How Does Light Help Me See Things And Communicate With Others?

1.1 pilot version - Dec. 2017

Synopsis: *In this unit, students start by exploring how many shapes can be seen in various locations around a darkened classroom on different pieces of paper. They can not see all the shapes in these conditions. This leads students to start noticing and wondering about other phenomena related to seeing in the dark, which in turn leads to new questions about ..*

- *What could we see if we made our room completely dark?*
- *How we can make our room as dark as possible?*
- *How can we use light to communicate, throughout different places in the school, without making any noise?*

What students figure out: *By the end of the unit, students develop powerful ideas about the interaction of different materials with light, and its effects on what we see. These ideas include:*

- *Objects can be seen if light is available to illuminate them or if they give off their own light; very hot objects give off light.*
- *Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach.*
- *People can use light to communicate (send and receive information) over long distances.*
- *A situation that people want to change or create can be approached as a problem to be solved through engineering.*

NGSS PERFORMANCE EXPECTATIONS BUNDLE

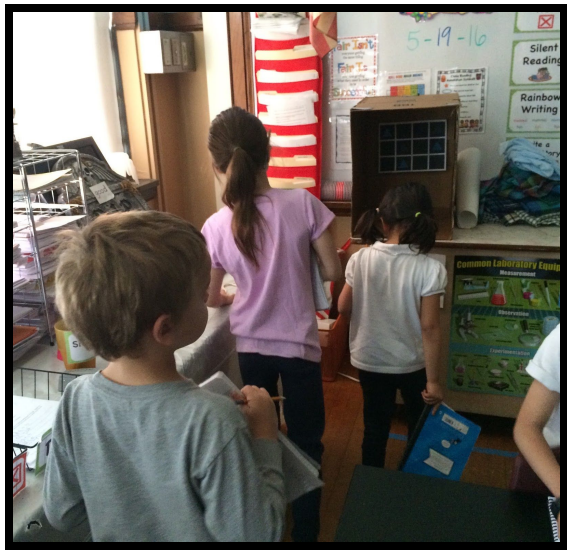
1.Waves: Light and Sound

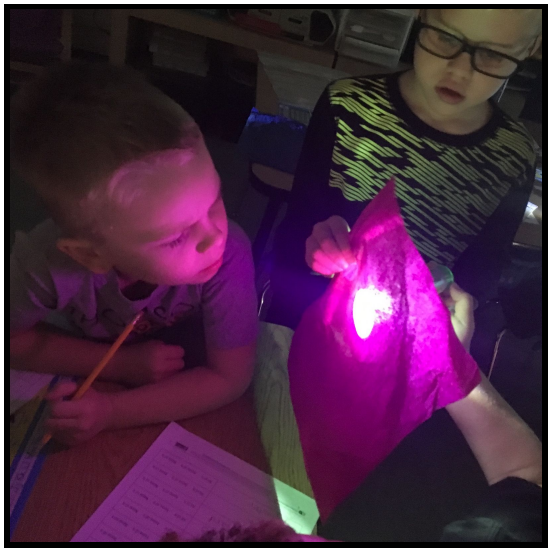
- 1-PS4-1
- 1-PS4-3
- 1-PS4-2
- 1-PS4-4

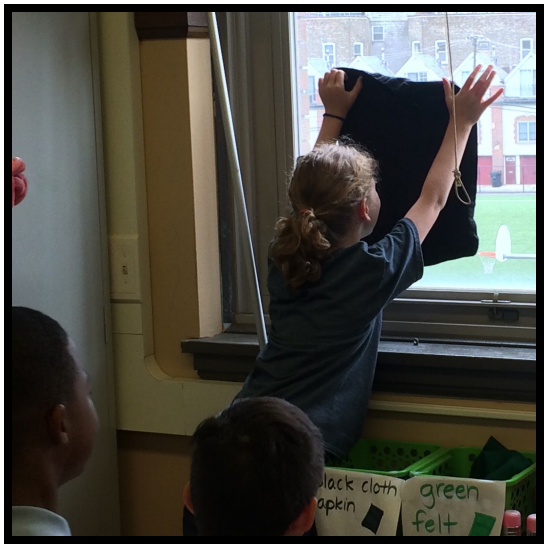
K-2.Engineering Design

- K-2-ETS1-1
- K-2-ETS1-3
- K-2-ETS1-2

- Gray boxes show topic arrangement of PEs in this grade band and prior grade bands where relevant.
- Yellow boxes indicate PEs targeted in this unit.
- White boxes indicate PEs to be targeted in future storyline revisions.







These materials were developed through with support from the Michigan Department of Education; the Gordon and Betty Moore Foundation, and support from the NGSX Project at Clark University, Tidemark Institute, and Northwestern University

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Teacher Guide

NGSS 1st Grade Storyline

Targeted NGSS Performance Expectation(s):

- **1-PS4-2** Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]
- **1-PS4-3** Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).]
- **1-PS4-4** Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance. [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.]
- **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.
- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- **K-2-ETS1-3** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Targeted Scientific Practice(s)

Constructing Explanations and Designing Solutions
- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-PS-4-2) (1-PS-4-3)

Planning and Carrying Out Investigations
- Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS-4-2) (1-PS-4-3)

Asking Questions and Defining Problems
- Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)

Developing and Using Models
- Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)

Analyzing and Interpreting Data
- Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)

Targeted DCI(s)

PS4.B: Electromagnetic Radiation
- Objects can be seen if light is available to illuminate them or if they give off their own light. Very hot objects give off light (e.g., a fire, the sun). (1-PS-4-2)
- Some materials allow light to pass through them, others allow only some light 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. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)

PS4.C: Information Technologies and Instrumentation
- People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)

ETS1.A: Defining and Delimiting Engineering Problems (K-2-ETS1-1)
- 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.

