...	I can hear...

Use the materials to make sounds and observe movements. First thump the material like your teacher did. Investigate different ways to make sound.

Material Description	Observations					
Thin, round, wood rod	When I thump it, it makes a sound that is ...			I can also make sounds that are...		
	Loud	Long	High	Loud	Long	High
	Soft	Short	Low	Soft	Short	Low
	I observe...			We made new sounds by...		

Lesson 3. Making Sense of Sound

Thick, square, wood rod	When I thump it, it makes a sound that is ...			I can also make sounds that are...		
	Loud	Long	High	Loud	Long	High
	Soft	Short	Low	Soft	Short	Low
	I observe...			We made new sounds by...		
Round, metal rod	When I thump it, it makes a sound that is ...			I can also make sounds that are...		
	Loud	Long	High	Loud	Long	High
	Soft	Short	Low	Soft	Short	Low
	I observe...			We made new sounds by...		
Flat, brass rod	When I thump it, it makes a sound that is ...			I can also make sounds that are...		
	Loud	Long	High	Loud	Long	High
	Soft	Short	Low	Soft	Short	Low
	I observe...			We made new sounds by...		

Round, plastic rod	When I thump it, it makes a sound that is ...			I can also make sounds that are...		
	Loud	Long	High	Loud	Long	High
	Soft	Short	Low	Soft	Short	Low
	I observe...			We made new sounds by...		

Vibration is a quick, back-and-forth movement.

Which material vibrated the most? _____
Which kind of sound did it make? _____

Answer the Question

Sound causes...

Sound is caused by...

A Comb Kazoo!

You can make sounds by constructing a kazoo with a comb and wax paper.

CHECK: when you make a sound, do you feel a vibration?

Take your kazoo home and show what you learned about sound and vibration.

Lesson 4. The train is coming!

In the dim light from the approaching train, Jessie notices that there are ripples in a puddle next to where she is sitting. She thinks it must be caused by the train. Can you help Jessie to investigate the connection between the train and the ripples?

Ask a Question

How could the train at the other end of the drift cause ripples in a puddle or water?

Observe the Model Drift

Observe the model drift carefully. Draw three things you see inside that might make sound and vibration from the train cause ripples in the puddle of water.

1	2	3

Make a Prediction

We predict that the ripples in the puddle are caused by...

Lesson 4. The train is coming!

Plan and Conduct an Investigation

Find three things in the bag of materials that are like the three things you noticed in the drift. Plan with your partner how you could test them using a tub of water to see if vibrations could cause the ripples.

Materials:	Plan:
We will use…	We will…

Collect Evidence

Material Description	My investigation shows me that…

Answer the Question

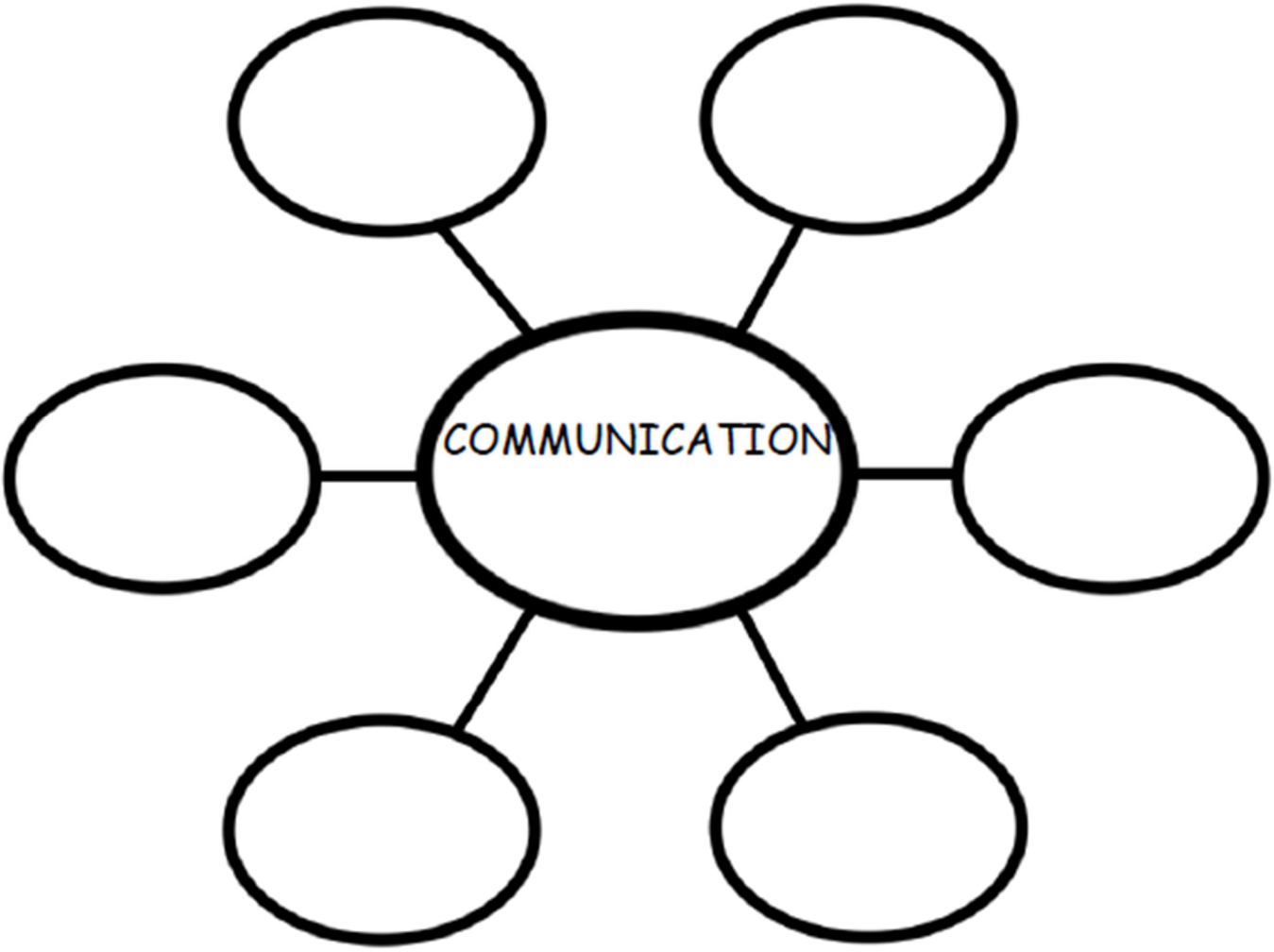
We think that the ripples in the puddle are caused by …

