

Lesson Plan: Shadow Systems

By: Mandi de Witte

Adapted from the California Science Framework

Target Grade: 1st

Teacher Prep Time: 15-20 minutes

Lesson Time: 4½ hours (we recommend doing this lesson over 5 days, Monday through Friday)

- Day 1: 60 minutes total
 - 25 minutes in morning: 10 minute introductory discussion about the sun and 15 minutes to record shadow data
 - 10 minutes right before lunch: recording shadow data
 - 25 minutes in afternoon: recording shadow data and class discussion
- Days 2-4: 45 minutes each day
 - 10 minutes each morning and at lunch: recording shadow data
 - 25 minutes each afternoon: recording shadow data and class discussion
- Day 5: 60 minutes
 - Conclusion and Classroom Shadow Exploration

Lesson Overview:

Students will go outside to observe and record data about their shadows for four consecutive days in the morning, noon, and afternoon. Each day will conclude with a classroom discussion that asks students to analyze their data and identify patterns and trends in the movement of their shadows and the sun. By the end of the week, the concept of systems will be introduced and applied to the shadows they observe. On the last day, students will apply what they have learned from watching their own shadows to create their own shadow system in the classroom.

Learning Objectives:

- Students will be able to analyze the data collected about their shadows to identify patterns in the daily movement of the sun.
- Students will be able to use their data to determine the components of a system required to produce a shadow.

NGSS: 1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted.

- **Science and Engineering Practice**
 - #4 Analyzing and Interpreting Data
 - Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.
 - Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.
- **Disciplinary Core Idea**
 - ESS1.A: The Universe and its Stars
 - Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.

- **Cross Cutting Concepts**

- #4 Systems and System Models (primary CCC)
 - In grades K-2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.
- #1 Patterns (secondary CCC)
 - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

Where this lesson fits in:

This lesson sequence is a great introduction to the Earth's Place in the Universe standards for first grade. It would fit well as a hands-on activity early in the year, or as a connection to Groundhog Day in February. First grade also has several PS4 performance expectations related to light, so this lesson would be a good connection to, or transition from the physical science unit to Earth science unit, or vice versa. Sun is required, so try to plan for a sunny time of year depending on where you live.

Materials Needed: *students will work in pairs*

- 1 Compass (if you do not have one, most smartphones have an app pre-installed)
- Chalk (1 piece per pair)
- Clipboards (one per student)
- Flashlights (1 per pair)
- Small/tall objects for classroom shadow observation (toys, stuffed animals, misc. classroom objects that will create a shadow from a flashlight – 1 per pair)
- Large Piece of Construction Paper (12" x 18" works) (to make placemats - 1 per pair)
- 1 Sharpie

Teacher Prep:

- Students should work in assigned partners
- Find a paved location appropriate for students to draw the outlines of their shadows with chalk. Use a compass to identify North, and to draw a large compass rose onto the ground in front of where students will line up. Students should face North.
- Copies: 1 shadow journal packet per student
- Print the vocabulary cards and sun photo in color and cut. If planning to use in the future, consider printing on cardstock and/or laminating.
- Make classroom shadow "placemats" by writing N,E,S,W onto large construction paper.

