Module 2: Shadows
5th Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek volunteers. The document has been composed with input from teachers, leads, volunteers, and SciTrek staff to provide suggestions to future teachers/leads/volunteers. The instructions are not intended to be used as a direct script but were written to provide teachers/leads/volunteers with a guideline to present the information that has worked in the past. Teachers/leads/volunteers should feel free to deviate from the instructions to help students reach the learning objectives of the module. Some places in which you can be creative and mold the program to meet your individual teaching style, or to meet the needs of students in the class are: during class discussions, managing the groups/class, generating alternative examples, and asking students leading questions. However, while running the module make sure to cover all the material each day within the scheduled 60 minutes. In addition, no changes should be made to the academic language surrounding conclusions or the conclusion activity.

Activity Schedule:
There are no scheduling restrictions for this activity.

Day 1: Conclusion Assessment/Technique/Observations/Variables (60 minutes)
Day 2: Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)
Day 3: Results/Table/Exercise/Graph/Conclusion Activity (60 minutes)
Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)
Day 5: Results Table/Exercise/Graph/Conclusion (60 minutes)
Day 6: Conclusion/Poster Making (60 minutes)
Day 7: Poster Presentations (60 minutes)
Day 8: Conclusion Assessment/Tie to Standards/Content Assessment (60 minutes)

The exact module dates and times are posted on the SciTrek website (http://www.chem.ucsb.edu/scitrek/elementary) under the school/teacher. The times on the website include transportation time to and from the SciTrek office (Chem 1105). Thirty minutes are allotted for transportation before and after the module, therefore, if a module was running from 10-11 then the module times on the website would be from 9:30-11:30.

Student Groups:

For the initial observation (Day 1) students work in three groups of ~ten students each. After Day 1 the groups of ~ten students are further subdivided into three subgroups, ~four students each, to perform their experiments. Students stay in these subgroups for the rest of the module. One volunteer is assigned to help each of the groups (three subgroups). We find these groups work best when they are mixed levels and mixed language abilities.

NGSS Performance Expectation Addressed:

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
Learning Objectives:

1. Students will know that shadow sizes are affected by the size of an object (height, width, and length) as well as the location of the light source (light distance, light height, and light angle).
2. Students will be able to draw an appropriate shadow given the location of a light source (including the sun) and an object.
3. Students will know that a conclusion is a claim supported by data.
4. Students will be able to distinguish between statements that are claim/data/opinion.
5. Students will be able to identify appropriate claims and data for a given data set.
6. Students will be able to list at least two ways that they behaved like scientists.

Classroom Teacher Responsibilities:

In order for SciTrek to be sustainable the program needs to work with teachers on developing their abilities to run student-centered inquiry-based science lessons on their own in their classroom. As teachers take over the role of SciTrek lead, SciTrek will expand to additional classrooms. Even when teachers lead the modules in their own classroom, SciTrek will continue to provide volunteers and all of the materials needed to run the module. Below is a sample timeline for teachers to take over the role as the SciTrek lead.

* Groups are made up of ~ten students and are subdivided into threer subgroups (~four students), to perform experiments.

1. Module 1 & 2 (year 1)
   a. Classroom Teacher Runs a Group

2. Module 3 (year 2)
   a. Classroom Teacher Runs a Group and Starts Leading Class Discussions
      i. Classroom teacher will start leading parts of group discussions (examples: conclusion activity, tie to standards, etc.).

3. Module 4 (year 2)
   a. Classroom Teacher Leads the Class with Co-Lead Volunteer
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, tie to standards, etc.).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. Classroom teacher will be responsible for all above activities, the SciTrek co-lead will only step in for emergencies.

4. Any Additional Modules (year 3 and beyond)
   a. Classroom Teacher Leads the Class
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, tie to standards, etc.).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.

SciTrek staff will be counting on teacher involvement. Teachers should notify the SciTrek staff if they will not be present on any day(s) of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact scitrekadmin@chem.ucsb.edu to learn more.

In addition, teachers are required to come to UCSB for the module orientation, ~one week prior to the start of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact scitrekadmin@chem.ucsb.edu to learn more. Contact scitrekadmin@chem.ucsb.edu for exact times and dates, or see our website at http://www.chem.ucsb.edu/scitrek/elementary under your class’ module times. At the orientation teachers will go over module content, learn their responsibilities during the module, and meet the
volunteers that will be helping in their classroom. If you are not able to come to the orientation at UCSB you must complete an online orientation. Failure to do an orientation for the module will result in loss of priority registration for next year.

**Prior to the Module (at least 1 week):**

1. Come to the SciTrek module orientation at UCSB.

**During the Module:**

If possible have a document camera available to the SciTrek lead every day of the module. If you do not have a document camera please tell the SciTrek staff at orientation.

Day 1:

Have three floor spaces available for the students to perform the initial observation. Each group will need a ~2 ft x 4 ft floor space for the experimental set-up as well as additional space for ~10 students to sit. This ensures that students can begin the module as soon as SciTrek arrives. The desk.tables do not need to be moved into groups.

Day 2-6:

Have the students’ desks/tables moved into nine groups and cleared off. This ensures that each student has a desk to sit at during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

Day 3 and 5:

Have nine floor spaces available for students to perform experiments. Each group will need a ~2 ft x 4 ft floor space for the experimental set-up as well as additional space for ~3 students to sit.

Day 7 and 8:

Have the students’ desks/tables cleared off. The desks/tables do not need to be moved into groups.

**Scheduling Alternatives:**

Some teachers have expressed interest in giving the students more time to work with the volunteers throughout the module. Below are options that will allow the students more time to work with the volunteers. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (~one week before your module, exact orientation times are found at: [http://www.chem.ucsb.edu/scitrek/elementary](http://www.chem.ucsb.edu/scitrek/elementary)). This will allow the SciTrek staff to provide you with all needed materials.

Day 1:

If you would like to have more time for your students to make observations and generate variables, you can do one or both of the following activities before SciTrek arrives:

1) Conclusion assessment
2) Technique discussion

Day 2:

If you would like to have more time for your students to design their experiments, you can do the example experiment that is outlined in the introduction before SciTrek arrives.
Day 3: If you would like to have more time for your students to perform their experiments, you can do one or both of the following activities:

1) Example graph outlined in the introduction before SciTrek arrives.
2) Conclusion activity after SciTrek leaves.

Day 4: If you would like to have more time for your students to redesign their experiments, you can finish the conclusion activity before SciTrek arrives.

Day 5: If you would like to have more time for your students to perform their experiments and write conclusions, you can do the example conclusion before SciTrek arrives.

Day 7: If you would like to have more time for your students to discuss their experiments during poster presentations, you may take more time for each presentation and finish the presentations after SciTrek leaves.

Day 8: If you would like more time for the tie to standards activity, you may give the conclusion assessment before SciTrek arrives.

**Materials Used for this Module:**

1. Maglite Mini AAA LED Flashlight (Walmart Part Number: 551779062)
2. Colored light filters (Sammy’s Camera part number: orange (Lee Filters 105 (S105), green (Lee Filters 139 (S139), blue (Lee Filters 075 (S075))
3. 152 cm/60” flexible measuring tape (ETA hand2mind Part number: IN524)
4. Ruler (Office Depot Part Number: 2125472)
5. Masking Tape
6. Wooden Blocks (height: 2 cm, 3 cm, 4 cm, 5 cm, 6 cm, 7 cm, 8 cm, 9 cm, 10 cm, for all blocks the widths are 7 cm and thicknesses are 3 cm) These blocks are cut to size from 2”×4”.
7. Support Stand with Rod (Spectrum Chemicals and Laboratory Products Part Number: 141-77765-E1)
8. White Oil Cloth (Amazon sold by Fabric.com) cut into 20”×30” pieces. (store flat)
9. Clamp (Fisher Scientific Part number: 599452)
10. Protractor with Arm (EAI Education: 502762)
11. Clipboard (OfficeMax Part Number: 21678980)

All printed materials used by SciTrek (student notebooks, materials page, lead picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekadmin@chem.ucsb.edu.
Day 1: Conclusion Assessment/Technique/Observations/Variables

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Conclusion Assessment (SciTrek Lead) – 10 minutes
- Module Introduction (SciTrek Lead) – 3 minutes
- Technique (SciTrek Lead) – 5 minutes
- Observation Discussion (SciTrek Lead) – 4 minutes
- Observations (SciTrek Volunteers) – 20 minutes
- Variable Discussion (SciTrek Lead) – 5 minutes
- Variables (SciTrek Volunteers) – 9 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- Student nametags
- (12) Student notebooks
- Picture of experimental set-up
- Volunteer instructions
- Volunteer lab coat
- (2) Pencils
- (2) Wet erase markers
- Measuring tape (152 cm)
- (3) Rulers
- Masking tape
- Flashlight with colored filter (filter must be group color)
- Flashlight without filter

Other Supplies:

- (3) Large group notepads
- (3) Ring stand poles
- (35) Clipboards

Lead Box:

- (5) Blank nametags
- (3) Extra student notebooks
- Picture of experimental set-up
- Lead instructions
- Shadows picture packet
- Lead lab coat
- (35) Conclusion assessments
- Time card
- (2) Pencils
- (2) Wet erase markers
- (3) Markers (orange, green, blue)
- (3) Measuring tapes (152 cm)
- (3) Rulers
- Masking tape

- Bag with (2) flashlights without filter, (3) colored filters (blue, orange, and green), and (4) AAA batteries
- (5) Protractors
- Clamp with string attached
- 5 cm Wooden block
- White plastic surface
SciTrek Notebook Pages and Notepad Pages:

TECHNIQUE
Protractors

Protractors and used to measure and draw angles.

How to measure an angle using a protractor:
1. Line up the origin with the center point of the block and place the baseline parallel to the bottom of the block.
2. Move the swinging arm to point to the center of the star.
3. The angle is the value on the outer scale.

Identify the angle of the star in relation to the box:

A. [Diagram of A]

B. [Diagram of B]

C. [Diagram of C] Angle: 90°

D. [Diagram of D] Angle: 45°

Observations

Experimental Set-Up:
- Block height = 5 cm
- Block width = 7 cm
- Block length = 3 cm
- Light angle = 60°
- Flashlight pointed at block

On the chart below, color the box that indicates the light distance and light height.

[Graph and chart]

Teacher: Ms. Gordon
Volunteer: Sierra
Color: Blue
Describe what happened during the experiment:

*Changing the color of the light does not change the shadow length and width, but the white light shadow is easier to see than the blue light shadow.*
Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the class question (front cover, student notebook), the technique activity (page 2, student notebook), and the block measurement pictures (page 1 and 2, picture packet). If the classroom does not have a document camera, then tape the example poster-size notebook page to the front board and write the class question on the board during the module introduction.

On the board, write the three group colors (orange, blue, and green) and the name(s) of the volunteer(s) that will be working with each group.

SciTrek Volunteer:

Put your name, the teacher’s name, and your group color on the top of your group notepad.

As students are taking the conclusion assessment, walk around the room and quietly place the students’ nametags, which are in your group box, on each student’s desk.

Once you have passed out the nametags, assemble the experimental set-up (seen in picture below as well as in the experimental set-up picture in your group box) on a spot on the floor where “ten students can sit. Use the following steps to help you with the set-up:

1. Attach the pole to the ring stand base by screwing them together.
2. Attach the clamp to the ring stand pole at a height of 35 cm.
3. Attach the flashlight with the colored filter to the clamp (each group will have a filter that is the same color as the group. For example, the blue group will have a blue filter). Make sure that the front of the clamp and the head of the flashlight are touching (see enlargement in picture below).
4. Make sure that the clamp and flashlight are pointing the correct way as indicated by the labels on the ring stand base and that the string is hanging down from the front of the clamp.
5. Place the white plastic on the floor so that one of the short sides of the plastic is closest to the ring stand.
6. Place the 5 cm block on the short side of the white plastic.
7. Place a protractor against the block with the swing arm pointed at 60°. Place the measuring tape under the protractor so that the zero mark of the measuring tape is touching the block. The protractor will be laying on top of the measuring tape and the swing arm will be tracing the measuring tape. Use the masking tape to tape down the measuring tape. Make sure to not cover up the 25 cm mark on the measuring tape.
8. Use the measuring tape to position the ring stand so that the string connected to the clamp is hanging over the 25 cm mark of the measuring tape.
9. Make sure that the flashlight is in line with the protractor.
10. Turn on the flashlight and adjust the clamp until the flashlight is pointed directly at the center of the block. When adjusting the flashlight, turn the head of the flashlight until the light forms the tightest possible circle on the center of the block. Then, turn off the light until the students have completed their observations of the experimental set-up.
11. Place the three rulers and the 12 crayons (which will all be the color of your group) on the white plastic.
12. Place the flashlight without a filter and ten clipboards next to the experimental set-up.
As soon as the assessment is complete be prepared to pass out student notebooks and protractors. The notebooks/protractors can be given to any student, not just the students in your group.

How to Measure Lengths and Widths of Shadows
When measuring the length of the shadow line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm you will need to use the measuring tape instead of the ruler. The lead box has extra measuring tapes if needed. Place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. Measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.
**Introduction:**  
*(2 minutes – Full Class – SciTrek Lead)*

“Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you an experiment and then you can make observations, come up with a class question, and design your own experiment to help answer the class question. We want to show you that you can do science and have fun.”

If you are a teacher that is leading the class tell your students that they are going to start a long-term science investigation and you have asked some scientists from UCSB to come and help. Allow the UCSB volunteers to introduce themselves and share their majors.

**Conclusion Assessment:**  
*(10 minutes – Full Class – SciTrek Lead)*

As the students are taking the assessment, the volunteers should get the student nametags out of their group boxes and walk around the room locating their students. Have the volunteers quietly lay each student’s nametag on their desk. If students do not have their name on their paper remind them to do so. After volunteers have handed out the nametags they should assemble the experimental set-up.

“Before we start with the module we will determine how your ideas on conclusions are developing.” Pass out the conclusion assessment and tell students to fill out their name, teacher’s name, and date at the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

For page 1, read the instructions to the students. Then read each of the statements and tell the students to circle if the statement is a claim, data, or opinion. As you are reading the statements walk around the room and verify that students have written their name on the top of the paper.

For page 2, have students circle the changing variable(s), underline the controls, and box information about data collection on the results table. Then have them decide if the group could make a conclusion.

Read step one of the instructions to the students (identify the following statements as either CLAIM or DATA and write a C or D on the line). Then have students fill in if they think statement “a” is a claim or data by writing a C or D on the line. Tell students this is similar to page 1 of the assessment. Read step two of the instructions to the students (look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested). Point to the results table and have students circle what they think is the correct answer for statement “a.” Once they have completed statement “a” move on to the next statement. Read each statement aloud and tell students to write the appropriate letter on the line then circle if the statement is a correct claim, correct data, or incorrect.

Repeat the process for page 3. Read the question at the bottom of page 3 to students and have them fill in the blank. When they are finished, collect the assessments and verify that the student’s name is on the top of the paper.
**Module Introduction:**
*(3 minutes – Full Class – SciTrek Lead)*

As soon as students complete the conclusion assessment volunteers should pass out a SciTrek notebook to each student.

