The Sun Moves in the Sky

Enlarged panoramic photo of the school's southern horizon mounted in the class. The photo is used three times a year on dates near the autumnal equinox (Sept. 22), winter solstice (Dec. 21) and spring or vernal equinox (Mar. 22).

Grade Level: 3rd grade (2nd grade-6th grade)

Time Required: **Part 1:** 40 minutes intro lesson inside and **Part 2**: 50 minutes lesson outside with 15 minutes every hour for small group recording.

Group Size: Whole class and small group recording teams

Summary: The class record observations of the Sun's apparent motion or path through the daytime sky from East to West. This activity of tracking the Sun's path along the Southern horizon should be repeated 3 times a year during three different seasons.

Keywords/ Vocabulary:

Horizon: the line where the sky and the Earth appear to meet

East, West, North, South: the four cardinal directions on the compass

Semi-circle: the shape of half a circle

Altitude: elevation above the horizontal, describes a direction

Landmark: An identifiable, readily visible object in a landscape, used as a reference point for describing other locations.

Educational Standards:

- Science:

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  - Objective 3.01 Observe that light travels in a straight line until it strikes and object and is reflected and or/absorbed.
  - Objective 3.02 Observe that objects in the sky have patterns of movement including: Sun, Moon, Stars.
  - Objective 3.03 Using shadows, follow and record the apparent movement of the Sun in the sky during the day.
- Math:
  - Objective 3.01 Use the appropriate vocabulary to compare, describe, classify two and three-dimensional figures.

Pre-Req Knowledge:

Students discuss, write and illustrate their understanding of any patterns they've noticed in the Sun's path in the sky prior to this activity.

Any interpretation of why the Sun appears to move across the sky and prior knowledge of East, West, North and South is **not necessary and doesn't need to be explained by the teacher before, during or after this activity.**

Learning Objectives

After this activity, students should be able to:

- Describe the shape of the Sun's path throughout the day.
- Describe the Sun's movement and its relation to other objects each hour.
- Use landmarks to record and make predictions of the Sun's changing positions.
- Compare the class' Sun's path observations and recording during each season.
- Understand that the Sun rises in the East and sets in the West.
- Predict where the Sun is before they arrive at and after they leave school.

Materials List

Teacher needs:

- Digital camera to produce the panoramic photo. To do this, take multiple photos, with some overlap, covering the desired view, and combine them to a panorama using appropriate software. One simple-to-use, free program is available at http://www.autostitch.net but there are many others. If you do not have access to a digital camera follow the lesson plan at http://hea-www.harvard.edu/ECT/Hello/hello.html#intro to allow your students to draw the horizon. Another alternative is to use an inexpensive, disposable panoramic film camera to take a picture of the southern horizon (since this comes with a film containing several shots, a camera can be shared with nearby schools) and produce large prints of the result. This can be done either by ordering huge prints, or by having the photo scanned and digitally enlarged, or even by putting the photo on an overhead slide and tracing its projection on a large paper.
- Compass
- Clear tape

- A large stone or some object to locate your class Sun's path observation site with an excellent view of the Southern horizon.

Teacher Needs:

- Panoramic photo enlarged to 7' x 3'
- 10 cut out Sun shapes the size of the bottom of a Styrofoam cup made of yellow construction paper
- Compass

Each student needs:

- Panoramic photo of Southern horizon for their science notebook

Background :

The apparent motion of the Sun across the sky from East to West, as well as the similar motion of all celestial objects, is explained as a result of the motion of the Earth and us with it. In fact, as we shall see later (in Activity 7) the actual path of the Sun's apparent motion reflects a somewhat complex interplay of the Earth's rotation, the resultant change in our orientation depending upon our latitude, and the position of the Earth in its orbit (Activity 9).

Our purpose in this activity is *not* to discuss any of this. Rather, we wish to create a baseline of concrete observations common to the entire class, to which we will refer as we work through our understanding of the motions of the Earth/Sun/Moon system. This activity is also an excellent opportunity to introduce the importance of careful, systematic observation and of presenting and sharing the results of observation in a clear and accurate way. It also invites students to realize that underlying our ability to comprehend nature is the fact that our observations reveal repeating, predictable patterns. In essence, science is the process of discerning, describing, and explaining these patterns.

