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Daytime Astronomy in the Northern Hemisphere Using Shadows

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Abstract

This brief article describes a method for teaching astronomy that was developed in New Zealand. Children observe and record the movement of their own shadows at regular intervals throughout the day and continue with a series of activities that can be extended throughout the year. This activity, which both children and teachers find fascinating, requires minimal equipment and is suitable for schools with very limited funding. This contribution describes the experiments and how they can be adapted for use in the northern hemisphere.

A method for teaching astronomy that was developed in New Zealand has proved to be an exciting experience for students. Children begin by observing and recording the movement of their own shadows at regular intervals throughout the day and continue with a series of activities that they find enthralling and that can be extended throughout the year. Because most teachers have had little astronomical education, they also find this method fascinating, as will students of all ages. Because the experiments performed by the students require minimal equipment, this approach is suitable for use even in schools with very limited funding. In this brief contribution, I show how the experiments can be adapted for use in the northern hemisphere.

Observing and recording shadows are usual activities in many introductory books on astronomy, but they often fail to make following important points.

1. When recording shadows, children are more interested in their own shadows than that of a pole.
2. Shadows are shortest at solar noon. This occurs when the Sun is halfway in time between sunrise and sunset, and is highest in the sky for that day at your place. It is different from clock noon and occurs

when the meridian* is on the Sun. The time of solar noon can be worked out from the sunrise and sunset times given in daily newspapers and is a challenging mathematical exercise.

3. At solar noon, all shadows lie in a true north/south alignment and point to the nearest geographic pole. That is the north pole in the northern hemisphere and the south pole in the southern hemisphere.
4. This line from the true north pole to the true south pole is the line of longitude for that place. When students stand in the Sun at solar noon facing their shadows directly, their heels point true south and the shadows of their heads point true north. When marked as a line along the ground for a couple of meters, it can be used as a compass. At this point, a discussion of the difference between the true north and south poles and magnetic north and south poles can be introduced.
5. Activities based on this north/south line can be used to find circumpolar stars and the paths of the moon, planets, and constellations of the zodiac.
6. A student's shadow recorded at solar noon at monthly intervals on the same strip of paper will show the relationship between the length of the shadow, the height of the Sun, and the season.

The points above may be explored in these activities.

1. Commence this activity at 9:30 a.m. on a day that is predicted to be sunny all day. Take the class outside to a paved area of the schoolyard. Arrange for them to work in pairs and have them draw with chalk around their partner's shadow (including shoes), recording the student's name and time in each shadow.
2. At 10:00, repeat the activity by standing back in the same shoe outlines. Draw around the shadow again and put in the new time. At 10:30, repeat the activity and get students to put a circle where they think the shadow of their heads will be at 11:00 a.m. At 11:00, the class should check to see how close their guesses were. (I mention guesses because there are insufficient records to make a prediction.) It is likely that the students will want to continue recording shadows at intervals for the rest of the day. They will be fascinated recording the changing size, shape, and direction of their shadows as the day progresses. This can lead to an animated discussion as to what is causing this to happen.
3. At solar noon on another sunny day, have the students record their shadows on the schoolyard. At this time, their shadows are shortest for the day and point to the true north pole, so a student can use his or her noon shadow as a compass because it lies along a true north/south line through your school. The time of solar noon can be determined from sunrise and sunset times given in a daily newspaper by using this method:

   From 12 noon, subtract sunrise time (e.g., 5:46 a.m.) and add sunset time (e.g., 7:24 p.m.). Divide your answer in half and add it to the sunrise time. Remember to calculate in hours and minutes.

   12.00 - 5.46 = 6.14 + 7.24 = 13.38

   13.38 / 2 = 6.49 + 5.46 = 12.35

   Therefore, 12:35 p.m. is solar noon in this example. The Sun is true south at this time, and all shadows point to the true north pole.

   Notes:

1. During the period of daylight savings, solar noon may be as "late" as 1:35 p.m.
2. Converting sunset time to 24-hour time may also be used to work out solar noon.

If students stand facing south at solar noon and raise their hands out sideways, their left hands will point east and their right hands west. By bringing their outstretched left hands above their faces and over to touch their outstretched right hands, they will make the apparent path of the Sun across the sky during the day. At night, this is the same apparent path across the sky along which to find the planets, Moon, and constellations of the zodiac.

Note: This apparent path becomes a band across the sky between the longest and shortest days (summer and winter solstices).

During the summer, the shadows are shortest and the Sun’s path across the sky is at it highest. During the winter, the shadows are longest and the Sun’s path across the sky is at its lowest.

4. If students do the above activity at solar noon at home over the weekend, they need to record this north/south line on the ground with chalk, a long stick, or string line. At dusk, stand astride the line facing south. By raising their hands to point east and west and bringing their outstretched hands together above their faces, they will discover that the bright objects in the sky along that path are likely to be planets and the Moon, if it is up. Any star patterns are constellations of the zodiac. Now turning and facing north, making a circle around their eyes and nose by touching the tips of their middle fingers and thumbs together, they will find the Little Dipper inside the circle, and in the center, the Pole star. From this orientation, the Big Dipper and Cassiopeia may also be found.
5. Record the same student’s shadow on a three-meter length of paper at solar noon on the same day each week for at least six weeks, or at monthly intervals for several months, and include date and time. At each record, stretch a length of string from the top of the student’s head to the end of the shadow of his or her head and record the angle where the string meets the ground.

   The students should:

   a) Note the changing lengths of the shadow
   b) Compare these with the changing angle where the string meets the ground (which is actually measuring the height of the Sun)
   c) Compare shadow lengths with the length of daylight (determined from the sunrise and sunset times).

How do these observations relate to seasonal changes?

Making these observations during the day while students are at school gives a good introduction to nighttime astronomy.

*The usual statement is "the Sun is on the meridian," but it is the meridian that is moving, not the Sun; hence, "the meridian is on the Sun."

Resources

Shadow Play: Making Pictures with Light and Lenses (Boston Children's Museum Activity Book) by Bernie Zubrowski.

The Ever-Changing Sky: A Guide to the Celestial Sphere by James Kaler

The Astronomical Society of the Pacific's *The Universe at Your Fingertips*, specifically Activities B-6 "Making Pictures of Motion" (using a traditional stick), B-7 "Making a Sun Clock" (using a sundial), and B-8 "Plotting the Apparent Motion of the Sun" (using a clear plastic hemisphere). Activity B-9 "Solar Motion Detector" addresses the yearly interval.

The reference list contains full information for each resource.

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References

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