Have students fill out their group color (color of their name on their nametag: orange, blue, or green), their name, teacher’s name, and volunteer’s name (volunteer’s names should be written on the board next to the group color they will be working with) on the front cover of their SciTrek notebook. Students should leave the subgroup number and class question blank. If a student does not have a nametag, only have them fill out their name and teacher’s name on the cover of their SciTrek notebook. They will be placed in a group when the class gets into groups for observations and they can fill out their group color and volunteer at that point.

Tell the class that for this module we are going to investigate shadows. Ask the class what shadows are and what causes them. By the end of the conversation make sure that students understand that shadows are formed when an object blocks light causing a dark area where the light would have been if the object was not there.

Ask the class if one object can make different sized/shaped shadows. By the end of the conversation make sure that students understand that the shadow size/shape can change depending on the light source.

Tell students for this module we will be exploring shadows to learn more about what changes shadows shapes/sizes. Therefore the question that we will be exploring as a class is “What variables affect shadows?” Write this question on the front page of the example notebook under the document camera and have students copy this question onto the cover of their notebooks.

**Technique:**
*(5 minutes – Full Class – SciTrek Lead)*

As soon as students write the class question on the front of their notebook volunteers should pass out a protractor to each student.

Tell the class that we will be working with light sources for this module and we will need to be able to describe the location of the light source. One tool that scientists use to do this is a protractor. Show the students a protractor. Have students turn to page 2 of their notebooks and place an example notebook under the document camera. Review the parts of the protractor while pointing to each part on an example protractor. Tell students that the outer clear scale shows the angle measurement from $0^\circ$-180$^\circ$ and the inner colored scale shows the angle measurement from 180$^\circ$-0$^\circ$. For this module we will only use the outer scale. The swing-arm is the part of the protractor that moves and is used to determine the angle of an object in relation to another object. The angle is read off the clear side of the swing arm regardless of the scale used. The origin of the protractor is where the swing arm is attached and should be placed at the center of one of the two objects. In our experiment we will place the origin on the center of a wood block. The baseline is where the start of the inner and outer scales meet and is what will be lined up with the base of the reference object (wooden block). To measure an angle, the protractor is put on one object and the swing arm is pointed at the other object. For this module the other object will be the light source. The angle between the light and the block can then be read from the outer scale on the clear side of the swing arm. A picture of these parts is shown below.
Tell the students we are now going to determine the angles of a star relative to a box. As a class, complete example “A” together and confirm that the angle of the star in relation to the block is 90°. Then have students complete the next three questions on their own. Once the majority of students are finished, go over the answers with the students. Tell students that it is okay if their answers differ by up to three degrees. See example notebook below. Volunteers should walk around and assist struggling students as they complete page 2. As soon as students have completed page 2, volunteers should collect the protractors.

Tell students that now that they know how to use a protractor to measure angles they will be able to use these skills to determine what angle the light is coming from to create a shadow. Tell students that they are going to make some observations of a shadow system. But before we do this we need to understand observations.
**Observation Discussion:**

(4 minutes – Full Class – SciTrek Lead)

Tell the students that scientists make lots of observations. Ask the class, “What is an observation? What are the types of things that you can record for an observation?” If they have trouble, show them an object and let them make some observations. Turn these observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, material, etc.

“In this experiment we are going to make observations of a shadow made from two different light colors.” Remind them to make both written and illustrated observations in their SciTrek notebooks. In addition, tell the students that they will need to measure the length and the width of the shadow. We will need to be able to compare our data with one another, therefore, we will all need to measure the length and width of the shadows the same. Put page 1 of the shadows picture packet under the document camera (shown below on the left). Explain to the students that when measuring the length of the shadow they will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If their shadow length is longer than 30 cm they will need to use the measuring tape instead of the ruler. Place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow, making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length for this example is 7 cm.

Explain when measuring the shadow width, place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. Measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H” with the rulers. The shadow width in this example is 8 cm.

![How to Measure Shadows](image)

Turn to page 2 of the shadows picture packet (shown above on the right) and walk the students through measuring the shadow length and width. For this example you should get the shadow length to be 7 cm and the shadow width to be 14 cm.

Tell the class they will now get in their groups and make observations. To determine their group they will need to look at the color of their nametag. Tell each colored group where to go and to bring a pencil and their notebook.

If a student does not have a nametag, identify the group with the least number of students in it and write the student’s name on one of the extra nametags that are in the lead box using that color of marker.
Observations:
(20 minutes – Groups – SciTrek Volunteers)

Once the students come over to your group, have them sit in boy/girl fashion on the floor around the set-up. Verify the floor is set-up as described in the set-up section. Pass out clipboards to each student and then have them turn to page 3 of their notebook.

As a group, have the students come up with ~six observations about the experimental set-up before you turn on the flashlight. This should take you no longer than 8 minutes. Observations should be recorded under experimental set-up on the group notepad and then copied into student notebooks. Make sure to record the following observations about the experimental set-up: block dimensions (height – 5 cm, width – 7 cm, length – 3 cm), and light angle (60°). Show students how to fill in the box representing the light distance (25 cm), and light height (35 cm) and the chart.

Have students turn to page 4 of their notebooks and turn to page 2 on the group notepad. Turn the flashlight on and ensure that it is pointed directly at the center of the block and the light is focused in as small of a circle as possible. The light color should be the same color as your group color (blue group will have a blue light source). Have students fill in the light color at the top of the chart. They should then fill in all of the observations for the colored light portion of the chart. For the shadow length measurement, have students measure from the front of the block to the longest end of the shadow. For the shadow width measurement, have students measure the widest part of the shadow. As students make observations, record them in the group notepad. Pass out a crayon to each student so that they can draw a picture of the shadow. While students draw their shadow picture for the colored light shadow, change the flashlight to the flashlight without the colored filter, which will produce white light and repeat the observation process.

In the example notebook the shadow colors for both the colored light and the white light were recorded as black. Some students may notice that the shadow from the colored light does have a slight color to it (orange light: blue shadow, blue light: black shadow, and green light: pink shadow). Do not bring this up if students do not notice this. However, students are welcome to record this if it is noticed. For example, students can record that for an orange light a black/blue shadow was observed.

If there is extra time have the students write a summary of what happened to the shadow when the color of the light changed. Have students focus on comparing and contrasting the two shadows. At the end of the observation section each group will be asked to share what colored light they used and what they learned about how light color affects shadows. Pick one student that will share this information with the rest of the class.

An example of the group notepad/student notebook is seen below; feel free to deviate from the example.
OBSERVATIONS

Experimental Set-Up:
- Block height = 5 cm
- Block width = 7 cm
- Block length = 3 cm
- Light angle = 60°
- Flashlight pointed at block

On the chart below, color the box that indicates the light distance and light height.

<table>
<thead>
<tr>
<th>Light Color:</th>
<th>Blue</th>
<th>White Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadow Color:</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Shadow Length:</td>
<td>6.5 cm</td>
<td>6.5 cm</td>
</tr>
<tr>
<td>Shadow Width:</td>
<td>10 cm</td>
<td>10 cm</td>
</tr>
</tbody>
</table>

Describe what happened during the experiment:
changing the color of the light does not change the shadow length and width but the white light shadow is easier to see than the blue light shadow.
Variable Discussion:
(5 minutes – Full Class – SciTrek Lead)

Have each group share what colors of light they used and what they learned about how changing the light color affects the shadow. By the end of the conversation students should have learned that changing the light color changes the color they see surrounding the object but it does not change the shadow color or size/shape of the shadow. Ask students which shadow was easier to see, the shadow generated from the colored light or the white light? They should reply the shadow generated from the white light. Ask them which light source they think we should use for other experiments and why? They should say the white light because these shadows are easier to measure and that the color of light does not affect the shape/size of the shadow.

Ask the students the following questions:
What does the word “variable” mean to a scientist?
(variables are parts of the experiment that you can change)
What was the changing variable in the experiment that we just did?
(light color)
Do you think that there are other variables that will affect the size of the shadow?
(multiple variables might affect the size of the shadow)

Explain that this is why we will need to work as a class to answer the class question: “What variables affect shadows?”

Tell the class that they are going to think about variables in the experiment that they could change to help us answer the class question. In addition to generating variables, they should think about how/why these variables might affect the outcome of the experiment. Ask the class to give you a variable that they think might affect the size of the shadow, then have them tell you how/why they think that variable would affect the experiment. Probe them on how they would design an experiment to test if this variable affected the shadow. Finally, have the students make a prediction of the results for the experiment they proposed.

Example: Variable: block height
Why might this variable affect the shadow? Shadows are caused by the object blocking light therefore different sized blocks might block different amounts of light.
How would you test this variable? Get blocks that are different heights and measure the shadow length.
Prediction: The taller the block, the longer the shadow.

Tell the students they will generate more variables and analyze them in their groups.

NOTE: If you are running behind and there is less than 5 minutes remaining, generate variables as an entire class instead of in groups.

Variables:
(9 minutes – Groups - SciTrek Volunteers)

As a group, generate a variable and make a prediction about how it will affect the shadow. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect the shadow. Repeat this process two more times and record these ideas on the group notepad and have students copy it into their notebooks. If students have different predictions, they can write their own prediction in their notebook. Next, students will individually generate additional variables and make
predictions about how different values of this variable will affect the shadow and record their ideas in their notebook. Have students share these ideas with the group.

Prepare one student to share a variable and why they think it will affect the shadow during the group discussion.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>How will changing this variable affect shadows?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Height</td>
<td>The taller the object, the longer the shadow. This will affect shadow length.</td>
</tr>
<tr>
<td>Light Distance</td>
<td>The farther out the light source, the longer the shadow.</td>
</tr>
<tr>
<td>Light Angle</td>
<td>The closer the angle is to 90°, the shorter the shadow.</td>
</tr>
<tr>
<td>Light Height</td>
<td>The lower up the light source, the longer the shadow.</td>
</tr>
<tr>
<td>Block Width</td>
<td>The block width will not affect the length of the shadow. Wider block will make wider shadow.</td>
</tr>
</tbody>
</table>

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Have one student from each group share a variable that they generated and how/why they think it will affect the shadow. Make sure that students tell you their predictions about how different values of that variable will affect the shadow. Challenge students to justify their thinking and explore with them how this might help them design an experiment to answer the class question. For example, if a student’s variable was light height and they predicted that the taller the light, the smaller the shadow length, ask the student why they predicted this. One possible answer could be: they have seen shadows decrease in size when as it approaches noon, which is when the sun is highest in the sky, so this should be the same for a flashlight. Probe the students deeper by asking them questions such as: if you designed an experiment to test this do you think it would be easier or harder to see if this variable affected the length of the shadow if you had light heights that were similar? Students should respond that it would be harder to see the effects of the variable if they have light heights that were similar. Therefore, they should choose values that are far apart for their experiment.

Tell the students that the next time we meet they will design an experiment to answer a question that they have about this experiment, which will help them learn about shadows.
Clean-Up:

Before you leave, have students attach their nametags to their notebooks and place them in the group box. Take the ring stand apart. Put all of the into your group box, except the clipboards and pole for the ring stand. Bring all materials back to UCSB. In addition, put your lab coat back into the box. If you would like to divide your group (~ten students) into three subgroups you can do this by writing a “1,” “2,” or “3” on the top of each student’s notebook to designate their subgroup. Make sure that the subgroups are made up of mixed gender and mixed ability students.

Day 2: Question/Materials Page/Experimental Set-Up/Procedure

Schedule:

Introduction (SciTrek Lead) – 13 minutes
Question (SciTrek Volunteers) – 10 minutes
Materials Page (SciTrek Volunteers) – 7 minutes
Experimental Set-Up (SciTrek Volunteers) – 8 minutes
Procedure (SciTrek Volunteers) – 19 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

(3) Volunteer Boxes:

☐ Student nametags  ☐ Volunteer lab coat  ☐ (2) Pencils
☐ Student notebooks  ☐ (3) Materials pages (group color & number indicated)  ☐ (2) Red pens
☐ Volunteer instructions  ☐ Notepad

Lead Box:

☐ (5) Blank nametags  ☐ (3) Materials pages  ☐ (3) Markers (orange, green, blue)
☐ (3) Extra student notebooks  ☐ Time card  ☐ Notepad
☐ Lead instructions  ☐ (2) Pencils  ☐ (2) Example blocks of different heights
☐ Shadows picture packet  ☐ (2) Red pens  ☐ Wet erase markers
☐ Lead lab coat
Experimental Considerations:

1. You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
2. All objects will be rectangular wooden blocks and you will only be able to change one dimension of the block.
3. You will only have access to the materials on the materials page.
4. See the materials page for restrictions on light placement.

**Changing Variable(s)** (Independent Variable(s))

You will get to perform two experiments. For your first experiment decide which variable(s) (max three) that you would like to test. For each changing variable that you select, discuss with your group why you think that variable will affect the shadow.

1. **Changing Variable 1: light distance**
   Discuss with your group how you think changing variable 1 will affect the shadow.

2. **Changing Variable 2 (optional): light angle**
   Discuss with your group how you think changing variable 2 will affect the shadow.

3. **Changing Variable 3 (optional): block width**
   Discuss with your group how you think changing variable 3 will affect the shadow.

**Question**

Question our group will investigate:

- If we change the **light distance**, **light angle**, and **block width**, what will happen to the **shadow length** and **shadow width**?

Insert what you are measuring/observing (dependent variable).

SciTrek Member Approval

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### EXPERIMENTAL SET-UP

Determine the values of your changing variable(s) (e.g., block height) from the materials page and write the values (e.g., trial A: 5 cm) for your four trials under each block.

<table>
<thead>
<tr>
<th>Changing Variable(s):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Light distance: 10 cm, 20 cm, 30 cm, 40 cm</td>
</tr>
<tr>
<td>2. Light angle: 90°, 20°, 30°, 135°</td>
</tr>
<tr>
<td>3. Block width: 1 cm, 2 cm, 3 cm, 4 cm</td>
</tr>
</tbody>
</table>

**Controls**: Variables you will hold constant.

Determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

- Light Color / White
- Block Height / 7 cm
- Light Angle / 90°

SciTrek Member Approval

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### PROCEDURE

Procedures Note:

Make sure to include all values of your changing variable(s) in the procedure. (Example: for a group that decided to change block height: one trial would be block height 7 cm wide, 1 cm long, and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on the white plastic.)

1. Set block that is 7 cm high, 3 cm long, and A) 2 cm, B) 5 cm, C) 7 cm, D) 10 cm wide
2. Place block on white plastic.
3. Set up light with height 25 cm, distance and angle A) 10 cm, 90°, B) 20 cm, 20°, C) 30 cm, 30°, D) 50 cm, 135°.
4. Turn on light pointed at center of block.
5. Measure shadow length and width.

SciTrek Member Approval
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the question (page 6, student notebook) and experimental set-up (page 7, student notebook). If the classroom does not have a document camera, then tape the example poster-size notebook pages to the front board.

SciTrek Volunteer:
Set out student notebooks to allow students within the same subgroup (same number on front of notebook) to work with each other.
- If students are not in the classroom before SciTrek starts set out the notebooks where you want students to sit when they come into the classroom.
- If students are in the classroom when SciTrek starts set out the notebooks where you want students to sit and students will move to these spots after the introduction

Make sure you have three materials pages each filled out with a group number (1, 2, or 3) and your group’s color. These will be given to students after they complete their question.