There is a somewhat subtle point here, on which educated adults have been known to be unclear. The issue may not come up in class until later activities, but we chose to address it early here. We typically describe the apparent motion of the Sun, as mentioned above, as a result of the Earth's spinning motion about its axis. The idea that the Sun is in fact moving around the Earth, it is thought, was overthrown by the Copernican revolution of the 17th century. This is, in fact, false. Indeed, all of our observations suggest the Earth is spinning about its axis, completing one rotation every 24 hours or so. These observations include the apparent motion not only of the Sun but also of *all* other celestial objects, essentially anything in the Universe that is not on Earth. One can, without contradiction with observations, say that the Earth is not spinning. But one then has to claim that the entire Universe is in fact spinning about the Earth as a center. One also has to posit some rather unnatural causes for the (weak, but certainly measurable) centrifugal forces that we ascribe to our motion as the Earth rotates. Most unnaturally, one will note that all the other planets in the Solar system, and indeed all other celestial bodies, rotate about their own axis *in addition* to their apparent motion about Earth. It is thus far more natural to assume Earth is also in constant rotation about its axis. But fundamentally, taking the point of view of an

Earth-bound person, describing the Universe as revolving around the Earth, is consistent if not simple.

The revolution engendered by Copernicus was not associated to this question at all. Instead, it addressed the fact that planets appear to be moving *relative to the stars,* in addition to the apparent uniform motion of everything that is explained by the Earth's rotation. This motion of the planets is far slower than the daily rotation of the entire sky, taking months or years to complete a cycle, depending on the planet in question. Before Copernicus, these apparent motions of the planets relative to the stars were explained by having planets move along complicated trajectories about the Earth (epicycles). Copernicus showed that the same apparent motion resulted from far simpler, essentially circular, motion of the planets around the Sun, provided we allow that we observe this from an Earth which itself orbits the Sun. The complicated apparent motions are the result of viewing simple motion from a moving platform. One can maintain the point of view of a stationary Earth even after Copernicus, at the cost of having the entire Universe perform a yearly compensating motion, but the level of complexity involved in this choice becomes so high that is is rarely attempted by scientists.

Preparation: Getting Ready

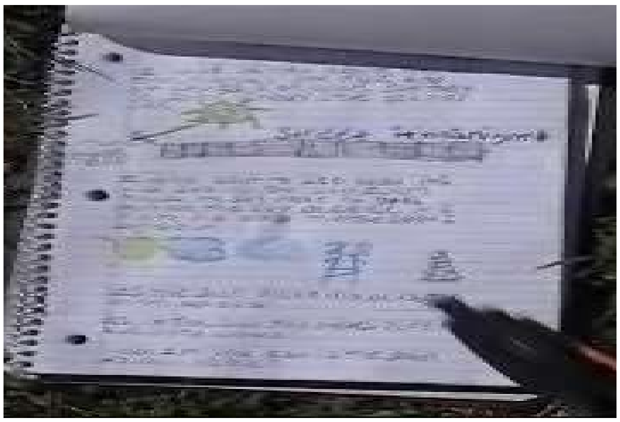
- Find a location on your school's campus to view the southern horizon. Mark the spot with a rock or some other semi-permanent object. Place a compass down and snap a panoramic photo facing due south. Print out a copy of the panoramic photo for each student. Print out an enlarged photo with an ideal size of about 7'x 3' for the entire class. Post the enlarged copy of the horizon up in your room.
- Take the time to familiarize yourself with the panoramic photo and to identify some landmarks or other features as they appear in the photo and in the actual view from the selected point. This will be helpful in explaining to students how the photo represents the actual horizon and how to relate positions in the photo to directions in the sky.
- Cut out 9 yellow construction paper Suns of an appropriate size to match the Sun's apparent size on the scale of your enlarged photo. For the dimensions listed above this is about 2" diameter. Write the date and an hour time on each. e.g. 9/22 9AM, 9/22 10AM etc…
- Make a list of Sun trackers groups with 4/5 students per group. Post in the class.

