Me and My Shadow

Purpose

In this Thread, we will become familiar with the orientation of shadows, their size in relation to the object casting them, and how the alignment of the Sun, the object, and the shadow tells us much about how shadows work. The National Science Education Standards stress that geometry and light should be integrated into curricula as tools for learning about three dimensional objects. Vocabulary words which can be used to help talk about our experiences are alignment, casting, angle, and light source.

Teacher Background

You will need: enough pebbles, coins, marbles or counting blocks for the entire class, a box of chalk, chalk/wipe board and markers, overhead projector or lamp.

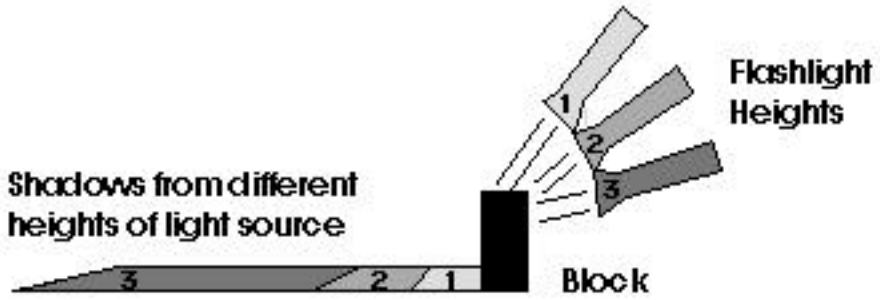
This requires one class session outside in the sunlight. Another class session or two inside is enough time to really think about our outdoor experiences. Materials gathering is quite minimal.

The height of a tilted light source (in other words, the angle between the light source and the ground) and the size of the object it is illuminating determine the length of the shadow that the object casts. The object blocks the light coming from the source so that nothing behind the object gets any direct light. The length of the shadow is a result of how high above or below the top of the object the light source is. Imagine if the light source were directly above the top of the object. Would there be a shadow? No, not one that would be visible around the object. Twist the light source a little down from the top, and a shadow appears behind the object, but is very short. This is because as the light source moves down, the shadow is being created by the small area of the object blocking the light. Imagine straight lines coming down from the light and hitting the object. The higher the light, the less light lines get blocked by the object and hence the less shadow. Thus, the lower the light source is

aimed at the object, the more the object blocks the lines, or rays, of light.

The key to understanding shadows is to realize that the light source and object must be lined up in order to make a shadow appear. In fact, if the object is placed anywhere along that line, it will produce a shadow of the same length. It is only when you change the orientation of light that the shadow changes its length.

Shadow basics make good sense in this order: light hits an object and casts a shadow behind the object. But experiencing the connection of light/object/shadow under different circumstances is good for rooting our experiences more firmly. This Thread will ask students to predict where to put an object to cast a shadow along a certain line towards a target area, i.e. experiencing *backwards*, in a sense, the circumstances under which they make a shadow .



"Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills."

—National Science Education Standards

Kindergarten through Second Grade

Developmental Issues

This Thread invites Kindergartners through second graders to continue to think about light and shadow while using their bodies to make observations. This roots our experiences by relating them to ourselves, which is fitting for this age group. It engages students in manipulating objects with a focus in mind as well as exercising balance and movement skills which are good for this age group. Teachers of second graders should consider using the grade 2-4 version of this Thread.

Inquiry Introduction

Remember the game Sun/Blocker/Shadow? Why does it work? What other game could we devise to play with the way light works? Everyone grab a marble or cube. (Don't call the cubes "blocks" or it will confuse the game.)

Inquiry Investigation

Together, let's go outside and find a place to spread out on an area of asphalt or concrete, etc. Where are our shadows? Can everyone find his or her own shadow? Where is it? Is everyone's shadow visible? Can the teacher come and step on someone's shadow? Does it hurt to step on a shadow? How far away from the person is the teacher who is stepping on the shadow? Is it hard to reach the person from where the teacher is standing? Why are shadows so far away from their makers?

