Shadow Tracing

Partners take turns measuring their morning shadows. They will take three shadow measurements throughout the day: morning, noon, and afternoon.

Grade Level 3rd

Time Required: 3 sessions, 45 minutes each session

Group Size: Whole class and partner measurement groups

Summary: The class will measure their shadow lengths outside three times throughout the day once in the morning, again close to midday and a final time close to dismissal. Students will explore how their shadow changes in shape, size, and direction over the course of the day, and relate this to their previous observations of the Sun's motion across the sky using the properties of light and shadows they have established in the previous Activities.

Keywords

Angle: The figure formed from two lines extending from the same point. Also, the measure of the degree to which the two lines "open" or fail to be parallel.

Alignment: Three objects are in alignment if one straight line can be drawn passing through all three.

Similar: Identical in shape but different in size, orientation, or position.

Educational Standards

- Science:
  - Objective 3.01 Observe that light travels in a straight line until it strikes and object and is reflected and or/absorbed.
- Math:
  - Objective 3.01 Use the appropriate vocabulary to compare, describe, classify two and three-dimensional figures.

Pre-Req Knowledge

It is possible to do this Activity with no preparation, but in the context of our Unit the students will draw both on their previous study of the Sun's motion across the sky and on their understanding of the nature of light and the way in which the relative orientations and distances of light source, object, and screen determine the size and shape of the shadow produced.

Learning Objectives

After this activity, students should be able to:

- Discover the location of the Sun based on the direction of a shadow.
- Describe why our shadow always touches our body at the feet.
- Explain why when the Sun is on one side of the horizon, the East, your shadow will be in the West and vice versa. The closer the Sun is to the horizon the longer the shadow.
- Predict that near midday an object casts the smallest shadow in the north because the Sun will be in the South and is near its highest altitude or distance from the horizon.
- Observe the changes in shadow size and shape over time. While the shadow's width remains approximately constant, its length varies, so that the shadow is distorted and "stretched" or "compressed."
- Predict, based on our observations of the Sun's motion in the sky, the size and direction of our shadow at various times of day.

Materials List

Each pair needs:

- Chalk (sidewalk chalk works best for this)
- Measuring tape or meter/yardstick
- compass

Background:

As the students have learned in the previous Activities, a shadow forms when an object obstructs light from a given light source, creating a region behind the object which light cannot reach. A screen placed behind the object will be dark where it lies in the shadow. In this Activity, the object will be a student standing up, and the screen will be the ground on which he or she is standing. The Sun will be the light source, and as the Sun moves in the sky, the shadow, since it is the part of space "behind" the student as viewed from the Sun, will move as well.

Because the screen touches the student at the feet, the shadow will always form an image connected to the student's feet. It will extend from there in a direction opposite to the direction to the Sun. When the Sun is in the East, in the morning, the shadow will extend to the West, and when the Sun is in the West in the evening, the shadow will extend to the East.

In the "Light in Space" Activity, students saw how the size and shape of a shadow changes when we change the orientation of the object and of the screen. Here, the object is connected to the screen, while the light source is moving (of course, we will eventually claim it is the screen – Earth that is moving, carrying the student-object with it, but for our purposes here only the relative

motion matters). When the Sun is near the horizon, the light strikes the ground at an oblique angle and the shadow will be long. When the Sun is nearly overhead, Sunlight strikes the ground at near a right angle, and the shadow will be short. If the Sun were to be directly overhead (this does not happen in the US) we would create no visible shadow on the ground, since the shadow of our entire body would fit into our footprints. The width of the shadow will also vary, depending on the angle at which the Sun strikes the student's body, since our body is wider than it is thick. If students face South, the shadow will be thickest at midday and thinnest in the early morning or evening, enhancing the distortion effect.

Preparation:

- Find a location on the school grounds to which you can travel three times (9 AM, Noon, 2:30 PM) to trace and measure the students' shadows. The location needs to have a relatively flat surface on which chalk can write (e.g. blacktop) and traffic, automotive and human, must be light enough that marks created in the morning are likely to remain visible in the afternoon. If the location from which students tracked the Sun in the first Activity satisfies these criteria, this would be the best place to use, as students will have an easier time relating the two observations.
- Create student partner teams with two in each team.

Procedure:

1) Introduce the activity with the following ***Motivation/Challenge:*** I asked someone's dad the other day to explain why their shadow changed shape, size and position from the morning to noon and again in the afternoon. The dad thought for a while and explained, "My shadow followed me and the Sun got closer and further away making my shadow taller and shorter." Explain to the students that this dad was wrong and is a little confused. We have been learning in the last two activities about what causes a shadow and why shadows are their shape and size and in a certain direction. With your table or partner brainstorm what you know or what this dad needs to know to answer the question of how and why their shadow changes size, shape and location throughout the day. Students should write and illustrate their responses in their science notebook for 5-7 minutes.
2) Have groups share their responses to the class. Record them on the board. After you are done have the class help you categorize each response into 2 groups: **(L)** for responses that are connected to the properties of light and (**M**) for responses connected to measurement. Keep these responses in the class during the investigation. Continue to refer to the questions that need to be answered or the explanations that are scientifically correct to help solve the intro/challenge. Be sure to clear up misconceptions that are listed on the chart paper during the lesson with evidence from the activity.
3) Take the class out to the location of the shadow tracing. Gather in a circle. You'll notice kids stepping on each other's shadows. Let them have some fun and allow the kids to play shadow tag for several minutes. Gather back in the circle and ask what they notice about their shadows and the Sun or our light source. Students will begin to make the observation that their shadow is on the opposite side of their body that the

Sun is on. Some will also notice their shadows are longer than their body. Take several responses.