Activity:

Part 1: Science Notebook Intro

1.Introduce the activity with the following ***Motivation / Challenge***:
Describe to your class that a kindergartner at our school needs your help because the following story took place: A kindergartner came running home off the bus from school extremely worried and very upset. His mother met him in the kitchen, and asked, "What's happened?" He explained, " When I left for school today the Sun was next to the big pine tree and when I just got off the bus at the end of the day the Sun wasn't there anymore. I'm afraid it's lost. And I'm worried because I don't know where it went and if it will ever come back?" Should the kindergartner be so upset? How can you help this kindergartner better understand what really happened to the Sun?

2.Hand out the panoramic photos and explain the photo's view is on the school's campus. Describe how their job will be to use this photo to help the kindergartner solve his/her student's mystery in the Motivation/ Challenge listed above. Ask (1) What things do you know that could help you answer your friend's brother's question? (2) What things do you need to know to answer the question? Allow small groups to brainstorm for 5 minutes. Students should record their groups' ideas in their science notebooks. Illustrations with captions are encouraged to explain their responses. Have each group share their ideas and record them on chart paper for the class to view.



Pre-Assessment in a Students' Science Notebook:

Student illustration and explanation of what they know and need to know about the Sun's path at the beginning of the lesson.

3.Label & categorize the students' responses into 3 categories: Sun info, Earth info, Light info. Ask the kids for feedback about how each response should be categorized.
4.Before going outside, teach your students how to label at least three landmarks and guide the class to label their individual photos with the terms: horizon, landmarks, East, West, and South. If necessary the class can record the definitions of each term in their science notebook glossary section.
5.Teach how to use fists to count up from the horizon. Starting at the horizon below the Sun, place one fist on top of another until you reach the Sun, counting as you go up. Students mark the position of the Sun on their photo sheet using the width of their index finger to represent the distance of one fist, i.e. three fists = three index fingers. Outside they will label the Sun with a small circle and note the time above it. **CAUTION: Stress to your students never to look directly at the Sun with even a glance, as it can cause blindness.**
6.Take your entire class out to the marked spot facing the southern horizon. Students should have their horizon photo sheet labeled & taped in their notebooks and a pencil. Ask (1)"Did anyone see where the Sun was this morning when they came to school?". Determine the direction of East and a nearby landmark on the horizon. Everyone should label this area "Sunrise". Ask, (2) "Does anyone know what direction or position the Sun is in at the end of the day when you are going home from school or close to dinner time?" label this area "Sunset". Label any additional landmarks that are important (trees, buildings, etc…). Have students point and face due South and North and check to see if they have labeled it correctly.
7.Ask, "How can you tell where the Sun is in the sky without looking at it? What clues give you hints about the Sun's position?" Possible answers include the position of shadows and feeling the light on a certain side of your face. A somewhat more precise method is to hold the hand up so that it obscures the Sun completely. It is then possible to safely look at the hand, which is now in the same direction as the Sun, and measure its direction relative to the horizon, landmarks, etc.

Students are observing the Sun's path and discussing where they would record it on the Sun's path panoramic photo in their Science Notebook.

8.Without looking at the Sun teach students how to identify the landmark on the horizon that the Sun is above. Use fists to count up from the horizon. Starting at the horizon below the Sun, place one fist on top of another until you reach the Sun, counting as you go up. ***Remember to warn the class not to look directly at the Sun as it can cause permanent eye damage.*** Students mark the position of the Sun on their photo sheet using the width of their index finger to represent the distance of one fist, i.e. three fists = three index fingers. Label the Sun with a small circle and note the time above it. Ask them to predict and explain, "Where will the Sun be in an hour? Why?"

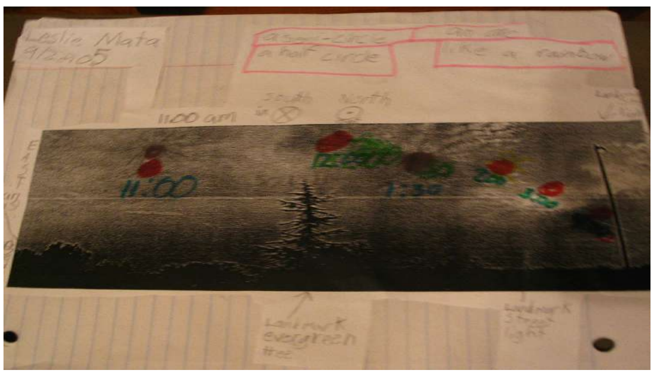
9.Come back in the class and have a student place the yellow construction paper Sun on the enlarged horizon photo to represent where they recorded it on their personal photo. Ask the class, "Where will the Sun be in an hour? Why?" Have someone place a Sun in the predicted position.