Play Shadow Tag again, this time with some questions afterward. Was it hard to play this game? We had to be careful to watch our shadows and the person who was "It" very carefully. When was it hardest to be careful: when running towards the Sun or away from it? Why? How are shadows made, then?

Now it is time to reverse our thinking. Everyone, drop your cube somewhere. Where is your shadow? Can you move your shadow so that the shadow of your hand can cover the little cube on the ground? This will at first seem quite difficult, but soon they will begin to cry out that they have done it. Helping is definitely OK.

How did you knew where to put your fingers? They will begin to vocalize in their own ways an important fact: that the sunlight is in straight lines to their hands and they need only line themselves up with the Sun and the cube to cast a shadow on it. In this way, they have figured out that one can determine the position of the light source from the angle of a shadow they can cast.

Can anyone think of a way to play this game in the classroom?

> "Somewhere, something incredible is waiting to be known."
>
> —Carl Sagan

> "A vision's just a vision if it's only in your head. If no one gets to hear it, it's as good as dead. It has to come to life!"
>
> —Stephen Sondheim, *Sunday in the Park with George*

> "Individuals internalize their experience in a way which is at least partially their own; they construct their own meanings. These personal 'ideas' influence the manner in which information is acquired. This personal manner of approaching phenomenon is also found in the way in which scientific knowledge is generated. Most philosophers of science accept that hypotheses or theories do not represent so-called 'objective' data but that they are constructions or products of the human imagination. In this way of thinking, observations of events are influenced by the theoretical frameworks of the observer. The observations children make and their interpretations of them are also influenced by their ideas and expectations."
>
> —Rosalind Driver, *Children's Ideas in Science*

Second Grade through Fourth Grade

Developmental Issues

This Thread will examine the orientation of the Sun, ourselves, and shadows from the reverse way around. It will seem like a tricky game, but once the idea of the linear nature of light travel is experienced, we can talk more about light in the next Thread. To do so, again we will exploit this age group's fascination with mystery, team learning, and the ability to string two or more variables together into a model. Second grade teachers should consider choosing this version of the Thread over the version intended for younger (K-2) students.

Inquiry Introduction

What has to happen before we can see a shadow of ourselves? There must be light. There is light and us, but there is something else we need to actually see the shadow. We need something for the shadow to land on. So, three things are required for shadows: a light, an object, and a surface. Is there any guideline for where the shadow should land when we are standing in the light? Does it matter where we put the light? What about in outer space?

Inquiry Investigation

Everyone should grab one small shiny object like a new penny or an interlocking math cube, a pink eraser or a marble. Let's go outside. Find an asphalt or concrete area with a lot of space, so that the entire class can spread out and be in sunlight. Is there enough room for their shadows? You might consider timing this for between 11 a.m. and 1 p.m., when the shadows are shorter but not so short as to make this impossible.

Everyone should spread out enough that they can twirl in place and not hit anyone. Next, everyone should drop their shiny object somewhere about 4-5 feet from them in any direction. Now find your own shadows and stick your arms out. Make an OK sign with your fingers, so that your shadows show a little ring or circle for your hands. Can you, without squatting, move your shadow ring so that it encircles the shiny object on the ground?

They will mock this as easy at first, until they find it is very difficult. There is some kind of trick to doing this, and it will be fun watching them catch on. What has to happen before the shadow can line up with the object? What else is needed to make a shadow besides the surface and the thing making the shadow? The Sun. See how many can incorporate this into their struggle. There has to be an alignment of the three crucial items needed in making a shadow happen.

Soon, (it takes about 3-4 minutes), they will begin crying out that they have figured it out, one by one. Ask them what they did, and they will try to explain they made things line up or they looked back to where the Sun was. It is the lining up of these objects which is so crucial to learning about how light and shadows work. If someone has managed to ring the object by luck, ask about the positions of the things needed to make a shadow. Is there any pattern? Can we shuffle from side to side and still make the shadow happen on the object? Can we shuffle forward and backward and still make the shadow happen on the object? How? Where must the Sun be in order for this to work? Directly behind our hand. Where must the object be in order for this to work? Directly in front of our hand.

