Tracking the Mystery of the Sun's Apparent Motion
by Ron Keith

Introduction
Looking for a new activity to interest your students in the practice of good science? Have your students investigate the apparent motion of the Sun. The potential for student learning is great. Although the presence of the Sun and its motion are everyday experiences, these phenomena do not seem to draw the attention or wonder of children, or of people in general for that matter. As a consequence perhaps, children hold beliefs or conceptions about the Sun which are not consistent with experience. For example, most students don't realize that the Sun does not always rise due east, nor is it ever directly overhead at noon (in the continental US). Based on their own Sun-tracking observations, students can construct more reliable knowledge to displace their prior conceptions and beliefs of these familiar but overlooked phenomena.

Sun tracking engages the students in the practice of good science in a new context. The context is new, not just because the Sun's presence and motion are taken for granted, but also because of the time scale involved in the experiment. Most physical science experiments occur within the science classroom over a period of tens of minutes, maybe hours. However, much of our understanding of earth and space science focuses on phenomena with time scales measured in days, months, years, and even millions of years. Sun tracking is a science activity that gives students experience investigating phenomena involving long-term variations. Students record the position of the Sun several times during the course of the day. They repeat this Sun tracking several times over the course of three, four, or more months. They come to understand the motion of the Sun across the sky, as well as the variation of this behavior over the course of weeks. In the end students may also draw connections between what they have observed and other familiar phenomena (e.g. changing number of daylight hours, changing seasons).

Materials
- clear plastic hemisphere (about 7 inches in diameter)
- water-soluble marker pen with pointed tip
- rigid flat platform
- sheet of paper to place under sky dome with a cross marked at the center
- circle or "bulls-eye" level
- small compass

The materials needed for this activity are relatively inexpensive and are generally easy to obtain. The materials for one activity set-up (e.g. clear plastic hemisphere, marker pen, compass, level, mounting platform) cost about $7. The most important item is a clear plastic hemisphere about 7 inches in diameter. The hemisphere will represent the dome of the sky; the hemisphere is the material on which the student's Sun-tracking data is recorded. The 7 inch size is good because it is large enough to display a lot of data without too much crowding; yet it is small enough to be easily transported to wherever the observations will be made. My students generally take the sky-domes home for the weekend, which is more convenient for making many observations over the course of a day. A

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plastic hemisphere designed for this activity is available from Learning Technologies, Inc.\(^1\), $15 for 10 hemispheres in 1992. Two other important materials are a water-soluble marker and a piece of stiff flat material as a platform on which to mount the hemisphere (see Figure 1).

![Figure 1](image)

The marker is used to record the observations directly onto the hemisphere. The platform is helpful in establishing a level base prior to observation. In addition to these materials, having a small compass and a "bulls-eye" or circular level is useful. The compass is used to align the hemisphere relative to north-south and east-west directions. The level is used to adjust the platform so that the top of the hemisphere is pointing at the local zenith. Compasses cost about 50 cents to $1 apiece from science supply stores. Levels cost about $3.00 to $3.50 apiece at hardware stores.

**Procedure**

*Preparing to record an observation:*

Before actually making a measurement, the sky-dome has to be properly oriented relative to the earth's surface. Students should be reminded that the clear plastic dome before them represents the dome of the sky that they see when they go outside. In order for them to be able to represent their observations accurately on this dome, they must adjust the orientation of their dome so that two conditions are met. First, the north-south line of the plastic dome must be aligned with the north-south line of the earth where they are. Make a mark at one point along the circumference of the plastic dome. Place the letter "N" there to indicate that it represents geographic north on the platform. Place the compass on the platform beside the plastic dome. Adjust the orientation of the platform until an imaginary line connecting the center of the dome and the point labeled "N" points in the same direction as the compass needle is pointing north. Then, students must align the top of the dome with the local zenith point. Place a circle level on the platform beside the plastic dome. Adjust the tilt of the platform until the level indicates that the platform is level in all directions. Now the dome is oriented so that the imaginary line connecting the center of the dome and the top of the dome is parallel to a true vertical line where the students are standing. In other words, the top of the dome now properly corresponds to the position directly over their own heads. If you do not have access to compasses and levels, you need to achieve reliable orientation of the dome relative to earth directions, north-south, east-west, and up-down.