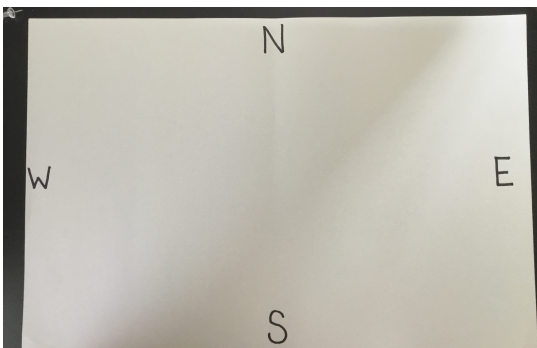


Figure 1: example placemat

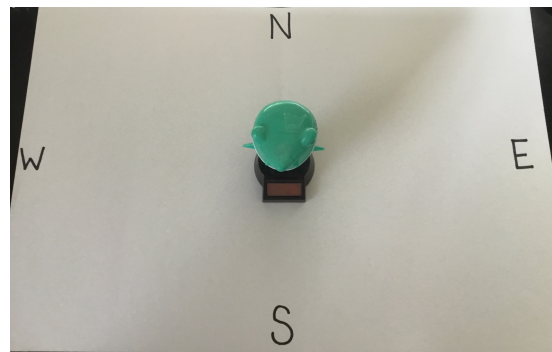
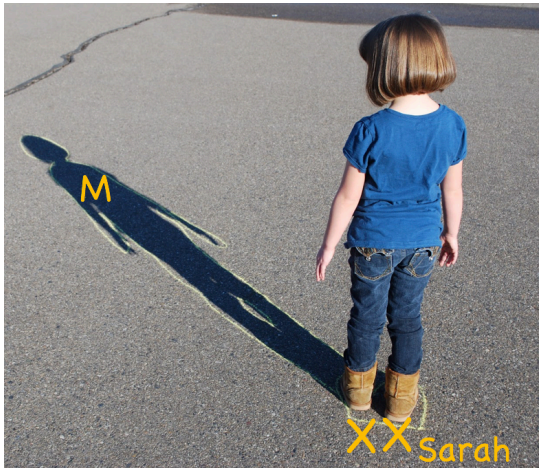


Figure 2: example placemat with toy to create shadow system

Lesson Sequence:

<p>Day 1 10 minutes in morning</p>	<p>Introductory Discussion about the Sun</p> <ol style="list-style-type: none">1. Bring students close together and hold up or project the picture of the sun. Tell them that we will be doing an activity to help us learn about the sun this week.2. Ask students to raise their hands to share what they know about the sun and record their answers on chart paper or a paper under the document camera, using the following cues as a guide:<ul style="list-style-type: none">○ Teacher (T): “What do we know about the sun?”○ Expected Student Response (ESR):<ul style="list-style-type: none">▪ “The sun is in the sky.”▪ “The sun gives us light to see.”▪ “The sun goes up and down.”○ T: “Should we ever look directly at the sun?”○ ESR:<ul style="list-style-type: none">▪ “No!”▪ “No, the sun can burn your eyes.”○ T: “Good job, we should not ever look directly at the sun because it can damage our eyes. What is something else we can look at to help us learn about the sun without directly looking at it? Talk to an elbow partner.” Provide 30 seconds to 1 minute for students to talk before calling on a student at random. You may need to circulate while students talk and ask them questions to guide their thinking. (see below)○ ESR:<ul style="list-style-type: none">▪ “We can look at how bright or dark it is outside.”▪ “Sometimes the sun makes shadows on the ground.”○ T: “Yes! Shadows are an excellent way to learn about the sun. In fact, we are going to watch our shadows all week to see what we can learn!” <p>Guiding Questions: If students do not come up with the idea of shadows on their own, here are suggested guiding questions to prompt their thinking: “When it is sunny outside, what can you sometimes see on the ground?” “Can we learn about the sun by looking at the ground? How?”</p>
<p>Day 1 15 minutes in morning</p>	<p>First Shadow Measurement – <i>the first time will take longest, and get easier with each measurement</i></p> <ol style="list-style-type: none">1. While students are still seated inside, explain that they will collect information about their shadows this week to see what they can learn about the sun.2. Pass out a shadow journal to each student with a clipboard.3. Using the document camera to model, fill in the top together with the date and time. Explain that they will go outside and work in partners to draw their shadow with chalk on the ground. After drawing their shadow on the ground, they will record the direction, length, and darkness of their shadow and draw a picture of it. Explain that for the direction of the sun, we will circle the direction on the compass rose on the paper. Explain what the compass rose abbreviations are to students. It may be helpful to draw a large compass rose onto the board and leave it up for the week for continued reference. Explain that the “XX” on the paper will represent their feet.4. Excuse students to line up in pre-determined partners by the door with their clipboards.