ETS1.B: Developing Possible Solutions
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)

ETS1.C: Optimizing the Design Solution
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)

Targeted Cross-Cutting Concept(s)

Cause and Effect
- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS-4-2) (1-PS-4-3)

Structure and Function
- The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

Connections to Engineering,Technology, and Applications of Science

Influence of Engineering, Technology, and Science, on Society and the Natural World
- People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4)

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Development Team:

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[A]Alpha pilot
[B]Beta pilot
[1.0]1.0 Field Trials
[1.1]1.1 Field Trials

Development History:

- Alpha version developed and piloted by Gretchen Brina at STEM Magnet Academy and presented at ISEC in fall of 2015.
- Design team expanded and Beta version of storyline developed in spring of 2016.
- Beta version of storyline piloted by Kristin Bostik, Alcott Elementary School in Spring of 2016.
- Design team expanded and 1.0 version of storyline developed in summer and fall of 2016
- 1.0 field trial PD in MI in fall of 2016; 1.0 field trials in MI in late fall of 2016.

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- 1.1 field trial PD in IL in dec. of 2016; 1.1 field trials in IL in Jan. of 2017

Development support: *These materials were developed in part with support from the Michigan Department of Education; the Gordon and Betty Moore Foundation, and support from the NGSX Project at Clark University, Tidemark Institute, and Northwestern University*

Key to storyline columns:

Lesson Question (time) *Building toward* ⬇ *NGSS PEs:*	**Phenomena**	**Lesson Performance Expectation(s):** • **Blue bold font: Science and Engineering Practice** • Regular font: Quoted from Appendix F Practices Matrix • *Italicized font: Specific storyline context (phenomena / question)* • Green font: Cross-cutting concept(s) (or pieces of these CCCs) • Orange font: Disciplinary Core Idea(s) (or pieces of these DCIs)	**What We Figure Out** (CCCs & DCIs), *New Questions* and **Next Steps** • Green font: Cross-cutting concept(s) • Orange font: Disciplinary Core Ideas (or pieces of these DCIs) • *Purple italicized font: New questions that we now have* • **Purple bold font: Our ideas for the next (or future) steps to pursue.**

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How Does Light Help Me See Things And Communicate With Others?

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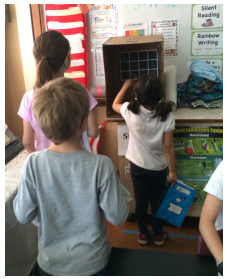
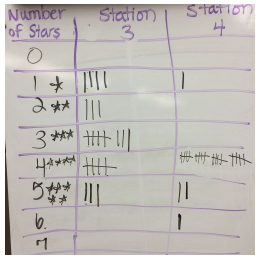
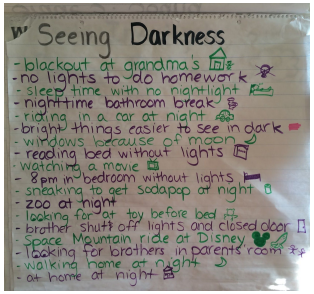
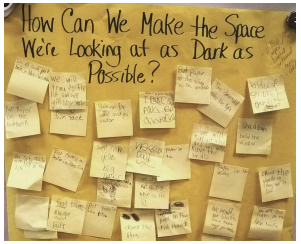
This Lesson….What we are doing now: This is the first lesson in the series. Up until this moment, students may never have considered whether or not they can see in total darkness. In this lesson you will draw upon their experience and create a shared experience to which you'll refer throughout the unit. Students will need to figure out that the how dark it is affects how much you can see. You will guide students to wonder what we would see if we could make the room as dark as possible. Encourage students to suggests ways to make that happen.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L1: What can we see in our room? 3 periods: L1a: 45 min L1b: 30 min L1c: 30-45 min *Building toward* *NGSS PEs:* *1-PS4-2* *1-PS4-3* *K-2-ETS1-1* *K-2-ETS1-2*	Some of the shapes that were printed on a pieces of paper in 12 squares are harder to see when we make the room dark, and some are harder to see in darker parts of the room  . Additional phenomena from our prior experiences where it has been really hard to see in the dark. And where the things we saw seemed easier to see in the dark then in a well lit room.	**Analyze data** by recording and sharing observations and using them to describe patterns *across everyone's data to determine how many of us could see the number of shapes that were actually at each station in the darker vs. better lit parts of the room.* **Ask questions** based on observations from this experience and from other prior experiences we've had where (we've seen similar patterns) *it has been difficult to see something in a dark place.* **Define problems** *and brainstorm solutions related to the question, "how can I make the space I am looking in as dark as possible?"*	L1a: Our observations from the stations showed some interesting patterns. • We could see some but not all of the shapes in a room with the lights off (or in dark spots of the room), but we could see all the shapes in a room with the lights on. • In parts of the room where there was more light it was easier to count how many shapes were actually on the paper.  L1b: We brainstormed related experiences and phenomena we've encountered: • We recalled experiences where it was harder to see certain things when it was dark. • We also thought of lots of examples of things that might be easier to see in the dark vs. a well lit room or space (stars, streetlights, movie and computer screens, night lights). Sharing these related experiences led us to wonder: • What could we see in the room if we made it as dark as we possibly could? • Could we ever make it completely dark? We had different predictions. • So we posted our first sub-question on our driving question board, "Q1 What can I see when it is completely dark?" and turned some of our predictions into questions to put in this category.  But these questions then raised a new problem we need to solve. How can we make the room as dark as possible to investigate our other questions? This led us to post another question, this time related to a design problem: "Q2 How can I make the space I am looking in as dark as possible ?" L1c: We brainstormed some design solutions to this question. In the end, we agreed we needed to turn off all the lights, but we also agreed that we might want to also try to try to use some different materials to block light that might be coming through the door or window. We posted our solutions to a Design Ideas Gallery.   **Next steps: We very much want to conduct some investigations to try to answer our questions in coming days.**

