

## Purpose

In this activity we will consider Practice 6 of the Next Generation Science Standards (NGSS), *explanations* (for science) and *solutions* (for engineering). Before you begin, review the NGSS expectations for elementary school children for this practice at the very end of this activity. You should have watched the video *Shedding Light on It* at home and brought your notes to class.



*What are the teachers' and students' roles in constructing explanations and designing solutions?*

## Predictions, Observations and Making Sense

### Part 1: Your Ideas about Explanations

Developing explanations is an important part of science. Often this begins with an observation. Scientists then collect evidence (additional observations, measurements, patterns) to develop or support an explanation.

Explanations consist of a claim, evidence that supports that claim and logical reasoning linking the claim to the evidence.

For example, consider the statement, "I think it is raining outside because the three people that just walked in were carrying wet umbrellas." This statement includes a claim ("It is raining outside") and evidence ("people carrying wet umbrellas"). In this case the logical reasoning connecting wet umbrellas to rain is implied, because it is assumed that most people would understand that wet umbrellas were logically connected to rain. However, if someone made the statement, "It must be raining because I just saw three people in swimsuits walk by," the evidence (people in swimsuits) is not clearly connected to the claim (raining) without the explicit logical connection that

the swimming pool closes down when there is rain because of the risk of lightning storms.

Think about your experiences during the Waves, Sound, and Light Module of Next Gen PET.



List three different observations about sound or light that you were able to explain.

Guiding students in developing explanations requires that the instructor set up appropriate opportunities for the students to make observations and support their developing of explanations.

Think of a *specific* example from Next Gen PET when you developed an explanation.



What did your instructor (or the curriculum materials) do to support your development of an explanation?



As a student, what did you do?

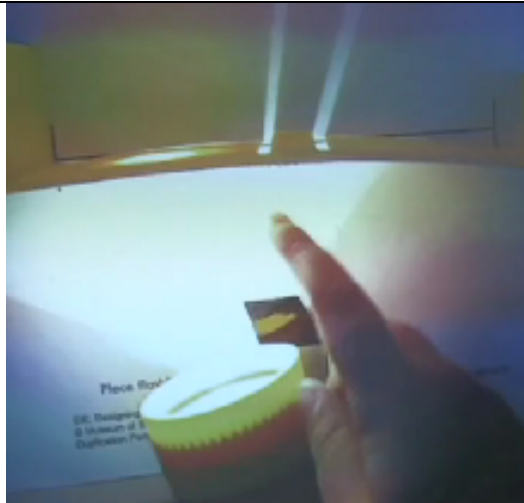
## Part 2: Observing a Teacher Support Students' Explanation

You should have watched the video *Shedding Light on It (1)*, grade 3 prior to this activity.

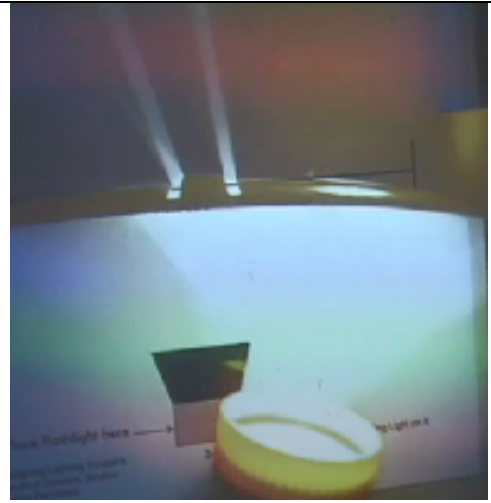


In the video the children made several observations in small groups (from time 1:30-3:55). First they observed that the light from the flashlight went out “like a fan.”

The second set of observations were that when they pointed the flashlight at a notecard with two slits and moved the flashlight, the light that goes through the slits appeared to move in the opposite direction.

