

Shadows

4th or 5th Grade

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Benchmarks:

(5th) SLC 10: A.) Students will investigate daily patterns of light and shadows due to the orientation of the sun and the earth.

Objectives:

After completing this assignment, the students should be better at the following:

- Making qualitative observations.
- Making measurements with a ruler.
- Recording data.
- Looking for patterns in data.
- Making and testing predictions.
- Using explanatory models.
- Understanding the need for "controls" (constants) in an experiment.

The students should have a familiar knowledge of these concepts:

- Shadows are caused by objects blocking light.
- Materials may block some (translucent), all (opaque), or none (transparent) of the light that strikes them.
- Light travels in straight lines.
- The size and shape of a shadow depends on the shape and orientation of the object casting the shadow as well as the distance of the object from the light source.

Materials:

- Frames made from Popsicle sticks
- Wax paper
- Plastic Wrap
- Cardboard
- Styrofoam Cups
- Toothpicks
- Clay
- Popsicle sticks
- Paper clips

For each group:

- 200 W light bulb in lamp
- 2 rulers
- Screen or light colored wall

Discussion:

What causes shadows?

* Ask the students what is needed to make a shadow? Answers should include a light source and something to block the light.

- * Ask where the shadow will be relative to the light and the object producing the shadow (i.e. blocking the light)? Answer--on the opposite side of the object from the light.
- * Ask what types of materials can produce shadows? Answer should contain the idea of materials that the light cannot pass through.

Target Model:

- A light source and something to block light is needed to make a shadow.
- Only materials that block light can produce shadows.
- A shadow will always appear on the opposite side of the object from the light.

Demonstration:

Take three frames made from Popsicle sticks, one covered with plastic wrap, one covered with waxed paper, and one covered with cardboard. In a dark room, use a 200-W unfrosted lamp and try casting shadows with the three materials. Ask the children to describe what happens in each case. Introduce or reinforce vocabulary relevant to these materials:

- * Transparent - allows light to pass through (relatively) undisturbed
- * Translucent - allows some light to pass through, but the light is scattered
- * Opaque - blocks light

Ask the students how they can tell the property of the materials by looking at the type of shadow (none, partial, or complete) cast by the materials. They can try to look through the materials. If they can see (fairly) clearly through the material and see recognizable objects on the other side, the material is transparent. If some light and forms are visible through the material, but not detail, the material is translucent. If nothing can be seen through the material it is opaque.

As an extension, ask the students, "During the day, can you see shadows if you are outside?" If the answer is yes, ask if that is always the case. Get the students to come to the point that they recognize that it needs to be sunny in order to see shadows. Then ask the students, "Can any light get through the clouds?" (Unless we have a pretty severe storm, the answer should be yes.) Then what class of material would the clouds be?

Target Observations:

- The plastic wrap let almost all of the light through, the wax paper let some of the light through, and the cardboard blocked all of the light.

Target Model:

- A light source and something to block light is needed to make a shadow.
- Only materials that block light can produce shadows.
- Some materials block different amounts of light:
 - Transparent: allows light to pass through (relatively) undisturbed
 - Translucent: allows some light to pass through, but the light is scattered
 - Opaque: blocks light
- A shadow will always appear on the opposite side of the object from the light.

Demonstration:

With the 200-W unfrosted lamp, cast a shadow of your hand on the wall. Turn on the room lights and try to see if the shadow of your hand is still there. Ask the students where the shadow should be when the room lights are used and why. Ask them why the shadow of your hand is hard to see when the room lights are used.

Follow up question: Where/when do you see the best shadows? (Outside in the sunlight.) Why does the sun cast such sharp shadows?

Target Observations:

- The shadow from the hand can't be seen very well because there are too many lights
- The shadow from the hand can't be seen very well because the lights are too spread out
- There are so many lights and they are so spread out that there isn't anywhere on the floor that light is not hitting from some direction.
- The sun isn't spread out very much, so it can cast shadows

Target Revised Model:

-A concentrated (not spread out) light source and something to block light is needed to make a shadow.

-Only materials that block light can produce shadows.

-Some materials block different amounts of light:

-Transparent: allows light to pass through (relatively) undisturbed

-Translucent: allows some light to pass through, but the light is scattered

-Opaque: blocks light

-A shadow will always appear on the opposite side of the object from the light.

Demonstration:

Shine the 200-W unfrosted lamp on the wall in a dark room. Have a student cast a shadow with a ruler. Ask the class, "What way will the shadow move if George moves the ruler to the right?" Try it. Then ask, "What way will the shadow move if George holds the ruler still and I move the light source to the right?" Try it. Ask the students why these two cases are different. Draw some ray diagrams to get to the idea that the shadow has to stay opposite the light source, with the light, object, and shadow all in a line.

Follow up question: "What does this tell us about how light travels?"

Target Observations:

- When George moved the ruler to the right, the shadow moved to the right
- When the light source moved to the right, the shadow moved to the left
- You can predict which way the shadow will move by making sure that the light, ruler, and shadow are all in a straight line

Target Model:

-A concentrated (not spread out) light source and something to block light is needed to make a shadow.

- Only materials that block light can produce shadows.
- Some materials block different amounts of light:
 - Transparent: allows light to pass through (relatively) undisturbed
 - Translucent: allows some light to pass through, but the light is scattered
 - Opaque: blocks light
- A shadow will always be on a line connecting the light source and the object, on the opposite side of the light source.*

Procedure:

Ask the students what determines the shape of a shadow. As the students discuss the question remind them that shadows are on a flat surface (i.e. are two-dimensional) but the objects that produce them are often solid (three-dimensional). So the shape of the object and how it is oriented relative to the light source affect the shape of the shadow. Illustrate the idea that shadows can be different shapes, depending on orientation, by casting three different shadows with a coffee mug: a rectangle, a rectangle with a handle, and a circle with a line sticking out one side. (Set or lay the coffee mug on a table and cast the shadow on a wall nearby.)