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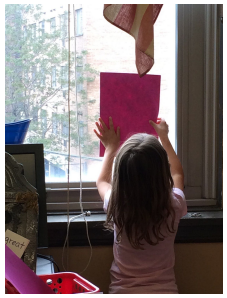
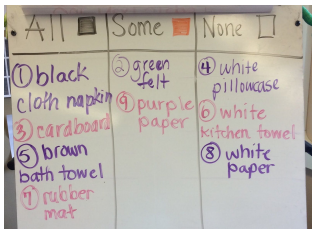
This Lesson….What we are doing now: Students will need to figure out that the how dark it is affects how much you can see. You will guide students to wonder what we would see if we could make the room as dark as possible. Encourage students to suggests ways to make that happen.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L2: How can I block the light that's coming into our room through the windows? 2 periods: L2a: 45 min L2b: 30 min *Building toward* ⬇ *NGSS PEs:* *1-PS4-2* *1-PS4-3* *K-2-ETS1-1* *K-2-ETS1-2* *K-2-ETS1-3*	We test various materials (cardboard, fabric, paper, tissue paper, towels, construction paper, transparencies, wax paper, mylar, plastic wrap, cardstock, etc.) to cover part of the window to see if they block the light from outside. 	**Plan and conduct an investigation** collaboratively to produce data to *help determine which materials will be the best (patterns) for blocking out the light coming through the windows in our classroom.* **Define problems** *and* **Develop solutions** *related to the question, "How can we make a smaller (scale) window on a smaller wall?" to test the materials again to determine which ones would block all the light coming into the room.*	L2a: **We have some ideas for how to conduct a fair test to see if different materials can block the light coming through the window.** • **We should only test one material at a time.** • **We should go to the same spot on the window for each test.** • **We will need to record the data in some way so we can tell others about it later after the investigation is over.** After making some predictions & testing the materials on the window we share results and noticed some patterns : • Some of the materials did a better job of blocking the sunlight than others: Some blocked all the light (like cardboard). Others blocked some, but not all of the light, and some didn't block any light!  We argued from evidence that the materials that block the light should be the ones we use to cover the windows of our classroom. We want to try to use cardboard to make our room completely dark L2b: When we tried using cardboard, we realized we didn't have enough to cover the windows. We have a constraint: the materials we have are really small. We identified a problem: We don't have enough cardboard to completely cover our windows. So our room was still too bright from the uncovered parts of the window.  Because we discovered that the windows were too big to cover completely, we brainstormed some design solutions to the question, "How can we make a smaller window on a smaller wall?" We posted our solutions to the Design Ideas Gallery. In the end, we agreed we could cut a small square on the side of the box, and tape a clear CD/DVD case to the box, and use this to test which materials completely block light from a flashlight outside of it by covering the window in it with different materials and us it completely to turn off all the lights. **Next steps: We want to try our smaller window and wall with a flashlight and the materials from last time to see if they block all the light coming through the window from the flashlight**

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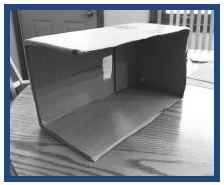
This Lesson….What we are doing now: Students will need to figure out that different materials block light better than others (some block all the light, some let all the light through, and some block some, but not all of the light), from the results of today's investigation.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L3: Which materials will block the light best (to help us make our room as dark as possible)? 2 periods: L3a: 45 min L3b: 30 min *Building toward* ⬇ *NGSS PEs:* *1-PS4-2* *1-PS4-3* *K-2-ETS1-1* *K-2-ETS1-2* *K-2-ETS1-3*	When various materials (cardboard, fabric, paper, tissue paper, construction paper, transparencies, wax paper, mylar, plastic wrap, cardstock, etc.) are place on/inside of a clear CD case (Faux Window) and a flashlight is placed we can see three different types of result in terms of what we can see on the other side of the material (all the light and flashlight, some of the light, but not the flashlight, no light and no flashlight). 	**Plan and conduct investigation** collaboratively to generate additional ideas for *how we could use a CD/DVD case on the side of a box, and a flashlight to test "Which materials block the light best (patterns)?" and then test those materials to provide evidence to answer this question.* **Define problems** *and* **Develop solutions** *related to the question, "How can we make a smaller (scale) window on a smaller wall?" to test the materials again to determine which ones would block all the light coming into the room.*	L3a **We have some ideas for how to conduct a fair test to see whether different materials can help block the light from the flashlight coming through the CD/DVD case that simulates where the window and outside light are located in our room.** After testing the materials in our setup and recording our observations, we share our results and notice some interesting patterns : • Some of the materials blocked all of the flashlight's light, others blocked some of the light, and then there were some that blocked no light at all. • The materials that blocked the light were not see-through at all. • The materials that were sort of see-through or completely see-through were the ones we shouldn't use to block the light coming into our classroom. L3b We thought that in the previous investigation investigation was easier to see how much light the materials blocked because it was smaller in size. But we discovered another problem. It still won't help us answer the original question "What would we see in our room if it was completely dark?" because of our material constraint (not enough cardboard to cover all the windows) from before Bu,t we think if we could make our box more like a smaller scale version of our room, we could use it to answer our question - by making it completely dark in it (letting no light into it) and then looking inside. This raised a new design problem we need to solve, We need to redesign our investigation again to address this problem, *"What else could we add to our window and wall to make it more like a small room?"* We brainstormed some design solutions. We posted our solutions to the Design Ideas Gallery. In the end, we agreed we needed four walls a ceiling and a floor (6 faces of rectangular prism) in order for it to have the same shape/structure as the room. And we need to add a door to open and close and put other stuff inside of it (objects to see) like furniture and/or posters on the walls. We posted our solutions to a Design Ideas Gallery.  **Next steps: We want to bring in some small objects to put inside our small room which we will make and work with tomorrow. We have some ideas for some investigations we want to conduct with it once we build it.**