	<ul style="list-style-type: none"> ○ T: "Alyson and José, line up side by side at the door. Next, Alex and Sarah." <ol style="list-style-type: none"> 5. Once students are lined up at the door, explain that you will walk to a special spot where we will mark our shadows for the next 4 days. Bring the container of chalk, but do not give to students yet. 6. Walk to the spot, and have students line up horizontally next to their partners facing North. Leave a few feet of space in between each student so that their shadow outlines do not overlap. Point out the compass rose you drew onto the ground, and review the abbreviations. 7. Choose one student to use as a model and ask students to watch. Explain that you have to stand in the exact same spot, and we will remember where we stand by having our partner marking right behind each foot with a big X and our name. Then our partner will carefully mark the outline of our shadow. Inside the shadow, write an "M" for morning. Do this procedure with the model student. 8. Pass out chalk and tell students they can set down their clipboards for now. For this first measurement, have all of the students work on each step at the same time. Give the direction: "Partner A stand still in your spot, and partner B mark their feet! Now write their name behind their feet. Now mark their shadow. Don't forget to write an M for morning in their shadow!" Repeat directions for Partner B. 9. After both partners have drawn their shadow outlines, remind students that after marking their shadow outlines, they should write down the direction, length, and darkness of the shadow in their journal and draw a picture. Give time to record this information. 10. Explain that we will come back outside right before lunch and at the end of the school day to record our shadows again and see if there are any changes. Collect the chalk, remind students to bring clipboards with them, and head back inside.
<p>Day 1 10 minutes right before lunch</p>	<p>Lunch Measurement</p> <ol style="list-style-type: none"> 1. Pass back the shadow journals on clipboards. Write down the time. Explain that we will stay with our same partners and return to our shadow spot outside to look at our shadows again. 2. Once outside, choose a student to model standing in front of the X's made that morning so that their measurements are consistent. Students will be surprised that their shadows have changed! Repeat the procedure of modeling tracing the shadow, but this time, write a big "L" for lunch time. 3. Pass out chalk and tell students they can set down their clipboards for now. Have all of the students work on each step at the same time. Give the direction: "Partner A stand still in your spot, and partner B mark their feet! Now write their name behind their feet. Now mark their shadow. Don't forget to write an L for lunch in their shadow!" Repeat directions for Partner B.



	<ol style="list-style-type: none"> 4. After both partners have drawn their shadow outlines, remind students that after marking their shadow outlines, they should write down the direction, length, and darkness of the shadow in their journal and draw a picture. Give time to record this information. 5. Explain that we will come back outside at the end of the school day to record our shadows again and see if there are any changes. Collect the chalk, remind students to bring clipboards with them, and head back inside.
<p>Day 1 ~10 Minutes in afternoon</p>	<p>Afternoon Measurement</p> <ol style="list-style-type: none"> 1. Repeat the procedure for the morning and lunch measurement, but this time using an “A” for afternoon in the shadow outline. Students should be getting better and faster at knowing what to do by this third time.
<p>Day 1 15 minutes in afternoon</p>	<p>Afternoon Shadow Talk: Analyze and Data</p> <ol style="list-style-type: none"> 1. Gather all students close. Hold up the Data vocabulary card and read it aloud to students, then do choral repeat. <ul style="list-style-type: none"> • T: “Talk to your elbow partner. What data did we collect today?” provide about 30 seconds for students to talk before calling on a random student. • ESR: <ul style="list-style-type: none"> • “We drew our shadows on the ground!” • “We looked at the direction of our shadow.” • “Our shadows were dark!” • “We wrote down how long our shadows were.” • T: “That’s right! We looked at and recorded the direction, length, and darkness of our shadows and drew a picture. This is our data! Whenever scientists try to figure out a problem, they collect data just like we are. When scientists collect data, they also analyze it to make sense of it. Let’s learn the word analyze.” Hold up analyze vocabulary card and read it aloud to students, then do choral repeat. • T: “Let’s practice analyzing our data. What happened to your shadows from morning to afternoon? Talk to your elbow partner.” Give 30 seconds for students to talk before calling on a random student. Ask students clarifying questions as needed after they respond. • ESR: <ul style="list-style-type: none"> • “Our shadows moved during the day even though we stayed on the same spot.” (direction) • “The shadow was long, then got shorter, then got long again.” (length) • “Our shadows were dark the whole time.” (darkness) • After giving them this chance to organically describe what happened, display the class data sheet. Ask the whole class the help you fill in out together. See key for expected results. • Wrap up the conversation by reminding them that what they just did was analyzing data, and that they will collect more data tomorrow to see if their shadows change or stay the same.