Have a red pen available to approve students’ question, experimental set-up, and procedure (pages 6, 7, and 8).

Introduction:
(13 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have the SciTrek volunteers set out the SciTrek notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk which is not their notebook and they should not move it.

Ask students what they did during the last meeting with SciTrek. They should reply that they did an experiment in which they changed the light color (white and colored light) and observed the shadow that a wood block cast. They learned that the color of the light does not affect the size/shape of the shadow. In addition, they generated other variables that might affect shadows. Ask the class if they remember the class question they will investigate. They should reply, “What variables affect shadows?”

Tell students that one way scientists answer questions is by performing experiments; today they will design an experiment to help answer the class question. Ask the class if they think there are multiple variables that could affect the shadow. They should respond that there probably are multiple variables. Therefore, each group is going to generate a smaller question to investigate. Once we put all the groups’ research together we should be able to answer the class question.

Groups will first generate a question based on the changing variable(s) that they plan to explore. They will then fill out their materials page, which will allow them to determine their experimental set-up. The experimental set-up will help them generate a procedure, or a list of steps that they will follow during their experiment. Tell students that they need to keep a few things in mind when they are going through this process.
Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
3. All objects will be rectangular wooden blocks and you will only be able to change one dimension of the block.

When you tell students experimental consideration 2, show students the two example blocks and tell them that two of their block dimensions must be 7 cm and 3 cm but they can rotate their block so that they will be able to choose to change either the height, width, or length of the block.

Tell students that we are now going to generate an example question/experimental set-up together and that you will write it in an example notebook so that they will be able to refer back to it when they are completing the process themselves. Make sure that students DO NOT fill out the example question/experimental set-up in their notebooks.

Tell students that for this example experiment, the changing variables will be light distance and block length, then write down the changing variables on the example notebook (page 6) under the document camera. Tell students when they are going through this process in their subgroups they can generate one, two, or three changing variable(s).

**Teacher Note:** It is important that you select the changing variables for the example experiment to have one variable about the block and one variable about the light height or light distance. The materials page for this module is complex and picking these two variables allows you to go over how to fill out the page for any changing variable.

Show students how to insert the changing variables and what they plan to measure/observe into the question frame to find the question that will be investigated. For the example discussed above the question would be: If we change the light distance and block length, what will happen to the shadow length and width? Explain to students that many times when there is a large question, like our class question, scientists break it down into smaller questions that individual scientists can investigate and then they compile their work to answer the large question.
Tell them once they have determined their question and have approval, their SciTrek volunteer will give them a materials page for determining the values of their changing variable(s) and controls. Ask students if they know how scientists define controls. Make sure that by the end of the conversation students understand that controls are variables that are held constant during an experiment. For example, if the light height was 45 cm for all of the trials, then one of their controls would be light height. These controls can be different than the original experiment that they conducted on day one, but must remain constant throughout all the trials that they do for this experiment.

Show students the materials page and have students tell you the changing variables for the example experiment and circle them, example: light distance. Then go through and underline all of the controls, example: light angle. Everything but the general materials should be either circled or underlined. Tell students that when a variable is a changing variable they will select four values and write the trial letter next to each value, example: 2cm A. When a variable is a control they will select one value. Read the general materials and ask students if they need each one and check the box when they say yes. For each variable, ask students how many values they will get to select. If a variable is a control then chose a value, such as the original value, example: 60° for light angle. For values that are changing variables allow students to select the values. When selecting the block, remind them that only one of the block dimensions can be a changing variable. Tell them that if one of the block dimensions is a changing variable this needs to go on the first line. If all of their block dimensions are controls, they can select any block dimension they would like to choose the dimension of and put it on the line. They can then select which other block dimension will be 7 cm and which will be 3 cm. Ask students “if we want a narrow or wide range of values for the changing variables and why.” Guide students though selecting a wide range of values for changing block dimension. If they choose a value contrary to their experimental design, question them on their reasoning. For example, if they said they wanted to use a wide range of block lengths and they picked 2 cm, 3 cm, 4 cm, and 5 cm ask them if these values would allow them to best answer their question. Then allow them to change their values if needed.
Once you have discussed how to select the block(s) dimensions, turn the materials page over and go over how to select the light location. Tell students that they will use the provided chart to select the light distance(s) and light height(s). If the space is greyed out, students may not use that particular placement. Tell them that since light height is a control we will need to fill out section 1. Tell students that for this experiment we will pick a light height of 25 cm (you can pick any light height). Write the light height on the line. Tell students they will now need to circle the row that corresponds to that value similar to the picture on the right. Circle the row corresponding to 25 cm on the materials page. Tell students that since light distance is a changing variable we will not need to fill out section 2. Read students the instructions directly above the graph and ask the following questions.

*If you have no circles you can select/mark any value that is not greyed out.*

Ask students if this is our case they should respond no. Tell students if it was they could fill in any four squares that are not greyed out.

*If you have one circle you can only select/mark values within that circle.*

Ask students if this is our case they should respond yes. Have students’ select four values within the circle that are spread out and mark them on the materials page.

*If you have two circles you can only select the values that is circled by both circles.*

Ask students when we had something like this. They should remember this is what they did on the first day when they were determining the light distance and height of the white and colored flashlights.

Once they have chosen the light distance(s) and light height(s) tell them they will select the light angle(s) they will use. They can pick any angle(s) between 20˚ and 160˚. They will circle the angle(s) they will be using in their experiment. If the angle is not on the picture they can write in the desired angle in the appropriate spot and then circle it.

Tell students that once they have completed their materials page they will fill out their experimental set-up. First, they will fill out the information on the changing variable(s). Ask students what the changing variables were for our example experiment and show them where to fill them in on the experimental set-
up. Only fill in the values for trial A and B. Second, they will fill in information about the controls. Ask students for one of the controls for the example experiment. Show students how to record the control on the left side of the slash (example: light color) and the value of that control on the right side of the slash (example: white). Have students tell you the controls and values until all of the blanks are filled. Four of the controls and values will come from the materials sheet the last control and value will not be on the materials sheet one possible example is surface/white plastic or direction of light/on block.

Tell students that once they have their experimental set-up complete they will have it approved by their SciTrek volunteer and then they will write a procedure that they will be able to follow next time. When writing a procedure they should write all the values of their changing variable(s) and controls as well as what data will be collected. Show students the example procedure step on page 8 of their notebook (place block that is 7 cm wide, 3 cm long and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on white plastic). Once their procedure is completed they will get it approved by a SciTrek volunteer.

If needed, tell students that they will now get into groups and design their experiments. Below is an example of what should be filled out for the experimental set-up and the results table during the introduction. Note that several sections are left blank.

![Experimental Set-Up](image)

**Question:**
*(10 minutes – Subgroups – SciTrek Volunteers)*

Have students decide what changing variable(s) they want to explore for their first experiment. If they only have one changing variable do not encourage them to have more and if they have two/three changing variables, do not encourage them to have fewer. Students will analyze their data and then perform an additional experiment to correct any mistakes that they made on their first experiment. Each group should briefly discuss why/how they think each changing variable will affect the shadow.
After groups have decided on their changing variable(s), have them fill out their question. When you sign off on their question give them a materials page with their group color and number designated in the upper right hand corner. An example notebook is seen below.

**Materials Page:**
*(7 minutes – Subgroups – SciTrek Volunteers)*

Have subgroups underline their controls and circle their changing variables on the materials page. Then have them use the materials page to determine the values for their changing variable(s) and controls. For changing variables values have students write the trial letter next to the values they select. Ask students to justify the values that they have chosen for their changing variable(s) and controls and if these values will make it easier or harder to answer their question.

Make sure that they have picked light distances and light heights that are within the limitations given on the page. In addition, ensure that students have no more than one block dimension changing.

**Experimental Set-Up:**
*(8 minutes – Subgroups – SciTrek Volunteers)*

Have subgroups use their materials page to fill in their experimental set-up on page 7 of the student notebook. When you sign off on their experimental set-up, collect the materials page and verify that it is filled out correctly and completely. Having the materials page filled out is essential for students to start their experiments during the next SciTrek visit. An example of an experimental set-up and materials page are seen below.
MATERIALS PAGE

You will only have access to the following materials:
1) Go through the list and circle your changing variable(s) and underline your controls. Do not add any new variables.
2) For variables that are controls, select 3 values. For variables that are changing variables, select 4 values and write the trial number (A, B, C, D) next to each value. For: 2 cm A

- Flashlight
- Tracing Paper
- Ruler

Look at the pictures below that define the block dimensions. Two of your block’s dimensions (which are controls) must be 7 cm and 3 cm. The third dimension can be either changing variable(s) and you may select the value(s). You may only circle ONE of these:

- Block length
- Block width
- Block height

The block’s width will be:
- 2 cm A
- 3 cm B
- 4 cm C
- 7 cm D

The block’s height will be 7 cm.

The block’s length will be 3 cm.

LIGHT DISTANCE and LIGHT HEIGHTS

Only fill out step 1 if light height is a control and step 2 if light distance is a control.

1) If light height is one of your controls:
   a. The value of light height that we will use is:
   b. Circle the row that corresponds to your control value (see example right top)

2) If light distance is one of your controls:
   a. The value of light distance that we will use is:
   b. Circle the column that corresponds to your control value (see example right bottom)

If you have no circles you can enter/record any value that is not grayed out.
If you have one circle you can only select/record values within that circle.
If you have two circles you can only select the value that is circled by both circles.

LIGHT ANGLE

Circle the angle(s) you will be using between 0° - 180°. If the light angle that you want to use does not appear in the picture below (example: 30°) write in the angle in the appropriate location and circle it.

EXPERIMENTAL SET-UP

Determine the values of your changing variable(s) (ex: block height) from the materials page and write the values (ex: trial A: 5 cm) for your four trials under each block.

Changing Variable(s):

1) Light distance
   10 cm 20 cm 40 cm 60 cm
2) Light angle
   0° 40° 90° 180°
3) Block width
   2 cm 4 cm 7 cm 10 cm

Controls (variables you must hold constant):

Determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

- Light Color: White
- Block height: 7 cm
- Light height: 25 cm

Sci-Trek Member Approval
Procedure:  
(19 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up they can start on their procedure (page 8). Keep procedures as brief as possible while still conveying the pertinent information about the experiment. Make sure that you have students include all changing variable(s) values in the procedure. For example, if block height is a changing variable one of the procedure steps would be: “Place block that is 7 cm wide, 3 cm long and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm tall on the white plastic.” In addition, make sure all control values and what they will be measuring or observing are included in the procedure. Some groups may struggle with writing a procedure. You can have these groups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once the students have finished, they should raise their hand and get it approved by their SciTrek volunteer. An example procedure can be seen below on the left.

If there is time, have your subgroups fill out the variables and prediction section of the results table (see day 3 for example page). First have students underline the variables that are controls, circle the variables that are changing variables, and box the data collection. When writing in the values make sure that for controls, they only write the value of the control in trial A and then draw a line through the remaining trials and for changing variable(s) they write the values in each of the boxes. They can also make their predictions.

Wrap-Up:  
(3 minutes – Full Class – SciTrek Lead)

If there is time have one student from each group share what question they will investigate. Tell students that on the next SciTrek visit they will start their experiments. Tell students that all of their experiments will help us answer the class question: What variables affect shadows?
Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Place the materials pages on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat back in your group box.

Day 3: Results Table/Experiment/Graph/Conclusion Activity

Schedule:

Introduction (SciTrek Lead) – 8 minutes
Results Table (SciTrek Volunteers) – 3 minutes
Experiment (SciTrek Volunteers) – 22 minutes
Graph (SciTrek Volunteers) – 10 minutes
Conclusion Activity (SciTrek Lead) – 15 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

☐ Student nametags ☐ Volunteer lab coat ☐ Notepad
☐ Student notebooks ☐ (2) Pencil ☐ (3) White plastic surfaces
☐ Volunteer instructions ☐ (2) Red pens
(3) Ziploc Bags labeled group 1, 2, and 3 each with the following:
☐ Measuring tape (152 cm) ☐ Requested wooden blocks ☐ Filled out materials page
☐ Protractor ☐ (3) Rulers

Other Supplies:

☐ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
☐ Tube with 9 ring stand poles ☐ (35) Clipboards

Lead Box:

☐ (3) Extra student notebooks ☐ (2) Red pens
☐ Lead instructions ☐ (2) Wet erase markers
☐ Shadows picture packet ☐ Notepad
☐ Lead lab coat ☐ (3) Measuring tapes (152 cm)
☐ Time card ☐ (6) Rulers
☐ (2) Pencils ☐ (2) Masking tapes
☐ Example block (any size)
☐ Bag 1: lead shadows supplies
☐ (2) measuring tapes (152 cm), (2) flashlights without filter, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) wooden blocks – one of each size)
☐ White plastic surface
**RESULTS**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Height</td>
<td>7 cm</td>
<td>9 cm</td>
<td>7 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>3 cm</td>
<td>4 cm</td>
<td>7 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>10 cm</td>
<td>26 cm</td>
<td>45 cm</td>
<td>60 cm</td>
</tr>
<tr>
<td>Light Angle</td>
<td>136°</td>
<td>20°</td>
<td>30°</td>
<td>30°</td>
</tr>
</tbody>
</table>

**Predictions**

For an "X" in the trial that will give the longest shadow and an "X" in the trial that will give the shortest shadow.

**Data**

<table>
<thead>
<tr>
<th>Final Observations/Measurements</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 cm</td>
<td>4 cm</td>
<td>12 cm</td>
<td>16 cm</td>
</tr>
</tbody>
</table>

**SCIENTIFIC PRACTICES**

**Conclusions**

1. **Directions**: Fill in the missing definitions.
   - **Conclusion**: A **claim supported by data**
     - **Claim**: A statement that can be tested. The explanation of the data, the first part of a conclusion.
     - **Data**: Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.

2. **Directions**: Circle if the statement is a **Claim**, **Data**, or an **Opinion**.
   - a. out of 10 people only 3 like ride a unicycle
   - b. puppies are cute
   - c. people who get 8 hours of sleep experience dizziness
   - d. ants were observed in groups, starfish, and toasted flakes
   - e. the fastest land animal in the world is the cheetah
   - f. when 2 ml of vinegar was mixed with 2 g of baking soda, 3 ml of gas was produced
   - g. the more among the flower the more bees on the flower

Circles are your initial thought and boxes are the correct answer.
Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the filled out results table (page 3, picture packet), graph (page 10, student notebook), conclusion activity (page 11, student notebook), and block measurement picture (1, picture packet). If the classroom does not have a document camera, then tape the example poster size notebook pages to the front board.

SciTrek Volunteer:
Set out student notebooks.

• If students are not in the classroom before SciTrek starts set out the notebooks where you want students to sit when they come into the classroom.
• If students are in the classroom when SciTrek starts set out the notebooks where you want students to sit and students will move to these spots after the introduction.

Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Do not put the clamp at the appropriate height; adjust the clamp to the lowest place on the ring stand allowing students to put the clamp at the appropriate height(s) when they do their experiment.

Place group bags, white plastic, and ring stands in three unique spots on the floor along with four clipboards.