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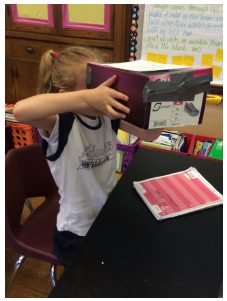
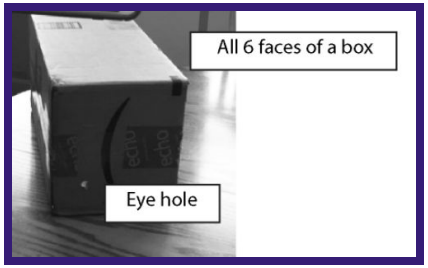
This Lesson….What we are doing now: Students will use a smaller room (a shoebox) with a "window" and a "door" on it to simulate what they can see in it (or in a room) in various conditions. In this informal exploration of the shoebox, students will generate conflicting results, regarding what they can see (if anything) when the close the box up completely with cardboard. You will use these conflicting results will motivate a redesign of this investigation using a camera phone to see inside the box all at once.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L4: What do we see when we look into a place where all the outside light is blocked from getting in? <u>2 periods:</u> L4a: 45 min L4b: 30 min *Building toward* ⬇ <u>*NGSS PEs:*</u> *1-PS4-2* *1-PS4-3* *K-2-ETS1-1* *K-2-ETS1-2* *K-2-ETS1-3*	When we use a shoebox with with a secured lid, and cut out flaps in the sides of the box that can be opened and closed in order to let light in, and small pictures we hung on the inside walls of the shoebox, we noticed different patterns when we looked into the shoebox with the window flap opened vs. closed. 	**Engage in argument from evidence** *to construct a claim about whether each person could or could not see any part (patterns) of the things inside the box with the flaps closed completely and no light from the outside could get into the space inside.* **Define problems** *and* **Develop solutions** *related to the question, "How can we use camera phones to help us all see inside each little room at the same time without letting light into each box?" so that we can determine for sure if we can see any part (patterns) of the things inside the box with the flaps closed completely and no light from the outside could get into the space inside.*	L4a We came up with different ideas for how we could modified the boxes we used in lesson 1 and lesson 3, to be a small space like our room (with doors and windows), all of which are covered up with another layer of material that blocks the light from getting in. We put our own drawings/objects into the boxes and conducted our investigation, we tested three different conditions: We tested our boxes, by closing the door and covering the window covered with cardboard, Window with a piece of cloth over it and by opening and closing the door on it. When we compared results, we noticed that the patterns between people weren't all the same. For the cardboard covering we weren't all in agreement on whether we could see something or nothing inside the box. This re-raised the question, "What if anything could we see if we look into a place where there is no light getting in it?" We decided we didn't have enough evidence to answer this question yet - because different people were reporting different results. This helped us identify a constraint: in our current box, only one person can look into it at once, without letting light in. This raised a new design problem, we needed a way to test all the boxes, and view the same results at the same time in order to resolve this question.  L4b We brainstormed some design solutions, related to the question, *"How can we use camera phones to help us all see inside each little room at the same time without letting light into each box?"* We shared out our design solutions. We posted our solutions to the Design Ideas Gallery. In the end, we agreed that one useful solution, would be if we could hold each of our boxes up against the camera of the phone and all look at the camera screen to see what we see inside of the room together, and we could try that for each room, opening and closing the door on the rooms. **Next steps: We want to try our solution out next time.**

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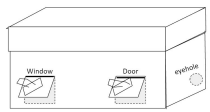
This Lesson….What we are doing now: Students will redesign their boxes to have different pictures on the walls inside, and as an entire class you will help students compare what we can see inside different boxes using an iPad as a shared view into the box, under different conditions (when the window is covered with cardboard, when it is covered with a piece of cloth, and when nothing was placed over the window). The results of this investigation will convince the class that you can't see objects when there is not light in the space of that object.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L5: How does letting light into the box affect what we can see inside it (with the ipad/smart phone)? 1 period: (60 min.) *Building toward* ⬇ *NGSS PEs:* *1-PS4-1* *1-PS4-2* *K-2-ETS1-3*	When we reuse the light box from the previous lesson, but place different small object to place inside the lightbox, we get more consistent results, particularly when we use the iPad as an "eye" to create a shared viewing experience into the viewing hole of each box we put in front of the class camera.  	**Plan an investigation** collaboratively to observe a phenomenon a different way *(allow us to all look into the closed box at the same time*). **Conduct an investigation** to produce data to serve as the basis for evidence to answer a question, "How does letting light into the box affect (cause-effect) what we can see inside the box?" **Engage in argument from evidence** *to construct a claim that if there is no light in the space of an object (cause), then we can not see that object (effect).*	**We decided we wanted to add different things to try to see into different boxes to test with the shared phone camera view into the boxes.** We each put our own drawings/objects into the boxes and conducted our investigation, we tested three different conditions: Window covered with cardboard, Window with a piece of cloth over it, window opened for a few different boxes. We analyzed our data and noticed patterns: • When the window was covered with cardboard we couldn't see the drawings or the objects in any of the boxes. • When the window was covered with a piece of cloth over it, we could see the outline of the objects, but it was hard to make out the drawings or details on the objects. • When nothing was placed over the window, we could see the details of the objects, and the drawings on the walls. *We are wondering, "If we can't see something, does that mean that it's not there?"* We quickly realized think it's possible that an object can be somewhere even when you can't see it, because sometimes you can feel something or hear something, even when can't see it with your eyes. We drew some conclusions that we think apply to other situations, related to our original question "What can I see when it is completely dark?" We are convinced you need light to see things ("Objects can be seen if light is available to illuminate them," PS4.B). i. Object in a space with no light are not visible. We can not see them. Ii. Objects in a space with enough light are clearly visible. We can see them. Ii. Objects in a space with very little light are somewhat visible but difficult to see clearly. We argue from evidence from all of our investigations to support these claims: • When we closed the flaps of the shoebox and covered the cracks with cardboard, the objects we put inside were not visible, because we kept the light from outside the box from getting into the box (cardboard blocked it from getting in). • When we opened the flaps of the window or door we could see the objects inside the box clearly. This is because we let light from outside the box into the box. **Next steps: We wondered if instead of blocking light from outside the box, there was a way to put light inside the box and keep it in there, to see what, if anything we could see then.**