Students' observations for Sept. 28 and Dec. 19 are recorded on the Sun's Path enlarged photo

10.Each hour for the rest of the school day have a Sun Trackers group of 4-5 students go to the marked observation location. Each group needs to measure the position of the Sun and record it on their photos. The group returns to the class and changes the predicted Sun to the position they observed & recorded. Lastly, they place an additional Sun in a predicted position for the Sun in an hour. This process continues every hour for the rest of the day until the last group before dismissal.

11.At the end of the day or the beginning of the next day review the enlarged and student photo recordings. The entire class should fill in all of the times recorded by each group on the panoramic photo. Ask the class, (1) What shape is the Sun's path? What shapes is this similar to? (i.e rainbow, a ball thrown up that comes down, etc…) (2) Where does the Sun go after you leave school? Next, have someone come up and make predictions for the next several hours. Allow small student groups to examine the Sun's path photos for clues that will help them explain to the kindergartner what happened to the Sun from before school to after. Have small groups make lists of five pieces of information that their Sun's path recordings tell them about the Sun's path, the Earth, and light. Use the additional questions listed in Activity Assessment section below.

12.Complete the Post-Assessment Activity in the in the Assessment section below.



Student Notebook with panoramic photo of Sun's path observations taped in-side

Safety Issues

- **Warn students never to look at the Sun directly even a glance, as it will cause blindness.**

Assessment

Pre-Activity Assessment

Panoramic photo labeling in Science Notebook during Activity: Part 1 Intro

Activity Assessment

Panoramic photo data recorded in Science Notebook with follow up questions:

1- If you were to draw the Sun at 6PM tonight where would it be?
2- Where would the Sun's position be at 12 AM or midnight?
3- Can you count on the Sun to be in the same positions tomorrow? In three months? In a year? Explain why or why not?
4- So, what will the position of the Sun in the sky tell you about the time of day?
5- Why do you think they call noon the middle of the day or midpoint of the day?
6- How will daylight savings affect our recordings?
7- How does the Sun's path in winter compare with the Sun's path in fall?
8- How or why do you think the Sun's path effects or controls your town's weather? Or how late you get to play outside after school?

Post-Activity Assessment

Computer generated illustrated model of the Sun's path with written explanation using computer graphics software (i.e. KidPix) to illustrate and answer the following questions:

1- Draw the southern horizon with East, South, West and at least 4 landmarks labeled.
2- Illustrate the Sun's path as it changes position each hour.
3- Describe the Sun's path's shape? What is the shape similar to?
4- What do you notice about the Sun's path's pattern each hour?
5- What happens to the Sun after it sets? Why can't we see it?
6- Some people say the Sun's path across the sky is not a real motion. The Sun appears to us to move because the Earth is spinning and we are spinning with it. Do your observations agree with this idea? Do they contradict it? What observations could you use to try to distinguish the two hypotheses.

Activity Extensions

Daily Sunrise and Sunset times:
Recording the daily Sunrise and Sunset times is a wonderful everyday morning meeting activity. Each day a student or you can research the Sunrise and Sunset times from the local paper or website. Chart the times to notice patterns and an order to the Sun's time spent moving across our sky. Additionally, add to the chart the high temperature of the day and see if they discover any patterns. These data can be graphed and interpreted to better understand the Sun's Path diagram.

Shadow Tracking:
Track the Sun's movement by tracking a stick's shadow each hour. Much like the Sun tracking groups each hour have a group track the stick's size, shape and direction each hour. Check out http://hea-www.harvard.edu/ECT/Stick/stick.html#intro
for a great lesson that helps your students record the smooth arced motion of the Sun across the southern horizon.

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

References

K-6 Astronomy activities from Harvard-Smithsonian Center for Astrophysics' Everyday Classroom Tools at http://hea-www.harvard.edu/ECT/

Language arts and Astronomy connections at Stanford's Solar Center at
http://solar-center.stanford.edu/interview/questions.html

Earth, Sun, and Stars Teacher's Guide by LHS GEMS
Lawrence Hall of Science University Of California at Berkeley