Students love to play shadow tag and other interactive shadow activities before getting started with their shadow tracing & measuring.

4) Explain their four tasks in their partner groups: (1) Face south and have your partner trace your shadow and then you trace your partner. Leave a good amount of space between each tracing. (2) Measure (inches and centimeters) each shadow tracing and record your measurement in your Science notebook. (3) Measure each student's actual length and record in your science notebook. (4) Calculate the difference between the body length and shadow length. Record in your science notebook.

Partners use measuring tapes to measure in inches and centimeters their shadow's length. Each of their three shadows will be compared to their actual height.

5) Once each group is finished with their measurements have them sit down by their shadow tracings and answer the follow questions:

- Where is the Sun in the sky? How many fists up from the horizon? Does the Sun's position in the sky cause your shadow to be a certain size, shape and direction? Explain how and why.
- Do you believe that the Sun, you and your shadow are lined up in a straight path? Explain your answer. Include an illustration to help your explanation.
- Later in the day the Sun's position in the sky will move. From what you know about light and shadows how will this effect or change your shadow's size, shape and location. Explain why your shadow will change?

If this step is done early in the day, and depending upon the time taken to complete it, the shadows may have changed sufficiently by the time students are ready to return to class that

they can notice this by comparing to their tracing. If so, point this out as a hint of things to come.

6) Repeat Step 4 and 5 near Noon and again near the end of the day.

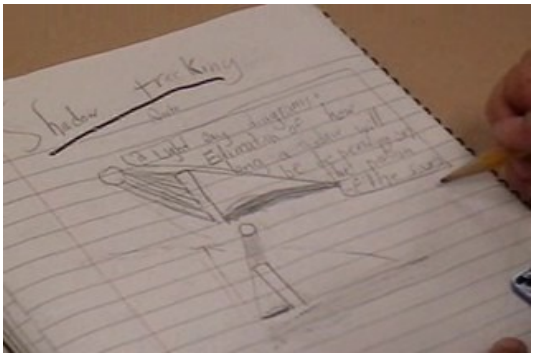
7) Before going home ask the kids to trace their shadows outside at home right before dinner tonight or right before the Sun sets.

8) That night your homework is to print out the student responses and questions that are on the chart paper for each partner group tomorrow.

9) At the beginning of the next day, hand out the print outs of the student responses from the beginning of yesterday's lesson. Allow the class to review their measurements and answers from yesterday while analyzing their data and explanations to see if it matches any of the student questions and comments from yesterday. Have each student highlight in their science notebooks where they answered or added further explanations to someone's question or beliefs from the day before.

10) Review with the class how their discoveries from the day before will help them explain to the confused dad why and how their shadow changes throughout the day.

11) Have each student write and illustrate an explanation to the question, "Why and how does your body's shadow change throughout the day?" The students will write their explanation to one of their partners' parents or guardians and their partner will bring it home that night. Ask the kids parents/guardians to write a note back to their partner about their work.



A student begins with an illustration showing two of the day's shadow measurements. She explains how the position of the Sun in the sky changed the size, shape and orientation of the shadow.

Safety Issues

- Remind students once again ***not ever to look directly at the Sun.***

Troubleshooting Tips

- Explain your expectations for teamwork and cooperation.

Assessment

Pre-Activity Assessment

After you have introduced the Challenge/Motivation, the students' drawings and writings in their Science Notebook as well as the class discussion act as a pre-assessment This pre-assessment is

based on their prior knowledge of the Sun, light, and shadow especially from the last two experiments.

Activity Assessment:

The four tasks repeated three times throughout the day: (1) Face south and have your partner trace your shadow and then you trace your partner. Leave a good amount of space between each tracing. (2) Measure (inches and centimeters) each shadow tracing and record your measurement in your Science notebook. (3) Measure each student's actual length and record in your science notebook. (4) Calculate the difference between the body length and shadow length. Record in your science notebook.

The follow questions answered in Step 5:

- Where is the Sun in the sky? How many fists up from the horizon? Does the Sun's position in the sky cause your shadow to be a certain size, shape and direction? Explain how and why.
- Do you believe that the Sun, you and your shadow are lined up in a straight path? Explain your answer. Include an illustration to help your explanation.
- Later in the day the Sun's position in the sky will move. From what you know about light and shadows how will this effect or change your shadow's size, shape and location. Explain why your shadow will change?

Post-Activity Assessment:

Each students' written and illustrated explanations for their partners parent providing an explanation for the question, ""Why and how does your body's shadow change throughout the day?"

Students displayed strong understanding of how and why their shadows changed throughout the day when they began their explanations with an illustration.

Activity Extensions

1) Each student plots his or her data on a graph. Y axis being the shadow's length and the X axis being the time of day.
2) Try out the wonderful activity where your students build a cut-out neighborhood and place it outdoors to observe and record the shadow's relation to the time of day, position of the Sun and time of year at http://www.sciencenetlinks.com/lessons.cfm?DocID=9

3) Present students with the animation at http://arb.nzcer.org.nz/nzcer3/science/planete/9000-099/Pe9094_flash.html. Challenge them to compare this with their observations. The Sun's path in this animation is reversed relative to our observations – the Sun appears to move from right to left – because this animation was designed in New Zealand, in the Southern hemisphere. This challenge foreshadows later activities in which we will introduce the effects on our observation of the Sun's apparent motion of the fact that Earth is round. It will likely puzzle students and keep them guessing; a promise that this will be explained later will build excitement and curiosity.

References