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This Lesson....What we are doing now: Students will claim that we should be able to see objects if light is available in the space of the object. You will help students brainstorm other safe and small light sources that we could put inside our box, to test what we predict we could see when we move the light source to inside the box. And students will read an interactive reader (and two optional reading book extensions) to gather information about other light sources in the world. They will use the examples from the texts that they look at to argue whether those light sources would be small enough and safe enough to put inside of our cardboard box.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L6: What are some light sources that are small enough and safe enough to bring into our box? 1 period: (45 min.) (additional time for reading extension lesson*) *Building toward* ⬇ *NGSS PEs:* *1-PS4-2*	a few photographs (in slideshow)   need videoes for the glow in the dark stuff. Reading on other light sources Flashlight .Two reading book extensions: ● Light is Everywhere: Sources of Light and Its Use ● Light Sources	**Obtain, Evaluate, & Communicate Information** from an interactive reader, that will be useful in help making claims about *"What are some light sources that are small enough (scale) and safe enough to bring into our box?"*	We brainstormed sources of light last time and discussed: • *What the source of the light outside of our box?* • *And whether we can we bring that light source into our closed box?* • *And what other light sources could we bring into our closed box that would help light up the space so we could see the objects inside even when it is closed?* We think that the light sources outside our box are things like the sun, and the light bulbs in our room. They are light sources, because they make their own light - they glow. We are curious about what other objects are like that - they glow on their own and our light sources. And we are wanting to identify some light sources that would be good ones to bring into our box because they are small enough and safe. We think that the flashlight is one example of something else that is a light source that small enough and safe enough to put in our box. We wanted to think of more examples, so we analyzed some photographs, and noticed some patterns: • There are lots of kinds of light sources in the world. • Some natural light sources exist in nature: fireflies, fish in the deep ocean • Others seem built or made by people (e.g. light bulbs) • Many of these light sources are not good ones to bring into our box because they are too big, too hard to move, or dangerous to use in class (hot or would burn you) When we discussed the connection between hot things and bright things, we realized that when objects are heated up they often become light sources (e.g. burning wood, heating metal, heating glass, turning on some light bulbs). But then we realized that there were some things that didn't seem to get really hot when they lit up (flashlights, glow in the dark stickers). **Next Steps: Now that we have learned about other light sources that our safe to bring into our box, we are wondering what we would be able to see in the box (or any closed space) if we did (or didn't bring a light source into it).**

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This Lesson….What we are doing now: You will help students develop and use a model to use the ideas students figured out in previous lesson to explain and predict what, if anything, a person going into a cave could see on the walls of the cave with different conditions, including bringing a light source into a cave. You will test the predictions for later, using the shoeboxes again. And you will help students start thinking about other places that people might try to block the light out from a space they are in.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L7: What would we be able to see in the box (or any closed up place, like a cave covered up at the opening) if we brought a light source into it? 1 period: (60 min.) *Building toward* ⬇ *NGSS PEs:* *1-PS4-2* *1-PS4-3* *K-2-ETS1-2*	Cave Explorer video - why can't we see anything in a cave? How do we reveal what's in the cave? Spelunking Video: https://www.youtube.com/watch?v=npHq5xqgCQE	**Develop and use a model** to help predict & explain *that we can see things inside a closed space (cave/box) when the is an opening for light from outside the (cave/box) to get into it, but we can't see things inside (effect) the cave/box when no light gets into a cave/box because (cause) a material blocks light on the outside from getting inside the box.*	We drew a model to predict what why wouldn't see the cave drawings on the wall of a cave if we were inside it, but there wasn't enough light getting into that part of the cave. In this model we included: • A person's eyes (to represent ourselves) carrying no light into the cave. • Darkness to show that we can't see anything on the walls of the cave. We drew a model to predict what drawings we would see on the cave wall if we were inside it and brought a light source into it. • A person (to represent ourselves) carrying a light source (flashlight, candle) into the cave • Darkness to show that we can't see anything on the walls of the cave. We analyzed a spelunking video and noticed patterns: • You can't see anything in the closed dark space (the cave) without a source of light • You can see things in the closed dark space (the cave) with a source of light. We concluded that: ("Objects can be seen only when light is available to illuminate them" and light travels from place to place," PS4.B. "People use their senses to learn about the world around them. Their eyes detect light…," PS4.C.) We tested and confirmed our claims about the cave further by simulating the three conditions of the cave phenomena with our shoe boxes. We argue from evidence from all of our investigations to answer the original questions the class posted in the room from lesson 1: "What can we see in the dark?" and "How can we make the room as dark as possible?" • We can see nothing in the complete dark. • We can make our room as dark as possible by making it like the box or the cave: remove all the light sources and cover every opening with materials that don't let outside light in. Our cave problem vs. room problem got us thinking again about *where else people try to block out light from a space they are in?* **Next steps: We decided we wanted to investigate this question a bit more.**