How to Measure Lengths and Widths of Shadows

When measuring the length of the shadow line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm you will need to use the measuring tape instead of the ruler. Place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. Measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.
Introduction:
(8 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have the SciTrek volunteers set out the SciTrek notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk which is not their notebook and they should not move it.

Ask the class, “What is the class question that we are investigating?” The students should reply, “What variables affect shadows?” Tell them that today they will start their experiment to answer this question. However, before they can start their experiment they need to have their results table completed (some students might have completed this the previous SciTrek visit). Once this is finished they can raise their hands and they will be dismissed to go to the spot on the floor that has their experimental supplies.

Tell the students that once they have collected their data they will display their measurements on a graph (page 10). Shows students how to make a graph using the class data but make sure they DO NOT copy this data into their notebooks; they will graph their own data. Take out the example results table, page 3 of the picture packet, and put it under the document camera. Tell the students that your question was, “If we change the block height and light distance, what will happen to the length of the shadow?” Tell students that in order to make a graph, you will need to follow the checklist shown on page 10 of the notebook.

☐ Write what you measured (example: shadow length (cm)) on the y-axis (vertical). Tell students that because your question is about both shadow length and width you can choose which dimension to graph, therefore, you will graph shadow length. Write shadow length (cm) on the y-axis of the graph.

☐ Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines. Tell students that we need to make sure that the longest shadow can be plotted on the graph. Ask the students what the longest shadow measured was (30 cm) and if we would be able to fit this shadow length on the graph if we counted by ones. The students should respond no. Then ask them what we should count by in order to make sure that the longest shadow’s length will fit on
the graph (by fives). When students make their own graphs, they should only count by ones, twos, or fives. Put the numbers on the graph, making sure that they know to start counting at zero. Make sure that you completely fill out the y-axis numbers to the top of the graph and do not stop numbering after you have passed the largest number that you will graph.

☐ Write your changing variable(s) #1, #2, and #3 on the x-axis title (horizontal) (example: block height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables. Ask students what the changing variables were in this experiment. Students should respond block height and light distance. Record block height as changing variable #1 and light distance as changing variable #2.

☐ On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement and 4 being the trial with the largest measurement. Tell students that graphs are used to see how changing variables affect the measurements. One way to make it easier to find patterns is to graph the data in increasing order. Put the example results table (page 3, picture packet) under the document camera and have students help determine the order that the trials will be graphed (A, C, D, then B) and write the appropriate number by each trial.

☐ Plot your data in increasing order. Tell students that now that they have determined the order they will graph their data that they need to plot their data in increasing order. To do this, there are a few steps that they need to take.

☐ Write each of the changing variable values (example: 3 cm) for the trial that you labeled 1 under the first column. Ask students which trial was labeled 1. (Trial A) Then ask them what you should write next to block height and light distance for the first trial. Write 5 cm for block height and 10 cm for light distance on the example notebook.

☐ Graph your data for that trial and write the measurement above the bar. Ask students what shadow length will be graphed for trial A (3 cm). Put your finger at zero and tell the students to tell you to stop once you reach the appropriate level. Once you have reached the level, draw the line, write the number value over the line, and quickly shade below the line. Tell students to look at how fast you filled in the chart and challenge them to fill in their graph faster than you when they graph their own data.

☐ Repeat the process for the other trials. Ask students what the values for the changing variables are for the trial that we will graph next. Write 3 cm for block height and 45 cm for light distance on the example notebook. Ask them what the shadow length is for this trial (7 cm). Have students help you identify where 7 cm is and then draw a line and write the number over the line. Tell students that you will only graph the first two data points, but in their groups they will graph all four points.
Remind students how we define the block dimensions. Show students the example block. Place the block on the edge of the picture pack and tell them that the picture pack will represent the white plastic and the light source would be in front of the block. Ask the students what we call the block dimension going up. They should respond height. Ask the students what we call the block dimension going across the front of the white plastic. They should respond width. Ask the students what we call the block dimension going away from the light. They should respond length. Show student that if they forget the dimensions they can look at the picture at the top of their results table.

Put page 1 of the picture pack under the document camera and review how to measure the length and width of the shadow. Explain to the students that when measuring the length of the shadow they will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). They will then place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow, making an “L” with the two rulers. Explain when measuring the shadow width they will place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. They will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.”
Results Table:
(3 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variables that are changing variables, and box the data collection. When writing in the values make sure that for controls, they only write the value of the control in trial A and then draw a line through the remaining trials and for changing variable(s) they write the values in each of the boxes.

When students have finished, have them make predictions about the shadow lengths. Have them write an “L” in the box of the shadow they think will be the longest and an “S” in the box of the shadow they think will be the shortest. They will leave two boxes empty. If they think all trials will be the same length have them write “same” over all of the boxes. Try to question each group on their thought process behind their predicted lengths. See example notebook above.

Experiment:
(22 minutes – Subgroups – SciTrek Volunteers)

Once groups have finished their results table tell them where their supplies are on the floor. If students are missing any of their experimental materials the lead box has extra materials. Remind students to make sure that the flashlight is in line with the protractor. In addition, verify that the string is hanging down from the front of the clamp. Have students show you their set-up for their first trial before taking any measurements. When checking the students’ set-up verify they have their block in the correct orientation. If the students chose to change the light angle and the shadow is too wide for the white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved.

When making measurements, make sure that the shadow is being measured as described in the set-up section above. It is important to make sure that the students draw pictures of their shadows as well as take measurements to compare to other shadows later. Recording of measurements and pictures should be done as each trial is completed. Once this is complete students can move onto the next trial. If your groups have things under control please help other groups. As soon as they finish with their experiment they can graph their results. Do not take down the experimental set-up until after students have finished their graph. This way they can check their measurements if needed. An example of a properly filled out result table is seen below.
Graph:
(10 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them go through and complete the checklist on page 10. Be sure that students label the y-axis with either shadow length (cm) or shadow width (cm) (students can pick which to graph) and the x-axis with all of their changing variable(s). Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. To make it easier to see patterns, students should arrange the trials in increasing measurements as done in the example above. In this example the trials were graphed in the following order: A, C, B, D. Once they have graphed their values, make sure that they write the shadow length/width on top of each column so that it is easy to discern the value.

If students finish early they can start working on the conclusion activity on page 11 of their notebooks by themselves.

**Note:** If students do not complete their graph by the time the lead starts the conclusion activity it is okay. DO NOT have students go back and finish their graph. These groups will move on to their second experiment after the conclusion activity and will present their second experiment to the class therefore, will not use the first graph.

Conclusion Activity:
(15 minutes – Full Class – SciTrek Lead)

**Note:** Even if all students are not finished with their graphs it is important to start the conclusion activity at least 10 minutes before the end of the session. Students that do not finish their graph can present their second experiment and therefore, will not need their first graph.
If students are still sitting on the floor have students return to their original class seats. Tell the students to turn to page 11 in their notebooks. Put a blank notebook under the document camera and turn to page 11. Mention that before they analyze their graph and draw a conclusion, it is important that they recognize and understand other’s conclusions.

Ask the class, “What is a conclusion?” After listening to the student’s answers make sure that the students understand that a conclusion is a claim supported by data. Write this definition on page 11 of the example notebook for the students to copy.

Tell the students that in order to make a conclusion we need to make sure that we understand the difference between a claim and data. First, read the claim definition and the example. Tell the students that a claim is a statement that we can verify by testing. Have the class generate approximately four examples of statements that are claims. After a student suggests a possible claim ask the class if the possible claim can be verified by testing. Have students hold their thumb up if it is a claim and down if it is not. Then ask someone else in the class to propose how you would test this claim. Several examples are seen below.

Examples:  
Claim: rabbits are faster than mice  
Test: time rabbits and mice running a certain distance

Claim: giraffes are taller than horses  
Test: measure the heights of horses and a giraffes

Claim: watermelons weigh more than pumpkins  
Test: weigh pumpkins and watermelons

Next, read the definition of data and the example. Note that the example data supports the example claim, therefore, by combining the two statements, a conclusion can be formed. This conclusion would be: Donuts have more fat than toast because 1 serving of donuts has 11 g of fat while 1 serving of toast has 5 grams of fat. Tell students that data often contains a numerical measurement such as a height (5 m) or a weight (20 kg). Box the measurements in the data. Ask the students if data has to contain a numerical measurement. Explain that data can also be in the form of observations. For example, plants are observed to have greener leaves when in direct light rather than indirect light. When you want to identify if a statement is data look for measurements or words such as recorded or observed that allow you to know that an experiment was performed. Tell students that when they see data in a statement they should box it. Have student’s box 11 g and 5 g. Tell them that if it is observational data they will box the word observed.

Ask the students if all statements have to be either a claim or data. Lead students into realizing that some statements are neither a claim nor data; a common example of a statement that is not a claim or data is an opinion statement. Have students generate approximately four examples of opinion statements.

Example:  
Watermelons taste better than pumpkins.  
Rabbits are cuter than cats.

Read the directions to part 2 aloud to the class. Tell the students to look for clues in the statements to identify if it is a claim, data, or opinion. Read the first statement to students then give them ~15 seconds to circle the answer. After, have a student share what they think is the correct answer and why. Have students vote using thumbs up/thumbs down if they agree/disagree with the student’s reasoning. After the class has come to agreement, tell students that they will now box the correct answer. Tell students not to erase the original answer because then they will be able to see which concepts/categories they are
struggling with. Mark the correct answer on the example notebook for students to copy. If the statement is a claim, have the students state what data they would need to collect in order to make a conclusion. If the statement is data, have the students generate a claim that could be supported by that data.

For each statement box any information that is data, underline information that is a control, and double underline information that is an opinion.

Below are the explanations and answers to part 2 letters a-g on page 11.

**Letter a:** out of 10 people only 3 can ride a unicycle

*Data (Data Collected: counted number of people)*

What type of statement is this and how do you know?

Data because it contains a measurement

What claim could be paired with this statement to make a conclusion?

more people do not know how to ride a unicycle than do

**Letter b:** puppies are cute

*Opinion*

What type of statement is this and how do you know?

Opinion because it contains the word cute

**Letter c:** people who get 4 hours of sleep experience dizziness

*Claim*

What type of statement is this and how do you know?

Claim because this is something that you can test

What data would you need to obtain to support the claim?

count the number of people that feel dizzy after only 4 hours of sleep
Are the numbers that are in this statement a measurement from the experiment?
No the numbers are describing the experiment, called descriptive numbers. Tell students
that descriptive number are controls because they are values that are the same for all
trials (write descriptive numbers above).

**Letter d:** ants were observed on syrup, starbursts, and frosted flakes

*Data (Data Collected: observed ants)*
- What type of statement is this and how do you know?
  - data because it contains an observation
- What claim could be paired with this statement to make a conclusion?
  - ants are attracted to sugar

**Letter e:** the fastest land animal in the world is the cheetah

*Claim*
- What type of statement is this and how do you know?
  - claim because it can be tested
- What data would you need to obtain to support the claim?
  - find the time it takes different animals to run a set distance

**Letter f:** when 2 mL of vinegar was mixed with 2 g of baking soda, 1 liter of gas was produced

*Data (Data Collected: measured amount of gas produced)*
- What type of statement is this and how do you know?
  - data because it contains a measurement
- What claim could be paired with this statement to make a conclusion?
  - mixing vinegar and baking soda results in a chemical reaction

**Letter g:** the more simple the flower the more bees on the flower

*Opinion*
- What type of statement is this and how do you know?
  - opinion because it contains the word simple

If there is extra time you can continue on to the next page of the conclusion activity. For details on how to
do this see day 4.

**Wrap-Up:**
*(2 minutes – Full Class – SciTrek Lead)*

Tell students that on the next SciTrek visit they will analyze other scientists’ data to identify appropriate
claims and data statements. They will then analyze their data to draw a conclusion. After, they will get to
design a second experiment.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box.
Bring all materials back to UCSB. In addition, put your lab coat back into your group box.
Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure

Schedule:
Introduction (SciTrek Lead) – 2 minutes
Conclusion Activity (SciTrek Lead) – 30 minutes
Conclusion (SciTrek Volunteers) – 5 minutes
Question (SciTrek Volunteers) – 5 minutes
Materials Page (SciTrek Volunteers) – 5 minutes
Experimental Set-Up (SciTrek Volunteers) – 5 minutes
Procedure (SciTrek Volunteers) – 6 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:
(3) Volunteer Boxes:
☐ Student nametags
☐ Student notebooks
☐ Volunteer instructions
☐ Volunteer lab coat
☐ (3) Materials pages (group color/number indicated)
☐ (2) Pencils
☐ (2) Red pens
☐ Notepad

Lead Box:
☐ (3) Extra student notebooks
☐ Lead instructions
☐ Shadows picture packet
☐ Lead lab coat
☐ (3) Materials pages
☐ Time card
☐ (2) Pencils
☐ (2) Red pens
☐ (2) Wet erase markers
☐ Notepad

SciTrek Notebook Pages:

[Image of SciTrek notebook pages with scientific practices and conclusions]
**Making a Conclusion from Your Data**

How many changing variables did you have in your experiment? __2__

Can you make a conclusion from your data? YES [ ] NO [x]

IF NO

Why? I cannot make a conclusion because my experiment had more than 1 changing variable.

IF YES (Make sure to look back at your questions [page 6] before you generate your conclusion.)

CONCLUSION

We can conclude ____________

because ____________

SciTrek Member Approval __[ ]__
**Set-Up:**

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the conclusion activity (pages 12-15, student notebook). If the classroom does not have a document camera, then tape example poster-size notebook pages to the front board.

SciTrek Volunteers:

Set out student notebooks.

- If students are not in the classroom before SciTrek starts, set out the notebooks where you want students to sit when they come into the classroom.
- If students are in the classroom, pass out student notebooks to them. They will move to their subgroup seats after the conclusion activity.

**Introduction:**

*(2 minutes – Full Class – SciTrek Lead)*

If needed, have the SciTrek volunteers hand out the SciTrek notebooks/nametags to the students in their seats. They will move into their subgroups after the conclusion activity.

Inform students that today they are going to match claim with appropriate data and then analyze other’s data to determine which claims and data are appropriate for a given set of results. Afterwards, they will analyze their own data to see if they can make a claim/conclusion. They will then have the opportunity to design a second experiment or redesign their first experiment, which will be carried out during the next SciTrek visit.
Conclusion Activity:
(30 minutes – Full Class – SciTrek Lead)

Tell the students to turn to page 12 in their notebooks. Place a blank notebook under the document camera and open to page 12.

Ask students what types of statements are needed to make a conclusion. Students should tell you that a conclusion is made from a claim and a supporting data statement. Ask students for the definition of a claim. Students should remind you that a claim is the explanation of your data, a statement that can be verified by testing. Ask students what type of information can be used for data. Students should remind you that data can be either measurements or observations.

Tell the students that now they are going to practice matching claims with supporting data. Have the students read the statements carefully because not all of the claims will make a match. Instruct them to only draw lines between the claims that match up with supporting data. Tell the students to work by themselves for the first couple of minutes (~2 minutes) and that afterwards we will go over the answers as a class.

Ask the class if anyone has identified a match and have them give you the number and the letter of the possible match. Read each suggested claim/data match and then ask the rest of the class if they agree/disagree using thumbs up/thumbs down. If they disagree, ask a student to explain. Continue asking students if they are able to make any other connections until all possible matches are made.