We think this because…

Lesson 5. Helping Jessie

Now that Jessie is seen by her co-worker on the train, she wants to communicate to tell them she needs help!

Draw six ways people can communicate *without* words.



With one color of crayon, circle any ways you came up with that use **light** to communicate.

With a different color, circle any ways you came up with that use **sound** to communicate.

Lesson 5. Helping Jessie

Ask a Question

"How can we use materials to design a tool or device to communicate over a distance using light or sound?"

Make a Plan

We will use	Our idea is…

"Stop" Code

We will use sound light
(circle one)

Our code is…

"Come Toward Me" Code

We will use sound light
(circle one)

Our code is…

Lesson 5. Helping Jessie

BUILD

Our device and code work like this:

TEST and REFINE

I can use the code to communicate when I...

I could make my device better if I ...

You helped Jessie!

What have we learned?

We learned that objects can only be seen in the **light**. In the **dark drift**, Jessie could not see anything and neither could we. We can see an object only when we **illuminate** an object with light.

We learned that different materials affect light differently.

- If the material is **transparent**, we can see an object clearly through it.
- If the material is **translucent**, we can see the object, but it looks blurry.
- If the material is **opaque**, we cannot see the object.
- If the material is **reflective**, the light bounces back and we can see ourselves.

We learned that a quick, back-and-forth movement called a **vibration** creates a **sound**. We also learned that sound causes material to vibrate and that some materials vibrate (and cause sound) more easily than others.

We learned that we can use light or sound to **communicate** with other people over a distance if both people know the 'code'.

Science Vocabulary

Word	Draw it!	Definition
Light		A form of energy that our sense of sight can detect
Dark		The absence of light
Drift		In mining, an underground tunnel
Illuminate		To brighten with light
Vibration		A rapid back and forth movement
Sound		A type of energy made by vibration
Transparent		Light passes through
Translucent		Some of the light passes through
Opaque		No light passes through
Reflective		Light bounces back
Communicate		Sending and receiving messages

Between a Rock and a Dark Place Refurbishment Inventory

Lesson	*Quantity*	*Item*
All	1	Facilitator Binder w/ USB
	1	Shipping Tote
	1	Book – Between a Rock and a Dark Place
	14	Model Drift with end caps & flaps
	1	Pliers
	14	Flashlights
	14	Rocks
	14	Set of 5 Light Materials
	14	Set of 5 Sound Materials
	30	Combs
	1	Roll Wax Paper
	14	Plastic Tubs

NOTICE: THE HEADER/FOOTER AND REVISION HISTORY OF THIS ATTACHMENT IS NOT INCLUDED IN THE PRINTED DELIVERABLE.ANY BLANK PAGES ARE LEFT SO INTENTIONALLY.

Revision History

Rev	Date	Section	Paragraph	Summary of Change	Authorized by
01	2/27/2024	NA	NA	Initial Release	CCR 911