*Making an observation:*

First illuminate a properly oriented dome. The Sun is the illumination source of choice and the one that the students will use during their long-term study. Then, another student in the group will take the marker pen and move it around close to the surface of the dome. A shadow of the pen will appear on the paper inside the dome. The student should move the pen around until the shadow of the pen's tip lies on top of the cross at the center of the

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\(^1\)Learning Technologies, Inc., 59 Walden Street, Cambridge, MA 02140, Ph# 800-537-8703. Ask for the Project Star materials, item # PS-03.
dome (see Figure 2). At this time, the student should press the tip of the pen against the dome so that it leaves a mark. This mark, relative to the center of the dome, accurately represents the current position of the Sun relative to the person making the observation at this moment.

![Diagram of Sun and Dome]

**Figure 2**

To introduce students to the process of recording an observation, a bright flashlight will stand in nicely for the Sun. One student can hold the flashlight one meter or so from the dome and shine it on the dome. Then proceed with the rest of the process.

**Long-term observation plan:**

In this activity, students investigate the daily motion of the Sun across the sky and how this motion varies with the seasons, or at least how this motion varies over the period of several weeks or months. For students to get a sense of the Sun's motion on any given day, students will need to perform many observations spread out over the daylight hours. A one-day observation series of eight to ten observations stretching from morning through afternoon should provide the student with enough points on the sky dome so that the student can sketch the path of the Sun on the sky. Each point along the path should be clearly identified with the time of observation. In order for students to investigate the seasonal variation of the Sun's daily motion, students must perform several one-day observation series over the course of many weeks. My students typically complete this investigation in groups of four over a period of about 12 weeks. Every 2-3 weeks one student will perform a one-day observation series. Over a period of 12 weeks, the group obtains, at roughly uniform intervals, sufficient information about the daily motion of the Sun that its seasonal variation is clearly evident.

**Group Product**

I have students work on this project collaboratively in groups of three or four. This is useful both in the data collection phase and in the analysis phase. Making a one day's observation record requires a significant commitment from the observer because many measurements of the sun are required over the course of the day. Through collaboration, a group of three or four students are able to collect a rich set of data with a lesser individual time investment. During data analysis, students discuss results, make hypotheses, and co-construct explanations.

**Observational record:**

After many weeks and three or more recorded observation series, the daily motion of the Sun across the sky and the variation in this motion is easy to recognize. Figure 3 depicts a sky-dome which exhibits observation.
series corresponding to the Winter Solstice, the Autumn or the Spring Equinox, and the Summer Solstice for observers at approximate latitude 40° N. This figure provides an example of the data that students will collect, although they may have recorded more than three observation series.

As a follow-up to their construction of a list of inferences, student groups might be asked to generate some specific predictions about the daily motion of the Sun. For example, what would you expect the path of the Sun to be in three weeks time, or in three months time. If time in the school year allows, further observations may be assigned to the groups in order to verify their predictions.

**Connections & Closure**

The Sun-tracking activity can be implemented as a stand-alone science activity or it can be used as a springboard to other science activities and discussion. In this activity the students will have practiced science skills of careful observation and inference. On the basis of their results, the students should be able to make specific knowledge claims about how the Sun moves across the sky, where the Sun rises and sets, how high in the sky the Sun gets on a given day, as well as how these properties of the Sun vary over weeks and months. For most students these knowledge claims will be different from their expressed beliefs prior to participating in this activity.

This activity may serve as a useful link to related science activities and discussions. With a flashlight, a cardboard tube, and some graph paper, students can investigate how the intensity of light energy absorbed by a surface varies with the inclination of the light relative to the surface. This conception, together with the Sun-tracking activity, helps students to explain the passive solar heating of houses, as well as the seasonal variation of the average daily temperature. Furthermore, the latter topic leads to a discussion of the inclination of the Earth's axis of rotation relative to the Earth's orbit around the Sun. More difficult for students to grasp would be a discussion of the seasonal variation of the number of daylight hours that we experience. In this discussion,
one would again discuss the inclination of the Earth's rotation axis relative to the Earth's orbital plane. By examining the Sun-illuminated Earth at the solstices and equinoxes, students will try to visualize the reason for the seasonal variation in the number of daylight hours. In doing so, students generate understanding of this phenomenon which complements the Earth-centered perspective constructed in the Sun-tracking activity.

The Sun-tracking activity and related activities involve students in the practice of good science. As well as making careful observations of the physical world around them, students construct new knowledge using their own observations and reasoning. Some related activities involve students in the practice of making scientific models which help them to understand their world in a way which goes beyond what they can immediately observe.

References

