Earth's Seasons

Summary

Globes, flashlights, and a light source are used to model the reason for the seasons.

Time Frame

1 class periods of 45 minutes each

Group Size

Small Groups

Materials

- Light bulb and socket (or a lamp without the shade)
- Earth globe (1 per group)
- Thumb tack (1 per group)
- Small piece of tape (1 per group)
- Flashlight (1 per group)

Background for Teachers

In your preparations for this activity you will need to be familiar with the causes of the seasons. This background is an attempt to refresh your knowledge about the causes of the seasons.

A misconception that students often have is that because the Earth is closer to the sun in the summer and farther away in the winter, it is hotter in the summer. This answer seems to make perfect sense. If you are closer to a fire, you are warmer. But in relation to the Earth and the sun, this explanation is not correct, especially since the Earth is farther away from the sun in July than it is in January.

Why isn't the Earth's distance a factor in explaining the causes of the changing seasons? The most important reason is that the Earth's orbit or path around the sun is almost circular. The distance of the Earth from the sun does change, but it is so slight that it makes very little difference in the heat energy felt on the Earth. For example, if you were sitting 30 meters from the fireplace and moved 30 centimeters closer, you would not feel that much warmer than what you felt before. Therefore, it is not the Earth's distance from the sun that causes the change in our seasons.

What causes the changes in the seasons on Earth? The two things that make an impact on the seasons are the angle of the Sun above the horizon and how long the sun stays in the sky at a given latitude (the amount of daylight). When the sun is most nearly overhead, the ground gets the hottest. At noon, the sun is at an angle that is most nearly vertical. At sunrise or sunset, the angle from the horizon is smaller so the ground is cooler.

When daylight lasts longer, there is more time for the sun to warm the ground each day. (See attached Daylight Diagram below.)

The angle above the horizon at noontime is important because it determines how much concentrated light and energy the Earth receives at a specific point. An area that receives more light more directly overhead, gets the hottest. Also, the longer the sun is above the horizon on a given day, the longer it will radiate light and energy. This factor is not nearly as important as the angle of the sun above the horizon.

To help illustrate this idea, here is an example you might want to use with your students. Take two round, hollow toilet paper tubes. Point one tube toward the sun at a 90° angle and the other tube at a 45° angle and allow the sunlight to strike the ground. Which ground will be hotter? The 90° angle tube will get more direct, concentrated heat and light energy. With the 45° angle tube, the light is spread out over a larger area, so the light and heat energy is not as concentrated. This illustration

demonstrates the sun's affect because of the Earth's tilt.
What causes the Earth to be at a different angle from the sun at different times of the year? The tilt of the Earth's axis is what makes this difference. The angle of the Earth's axis from the plane of its orbit is about 66.5° above the plane, which is 23.5° from being perpendicular to the plane of the Earth's orbit (90° - 66.5° = 23.5°). The seasons are caused because the Earth is not perpendicular (90° angle) to the Earth's orbit around the sun. (See the attached Orbit Diagram below. Note: this diagram is not drawn to scale.) Though the orbit of the Earth, from this diagram, looks very elliptical, this is due to the nature of the angle of view portrayed. The Earth's orbit is nearly circular. For instance, look at a paper plate from above. It looks like a circle. Hold the paper plate horizontal to the ground and slightly below eye level. From this view, the paper plate looks like a severe ellipse--as seen in this diagram. This difference is a source of many misconceptions. It is an important point to discuss with your students.
If your students have either studied the celestial sphere or have done some observations of the sun then it will help them be more prepared for this activity. Students should be made aware that the sun moves across the sky always staying above the same latitude on a given day.
In summary, the reason for the seasons is the angle at which the sun's rays strike the earth, caused the by the tilt of the Earth on its axis. The tilt of the Earth also causes the change in the number of daylight hours experienced throughout the year.

Intended Learning Outcomes

- Make observations.
- Collect, record, and analyze data.
- Weigh evidence before drawing conclusions.
- Recognize relevance of science in everyday life.
- Explain science concepts.
- Explain how parts of a system are interconnected.
- Construct and use models.

Instructional Procedures

ACTIVITY INFORMATION:

This lesson consists of three activities: two completed in small groups and one as a whole group. You may want to first model the procedures for small group activities.

It is best to have a globe that is 'tilted'; e.g. the N-S axis sits at 23.5o to the vertical. If you do not have a tilted globe, you can use a plain globe with an axis, but you must be careful that the axis doesn't change orientation in space.

SMALL GROUP ACTIVITY #1

- Set the Earth globe on a table. Locate your city or town on the globe. Push the thumb tack through the small piece of tape, and tape the flat side of the tack to your location on the globe. The tack should be standing straight out from the surface.
- Select some sort of marker in the room. (A bulletin board may work well.) The axis of the Earth should always be pointed at this spot.
- Rotate the globe so that your city is at its highest point. Shine the flashlight toward the tack, starting from the East side of the globe and moving across to the West.
- Observe the shadow cast by the tack as you move the flashlight. Where is the light when the shadow of the tack is the shortest?

SMALL GROUP ACTIVITY #2

- Point the beam of the flashlight at the equator. Hold the flashlight in a stationary location, but allow it to rotate to keep the beam pointed toward the globe. Carry the globe in a counterclockwise revolution around the flashlight making sure to keep it tilted toward the key

object in the room. Observe how much daylight the tack experiences.
Point the beam of the flashlight at the Tropic of Cancer. Repeat the same procedure as above. Observe how much daylight the tack experiences.
Point the beam of the flashlight at the Tropic of Capricorn. Repeat the same procedure as above. Observe how much daylight the tack experiences.
Have students discuss in their groups to predict which flashlight location represents each season of the year for their city (marked by the tack.) Observations, predictions,and evidence should be recorded in their science journals.

WHOLE CLASS ACTIVITY:

Place a bright light source in the center of the group. This represents the sun.
Carry the globe and walk counterclockwise one revolution around the light source. Be sure to keep the globe tilted the same direction.
Now complete a second revolution stopping at key positions for discussion and observations. (See the following steps.)
At the beginning position, before you start walking, rotate the globe through one complete rotation. Observe the patterns of light and shadow on the Earth.
Now go 1/4 of a revolution in your orbit and stop again. Rotate the Earth. Repeat the observations.
Stop at 1/2 of a revolution. Rotate the Earth. Repeat observations.
Stop at 3/4 of a revolution. Rotate the Earth. Repeat observations.
Stop at one full revolution. Rotate the Earth. Repeat observations.
Have students use their science journals to draw the Earth in each position at which you stopped and indicate on their drawings how the light strikes the Earth. This drawing should show the light and dark portions of the Earth in relation to the sun.
Discuss the season experienced by their city (the tack) at each position. Be sure to emphasize that the tilt in the Earth determines the season and the number of daylight hours in each day.
Students should determine which parts of the Earth's orbit correspond to the different seasons and record their answers by writing and illustrating in their science journals.
Once students understand the seasons their city experiences (the Northern Hemisphere,) have them apply their knowledge to the Southern Hemisphere and identify that their seasons are opposite from what we experience. You may need to reuse the models to assist their understanding.
Further consider the following discussion questions: For each position, is there any part of the Earth that gets no light during a complete rotation? If so, which? Is there any part that gets light all during the rotation? Again, if so, which?
Conclude the activity by having students write a paragraph in their science journals summarizing why the Earth has seasons.

Assessment Plan

Review student journal entries using the rubric below to check for understanding.

Rubrics

Science Lab Report Rubric

Bibliography

This lesson plan was adapted from Operation Physical Science, NSF grant #8751216 by Dr. Donald Kirwan.

Authors

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