Break the class up into groups of 3-4 students per group. Ask the groups to construct an object that will have three very different shadows. Provide the groups with Styrofoam cups, toothpicks, clay, paper clips, and Popsicle sticks. Before using the light source to cast shadows, students should predict what the three different shadows that the object can cast will look like by sketching them.

Target Observations:

- We could get at least 3 different shaped shadows with the object we created

Target Revised Model:

- A concentrated (not spread out) light source and something to block light is needed to make a shadow.
- Only materials that block light can produce shadows.
- The shape and way the object is oriented can affect the shape of a shadow.*
- Some materials block different amounts of light:
 - Transparent: allows light to pass through (relatively) undisturbed
 - Translucent: allows some light to pass through, but the light is scattered
 - Opaque: blocks light
- A shadow will always be on a line connecting the light source and the object, on the opposite side of the light source.

Demonstration:

How does the distance between a light source and an object affect the size, shape, or darkness of the shadow? Have groups design an experiment to make observations about this phenomenon, using a light source, two rulers, and a light colored wall or screen. Note: for both experiments, the light source, object, and wall need to be in a straight, perpendicular line.

Safety: Never touch the 200 W light bulb or the metal surrounding the light – it is very, very hot. Never look directly into the light.

Target Experiments:

- Students keep the light source fixed, while moving the object back and forth. The following distances should be measured: from the light source to the screen, from the light source to the object, the height of the object, the height of the shadow. Groups who choose this experiment should have a data table similar to the one below:

Distance from light to screen	Distance from light to object	Size of Object	Size of Shadow
<i>100 cm</i>	<i>30 cm</i>	<i>18 cm</i>	<i>21 cm</i>
<i>100 cm</i>	<i>45 cm</i>	<i>18 cm</i>	<i>23 cm</i>
<i>100 cm</i>	<i>60 cm</i>	<i>18 cm</i>	<i>30 cm</i>

What pattern do you see with the size of the shadow?

- Students keep the object fixed, while moving the light source back and forth. The following distances should be measured: distance from light to screen, distance from object to screen, distance from light to object, height of object, height of shadow. Groups who choose this experiment should have a data table similar to the one below:

Distance from light to screen	Distance from object to screen	Distance from light to object	Size of Object	Size of Shadow
<i>80cm</i>	<i>30 cm</i>	<i>50 cm</i>	<i>18 cm</i>	<i>38 cm</i>
<i>90 cm</i>	<i>30 cm</i>	<i>60 cm</i>	<i>18 cm</i>	<i>32 cm</i>
<i>120 cm</i>	<i>30 cm</i>	<i>90 cm</i>	<i>18 cm</i>	<i>26 cm</i>

What pattern do you see with the size of the shadow?

Target Observations:

- The shadow gets smaller as the object is moved further from the light source
- When the screen is four times farther from the light than the object, the shadow is four times larger than the object
- The shadow gets smaller as the light is moved further from the light source
- When the screen is four times farther from the light than the object, the shadow is four times larger than the object

Target Model:

-A concentrated (not spread out) light source and something to block light is needed to make a shadow.

-Only materials that block light can produce shadows.

-The shape and way the object is oriented can affect the shape of a shadow.

-Some materials block different amounts of light:

-Transparent: allows light to pass through (relatively) undisturbed

-Translucent: allows some light to pass through, but the light is scattered

- Opaque: blocks light
- A shadow will always be on a line connecting the light source and the object, on the opposite side of the light source.
- The larger the distance between the light source and the object, the smaller the shadow.*
- The smaller the distance between the object and the screen, the larger the shadow.*

Extension:

When the students understand the qualitative pattern have each group decide on light-to-screen and object-to-screen distances and predict what the shadow size will be. Then let them test their prediction.

SHADOWS Worksheet

Name

Activity 1: Light and Shadow

What happened when the following materials were placed in front of the light?

Were you able to make shadows? Record your observations below.

Plastic wrap:

Wax paper:

Cardboard

Activity 2 Motion of Shadows

If the ruler is moved to the right which way will the shadow move? Explain why this will happen.

If the light is moved to the right which way will the shadow move? Explain why this will happen.

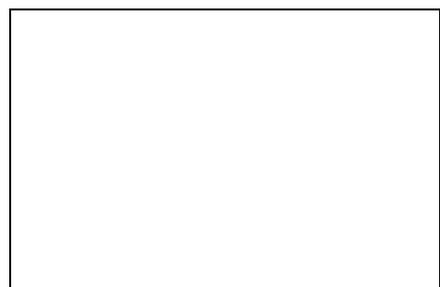
Activity 4 Shapes of Shadows

Draw your three different shapes below:

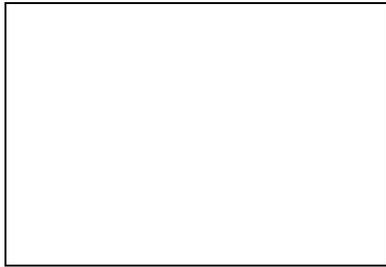
1.



2.



3.



Activity 5 Measuring Shadows

Data Collection:

Conclusions: How does the distance between the light and the object affect the shadow? The light and the screen?