<p>Days 2-4 ~ 10 minutes each time</p>	<p>Measuring Shadows</p> <ol style="list-style-type: none"> 1. Repeat the same measurement procedure for morning, lunch, and afternoon for Days 2-4. On Day 3 students will add the sun to their pictures, so take a moment to explain this before heading out to record data before the morning measurement and remind them to just look for the general location of the sun – and NOT to look directly at it! 2. At the end of each afternoon measurement, the teacher will gather the students and lead them through a “shadow talk” focusing on something different each day:
<p>Day 2 15 minutes</p>	<p>Day 2 Afternoon Shadow Talk: Pattern and Trend</p> <ol style="list-style-type: none"> 1. Gather students close and use the vocabulary word cards to review the words data and analyze from yesterday using choral repeat. Tell students we will analyze the new data we collected today and compare it to yesterday. 2. Pull out the class data chart and ask the whole class to help you fill it out together for Day 2. 3. Introduce the word pattern with the vocabulary card and choral repeat. Ask students <ul style="list-style-type: none"> • T: “From our class data both yesterday and today, do you notice any patterns in our data?” • ESR: <ul style="list-style-type: none"> • “On both days the shadow started long, got shorter, then longer again.” • “Yesterday the shadow started on the west and ended on the east, and then today it started on the west and ended on the east again.” <i>(it may be helpful to draw a large compass on the board and practice North, East, South, and West during this lesson if students are struggling to use these directional vocabulary words)</i> 4. Introduce the word trend with the vocabulary card and choral repeat. Ask students <ul style="list-style-type: none"> • T: “From our data both yesterday and today, do you notice any trends in our data?” Add their responses to the chart from yesterday. <ul style="list-style-type: none"> • “On both days the shadow moved from this side (west) to this side (east)” <p>Note: the difference between patterns and trends is subtle, and if students mix them up at the first grade stage that is ok, but it is still helpful to introduce them at this early stage of analyzing data.</p> 5. Wrap up the conversation by reminding students what they just did was analyzing data by looking for patterns and trends in show their shadows were changing. Tell students that tomorrow they will look for one more piece of data to discuss: where the sun is in the sky relative to where they are standing. They will add this to their pictures when they measure their shadows tomorrow.