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This Lesson….What we are doing now: You will help students brainstorm examples of where else in the world people try to block out light and you will show them different images of places in the world for them to analyze for evidence of objects in the photograph that may have been designed by people to block out the light. In analyzing the data, you will help students uncover a new phenomena – evidence that these objects are forming shadows. You will guide students to consider a new question, which will raise new disagreements to investigate further, related to whether we could make shadows with any material.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L8: Where else do people use materials to block out the light? 1 period (40 min.) *Building toward* *NGSS PEs:* *1-PS4-2* *1-PS4-3* *K-2-ETS1-1* *K-2-ETS1-2*	Photographs of designed objects in bright sunlight Umbrellas, awnings, sun visors, domes, show striking shadow regions on other objects around or underneath them.	**Analyze Data** using observations (from photos) to describe relationships in the designed world between man-made objects that people use to try to block out sunlight and the patterns we see on the surfaces under/behind them that provides evidence that they are blocking light. **Engage in Argument From Evidence** making a claim that objects in the photographs are producing (causing) shade/shadows (effect).	Now that we figured out what materials would be best for blocking light coming into our box or room, we started wondering: • *Where else in the world people try to block out light?* We brainstormed a few examples, and then analyzed some photographs of other phenomena to see if we could find evidence of people using objects to try to block out some light. From the images we analyzed we noticed some patterns: • There are different shapes of objects that people make out of materials to help block the light in different situations. • When light is blocked from a light source the a spot of shade (or a shadow) is made on surface of another object. We predicted where a shadow would be formed from a flashlight and a cut out shape made of cardboard held in front of it, it various configurations, and tested it. We noticed some patterns: • The shadow is seen on the surface of a an object that the light source is pointing at, but on the other side of the object than the light source was on. This raised the question, *is cardboard the only type of material that makes shadows?* We thought no, and gave examples, from the photographs we looked at earlier.So we decided to re-analyzed the photographs from before, again, this time to determine what type of material the objects that were making the shadows were made of. We noticed some patterns: • Lots of different kind of materials, besides cardboard can make shadows. This led us to wonder: *Could we make shadows with any material?* This raised some disagreements, as we all had different ideas about this and we weren't sure if all the materials we tested would make as good of shadows. **Next Steps: We wanted to try to investigate this question next and our teacher encouraged to think of how we can reuse some of the materials we've used in previous lessons (the flashlight, miniature window, and samples of materials) to do this as well as ways we could investigate this outside or at home.**

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This Lesson....What we are doing now: Students will investigate which materials make shadows testing the materials they used before to see which ones let light through. You will help them analyze the data from this investigation and compare it to data from earlier investigations to discover a pattern - that the materials that block light make shadows and those that light through do not. And you will help students take stock of all of their discoveries to motivate wanting to look for evidence of what they figured out in the world outside their school (to plan a Light & Shadow hunt field trip).

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L9: Will all materials create a shadow? L9a: 35 min. L9b: 25-25 min. L9b is an embedded assessment. *Building toward* ⬇ *NGSS PEs:* *1-PS4-2* *K-2-ETS1-3*	e test our materials again in the CD window case, but this time our materials were in different shapes (triangles, stars) and notice patterns in whether they make shadows or not.	**Plan and Carry Out an investigation** collaboratively to produce data to determine whether any type of material (cause) will create a shadow (effect). **Analyze data** to describe patterns in the data (from the investigation above) to to determine if there is a relationship between whether a material makes a shadow and whether it blocks light.	9a: We recall that in lesson 2 and 3, we tested our classroom materials and found that some of them block light from a flashlight, some let the light through, and some only let some light through. Now we make some predictions about whether all of these materials would make a shadow. We conducted and investigation using the CD/DVD window cases from earlier and 3 flashlights, and we notice some patterns in testing three different materials: • one made a dark shadow, another made no shadow, and one of them made some shadow, but it wasn't as dark as the first one. We repeated that investigation for another 2 sets of 3 materials and noticed another pattern: • The materials that blocked all the light from the flashlight made a dark shadow • The materials that didn't block the light from the, didn't make a shadow • The materials that blocked some of the light,,made a shadow, but it wasn't as dark as the ones made from the materials that blocked all the light. We argued that the materials that the materials that make shadows are the ones that would be good for blocking light. L9b: We make more predictions based on the relationship we discovered between between whether a material blocks light and whether it will make a shadow. We test one part of this relationship together as a class using 2 sets of 3 new materials and record our predictions (this is the embedded assessment) Optional: We wanted to test our predictions and worked in small groups with a bin of the new materials and a flashlight to see if the relationship between blocking light and making a shadow still holds. **Next Steps: We want to look for phenomena in our world outside our classroom where we can use these ideas to explain what is going on. We want to plan a Light and Shadow Hunt field trip to go on.**

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This Lesson....What we are doing now: In this three part lesson you will help students design an investigation plan for going on a walking field trip to collecting data about light sources, materials being used to let light through, materials being used to block light, and interesting shadows we notice being formed in the world outside our school. Then you will take students on a walking field trip to conduct that investigation and collect that data. When you return with your data, you help students analyze the data. On a second pass through the data you will help students uncover a new phenomena - light sources that appear to be used for communicating information (e.g. brake lights, turn signals, stop lights, store signs).