<table>
<thead>
<tr>
<th>Claim</th>
<th>Because</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. More people go to soccer matches than basketball games</td>
<td></td>
<td>a. 1 ml of diet coke weighs 5 grams and 1 ml of coke weighs 1.1 grams.</td>
</tr>
<tr>
<td>2. Spicy food causes heartburn</td>
<td></td>
<td>b. 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don’t use hot sauce</td>
</tr>
<tr>
<td>3. Cars increase air pollution</td>
<td></td>
<td>c. The air has been observed to be brown in areas with large numbers of cars.</td>
</tr>
<tr>
<td>4. Diet coke weighs less than regular coke</td>
<td></td>
<td>d. 10 people went to the movies while 15 went shopping.</td>
</tr>
</tbody>
</table>

42
Below are correct matches that can be made from this activity.

1. Spicy food causes heartburn because 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don’t use hot sauce.

   This is a correct match because the data clearly supports the claim using numerical values as data to make a conclusion.

2. Cars increase air pollution because the air has been observed to be brown in areas with large numbers of cars.

   This is a correct match because the data clearly supports the claim using an observation to make a conclusion.

Below are incorrect matches that can be made from this activity.

3. Diet coke weighs less than regular coke because 1 mL of diet coke weighs 5 grams and 1 mL of coke weighs 1.1 grams.

   This is an incorrect match because the data does not support the claim. The claim says that diet coke weighs less than regular coke, however, the data supports the opposite claim that diet coke weighs more. Ask students, in order to make a conclusion do you think scientists can change the claim or the data? Students should realize that scientists can change their claims but they cannot change their data. In addition, scientists must include all data when generating a claim.

4. More people go to soccer matches than basketball games because 10 people went to the movies while 15 went shopping.

   This is an incorrect match because the data has nothing to do with and does not support the claim. Therefore, this is an incorrect conclusion.

Once this page is complete have the students turn to page 13 in their notebooks.

Have students annotate the results table. As a group identify and then circle the changing variable(s) (light angle), underline the controls (light color, block height, block width, light distance, and light height) and box the information about the data collected (shadow length and shadow picture).

Tell the students that we are now going to look over a list of statements about this results table and decide if each statement is an example of a claim or data. If the statement is data we will box the data in the statement and if the statement is a claim we will identify and circle the changing variable. We will then use the results table to tell if the statement is a correct claim, correct data, or incorrect.

First, read the statement and have students classify the statement as claim or data and write the corresponding letter, C or D, on the line. Second, have student help you annotate the statement by circling changing variable (every claim statement will have a changing variable), underling controls, and boxing any data. Third, have students check the results table to see if the statement is a correct claim, correct data, or incorrect and circle the appropriate answer. Repeat this process for each statement.

If students are struggling to identify the changing variable, ask them what experiment would need to be carried out to test this claim. From their answer, have them identify what they changed.
Letter a: the light height affects the length of the shadow

Claim/Incorrect (Variable Held Constant)

What type of statement is this and how do you know?
Claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light height (circle light height)

Is light height a changing variable in the experiment?
No

What should we circle?
Incorrect

Letter b: a larger light angle will result in a longer shadow

Claim/Correct Claim

What type of statement is this and how do you know?
Claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light angle (circle light angle)

Is light angle a changing variable in the experiment?
Yes

Is the claim consistent with the data?
Yes

What should we circle?
Correct claim

Letter c: when a block is 9 cm tall, different light angles give different shadow lengths

Claim/Correct Claim

What type of statement is this and how do you know?
Claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light angle (circle light angle)

Is the 9 cm data?
No it is a descriptive number (one of the controls) (underline 9 cm)

Is light angle a changing variable in this experiment?
Yes

Is the claim consistent with the data?
Yes

What should we circle?
Correct claim

Letter d: when the light angle was 60˚ the shadow length was 6 cm

Data/Incorrect

What type of statement is this and how do you know?
Data because it contains a measurement (write D on the line and box 6 cm)

What is the 60˚?
This is a value of the changing variable (circle 60˚)

Is the data correct based on the results table?
No

What should we circle?
Incorrect
Tell the students we are now going to determine the data to support claim b. Read claim b aloud (a larger light angle will result in a longer shadow) and ask the students what data can be used to support this claim. They should respond that when the light angle was 30° the shadow length was 6 cm and when the light angle was 60° the shadow length was 10 cm. Record this statement in the example notebook. Ask the students how people would know that the statement generated was data. They should reply that it contains measurements, box the measurements in the statement. Then read the complete conclusion: a larger light angle will result in a longer shadow because when the light angle was 30° the shadow length was 6 cm and when the light angle was 60° the shadow length was 10 cm.

Ask the students if there can be multiple claims that can be made about a given set of results. The students should see that two different claims could be made from the data collected. Ask the students which claim they think gives the most information, or tries to explain why the shadow is changing lengths. Students should realize that the claim (claim b), a larger light angle will result in a longer shadow, gives the most information because it states why the shadow might be getting longer. Tell them this type of claim also allows scientists to make predictions about systems that have not been experimented with yet. Encourage students to think about why their shadows are changing lengths when they make a claim from their own data.

Have students annotate the results table. As a group identify and then circle the changing variable(s) (block height and light distance), underline the controls (light color, block width, light height, and block angle), and box the information about the data collected (shadow length and shadow picture).

Tell the students that we are now going to go through the same process that we went through for the statements about the last results table.

Have students turn to page 14 in their notebooks. Turn the example notebook to page 14.
Letter a: the brighter the light the longer the shadow
Claim/Incorrect (No Data Gathered)

What type of statement is this and how do you know?
claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
light brightness (circle brighter the light)

Is light brightness a changing variable in the experiment?
no

What should we circle?
correct

Letter b: when the block height was 6 cm the shadow length was 6 cm and when the block height was 10 cm the shadow length was 13 cm
Data/Correct Data

What type of statement is this and how do you know?
data because it contains measurements (write D on the line and box 6 cm and 13 cm)

What are 6 cm and 10 cm?
6 cm and 10 cm are both changing variables (circle 6 cm and 10 cm)

Is the data correct based on the data table?
yes

What should we circle?
correct data

Letter c: when the block height is smaller the shadow length is longer
Claim/Incorrect (Inconsistent with Data)

What type of statement is this and how do you know?
claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
block height (circle block height)

Is block height a changing variable in the experiment?
yes

Is the claim consistent with the data?
no

What should we circle?
correct

Letter d: the longer the light distance the longer the shadow length
Claim/Incorrect (More than One Changing Variable)

What type of statement is this and how do you know?
claim because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
light distance (circle light distance)

Is light distance a changing variable in the experiment?
yes

Is the claim consistent with the data?
yes

Is this claim fair or could the shadow length be changing because of another reason?
this claim is not fair because the shadow length could have changed as a result of changing the block height

What should we circle?
correct
Ask the students why no claims can be made from the data. They should say that because there is more than one changing variable and you cannot tell which variable affected the results or how/why these changing variables affected the shadow length. Record this answer on the example notebook and have students copy this into their notebooks.

Ask the students if they think they would be able to make a conclusion when a claim cannot be made from the data. Since a conclusion is defined as a claim supported by data, you would need both a claim and data to make a conclusion. Since no claims can be made, a conclusion cannot be made either. Have students check the “no” box in their notebook.

![Scientific Practices Conclusions](image)

Ask the students what they learned about conclusions from this activity. Make sure by the end of the conversation that students understand that in order to draw a conclusion, they must only have one changing variable.

Tell students they are now going to look at three results tables and one graph and determine which data sets would allow them to make a claim/conclusion. Tell them to look at A-D, and circle the changing variable(s), underline the controls, and box information about data collection for each. They should then decide if a claim/conclusion can be made from the results. Give students approximately one minute to try the activity by themselves before discussing the results as a class.
Ask students the following questions:

**Table A**

What is/are the changing variable(s)?
- block height, light distance, and light angle

How many changing variables are there?
- three

Can a conclusion/claim be made from this data?
- no

Why not?
- This experiment had three changing variables and conclusions/claims can only be made when there is one changing variable.

**Table B**

What is/are the changing variable(s)?
- light height

How many changing variables are there?
- one

Can a conclusion/claim be made from this data?
- yes

Did the light height affect the length of the shadow?
- yes
Table C
- What is/are the changing variable(s)?
  - block height
- How many changing variables are there?
  - one
- Can a conclusion/claim be made from this data?
  - yes
- Did the block height affect the length of the shadow?
  - yes

Graph D
- What is/are the changing variable(s)?
  - block width and light height
- How many changing variables are there?
  - two
- Can a conclusion/claim be made from this data?
  - no
- Why not?
  - This experiment had two changing variables and conclusions/claims can only be made when there is one changing variable.

Tell students that tables (such as tables A-C) and graphs (such as graph D) represent two different ways of displaying results from an experiment. Ask the students what the advantages and disadvantages are for tables versus graphs. Students should realize that viewing the data in table form yields a complete idea about what experiment was conducted and which controls were used. However, it is harder to see patterns in the data. Alternatively, viewing the data in graph form allows patterns and trends to be viewed but does not display the controls the experimenter used.

Tell students that they will now analyze their data to see if they can make a conclusion. Remind them that it is okay if they cannot draw a conclusion from their first experiment because they will have the opportunity to run another experiment in which they should only have one changing variable so that they will be able to draw a conclusion.

Inform students that once they have decided if they can/cannot make a conclusion they will either state why they cannot make a conclusion or use their results to make a conclusion. Once this is complete, they can move on to designing their new experiment. Tell them that they are going to give poster presentations at the end of the module and the presentations will be more interesting if there are a wide range of changing variables that have been tested. In addition if a wide range of variables are chosen, the class question (What variables affect shadows?) will be more completely answered. Therefore, they should try to explore a changing variable that they think no one else in the class is investigating.

Tell students they will now start working with their group to analyze their old experiment and start their new experiment.
Conclusion: (5 minutes – Subgroups – SciTrek Volunteers)

Help groups fill out page 16 of their notebook. If the group has more than one changing variable they will not be able to draw a conclusion. An example of when the students cannot make a conclusion is seen below on the left.

If the group has only one changing variable they will be able to make a conclusion. Make sure that the students’ conclusions have both a claim and supporting data and that these statements are in the appropriately labeled sections. Claims must be something that can be tested and data statements must include either an observation or a measurement. Conclusions are still valid, and important, if they show that the changing variable tested did not affect the shadow. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data. If you think that their data is flawed it is okay to ask them what they think went wrong, and encourage them to repeat their experiment. An example of when the students can make a conclusion is seen below on the right.

Question: (5 minutes – Subgroups – SciTrek Volunteers)

Have students decide what changing variable they want to explore for their second experiment. Make sure each group has only one changing variable so they will be able to make a claim/conclusion after their experiment. Encourage your subgroups to have different changing variables.

After groups have decided on their changing variable, have them fill out their question. When you sign off on their question, give them a materials page with their group color and number designated in the upper right hand corner. An example notebook is seen below.
Materials Page:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variables on the materials page. Then have them use the materials page to determine the values for their changing variable and controls. For changing variable values have students write the trial letter next to the values they select. Ask students to justify the values that they have chosen for their changing variable and controls and if these values will make it easier or harder to answer their question.

Make sure that they have picked light distances and light heights that are within the limitations given on the chart. In addition, ensure that students have no more than one block dimension changing.

Experimental Set-Up:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use the materials page to fill in their experimental set-up on page 18 of the student notebook. When you sign off on their experimental set-up collect the materials page and verify that it is filled out correctly and completely. Having the materials pages filled out is essential for students to start their experiments during the next SciTrek visit. An example of an experimental set-up and materials page are seen below.
MATERIALS PAGE
You will only have access to the following materials:
1) Go through the list and circle your changing variable(s) and underline your controls. Ex: Control: Block Length, Ex: Changing Variable: Block Height
2) For variables that are controls select 1 value.
3) For variables that are changing variables, select 4 values and write the trial letter (A,B,C,D or E/F/G/H) next to each value. Ex: 52 cm a

General Materials:
✓ Flashlight
✓ Ring Stand with Clamp
✓ Protractor
✓ White Plastic
✓ Measuring Tap
✓ Rulers

Look at the picture below that defines the block dimensions. Two of your block’s dimensions (which are controls) must be 7 cm and 3 cm. The third dimension can be a control or changing variable and you may select the value(s). You may only circle ONE of these:

<table>
<thead>
<tr>
<th>Block Length</th>
<th>Block Width</th>
<th>Block Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The block’s ______ cm can be a control and will be ______ cm (original).

The block’s ______ cm will be ______ cm.

The block’s ______ cm must be a control.

Light Distance and Light Height:
Only fill out step 1 if light height is a control and step 2 if light distance is a control.

1) Light height is one of your controls:
   a. The value of light height that we will use is:
   b. Circle the row that corresponds to your control value (see example right top)

2) Light distance is one of your controls:
   a. The value of light distance that we will use is:
   b. Circle the column that corresponds to your control value (see example right bottom)

If you have no circles you can select/mark any value that is not greyed out.
If you have one circle you can only select/mark values within that circle.
If you have two circles you can only select the value that is circled by both circles.

Light Angle: (Circle the light angle(s) you will be using between 20º - 180º. If the light angle that you want to use does not appear in the picture below (example: 30º) write in the angle in the appropriate location and circle it.

EXPERIMENTAL SET-UP
Determine the value of your changing variable(s) (ex: block height) from the materials page and write the values (ex: trial E: 5 cm) for your four trials under each block.

Changing Variable(s):

1) black length
   a. 8 cm
   b. 10 cm
   c. 8 cm
   d. 10 cm

Controls (variables you will hold constant):
Determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

<table>
<thead>
<tr>
<th>Light Color</th>
<th>Light Height</th>
<th>Light Distance</th>
<th>Light Angle</th>
<th>Block Height</th>
<th>Block Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>50 cm</td>
<td>50 cm</td>
<td>90º</td>
<td>7 cm</td>
<td>3 cm</td>
</tr>
</tbody>
</table>

SciTrek Member Approval: 

Last Revised: 1/2/2018
Procedure:
(6 minutes – Subgroups – SciTrek Volunteers)

After each small group has filled out their experimental set-up, they can start on their procedure (page 19). Keep procedures as brief as possible while still conveying the pertinent information about the experiment. Make sure that you have students include all changing variable values in the procedure. For example, if block height is a changing variable one of the procedure steps would be: “Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic.” In addition, make sure all control values and what they will be measuring or observing are included in the procedure. Some groups may struggle with writing a procedure. If they are having problems with their procedure, they should look back at their initial procedure on page 8 of their notebook. If they are still having trouble, you can have these groups dictate each step while you transcribe them onto a notepad found in the group box. Give this sheet to the students to copy into their notebooks. Students might not finish their procedure this day. There will be additional time for them to finish their procedure on day 5. If students do finish their procedure they should raise their hand and get it approved by their SciTrek volunteer. An example procedure can be seen below.

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell the students that during the next SciTrek visit they will carry out the experiments that they designed today.
**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Place the materials pages on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat in your group box.