Day 3
20 minutes

Day 3 Afternoon Shadow Talk: Sun Location and Prediction

1. Gather students close and use the vocabulary word cards to review the words **data**, **analyze**, **pattern**, and **trend** from yesterday using choral repeat. Tell students we will analyze the new data we collected today and compare it to the last two days.
 2. Pull out the class data sheet and fill it out for the shadow data only.
 - T: "Were the patterns and trends in the data today the same or different as Day 1 and 2?" Prompt about each data point.
 - ESR:
 - "Yes they were the same!"
 - "Yes, the shadow still moved from west to east."
 - "Yes, the shadow still stayed dark every time."
 3. Remind students that today they also recorded where the sun was. Draw a picture with XX on the board similar to the one on their journals. Ask students to talk to their elbow partner about where the sun was in the morning, lunch, and afternoon. Pull out the large picture of the sun, and call on a student to tape it to the board where it was during the morning. Confirm with the class. Then repeat for lunch and afternoon. See photos for an example. Ask students to talk with their elbow partners before calling on a random student:
 - T: "What **trend** do you see in the movement of the sun?"
 - ESR:
 - "The sun moved from East to West!"
 - T: "How does the movement of the sun compare to the movement of the shadow?"
 - ESR:
 - "They moved opposite."
 - "When the sun was in the East the shadow was in the West."
- Note: this may take prompting and help through pointing to the compass rose drawn on the board, to the pictures themselves, and allowing students to walk forward and point to the pictures.
4. After helping students to recognize this relationship between the location of the sun and shadow, add the location of the sun to the class data sheet. This will make it even more visible that the sun and shadows moved in opposite directions.
 5. Introduce the word **prediction** with the vocabulary card and choral repeat. Ask students to turn to an elbow partner and **predict** what will happen when we measure our shadows tomorrow. Most students will realize that the following day the data will be the same. After they talk to their partners about their predictions, ask students
 - T: "Why did you make this prediction?"
 - ESR:

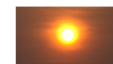
Morning



Lunch



Afternoon



	<ul style="list-style-type: none"> • “Because three days in a row the same thing happened, so it will probably happen again tomorrow.” • “If you look at our class data sheet it was the same for Days 1, 2, and 3.” <p>• T: “When things happen over and over again, remember this is called a pattern which makes it easier for us to predict what will happen. Let’s see if the same pattern and trends happen tomorrow!”</p>
<p>Day 4 15 minutes</p>	<p>Day 4 Afternoon Shadow Talk: Systems</p> <ol style="list-style-type: none"> 1. Gather students close and use the vocabulary word cards to review the words data, analyze, pattern, trend, and prediction from yesterday using choral repeat. Tell students we will analyze the new data we collected today and compare it to Days 1,2 and 3. 2. Pull out the class data sheet and ask the class to help you fill it out for Day 4. 3. Remind students that yesterday they made a prediction about what would happen. Have them quickly share with their elbow partners how their predictions turned out. <ul style="list-style-type: none"> • T: “If your prediction turned out the way you thought it would, why?” • ESR: <ul style="list-style-type: none"> • “Since the same thing happened Days 1,2,3 then it made sense to happen on Day 4.” • T: “When scientists carefully analyze data and look for patterns and trends, they can usually make pretty good predictions about what will happen!” 4. Introduce the word system by reading the word card with choral repeat. Explain that the picture of the bike on the word card is a good example of a system, because all of the parts must work together to make the bike move. If needed, you can ask students to identify parts of the bike that work together. (wheels, chain, seat, etc.) <ul style="list-style-type: none"> • T: “Shadows are part of a system. When we measured our shadows outside, what were the parts of the system that were needed to make the shadow?” Give students time to talk with an elbow partner before calling on a random student. • ESR: <ul style="list-style-type: none"> • “We had to stand on the ground and the shadow showed up of our body on the ground.” (person) (ground) • “The sun had to be there to make the light for the shadow!” (sun) • “The shadow was part of the system!” (shadow) 5. As students share out their ideas, write down the parts that make up the system onto the board: <u>OUTSIDE SHADOW SYSTEM:</u> <ul style="list-style-type: none"> - sun - person - ground -shadow 6. Wrap up the conversation by what they just did was analyzing data to determine the parts of a system. Tell students that tomorrow they will see if they can re-create their outside shadow systems inside the classroom!