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L10 Where else in the world do we see light sources, light going through different materials, and different materials making shadows? 3 periods: L10a: 45 min (prep) L10b: 60+ min. (conduct) L10c: 45 min (analyze) *Building toward* ⬇ *NGSS PEs:* *1-PS4-2,* *1-PS4-3,* *1-PS4-4* *K-2-ETS1-1*	Light hunt: Take our ipads and go record stuff in the world outside Photographs/video clips from the light hunt (exit signs, signal lights on a car, stoplight, crosswalk sign, neon signs, street lights, railroad crossings, lights on an elevator, ambulance/fire truck lights, lighthouses)	**Plan and conduct an investigation** collaboratively to gather data that provides evidence *for patterns in the way/where people are using light sources, materials and objects are being used for blocking light or letting light through,, and shadows are being formed in the world outside our school.* **Engage in argument from evidence** making a claim, supported by evidence from the above investigation, that some light sources in the world around us are doing more than just providing light for us to see, they are also be used to communicate a message because of a pattern between their structure and function.	L10a: We came up with the idea of wanting to look for more phenomena in the world outside our classroom, to try to explain using what we figured out about light sources, materials (and shapes of materials) for blocking light or letting it through, and shadows, and this led us to the idea of going on a Light and Shadow Hunt. But then we started to brainstorm, what was it we wanted to look for? How are we going to record what we see? We agreed on wanting to keep track of: • Light sources we see and what they look like • Places that we notice certain materials being used to let light through • Places that we notice certain materials being used to block light • Interesting shadows we notice We practice walking in our hallway to prepare for our field trip - be sure there is something for students to observe during the practice run so they can practice writing down data. L10b: We conducted our hunt and collected data. L10c: When came back from our hunt, we analyzed our data and noticed patterns: • There are a lot examples of light sources, materials, and shadows in our world around us. • There is a new kind of pattern we noticed in the way light is used in our world - sometimes it does the job of sending messages! We talked about this new pattern of how light is used and realized that light sources are often used to send messages in our world does it without making any noise.! People can observe colors of stoplights, brake lights, crosswalk lights, and none of them require sound to understand what the messages mean. Other times people can observe light sources that are the shape of letters and understand what the spell out, or what they letter stands for (a symbol to represent a certain kind of restaurant). Our teacher gives us a new challenge - we want to try to use light to communicate messages through our school hallways so that we do not disturb classes as we transition from one class to the next. We think we can use ideas from what we discovered about light sources, different materials, and shadows to come up with some solutions

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			Before we can apply ideas from outside, we want to analyze our data a bit more. We go back to the data (photos and sketches) from our light hunt and break down the messages we thought were most powerful. We asked ourselves a lot of questions about what we saw: • Why the circle? Why red vs. green? Why blinking? Why a big hand? Why this patterns? Why are exit signs always illuminated? How do lights work in combination? We figured out that patterns (blinking), changes in brightness, color, symbols can be used to communicate complex messages. We will keep these in mind as we develop our own communication tools and methods to communicate in the hallway. And we realized that light sources can communicate messages over really far distances, without making any noise. **Next time: We want to try to use this discovery to solve some problems in our school.**

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This Lesson….What we are doing now: You will help students identify a potential need for an engineering solution and investigate whether the need they identified matches actual problems that need to be solved in their school. You will help students identify criteria and constraints that emerge in this process. Students will use these to design possible solutions on paper that they want to construct and test. They will build devices, and test their solutions and record evidence of their relative effectiveness. Students will return to repeating a round of this design process after the next lesson.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L11(a-c) How can we use light to communicate without making any noise? 2 rounds of about 4 periods 2 x (4 x 45 min) *Building toward* *NGSS PEs:* *1-PS4-2, 1-PS4-3, 1-PS4-4, K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3*	School hallway communication problem. Give students a mystery bag of materials so that all students have different materials to work with. This will encourage students to manipulate the materials.	**Defining problems** *where there may be a need for designing a way to use light to communicate messages over a large distance to a group of people in our school without making a sound.* **Design a solution** *including both the tool and the code (the structure and its function)* to communicate messages *to other students in our school down the hall using light, without making a sound.* **Plan and Conduct Investigations** with partners to gather data to serve as the basis for evidence for the argument below related to the solution above.	Now that we realized that light might help us communicate over really large distances without making a sound, we thought about some potential problem places in our school where it would be helpful to communicate with other people without making a sound and/or needing to communicate over a large distance. We brainstormed some possibilities and identified some possible situations: • In the cafeteria where it is already too loud • Down the halls where we don't want to disturb other classes • In the library where we don't want to disturb people reading • Outside for P.E. or recess when we are far away from other people We also identified possible messages that people might want to send in to other people or groups of people in those settings. We wondered if these are real problems or only made up ones, so we decided we wanted to talk to people around the school and interview them to better define what if any problem might exists. From the interviews we determined some places where it could be useful to design a solution. We identified the criteria for that solution based on the interviews and what we decided counts as a successful communication device that uses light. We identified constraints such as 1) the materials available, where and how we can test our devices & methods *We begin to wonder what we can do with our bodies and other materials to make light and shadows that send a message?* We began to design solutions on paper - both in terms of devices and communication codes. Each person tested at least two (some more than two) different method/device for sending messages, recording evidence regarding the effectiveness of each design change along the way. Some groups try using simple light signals (on/off for yes/no), others use patterns of light (rudimentary morse code), others use shadows, some use materials to cast a colored light. **Next Steps: As we saw others working on their designs we thought they were cool too and wanted to check them out and we wanted to share what we discovered in our own designs with others, so we decided we wanted to share the results of initial design tests to our classmates.**