**Day 5: Procedure/Results Table/Experiment/Graph/Conclusion**

**Schedule:**

- Introduction (SciTrek Lead) – 10 minutes
- Procedure (SciTrek Volunteers) – 5 minutes
- Results Table (SciTrek Volunteers) – 5 minutes
- Experiment (SciTrek Volunteers) – 25 minutes
- Graph (SciTrek Volunteers) – 5 minutes
- Conclusion (SciTrek Volunteers) – 8 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

**Materials:**

- Volunteer Boxes:
  - □ Student nametags
  - □ Student notebooks
  - □ Volunteer instructions
  - □ Measuring tape (152 cm)
  - □ Protractor
  - □ Measuring tape (152 cm)
  - □ Requested wooden blocks
  - □ Filled out materials page
  - □ Volunteer lab coat
  - □ (2) Pencils
  - □ (2) Red pens
  - □ Notepad
  - □ (3) White plastic surfaces
  - □ (3) Ziploc Bags labeled group 1, 2, and 3 each with the following:
    - □ Measuring tape (152 cm)
    - □ Requested wooden blocks
    - □ Filled out materials page
  - □ (2) Pencils

- Other Supplies:
  - □ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
  - □ Tube with 9 ring stand poles
  - □ (35) Clipboards

- Lead Box:
  - □ (3) Extra student notebooks
  - □ Lead instructions
  - □ Shadows picture packet
  - □ Lead lab coat
  - □ Time card
  - □ (2) Pencils
  - □ (2) Red pens
  - □ (2) Wet erase markers
  - □ Notepad
  - □ (3) Measuring tapes (152 cm)
  - □ (6) Rulers
  - □ (2) Masking tapes
  - □ Bag 1: lead shadows supplies
  - □ (2) measuring tapes (152 cm), (2) flashlights without filter, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) wooden blocks – one of each size)
  - □ White plastic surface
SCIENTIFIC PRACTICES

Conclusions

Question: If we change the block material, what will happen to the shadow length?

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color:</td>
<td>White</td>
<td>White</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Block Height:</td>
<td>2 cm</td>
<td>2 cm</td>
<td>2 cm</td>
<td>2 cm</td>
</tr>
<tr>
<td>Block Width:</td>
<td>1 cm</td>
<td>1 cm</td>
<td>1 cm</td>
<td>1 cm</td>
</tr>
<tr>
<td>Light Distance:</td>
<td>20 cm</td>
<td>20 cm</td>
<td>20 cm</td>
<td>20 cm</td>
</tr>
<tr>
<td>Light Angle:</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
</tr>
<tr>
<td>Block Material:</td>
<td>Wood</td>
<td>Foam</td>
<td>Metal</td>
<td>Cardboard</td>
</tr>
<tr>
<td>Shadow Length</td>
<td>12 cm</td>
<td>12 cm</td>
<td>12 cm</td>
<td>12 cm</td>
</tr>
<tr>
<td>Shadow Pictures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write a conclusion from the results above:

We can conclude that for a given block dimension, the shadow length will be the same regardless of the material the block is made from, because the blocks made from wood, foam, metal, and cardboard all had a shadow length of 12 cm.

RESULTS

Graph

Check all the steps as you complete them:
- Record what you measured (example: shadow length [cm]) on the y-axis (vertical).
- Generate an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Fill in changing variables #1, #2, and #3 on the x-axis (horizontal) (example: block height). Changing variable #2 and #3 will only be plotted if you have 2 or 3 changing variables.
- On your results table label your measurements from 1 to 4, with 1 being the trial with the smallest measurement and 4 the trial with the largest measurement.
- Plot your data in increasing order:
  - Write each changing variable value (example: 3 cm) for the trial that you labeled 1 under the first column.
  - Draw the graph until all the columns have values under them.
- Graph your data and write the measurements above the bar.

CONCLUSION

We can conclude that increasing the block length will slightly increase the shadow length when the light distance and light height are both 50 cm because when the block was 3 cm long it had a 7 cm shadow length and when the block was 10 cm long it had a 9 cm shadow length.

Can you test the first part (claim) of the conclusion?

- Yes
- No (If you checked this box go back and revise your claim so that it can be tested.)

The second part of the conclusion is data because it contains a measurement.

I acted like a scientist when I wrote a procedure about the experiment.
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the conclusion example (page 20, student notebook) and the block measurement pictures (page 1, picture packet). If the classroom does not have a document camera, then tape up the poster-size notebook pages on the front board.

SciTrek Volunteer:
Set out student notebooks.
- If students are not in the classroom before SciTrek starts set out the notebooks where you want students to sit when they come into the classroom.
- If students are in the classroom pass out student notebooks to them. They will move to their subgroup seats after the introduction.

Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Do not put the clamp at the appropriate height; adjust the clamp to the lowest place on the ring stand allowing students to put the clamp at the appropriate height(s) when they do their experiment.

Place group bags, white plastic, and ring stands in three unique spots on the floor along with four clipboards.

How to Measure Lengths and Widths of Shadows
When measuring the length of the shadow line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm you will need to use the measuring tape instead of the ruler. The lead box has extra measuring tapes if needed. Place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. Measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.
**Introduction:**
*(10 minutes – Full Class – SciTrek Lead)*

If needed have the SciTrek volunteers hand out the notebooks/nametags to students in their seats. They will move into their subgroups after the introduction.

Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect shadows? Tell the students that today they are going to perform their second experiment. Once the experiment is complete they will analyze their data and determine what conclusions can be drawn from their results. Tell students that their conclusions will help answer the class question. Ask the students for the definition of a conclusion. They should respond that it is a claim supported by data. Ask the students how many changing variables experiments can have to be able to make claims/conclusions. They should respond that there can only be one changing variable. Ask them why they can only have one changing variable in order to draw a conclusion. They should say that if there is more than one changing variable they would not be able to tell which one of the multiple changing variables affected the shadow.

To help learn how to analyze data, we will look at other scientists’ data to see if we can draw a conclusion from their results. Have students turn to page 20 of their notebook and place an example notebook under the document camera. Tell the students to look over the data in this results table. Ask the students what was the changing variable in the experiment. They should respond block material. Have students circle block material. Next, have students identify and underline the controls for the experiment. Students should underline light color, block height, block width, block length, light distance, light height, and light angle. Lastly, have students identify the data the scientists collected and box that information. Students should box shadow length and picture Ask students what was the question that these scientists were exploring. They should reply: “If we change the block material, what will happen to the shadow length?” Fill in the changing variable in the question above the results table. Ask students if a claim/conclusion can be made from this data. Students should realize that there is only one changing variable so a claim/conclusion can be made from these results.

Tell the class that now that they know a conclusion can be made from the data, they are going to work together to come up with a conclusion. Explain that when drawing a conclusion from data the first step is making a claim to explain the results.
Then ask, “Can anyone look at the data and tell me how the block material affected the shadow length?”

Since all of the shadow lengths are the same, the block material does not affect the shadow.

Example claim that states how the shadow is affected by the block material:

1. for a given light source and a given block dimension, the shadow length will be the same regardless of the material the block is made from

Example claim that states what happened:

1. the block material does not affect the length of the shadow

If possible try to lead the students to a claim that explains how the shadow changed instead of a claim that just states what happened to the shadow. Tell students that claims that allow you to make predictions are more valuable in science because we can then go out and further test our claims to see if they are correct. Therefore, when they try to generate a claim about their data, they should try to have a claim that would allow them to make a prediction. Write the claim in the example notebook and have students copy it into theirs.

Ask the students what data was collected to support this claim. Below is an example of data that backs up claims that stated how the shadow was affected.

1. the blocks made out of wood, foam, metal, and cardboard all had a shadow length of 12 cm.

Ask students how they know that the statement generated was data. Students should say that the statement contains measurements showing that scientists had to go and physically carry out an experiment to discover the results. Write the data in the example notebook and have students copy it into their notebooks. Make sure students understand that the conclusion that they made is the outcome of their experiment and should answer the experimental question. In addition, these smaller experimental questions can be combined to help answer a larger question, such as the class question.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Height</td>
<td>7 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Width</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Length</td>
<td>5 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Height</td>
<td>25 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Angle</td>
<td>50°</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Data**

<table>
<thead>
<tr>
<th>Block Material</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>12 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foam</td>
<td>12 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>12 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard</td>
<td>12 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write a conclusion from the results above:

We can conclude that for a given block dimension, the shadow length will be the same regardless of the material the block is made from because the blocks made from wood, foam, metal, and cardboard all had a shadow length of 12 cm.

Remind students how we define the block. Show students the example block. Place the block on the edge of the picture pack and tell them that the picture pack will represent the white plastic and the light source...
would be in front of the block. Ask the students what we call the block dimension going up. They should respond height. Ask the students what we call the block dimension going across the front of the white plastic. They should respond width. Ask the students what we call the block dimension going away from the light. They should respond length. Show student that if they forget the dimensions they can look at the picture at the top of their results table.

Put page 1 of the picture pack under the document camera and review how to measure the length and width of the shadow. Explain to the students that when measuring the length of the shadow they will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). They will then place another ruler (numbers not showing) perpendicular to the first ruler at the edge of the shadow, making an “L” with the two rulers. Explain when measuring the shadow width they will place two rulers (numbers not showing) perpendicular to the short side of the white plastic on either side of the shadow. They will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.”

Remind students that they must have their procedure and results table completed before they can start their experiment. If needed, tell students to get together with their group and start working.

Procedure:
(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups complete their procedures (page 19). Keep procedures as brief as possible while still conveying the pertinent information about the experiment. Make sure that you have students include all changing variable values in the procedure. For example, if block height is a changing variable one of the procedure steps would be: “place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic.” In addition, make sure all control values and what students will be measuring or observing are included in the procedure. Some groups may struggle with writing a procedure. If they are having problems with their procedure they should look back at their initial procedure on page 8 of their notebook. If they are still having trouble, you can have these groups dictate each step while you transcribe them onto a notepad found in the group box. Give this sheet to the students to copy into their notebooks. Once the students have their procedure written in their notebooks they should raise their hands to get approval by their SciTrek volunteer. An example procedure can be seen below.
Results Table:
(5 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variable that is the changing variable, and box the data collection. When writing the values make sure that for their controls they only write the value of the control in trial E and then draw a line through the remaining trials and for the changing variable they write the values in each of the boxes.

When students have finished, have them make predictions about the shadow lengths. Have them write an “L” in the box of the shadow that they think will be the longest and an “S” in the box of the shadow that they think will be the shortest. They will leave two boxes empty. If they think that all trials will be the same length have them write “same” over all of the boxes. Try to question each group on their thought process behind their predicted lengths. See example notebook above.

Experiment:
(25 minutes – Subgroups – SciTrek Volunteers)

When students are ready to start their experiment they may go where their supplies are on the floor. If students are missing any of their experimental materials the lead box has extra materials. Remind students to make sure that the flashlight is in line with the protractor. In addition, verify that the string is hanging down from the front of the clamp. Have students show you their set-up for their first trial before taking any measurements. When checking the students’ set-up verify that they have their block in the correct orientation. If the students chose to change the light angle and the shadow is too wide for white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved.
When making measurements, make sure that the shadow is being measured as described in the set-up section above. It is important to make sure that the students draw pictures of their shadows as well as take measurements to compare to other shadows later. Recording of measurements and pictures should be done as each trial is completed. Once this is complete students can move onto the next trial. If your groups have things under control please help other groups. As soon as they finish their experiment they can graph their results. Do not take down the experimental set-up until after students have finished their graph. This way they can check their measurements if needed. An example of a properly filled out result table is seen above.

**Graph:**

*(5 minutes – Subgroups – SciTrek Volunteers)*

Help students fill out their graph by having them go through and complete the checklist on page 22. Be sure that students label the y-axis with either shadow length or shadow width (students can pick which to graph) and the x-axis with their changing variable. Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. To make it easier to see patterns students should arrange the trials in increasing measurements as done in the example below. In this example the trials were graphed in the following order: E, H, G, F. Once they have graphed their values, make sure that they write the shadow length/width on top of each column so that it is easy to discern the value.

**Conclusion:**

*(8 minutes – Subgroups – SciTrek Volunteers)*

Have students summarize their findings. Challenge students to think about how their changing variable did or did not affect shadows.
When writing their conclusion, make sure that students start the statement with a claim about the trend or pattern in their data and then write “because” and use data to back up the claim. The data in this experiment is usually in the form of measurements.

If the values of their changing variable have an order (example: 2 cm → 5 cm → 8 cm → 10 cm) then that variable affected the shadow length/width. If, on the other hand, there was no order for their changing variable (example: 5 cm → 10 cm → 2 cm → 8 cm) and the difference between shadow length/width for each trial is small, then that variable did not affect the shadow length/width. If possible, try to have students come up with a claim that allows them to make a prediction about something that they have not tested. Challenge students to think about how (claim 1 and 2 below) their changing variable did or did not affect their measurements instead of just what happened (claim 3 and 4 below).

Example claims that state how the changing variable did or did not affect the shadow
  Claim 1: the taller the block, the longer the shadow
  Claim 2: as the light height increases, the shadow becomes more rectangular and less trapezoidal

Example claims that state what happened to the shadow
  Claim 3: the block height affects the shadow length
  Claim 4: the block length does not affect shadow length

Once they have discussed their idea, have the students fill out the section labeled: “Generate a claim about how your changing variable affected your results” (page 23).”

Conclusions are still valid, and important, if they show that the changing variable tested did not affect the shadow. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data.

If there is time, students can determine the data to support their claim. For an example of how to do this, see the conclusion section on day 6. Example student work for the conclusion section can be seen below.
**Wrap-Up:**
(2 minutes – Subgroups – SciTrek Lead)

Tell the students that during SciTrek’s next visit they will get time to finish their conclusions and then create a poster to share their results with the class.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Bring all materials back to UCSB. In addition, put your lab coat back in your group box.

**Day 6: Conclusion/Poster Making**

**Schedule:**

- Introduction (SciTrek Lead) – 2 minutes
- Conclusion (SciTrek Volunteers) – 18 minutes
- Poster Making (SciTrek Volunteers) – 35 minutes
- Wrap-Up (SciTrek Lead) – 5 minutes
Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- ☐ Volunteer lab coat

(3) Poster Parts Packs
- ☐ Scientists' names
- ☐ Question
- ☐ Experimental set-up

☐ Poster diagram (full page)
☐ (3) Stickers on how to present graph
☐ (2) Pencils
☐ Notepad

☐ (3) Sticker(s) on how to present graph
☐ (2) Pencils
☐ Notepad

☐ (9) Paperclips
☐ Highlighter
☐ Scissors
☐ (2) Glues

☐ (2) Glues
☐ Wet erase markers
☐ Notepad
☐ (9) Paperclips

☐ (3) Extra student notebooks
☐ Lead instructions
☐ Shadows picture packet
☐ Lead lab coat
☐ Time card

☐ (3) Stickers on how to present graph
☐ (2) Pencils
☐ (2) Wet erase markers
☐ Notepad
☐ (9) Paperclips

Other Supplies:
- ☐ Poster paper tube

☐ Poster paper tube

☐ (3) Extra student notebooks
☐ Lead instructions
☐ Shadows picture packet
☐ Lead lab coat
☐ Time card

☐ (3) Stickers on how to present graph
☐ (2) Pencils
☐ (2) Wet erase markers
☐ Notepad
☐ (9) Paperclips

☐ (2) Glues
☐ Scissors
☐ (2) Wet erase markers
☐ Notepad
☐ (9) Paperclips

☐ (2) Highlighters
☐ (2) Scissors
☐ (2) Glues

☐ Scotch tape
☐ Poster part pack (1 each color)

□ (4) “I acted like a scientist when ______”

□ (4) Picture spaces

Set-Up:

SciTrek Lead:
- Ask the classroom teacher for a place to leave the student posters in the classroom.