Day 5

60 minutes

Classroom Shadow Systems

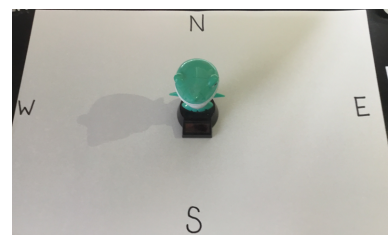
1. Gather students close and use the vocabulary word cards to review the words **data, analyze, pattern, trend, prediction, and system** from all four days using choral repeat.
2. Pass out the shadow journals and ask students to turn to the last page. Tell students that today instead of going outside, we will stay inside to see if we can recreate our shadow systems! Ask students to share out the parts of the outside shadow system to review. (sun, person, ground, shadow)
 - T: "What could we use to explore classroom shadows?" give time for students to talk with elbow partner, then call on students randomly
 - ESR:
 - "We can use the projector to make shadows with our hands!"
 - "We can turn off the lights and use a flashlight!"

If needed, guide students with asking if there are other things besides the sun that make shadows.

3. Tell students they will work with their same partner as outside. Each pair will get a flashlight and a toy. Tell students they are to use this toy as a mini version of their body, like outside – not to play with. Tell the students that they will try to make the same shadows as we saw outside for morning, lunch, and afternoon. Display the worksheet page or write onto the board the prompt "When I _____ it causes _____." Explain to students that you want them to think about what happens when they move the flashlight in different ways.
4. Turn off the lights, pass out the flashlights and toys, and provide students with at least 5-10 minutes just to explore. As you walk around, encourage students to:
 - Shine the light on their toy from very close and very far away (even from across the room!)
 - Shine their light from right above their toy, and even from far above their toy!
5. After 5-10 minutes of exploring time, gather their attention and remind them they will try to recreate their systems from outside. Tell them you've made them a placemat with North, South, East, and West labeled that they can use to recreate their outside shadow system. Tell them to make the flashlight like the sun and the toy like them and place the toy into the center of the placemat. (pass out placemats) Point out the 4th question on their worksheet, and ask them to think and share "To model _____, I need to move the flashlight _____."



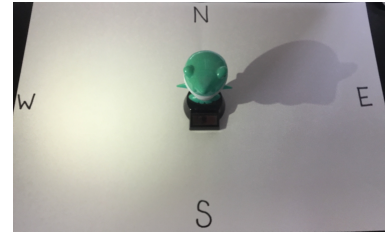
6. Continue to circulate and check in with pairs. Students should move the light from right to left, which mimics how the sun moves from East to West in the sky. They should notice how this projects a shadow in the opposite direction, and that as they move the flashlight from right to left, the shadow moves left to right. They might need a lot of support and guidance to be able to get to this point, so be sure to walk about the room checking in with each pair.
 - T: "When you hold the light here (on the right) what time of day is it like?"
 - ESR: "Morning"
 - T "Now let's try the prompt." – point to prompt



- ESR: “To model morning time, I need to move the flashlight towards the East and kind of low.”
- ESR: “To model lunch time, I need to move the flashlight towards the South and higher up above the toy”
- ESR: “When I move the light to the left side, it causes a shadow on the right side.”

7. After you have checked in with each group, collect all of the supplies and gather everyone at the front once more. Pull out the class data sheet for comparison.

8. Place a toy on a table in front of the front wall so that the shadow will project onto the wall. Ask a student volunteer to be the sun. Ask them to shine the light so that it makes the same shadow as in the morning time. Ask students



- T: “Where does s/he have to stand in order to make the morning shadow? Does that match our class data?”
- ESR: “Yes, when the sun was on that side (East) it made the shadow in the opposite way (West.)”

Call on a different volunteer to be the sun.

- T: “Where does s/he have to stand in order to make the lunch shadow? Does that match our class data?”
- ESR: “Yes, when the sun was straight up our shadows went straight out.”
- T: “What else was different about the shadow at lunch time?”
- ESR: “The shadow was shorter” (remind them to look at data if needed)
- T: “How can we make the shadow shorter with our flashlight?”
- ESR: “We have to hold it higher up above the toy.”
- T: “How does that compare to how the sun was in the sky?”
- ESR: “At lunch time the sun was higher in the sky than in the morning.”