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This Lesson….What we are doing now: Students will go public with the results of their different designs. You will facilitate a discussion to help audience members articulate a design features in other people's devices that they might want to incorporate in their own devices and ideas for possible ways to improve the performance of other's devices and make a public record of student's design ideas for them to (re)use and incorporate in a new round of redesign, returning to the previous lesson one more time.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L11(d-f) How can we evaluate our designs and use the results of everyone's tests to improve our own design? 2-3 rounds of (60-75 min) *Building toward* *NGSS PEs:* *1-PS4-2* *1-PS4-3* *1-PS4-4* *K-2-ETS1-1* *K-2-ETS1-2* *K-2-ETS1-3*	School hallway communication problem. Give students a mystery bag of materials so that all students have different materials to work with. This will encourage students to manipulate the materials.	**Communicate information** about the design solutions (structure & function) tried and the results generated (patterns), to make evidence-based claims (argument from evidence), about which solutions are more effective at solving the original problem (see previous lesson). **Evaluate alternate solutions** that other people tried to identify new design features (possible causes and effects & structure / function relationships) that may help make our own designs more effective at solving the original problem (see previous lesson) if we incorporated them into a redesign of them.	All groups shared their design ideas with the class in order to get feedback on their designs. As our classmates presented and received feedback, we noticed patterns in what everyone is including in their designs. We decided it would be helpful to draw a model of what should definitely be included in our designs to make sure the design is effective at communicating the intended message. We each identified designs/design features from our classmates might be useful to incorporate in a final design. And we argued that we should try to improve the design in another round of engineering. We went back to our designs and applied the feedback we got from classmates. When everyone was finished, we evaluated a different prototype to start using when we move through the hallways to send messages to people in long lines and in the cafeteria in our grade.

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This Lesson….What we are doing now: You will test the communication device in field trials (with your students in the hallways and other settings for a couple days in real school setting). From these experiences you help students identify a new problem that emerges from the field trials - students in line around a corner can't see the message. You will use this new problem to motivate need for designing a new solution. Students will explore the behavior of some new materials (reflective ones) and share ideas for how they might be used in the design of a solution. Then students return to the design process to draft, create, and test two or more solutions to the problem.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
Extension lesson: **L12 What materials could we use to redirect light around a corner to communicate with someone in a different room, or in a different hallway, or on a different floor, without making a sound?** (2 x 45 min to intro. New problem and introduce to new material) + 1-2 rounds of (re)design similar to L11a-c (flexible) *Building toward* ⬇ *NGSS PEs:* *1-PS4-2* *1-PS4-3* *1-PS4-4* *K-2-ETS1-1* *K-2-ETS1-2* *K-2-ETS1-3*	Mirrors/reflective materials in addition to the original materials presented in Lesson 2 (Foil, mirrors, curved pipe (pvc or paper towel tubes), sequins, tin cans (from canned goods,).	**Defining problems** *where there may be a need for designing a way to use light to communicate messages over a large distance AND redirect it around a corner to a group of people in our school without making a sound.* **Design a solution** *including both the tool and the code (the structure and its function)* to communicate messages *to other students in our school down the hall and around the corner using light, without making a sound.* **Plan and Conduct Investigations** with partners to gather data to serve as the basis for evidence for the argument below related to the solution above. **Communicate information** about the design solutions (structure & function) tried and the results generated (patterns), to make evidence-based claims (argument from evidence), about which solutions are more effective at solving the original problem (see previous lesson).	(*This lesson is an extension lesson to allow for catching kids up from previous design work, provides enrichment challenges for students who are ready to move on) and additional days for remediation & assessment.* After trying our devices out in the hallways a few times, we identified a new constraint we didn't realize before. People around the corner can't see the message. We decided we wanted to try to solve this problem as well. We redefined the problem and the criteria and brainstorm some possible solutions. We were introduced to a set of new materials bin to explore that might be useful for our problem - they are different because they are shiny. In playing around with the materials we noticed that if we shine a light on a shiny material (foil, mylar balloon, mirror) that it looked like the light is "bouncing" and we can see the light on another surface. This is different from the materials we tried before, because those either let some light through, all the light through or no light through. We realized that we can use shiny materials to send the light around a corner (or someone else even), to a place where it wouldn't go otherwise. We decided to redesign a solution to this new problem using additional materials and old methods and materials to help communicate messages to lines of students around the corner of the hallways without making a sound.

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Reading extension lessons (under development)

Student Generated Question That Motivates This Reading	Phenomena	Scientific Practices	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L8.re.1 What did people use as light sources in the past? (Can be used after lesson 8 is completed)	Readings - on historical periods before and after light bulbs (e.g. lamps, candles)	**Gather and communicate information**	Extension activity - to build out the literacy connections.

Student Generated Question That Motivates This Reading	Phenomena	Scientific Practices	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L11.re.1 Optional: How else do people use light sources to communicate messages? (Can be used after lesson 11 is completed)	Readings - on everyday light sources on things like stoves, alarm clocks, chargers, dashboards of cars, boat lights, etc...	**Gather and communicate information**	Extension activity - to build out the literacy connections.

Student Generated Question That Motivates This Reading	Phenomena	Scientific Practices	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L11.re.2 Optional: How else have people used light sources to communicate messages long ago? (Can be used after lesson 11)	Readings - on historical examples of things like lighthouses, signal fires, ships lanterns, etc...	**Gather and communicate information**	Extension activity - to build out the literacy connections.

Student Generated Question That Motivates This Reading	Phenomena	Scientific Practices	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L12.re.3 Optional: Where else have mirrors been used to redirect light? (Can be used after lesson 12)	Readings - Engineering related, history related, survival….(mirrors on cars, mirrors on disco balls, skylights	**Gather and communicate information**	Extension activity - again to allow for catching kids up, for students who finish the assessment,, and to build out the literacy connections.

Student Generated Question That Motivates This Reading	Phenomena	Scientific Practices	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L12.re.4 Optional: How do they make mirrors anyway? (Can be used after lesson 12)	https://www.youtube.com/watch?v=z9TNSuZ76RQ	**Gather and communicate information**	Extension activity - again to allow for catching kids up, for students who finish the assessment,, and to build out the literacy connections.

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