SciTrek Volunteer:
- Set out student notebooks.
  - If students are not in the classroom before SciTrek starts set out the notebooks where you want students to sit when they come into the classroom.
  - If students are in the classroom when SciTrek starts set out the notebooks where you want students to sit and students will move these spots after the introduction
- Have poster parts ready for students.
**Introduction:**
(2 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have the SciTrek volunteers set out the SciTrek notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk which is not their notebook and they should not move it.

Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect shadows?” Inform the class that they will be making posters to present their findings to the class. Before they make posters they will have to finish their conclusions. Ask the class how scientists define a conclusion (a claim supported by data). Ask the class what a claim is (the explanation of your results, something that can be tested) as well as what can be used for data (measurements or observations).

After they finish their conclusion they will create a poster to present during the next SciTrek visit. This presentation will be their chance to tell the class what their group has discovered about the class question. Tell students that they should write as neatly as possible on the poster parts so that the other class members can read their poster. In addition, they will pick one of their two experiments to present. Remind them that they should pick an experiment from which they were able to draw a conclusion.
Conclusion:
(18 minutes – Full Class – SciTrek Lead)

If students have not made a claim about their data, have them make one. For an example of how this is done, see the conclusion section in day 5. After students have determined their claim have them determine the supporting data. Have students look at their results table/graph and write in words what measurements or observations were used to support their claim. In most cases, you can have students select the two data points that best support their claim. This is usually the largest and the smallest measurements.

Example data to support the four claims that were previously listed.

Data 1: the shadow for the 10 cm (tallest) block was 15 cm long and the shadow for the 3 cm (shortest) block was 4.5 cm long.
Data 2: it was observed that when the light height was 10 cm the shadow was a trapezoid and when the light height was 60 cm the shadow was a rectangle
Data 3: the shadow for the 10 cm block was 15 cm long and the shadow for the 3 cm block was 4.5 cm long
Data 4: when the block was 3 cm thick the shadow was 9 cm long and when the block was 8 cm thick the shadow was 9 cm long

Once students have determined their conclusion, have them complete the two questions that follow. First, have them verify that the first part of their statement is testable, making it a claim. If it is not a claim have them go back and revise the first part of the statement. Second, have students justify how they know the second part of the statement is data. (Statements that are data contain measurements or observations. If the statement is an observation make sure the word “recorded” or “observed” is in the statement to indicate that the experiment was carried out.) If the data statement does not have a measurement or an observation, have students modify their statement.

Example student work for the conclusion section can be seen below.
Before starting their poster, have students fill in the sentence frame (page 23): “I acted like a scientist when______.” Their response should be unique for each student and should NOT be “when I did an experiment.” If students are having trouble with this sentence frame ask them what they did during each SciTrek visit.

**Poster Making:**
(35 minutes – Subgroups – SciTrek Volunteers)

Each subgroup (three/four students) will make one poster on one of their experiments from which they were able to draw a conclusion.

Pass out the writing portions (general poster parts and “I acted like a scientist when______”) and have students write their name on them and complete them. In addition, have each student write their name on the scientists’ names part. Use the following guidelines when assigning poster parts:

<table>
<thead>
<tr>
<th>Number of Students in Subgroup</th>
<th>Poster Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Each student gets an “I acted like a scientist when______” and picture space.</td>
</tr>
<tr>
<td></td>
<td>1. Question and Experimental Set-Up</td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
</tr>
<tr>
<td></td>
<td>3. Results Graph* and Conclusion</td>
</tr>
<tr>
<td></td>
<td>Student that finishes 1st completes the results table (not presented)</td>
</tr>
<tr>
<td>4</td>
<td>1. Question and Experimental Set-Up</td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
</tr>
<tr>
<td></td>
<td>3. Results Graph*</td>
</tr>
<tr>
<td></td>
<td>4. Conclusion</td>
</tr>
<tr>
<td></td>
<td>Student that finishes 1st completes the results table (not presented)</td>
</tr>
</tbody>
</table>

*Give the results graph to the student that is most confident in presenting.

Once all writing sections are completed, have students draw a picture of their experiment or how they acted like a scientist.
In the students’ notebooks, highlight and number the section that they will present. The parts should be numbered as follows: 1) scientists’ names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) conclusion (see example below). Students will NOT present the results table or “I acted like a scientist when ______” form their posters. If a student is presenting multiple sections, use the paperclips in your group box to clip together the sections that they are reading so that when presenting, it will be easy to flip back and forth between pages.

Place the following sentence frame sticker on the top of the notebook page of the student that is completing the results graph (page 22).

When the ______ out for the student _______ was ______ value ______ changing variable ______ measurement ______ length or width ______

Then practice reading the four sentences with that student. For the poster below, the sentence would be: When the block height was 3 cm the shadow length was 3.5 cm. Make sure you fill in the “block height” and “length” for the student in the sentence frame but leave the “value” and “measurement” blanks empty.

As soon as students have completed some of their pieces start gluing them onto the large poster paper exactly as they are arranged in the example below. Do not wait until students have completed all the pieces to start gluing them onto the poster.
Once the poster is complete, have students start practicing for the presentation. Make sure that students read from their notebooks instead of off the poster.

If there is time, ask each of your groups a few questions about their poster. Have them use their findings to predict what would happen to the shadow for other experiments that they did not perform but are related to their experiment. For instance if the group conclusion was, “the shorter the light height the longer the shadow because when the light height was 25 cm the shadow was 40 cm long and when the light height was 45 cm the shadow was 20 cm long,” ask the group what if a light height of 61 cm or 43 cm would give them a longer shadow length. They should be able to predict that the light height 43 cm would give a longer shadow.

**Wrap-Up:**
*(5 minutes – Full Class – SciTrek Lead)*

Ask the students the following questions:

- How did you act like a scientist during this project?
- What did you do that scientists do?

After having a discussion about how they acted like scientists and talking about how everyone does things that scientists do in their everyday lives, tell students that they will present their findings during the next SciTrek visit and that you are looking forward to hearing about all of their experiments.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Leave student posters in the classroom. Bring all materials back to UCSB. In addition, put your lab coat back in your group box.
Day 7: Poster Presentations

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Practice Posters (SciTrek Volunteers) – 5 minutes
- Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 51 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- ☐ Volunteer lab coat
- ☐ (2) Pencils
- ☐ (9) Paperclips
- ☐ Highlighter

Lead Box:

- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ Teacher evaluation
- ☐ (9) Stickers on how to present graph
- ☐ (2) Wet erase markers
- ☐ (9) Paperclips
- ☐ (2) Highlighters
- ☐ Scotch tape

*Student posters should already be in the classroom.

Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the notes on presentations (pages 4 and 5, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect shadows?” Leave enough room to record student findings under the question.

Organize the posters so that groups that had the same changing variable present back to back.

Give the teacher the “Evaluation of the SciTrek Program by Participating Teachers” form. Ask teachers to fill this form out and give it back to you the next time you are there.

SciTrek Volunteer:

Set out the SciTrek notebooks/nametags. Today students will be sitting in their regular classroom seats during poster presentations.
Introduction:
(2 minutes – Full Class – SciTrek Lead)

Tell students that today they will present their poster to the class. Inform students that this is a common practice in science. Scientists go to conferences where they present posters about the experiments they conducted. At these presentations, other scientists give them feedback on their experiments, which allows them to return to the lab with new ideas for future experiments.

Tell the students that they will have 5 minutes to practice presenting their poster with their group. Remind students to read from their notebooks when presenting. Tell students that after practicing, they will return to their normal classroom seats.

Practice Posters:
(5 minutes – Subgroups – SciTrek Volunteers)

If the posters are not already in order, the lead should organize the posters so the experiments that are about the same changing variable are presented back to back.

Have subgroups practice their poster presentation, making sure they are reading the poster parts in the correct order (scientists’ names, question, experimental set-up, procedure, results graph, and conclusion). Make sure each student’s part is highlighted in their notebook. If students are reading from multiple pages, use a paperclip to clip these pages together. Remind students to read from their notebook rather than from their poster.

Do not let poster practice go over 5 minutes.
**Poster Presentations:**
*(51 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)*

Have students return to their original class seats. Ask the class, “What is the question that we have been working on solving?” Students should tell you, “What variables affect shadows?” Tell students that during the presentations they are going to take notes. Have them turn to page 24 in their notebook while you turn to page 5 of the picture packet. Tell them that they need to record the group’s changing variable when they say what their question was as well as the values of that changing variable and the data that was taken when they present the graph.

After each presentation, students will be given the opportunity to ask scientific questions to the presenting group to help them determine if/how the variable investigated affected the shadow. Tell them that these questions are important because they will have to record a summary of what they learned from the group. Therefore, their questions should focus on helping them be able to summarize the group’s findings.

Student notebooks only have room for notes on 8 presentations. Therefore, they will not take notes on their own presentation.

Volunteers should make sure that students are quiet and respectful when other groups are presenting. When one of your groups is presenting, go to the front of the room with them and prompt students if they do not know who talks next and remind them to read from their notebooks.

During the student question time, the SciTrek lead and/or volunteers should ask at least one question. Examples of possible questions are: “How do you know...?” or “Is there anything else you can do to get more information about your question?” Each group should answer approximately four questions (one question per student).

Below is an example of notes that the lead/students could have taken during the poster presentations.
After all poster presentations have been given, ask the class, “What did we learn about shadows?” Have them summarize the class findings. The highlights from many experiments are seen below. Do not expect students to know highlights from experiments that were not run.

- The taller the block height, the longer the shadow but the shadow width stays the same
- The wider the block width, the wider the shadow but the shadow length stays the same
- The longer the block length, the longer the shadow but the shadow width stays the same
- As the light distance increases, the shadow length increases but the shadow width stays the same
- As the light height increases, the shadow length and width decreases
- The closer the light angle is to 90° the longer and thinner the shadow

When summarizing experiments, use students collected data and not what they should have found from the list above. Tell students you want to get the longest shadow and that you need them to tell you what values of variables you should use.

- Block Height: As tall as possible
- Block Width: Any width
- Block Length: As long as possible
- Light distance: As far out as possible
- Light Height: As low as possible
- Light Angle: 90°

If no one in the class did experiments on one of the variables above, then they will not know how that variable affects the shadow length and do not expect them to tell you which value to use. Tell students they have taught you a lot about shadows.
Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell the students that the volunteers that have been working with them are undergraduate and graduate students that volunteer their time so that they can do experiments. Have the students say thank you to the volunteers. This is the last day with their SciTrek volunteers, therefore, they should say goodbye to them. Tell students that you will be back one more time.

Tell students to remove the paper part of their nametag from the plastic holder and that they can keep the paper nametag but need to give the plastic holder back to their SciTrek volunteer.

Clean-Up:

Before you leave, collect the plastic nametag holders and put them in the group box. Students can keep the paper part of their nametag. Collect notebooks and place them in the group box. Leave student posters in the classroom. Bring all materials back to UCSB. Remove tape from the lid of your group box and place inside. In addition, remove all materials from lab coat pockets, remove your nametag, unroll lab coat sleeves, and put your lab coat back in the dirty clothes bag at UCSB.

Day 8: Conclusion Assessment/Tie to Standards/Content Assessment

Schedule:
Conclusion Assessment (SciTrek Lead) – 15 minutes
Tie to Standards (SciTrek Lead) – 35 minutes
Content Assessment (SciTrek Lead) – 10 minutes

Materials:
Lead Box:

- □ (3) Extra student notebooks
- □ Student notebooks
- □ Lead instructions
- □ Shadows picture packet
- □ Lead lab coat
- □ (35) Content assessments
- □ (35) Conclusion assessments
- □ Time card
- □ (2) Pencils
- □ (2) Wet erase markers
- □ (35) Red pens
- □ (3) Rulers
- □ 7 cm block
TIE TO STANDARDS

1. Using the given information for each experiment draw a circle around your prediction of what will happen to the shadow length and width. Once you have seen the pictures of the experiment draw a box around what actually happened to the shadow length and width. For all the experiments a 5 cm x 7 cm x 3 cm block was used.

Experiment 1: Effects of Changing Light Color

- Light Color: Orange
  - Light Height: 20 cm
  - Light Distance: 10 cm

  What will happen to:
  - Shadow Length
    - Shorter
    - Longer
  - Shadow Width
    - Thinner
    - Wider

Experiment 2: Effects of Changing Light Height

- Light Color: White
  - Light Height: 20 cm
  - Light Distance: 10 cm

  What will happen to:
  - Shadow Length
    - Shorter
    - Longer
  - Shadow Width
    - Thinner
    - Wider

Experiment 3: Effects of Changing Light Distance

- Light Color: White
  - Light Height: 20 cm
  - Light Distance: 10 cm

  What will happen to:
  - Shadow Length
    - Shorter
    - Longer
  - Shadow Width
    - Thinner
    - Wider

Experiment 4: Effects of Changing Light Angle

- Light Color: White
  - Light Height: 20 cm
  - Light Distance: 10 cm

  What will happen to:
  - Shadow Length
    - Shorter
    - Longer
  - Shadow Width
    - Thinner
    - Wider

2. What is the most important light source in your life? __________

3. The sun rises in the __________ and sets in the __________

4. What causes the changes in the sun's position throughout the day? The earth is rotating.

5. Draw the sun's position and the corresponding shadow for each of the following times:
   A: Sunrise    B: Midmorning    C: Noon    D: Afternoon    E: Sunset

6. What time(s) of day are shadows the longest? __________

7. What time(s) of day are shadows the shortest? __________

8. Using what you have learned about shadows make a line graph showing how shadow length changes over the course of 24 hours in the summer. Use a red line to show your predicted values and a pencil line to show the actual data.

   How Shadow Length Varies in the Summer

9. Using the information learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the winter. Use a red line to show your predicted values and a pencil line to show the actual data.

   How Shadow Length Varies in the Winter

10. What conclusion can you make from the graphs about the amount of daylight throughout the year?

    We can conclude that the number of daylight hours in the summer is __________ than in the winter because __________

    __________ hours of daylight in the summer and there were __________ hours of daylight in the winter.

11. Using the sundials below, determine what time of day it is (morning / noon / afternoon).

    What time of day is it? __________
    What time of day is it? __________
    What time of day is it? __________
Set-Up:

SciTrek Lead:

Collect the “Evaluation of the SciTrek Program by Participating Teachers” from the teacher. If they have not filled out the form ask them to do it during the tie to standards activity.

If the classroom has a document camera, ask the teacher to use it for the tie to standards activity (pages 26-28, student notebook) and tie to standards pictures (pages 6-11, picture packet). If the classroom does not have a document camera, then tape example poster size notebook pages to the front board.