Where is the Sun? Where is our shadow? Have them face the Sun. Where is our shadow? Turn to the left. Where is the Sun? Where is our shadow? Is there a pattern here? What if the Sun were over there (point to the left)? Where would our shadows be? What is true then about shadows and the Sun? Shadows point away from the Sun. Do shadows point away from a lamp as well? We can play with this back in the classroom.

They will want to play more with this trick once they all have caught on. You can ask them if they can get two people to circle the object at once from different positions. Break into teams of shadow makers. Can anyone make other shapes with your body to circle the object? Does everyone have to stand at the same distance from the object to ring it? How many people can you line up who are casting a shadow around the object but are standing apart from each other?

Back in the classroom, let's pool what we've seen. We saw that we had to line our hand up with the Sun to make a shadow, but we also had to line that shadow up with the shiny object. We had to move our entire bodies so that the Sun was at our back to get the OK sign over the object. We found that we could also move towards it and away from it and still keep the OK ring around the object by moving our hand only slightly.

Draw on the board a Sun, a person with her hand out, and the object, but do not line them up in the proper was for the person's shadow to hit the object. Will this person's shadow hit the object? Why or why not? Students should gather in the same teams that they were in outside. They should think about the question on the board and then come up with

an answer. Ask the teams in turn what they think. They will hopefully mostly say no, this cannot happen. Why not? They will talk about things not being lined up. You could prod them more by asking if they mean you can't draw a straight line which connects them all. Draw a line that connects the three items, first asking what the order is. Sun, object, shadow....It should be a terrible angle whose sides do not make a 180° angle. Where would I need to put the person to make the line straight? Teams can confer and answer you in rotation. Have them come up to the board and place an X where they think the person's hand should be. Different colored chalk would work well for different teams, otherwise numbers will suffice. Does everyone agree? If not, more examples like this could be done.

Is this what we experienced outside? We had to line up everything to make it work! Why? What must be true about sunlight or any other light source? It travels in straight lines.

"When long shadows fall
And dwarf the trees at evening
When white winter light
Burnishes the trees,
Then I will bring you a coat
Of soft lamb's wool,
To keep your back from
The keen northern wind."

—Maddy Prior, *Long Shadows*

"People always say that it's the simple ideas that are truly the ingenious ones, because millions of others have already overlooked them. Take off the blinders and never think that an idea is crazy. If one idea doesn't work, don't get discouraged. Get back up and start again. If people call your idea crazy, it's probably because they don't understand it, or because they're jealous that they didn't think of it first."

—Karen Schlangen

Fourth Grade through Sixth Grade

Developmental Issues

For this age group, this Thread involves a quick investigation outside to exercise our powers of perception. Although this is probably a little easy for them, it is still a good idea for them to be familiar with every aspect of the shadow making process.

Inquiry Introduction

What makes a shadow? Most will know that shadows are caused by the Sun or other light hitting an object and blocking the path of light behind the object. This is easy, right? You can make a shadow fairly easily and determine where the light source is from just looking carefully at a shadow. But can you aim a shadow at an object? Huh?

Inquiry Investigation

Everyone should grab one small shiny object like a new penny, interlocking math cube, a pink eraser or a marble. Let's go outside. Find an area of asphalt or concrete with a lot of space, enough that the entire class can spread out and be bathed in sunlight. Is there enough room for their shadows? (You might consider timing this for 11 a.m. or 1 p.m., when the shadows are shorter.)

Everyone should spread out enough that they can twirl in place and not hit anyone. Next, everyone should drop their shiny object somewhere about 4-5 feet from them in any direction.Now find your own shadows. Make an OK sign with your fingers, so that your shadows show a little ring or circle for your hands. Can you, without squatting, move your shadow ring so that it encircles the shiny object on the ground?