Call on a different volunteer to be the sun, and repeat similar questioning to model the shadow system for the afternoon.

9. Remind students that outside the parts of their shadow system were the sun, person, ground, and shadow. Ask them, what were the parts of their classroom shadow system?

- ESR: flashlight (sun), toy (person), floor/wall (ground), shadow

10. Tell students that it is now their job to draw their classroom shadow system on their paper. Express that since all parts of a system are important and essential to making the shadow, each part of the system must be present.

11. Allow students about 10-15 minutes to draw their systems, walking around to help as needed.


Extension Idea: Teachers can work with the afterschool program or parents to take shadow measurements after school as well, and ask students to share what they learned in class or have an adult take their photo to share.

Example Student Work:

My Shadow Journal Name: _____

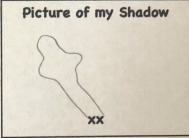
Day 1: Monday the 3 of October, 2018

Time One 8:20


Shadow Direction: 

Shadow Length: short medium long

Shadow Darkness: light dark

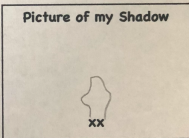
Picture of my Shadow 

Time Two 11:50


Shadow Direction: 

Shadow Length: short medium long

Shadow Darkness: light dark

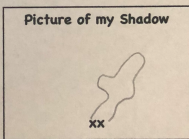
Picture of my Shadow 

Time Three 2:10

Shadow Direction: 

Shadow Length: short medium long


Shadow Darkness: light dark

Picture of my Shadow 

1 1st Grade Shadow Systems, M. de Witte, 2018. SCSF

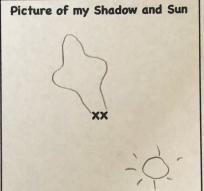
Day 3: Wednesday the 5 of October, 2018

Time One 8:15


Shadow Direction: 

Shadow Length: short medium long

Shadow Darkness: light dark

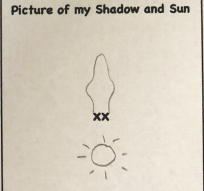
Picture of my Shadow and Sun 

Time Two 11:50


Shadow Direction: 

Shadow Length: short medium long

Shadow Darkness: light dark

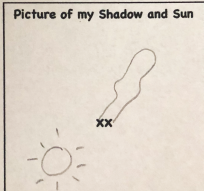
Picture of my Shadow and Sun 

Time Three 2:10

Shadow Direction: 

Shadow Length: short medium long


Shadow Darkness: light dark

Picture of my Shadow and Sun 

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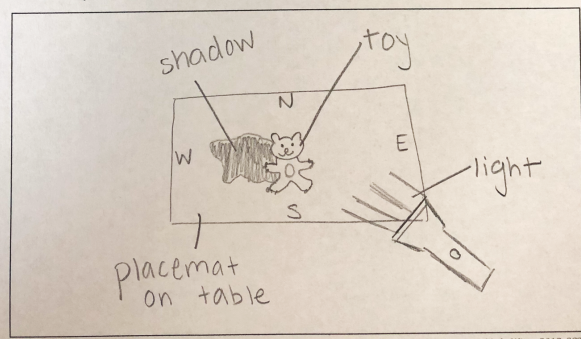
* Students do not need to write responses, just talk

Exploring Classroom Shadows

Talk Symbol 

- What parts make up the outside shadow system we explored? sun, person, ground, shadow
- What could you use to explore classroom shadows? flashlight, toy, surface, shadow
- As you play with classroom shadows, think and share:
shine the light from up high
it causes the shadow to be smaller/shorter.
- With your placemat, try to make the same shadows we saw outside for morning, lunch time, and afternoon. Think and share:
To model morning, I need to move the flashlight low and to the East.
time of day flashlight location

Draw and label picture of your classroom shadow system, showing all of the important parts that make your shadow:



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