Pass out notebooks to students. If you do not have time to get set-up before the start of the module ask the teacher to pass out notebooks during the conclusion assessment.

Remind the teacher to give you their lab coat at the end of the day.

Conclusion Assessment:

(15 minutes – Full Class – SciTrek Lead):

“Before we start our activity today we will determine how your ideas on conclusions are developing. One of the ways that we get program funding is by demonstrating the program effectiveness. Therefore, we need you to do your best on the assessment.” Pass-out the conclusion assessment and tell students to fill out their name, teacher’s name, and date on the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

For page 1, read the instructions to the students. Then read each of the statements and tell the students to circle if the statement is a claim, data, or opinion. As you are reading the statements walk around the room and verify that students have written their name on the top of the paper.

For page 2, have students circle the changing variable(s), underline the controls, and box information about data collection on the results table. Then, have them decide if the group could make a conclusion.

Read step one of the instructions to the students (identify the following statements as either CLAIM or DATA and write a C or D on the line). Then have students fill in if they think statement “a” is a claim or data by writing a C or D on the line. Tell students this is similar to page 1 of the assessment. Read step two of the instructions to the students (look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested). Point to the results table and have students circle what they think is the correct answer for statement “a.” Once they have completed statement “a” move on to the next statement. Read each statement aloud and tell students to write the appropriate letter on the line then circle if the statement is a correct claim, correct data, or incorrect.

Repeat the process for page 3. Read the question on the bottom of page 3 to students and have them fill in the blank.

For page 4, tell students to take three minutes to draw a picture of a scientist. After which, read the two questions on the bottom of the page to students and have them answer them. When students are finished collect the assessments and verify that they have written their name on the assessment.
Tie to Standards:
(35 minutes – Full Class – SciTrek Lead)

Effects of Changing the Light (10 minutes)

Tell the students that today they are going to talk about their previous experiments and hopefully answer any questions that they may still have about what variables affect shadows. Have the students turn to page 26 in their notebooks. Tell the students that we are going to look at four experiments and compare the lengths and widths of the shadows to one another. The four experiments that we will look at are light color, light height, light distance, and light angle. For all experiments a 5 cm × 7 cm × 3 cm block was used.

For the first experiment, we are going to explore how changing light color affects the shadow when the light height is 20 cm, the light distance is 10 cm, and the light angle is 90°. Tell the students to circle if they think the shadow length will be shorter, stay the same, or be longer and if they think the shadow width will be thinner, stay the same, or be wider when the light color is changed from orange to blue. Once students have finished their predictions have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 1 picture (page 6, picture packet, seen below). Ask students when the light color changed what happened to the show length and width. Tell students not to erase their predictions but to put a box around the correct answers. On the example notebook box “same” for shadow length and shadow width.

Tell students that for the second experiment we will explore changing light height. For this experiment, we will use the same block as the previous experiment, a light distance of 10 cm and a light angle of 90° but instead of using colored light we will use white light. Have students circle what they think will happen to the shadow length and width when the light height is increased from 20 cm to 60 cm. Once students have finished their predictions, have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 2 picture (page 7, picture packet, seen above). Ask students when the light height increased what happened to the show length and width. Tell students not to erase their predictions but to put a box around the correct answers. On the example notebook, box “shorter” for shadow length and “thinner” for shadow width.

Tell students for the third experiment we will explore changing light distance. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light angle of 90°. Have students circle what they think will happen to the shadow length and width when the light distance is changed from 10 cm to 60 cm. Once students have finished their predictions have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show the students the experiment 3 picture (page 8, picture packet, seen below). Ask students when the light...
distance increased what happened to the show length and width. Tell student not to erase their predictions but to put a box around the correct answers. On the example notebook box “longer” for shadow length and the “same” for shadow width.

**Teacher Note:** If students do not believe that the widths are the same use the rulers in the lead box to measure the shadow width.

Tell students that for the fourth experiment we will explore changing light angle. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light distance of 10 cm. Have students circle what they think will happen to the shadow length and width when the light angle is changed from 90° to 150°. Once students have finished their predictions, have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show the students the experiment 4 picture (page 9, picture packet, seen above). Ask students when the light angle increased what happened to the shadow length and width. Make sure by the end of the conversation, students understand that the shadow will always be in line with (or 180° from) the light source. Tell students not to erase their predictions but to put a box around the correct answers. On the example notebook, box “shorter” for shadow length and “wider” for shadow width.
Connection to the Sun (5 minutes)

Tell students now that they understand how to predict what shadows will look like, they will connect these predictions to other uses. Have the students turn to page 27 in their notebooks and ask them, “What is the most important light source in your life?” They may answer the lights in their home. Lead students to understand that the lights in their home are useful, but humans have lived without them in the past, so if needed, people could live without them again. However, there is one source of light that no one would be able to live without. The light source that is most important in all of our lives is the sun. Have students fill this out in their notebooks.

Next, ask students which direction (north, south, east, or west) the sun rises in and which it sets in and have them fill this in for question 3 in their notebooks. Then ask them what causes the change in the sun’s position throughout the day. Lead the students to understand that the sun is not moving, but the earth is rotating, causing it to look like the sun is moving. Then have them record this in their notebook for question 4.

Now that students understand where the sun rises and sets as well as what a shadow will look like for a corresponding light source, they are going to draw a picture showing where the sun will be and what the shadow will look like for the sunrise, midmorning, noon, afternoon, and sunset. With the students, draw in the location of the sun for each of the points. Have the students draw the suns in the following order: A (sunrise), C (noon), E (sunset), D (afternoon), B (midmorning). Draw in the shadow for A (sunrise) then...
have students try to fill in the remaining shadows in their notebooks. Have one student volunteer to share their shadow placement with the rest of the class. Put that student’s notebook under the document camera and have the rest of the class discuss the placements of the shadows and if they agree or disagree with the placements. Once a consensus is reached draw the shadows into the example notebook. Make sure by the end of the conversation students understand that the shadow will initially be in the west and very long, at approximately noon the shadow will be the shortest and right before sunset the shadow will be very long and in the east. An example is seen below.

After completing the picture, ask students at what time of day shadows are longest and when they are shortest. Students should see that at sunrise and sunset, when the sun is low, the shadows are the longest and that at noon, when the sun is directly above objects, the shadows are the shortest. Next, ask students how we know this. They should respond that during sunrise and sunset the light source is coming from the side of the object rather than directly above. As we have learned earlier, when the light is coming from a low light height the shadows are longer. A low light height could represent the sunrise and sunset. We also learned that a high light height will lead to a short shadow. A high light height could represent noon.

Seasonal Shadows (18 minutes)

Pass out a red pen to each student.

Tell the students that they are now going to predict what a graph of shadow length over the course of 24 hours would look like in the summer. Ask students what the first point on the graph is. Students should respond midnight. Ask students what is it like outside at midnight. They should say that it is dark. If it is dark will there be a shadow. (No) Therefore, our first point will most likely be at a shadow height of 0. Put a red dot at 0 shadow length at midnight. Ask students what they think the shadow length will be at 2:00 am and why. They should also say 0 because it is still dark. Put a red dot at 0 shadow length at 2:00 am. Tell students that they will now predict the shadow length for the rest of the 24-hour period. Tell them to put down dots for each time and then connect the dots. Therefore, if they thought the shadow length was 0 for the entire 24-hour period there graph would look like a straight line as 0. Show them what this would look like on the example notebook (seen below). Ask students if this prediction is correct. They should say no.
Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have the students give critiques of the graph. In addition, you should ask questions to help guide student thinking.

Tell students that they will now graph the actual data showing how shadow length changes with time during the summer using their pencils and not the red pen. Show students the results table while reading it to them (page 10, picture packet, seen below on the left). In addition, plot the data points in the example notebook. Draw in a solid line connecting the points. Ask the class why the data points are all zero between midnight and 4 am. They should say it was night so there was no shadow. Ask the students what time sunrise occurs and how they know. It occurs at approximately 6 am because this is the first time a shadow was seen. Ask students if shadow length changes faster in the morning or closer to midday. They should respond that shadow length changes faster in the morning and evening and slower as it approaches midday. Ask students what time the sun was directly overhead. Students should notice that the shadow length is 0 at 1 pm, therefore, the sun must have been directly overhead at this time. Ask the students how many hours passed between the time that the sun rose and the time the sun was directly overhead. They should be able to determine that 7 hours passed. Ask the students how much time passed between the time the sun was directly overhead and the time the sun set. They should be able to determine that 7 hours passed. Tell them that this shows that the graph is symmetric. Ask the students how many hours of daylight are there during the summer. (14 hours)

<table>
<thead>
<tr>
<th>Time</th>
<th>Shadow Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 am</td>
<td>0</td>
</tr>
<tr>
<td>2:00 am</td>
<td>0</td>
</tr>
<tr>
<td>4:00 am</td>
<td>0</td>
</tr>
<tr>
<td>6:00 am</td>
<td>5</td>
</tr>
<tr>
<td>8:00 am</td>
<td>2</td>
</tr>
<tr>
<td>10:00 am</td>
<td>1</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>0.5</td>
</tr>
<tr>
<td>1:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>2:00 pm</td>
<td>0.5</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>1</td>
</tr>
<tr>
<td>6:00 pm</td>
<td>2</td>
</tr>
<tr>
<td>8:00 pm</td>
<td>5</td>
</tr>
<tr>
<td>10:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>0</td>
</tr>
</tbody>
</table>

***Teacher Note:*** The reason that the sun is not overhead at noon is because of daylight savings time. Do not bring this up with students unless they ask specifically about this. Daylight saving times shifts our clocks one hour later in the day.

Ask students if a graph of shadow length vs. time would be the same for all times of the year. (No). On problem 9 have students draw a red line to show their predictions of what a graph of shadow length vs. time would look like during the winter. Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have students give critiques of the graph. In addition, ask questions to help guide student thinking. Collect the red pens.

Tell students that they will now graph the actual data showing shadow length vs. time during the winter using their pencil. Show students the data table while reading it to them (page 11, picture packet, seen below on then left). In addition, plot the data points in the example notebook. Draw in a solid line connecting the points. Ask the students how many hours passed between the time that the sun rose and the time the sun was directly overhead. They should be able to determine that 5 hours passed. Ask the students how much time passed between the time the sun was directly overhead and the time the sun set. Tell them that this shows that the graph is symmetric. Ask the students how many hours of daylight are there during the winter (10 hours).
**Teacher Note**: Shadows are longer in the winter than in the summer because of the tilt of the Earth. During the summer the distance that the sun’s rays travel to reach the earth is slightly smaller (the light distance is smaller), making the shadow shorter. During the winter the distance the sun’s rays travel to reach the earth is slightly larger (the light distance is larger), making the shadow longer. See picture below which can be found on page 12 of the picture packet. Do not bring this up with students unless asked.

Ask students what conclusion they can make from the graphs about the number of daylight hours throughout the year. Have one student share with you what they think the conclusion will be and once a class consensus is reached record the conclusion in the group notebook and have students copy it into their notebook. Ask the class what part of the conclusion was the claim and how they know this. They should reply “the number of daylight hours in the summer is more than in the winter” is the claim because it is a statement that we can test. Ask the class what part of the conclusion is the data and how they know this. They should reply that “in the summer there were 14 hours of daylight and in the winter there were 10 hours of daylight” is the data because it contains measurements. If students are having trouble go back to the graphs and count the number of daylight hours in both graph with the students.

**How Shadow Length Varies in the Winter**

<table>
<thead>
<tr>
<th>Time</th>
<th>Shadow Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 am</td>
<td>0</td>
</tr>
<tr>
<td>2:00 am</td>
<td>0</td>
</tr>
<tr>
<td>4:00 am</td>
<td>0</td>
</tr>
<tr>
<td>6:00 am</td>
<td>0</td>
</tr>
<tr>
<td>7:00 am</td>
<td>5</td>
</tr>
<tr>
<td>8:00 am</td>
<td>2</td>
</tr>
<tr>
<td>10:00 am</td>
<td>0.5</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>2:00 pm</td>
<td>0.5</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>2</td>
</tr>
<tr>
<td>5:00 pm</td>
<td>5</td>
</tr>
<tr>
<td>6:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>8:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>10:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>0</td>
</tr>
</tbody>
</table>
Tell students that in the past, before there was electricity, people relied on the sun to determine what time of the day it was. One method of doing this was by using a sundial. Sundials are set so that their gnomons (piece that sticks up out of a sundial) point to the north. People who know and understand the properties of shadows can determine the time of day by looking at the shadow on the dial plate. Tell students to use the three sundials in their notebooks to determine what direction (east/west/directly above) the sun is coming from as well as what time of day it is (morning/noon/afternoon).

***Teacher Note:*** sundials are made for a specific latitude to account for the actual distance the sun is away from the location it is being used. If you know the latitude that your sundial is made for, you can make mathematical corrections to find the time for your latitude if the two are different. Additional corrections need to be made in areas where there is daylight savings time. Do not bring this up with students unless asked.

Tell the students that they have taught you a lot about shadows. You have learned that that the larger the light distance and the smaller the light height, the longer the shadow. You have also learned that the angle the light is coming from affects the angle the shadow will be relative to the block. You now know that knowing the properties of shadows can also allow you to tell time. Tell students that before you go you are going to give them a short assessment to find out what they learned during SciTrek.

**Content Assessment:**
(10 minutes – Full Class – SciTrek Lead):

Tell students to close their SciTrek notebooks and to place the notebook in the corner of their desk. Pass out the Content Assessment to the students. Tell students to put their name, teacher’s name, and date on the top of their paper. During the assessment, remind students to work by themselves. Read each of the content questions to the students and have them select/fill out the correct answer. When students are finished, collect the assessments and verify that they have written their name on the assessment.

Tell students that they can keep their SciTrek notebooks and that you have enjoyed working with and learning with them and that you hope they continue to see themselves as scientists and explore the world around them.

**Clean-Up:**

Get the lab coat from the teacher. Bring all materials back to UCSB.
Extra Practice Solutions:

**EXTRA PRACTICE**

**Conclusions**

Directions:
On the results table, circle each changing variable(s) and underline each constant and free information about data collection.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Block Height</td>
<td>5 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Block Shade</td>
<td>7 cm</td>
<td></td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td></td>
</tr>
<tr>
<td>Light Shade</td>
<td>25 cm</td>
<td></td>
</tr>
<tr>
<td>Shadow Length</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadow</td>
<td>7 cm</td>
<td>15 cm</td>
</tr>
</tbody>
</table>

Can this group make a claim/conclusion? Yes [ ] No [X] I Don’t Know [ ]

1. The shorter tool at a shorter length and the shorter block casts a shorter shadow length.
   - Correct [ ]  Correct [ ] Incorrect [ ]
2. The tool height does not affect the shadow length.
   - Correct [ ] Correct [ ] Incorrect [ ]
3. When the light height is 30 cm, the tool results in a longer shadow.
   - Correct [ ] Correct [ ] Incorrect [ ]
4. The distance affects the shadow length.
   - Correct [ ] Correct [ ] Incorrect [ ]
5. The tool height affects the shadow length.
   - Correct [ ] Correct [ ] Incorrect [ ]

What data can be used to support the correct claim(s) above?

When the block height was 50 cm, the shadow length was 7 cm and when the block height was 10 cm, the shadow length was 15 cm.