They will mock this as easy at first, until they find it is difficult. There is a trick to doing this, and it will be fun watching them catch on. What has to happen before the shadow can line up with the object? What else is needed to make a shadow besides the surface (shiny object) and the thing making the shadow? The Sun. See how many can incorporate this into their struggle. There has to be an alignment of the three crucial items needed in making a shadow happen.

Soon, (it takes about 1-2 minutes), they will begin calling out that they have figured it out, one by one. Ask them what they did, and they will try to explain they made things line up or they looked back to where the Sun was. It is the lining up of these objects which is so crucial to learning about how light and shadows work. If someone has managed to ring the object by luck, ask about the positions of the things needed to make a shadow. Is there any pattern? Can we shuffle from side to side and still make the shadow happen on the object? Can we shuffle forward and backward and still make the shadow happen on the object? How? Where must the Sun be in order for this to work? Directly behind our hand. Where must the object be in order for this to work? Directly in front of our hand.

> Today, all sciences are based on actual experiments, although much of the application of scientific facts is still a matter of theory. The fact, however, that we strongly believe in a theory is no proof of it, and this should always be kept in mind.
>
> — Pulvermacher and Vosburgh, *The World About Us*

Pourquoi Tales

Pourquoi tales are ancient stories which explain why something has happened. Here are a few modern Pourquoi tales written by third graders whose teacher integrated the ancient tales into her Threads of Inquiry curriculum.

•Why we have Clouds in the Sky

Once upon a time, about six million years ago, there was a boy, six years old, named Duran. He lived in India. One day, he was digging in his yard when he felt something cold and wet. "A stream!" he said. Then Duran had a mischievous idea. "Oh, Dulran," he said in a sing-song voice. Dulran, Duran's identical twin brother, came outside. "What do you want?" asked Dulran. Duran told Dulran to fetch his pea shooter. Dulran got it for Duran. Duran sucked up the water from the stream and shot it out of the pea shooter, aiming straight for Dulran. Dulran ducked, so the water went up into the sky. That is why we now have clouds in the sky.

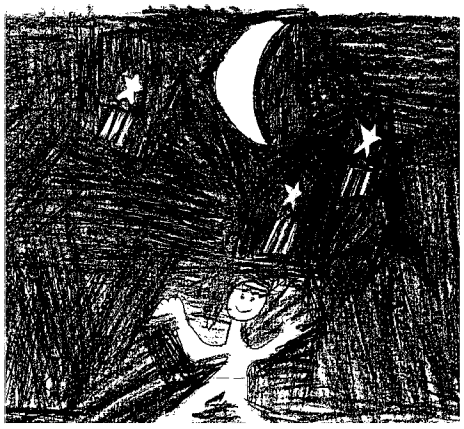
•Why the Clouds Are in the Sky

Once there was a bunch of kids who were in camp. There were around a camp fire. They were roasting marshmallows on the camp fire. They were having fun, but all of a sudden the fire blew up. And the marshmallows blew up into the sky. And that is why we have clouds in the sky.

•How the Moon Got in the Sky

There once was a lazy moon. He lay about and did no work. So the people tried to put him in the sky. They got a helicopter and got the lazy moon from the tree. They put him on a platform in the sky. There he stayed for ever and ever until the moon comes down and starts all over again. Now the lazy moon has to work all the time lighting up the night sky. The best punishment. OY!

•How the Moon and the Stars Were Made



Long ago there was a little boy called Flying Eagle who worked a lot but he lived in the small little wigwam. When he was digging for water he found something shiny. It was gold. He dug more. He found more and more. When he was eating a banana, he thought of making bananas out of gold. He made a golden banana and threw the golden banana up and up. That is how the moon was made. But some gold was left, so he threw the gold up to the sky and that is how the stars were made.