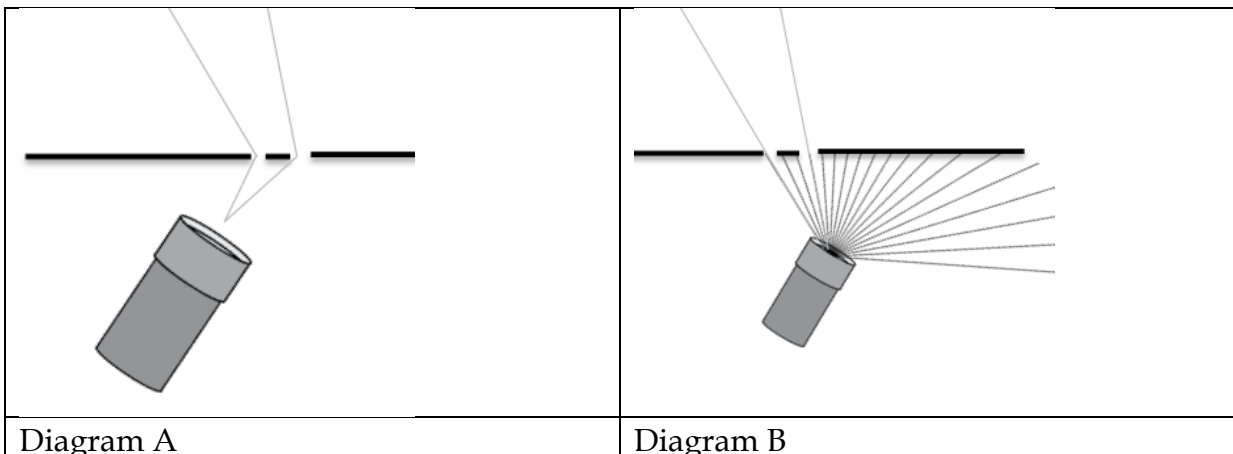


When flashlight pointed to the left, light transmitted through slits angles to right.



When flashlight pointed to the right, light transmitted through slits angles to left.

First think about how you would explain this observation. Below are two diagrams that students may have drawn to show the light angling to the left when the flashlight angles to the right.





Which of the two diagrams above do you think best shows how light from the flashlight travels as it passes through the slits in the cardboard? Explain your choice.



The teacher in the class brought everyone's attention to this observation. Why do you think the teacher decided to bring everyone's attention to this observation?





How could children use this observation to support the claim that light travels in a straight line?

Later in the video (time 5:29-10:10) the students developed the idea that the angle of incidence and angle of reflection were equal. Specifically, at time 9:15, the teacher facilitated the construction of the statement, "The angle of incidence and angle of reflection kept matching up. For example, the angle of incidence in test 2 was 40 degrees and the angle of reflection was 40 degrees."



What types of evidence were the students collecting?

 What were some things you noticed the teacher doing to help students in the class understand the significance of this statement?

 Look at the chart for student expectations for this practice. Which expectations of the practices did you notice students engaged in?

### Part 3: Designing a Teaching Scenario

In this section, you are going to design two different teaching scenarios and think about how to use them to support students in constructing explanations. You may have an opportunity to use one of these teaching scenarios in Extension L.



#### Option A: Observations of Shadows

Imagine you are a teacher who is outside at lunchtime with your third grade students. You overhear the following conversation:

Nina: What happened to my shadow?

Leo: It's right there under your feet.

Nina: But it got smaller. This morning before school, my shadow was *very* big.

	
<p>Nina notices she has a very long shadow in the morning before school.</p>	<p>Nina notices her shadow is small during lunchtime recess.</p>

After lunch, during science time, you might use this conversation and ask your students to construct an explanation of why Nina's shadow was smaller at lunchtime today than it was in the morning before school.

Your goal is to help them recognize that their shadow appears when their body blocks the light from the sun; that when the sun is low in the sky, (morning and evening) their shadow is long; and when the sun is high in the sky (middle of the day), their shadow is shorter.

Below are some ideas about light, shadows, and the sun. Which of these ideas do you think the children will need to know *in order to construct an explanation of this phenomenon*?

- Light travels in a straight line.
- When light is reflected, the angle of incidence is equal to the angle of reflection.
- Light must enter your eyes for you to be able see an object.
- The sun is low in the sky (close to the horizon) in the morning and evening and directly overhead around noon.
- Shadows are created when light is blocked by an object.
- The angle of the light source with respect to an object changes the length of a shadow.

Choose just one of the ideas above that you think children need to know in order to explain Nina's changing shadow. Write that idea here.

Your goal is to help children be able to make that claim (the idea you chose) and support it with evidence.



Describe the types of evidence you might ask them to collect.



Write out the claim you hope your child will make and how s/he might state this using supporting evidence. Use the format:

I think that \_\_\_\_\_. I think this because \_\_\_\_\_.

For example if your goal was to help students recognize that shadows are formed when an object blocks light, you might write.

*"I think that shadows are formed when something blocks light. I think this because I put a block, a spoon, and a toy car in front of a flashlight and each one made a shadow on the wall across from the flashlight and when the object was not there, the wall was light with no shadow."*

### Option B: Designing a Communication System

Imagine that that two groups of students representing people at a campsite (Campsite group) and people who have hiked away from the site (Hikers group). The groups have the following materials.

Campsite group: Flashlight, mirror, metal cooking pot, wooden spoon, 4 plastic plates, 4 metal forks

Hikers group: Flashlight, mirror, whistle

Their task is to design a way to communicate with each other. You can assume that the hikers are always within hearing distance (but not so close that they could understand words people are saying) and that there will not be large trees to block their view.

Think about the properties of sound and light and how they constrain or facilitate communication. For example, light travels in a straight line, which makes it hard to use to communicate around corners.



List some properties of *light* that are important to consider when designing a communication device.



List some properties of *sound* that are important to consider when designing a communication device.



Come up with one design you think an elementary student might think of to communicate between the groups. Draw a picture and answer the questions below.

What materials does it use?

How is information communicated?

How is information received?

Can information be communicated in both directions (from the camp to the hikers *and* from hikers to camp) or just in one direction (from the camp to the hikers)?

How would this system be used to communicate *different* messages, for example, “dinner is ready” or “come back.” (You can assume you had time to plan a system or code for deciphering messages before hand.)

What are the limitations of the system? For example, you might not be able to use it in the night or in the daytime or from a certain distance away.



Compare your ideas to another student or group of students. How could you decide which design was *better*? When designing a solution, engineers try to optimize among goals and constraints. What criteria would you use to evaluate how well the designs optimize the goals and constraints?

## Summarizing Questions

**S1:** In activities where teachers are supporting students' development of explanations, what do you think teachers need to do *before* instruction? For example, one thing they need to do is develop goals for what phenomena children will explain and what an appropriate explanation for that grade level looks like. List some others.

**S2.** In activities where teachers are supporting students' development of explanations, what do you think teachers need to do *during* instruction?

## Constructing Explanations and Designing Solutions

*“The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories” (NRC Framework, 2012, p. 52).*

*“In engineering the goal is a design rather than an explanation. The process of developing a design is iterative and systematic, as is the process of developing an explanation or a theory in science” (NRC Framework, 2012, p. 68).*

Grades K-2 Expectations	Grades 3-5 Expectations
<p>Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence- based accounts of natural phenomena and designing solutions.</p> <ul style="list-style-type: none"> <li>• Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.</li> <li>• Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.</li> <li>• Generate and/or compare multiple solutions to a problem.</li> </ul>	<p>Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.</p> <ul style="list-style-type: none"> <li>• Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).</li> <li>• Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.</li> <li>• Identify the evidence that supports particular points in an explanation.</li> <li>• Apply scientific ideas to solve design problems.</li> <li>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.</li> </ul>