Earth-sun distance versus solar radiation: Teacher Worksheet

Level: Beginning

Subject: Geography

Duration: 40 minutes

Type: Classroom Activity

Learning goals:

- Define: Solar radiation, revolution, aphelion, perihelion
- To find out how revolution affects the Earth-Sun distance
- Understand how Earth-sun distance affects the amount of solar radiation the Earth receives

Materials:

- Globe
- Torch/Flashlight
- Tape Measure or Ruler
- Blackboard compass
- Flat platform (preferably a round table)
- Marker or chalk

Introduction:

This lesson plan is designed to be a classroom activity and discussion. There is no student worksheet because students are encouraged to be actively involved by watching, observing, and asking questions throughout the activity. Students should make sure they can see the demonstration, this may require standing around the table where the activity takes place. Throughout the methods, be sure to ask students clarifying questions or to encourage them to contribute their observations. Depending on the background knowledge of the class, it may be necessary to provide them with background information on the Earth's orbit around the sun.

Background:

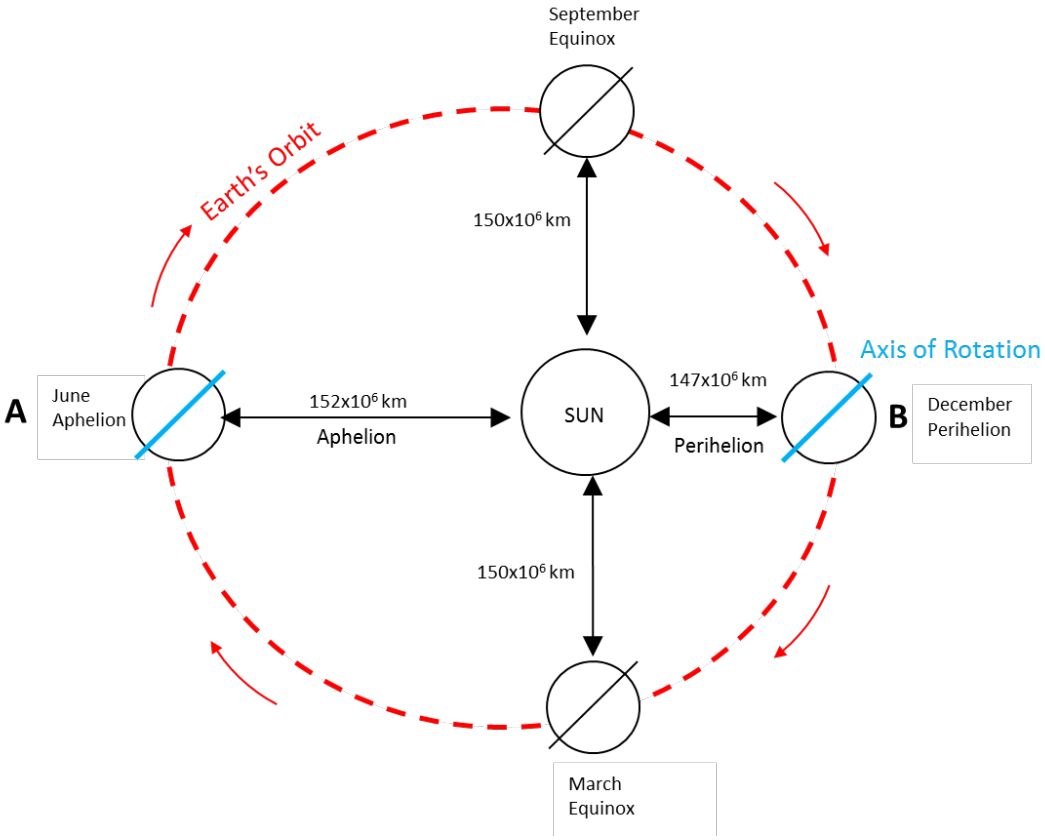
The Earth orbits the Sun at a speed of 108,000 km/hr. The length of the Earth's orbit is 940 million km. One orbit of the Earth around the Sun is called one revolution. The Earth completes one revolution every 365.25 mean solar days, which is why we observe a leap year (a year with an extra calendar day in February) every 4 years (so that 4 years is exactly 1461 days). In addition to the Earth orbiting around the Sun, the Earth rotates on its axis. One rotation of the Earth takes 24 hours, one day, which is why we have day and night. The Earth's rotates on an axis at an angle of 23 degrees, the axis of rotation is what causes seasonal changes of weather throughout the year. So, one revolution is one year and one rotation is one day.

The average distance from the Earth to the Sun is 149.6×10^6 km, but the Earth's distance from the sun varies during its orbits. When the Earth is closest to the Sun, it is said to be at perihelion and occurs in December of each year at a distance of approximately 147×10^6 km. When the Earth is farthest from the Sun, it is said to be at aphelion and occurs in June of each year at a distance of approximately 152×10^6 km. The average distance of the Earth from the Sun is about 149.6 million km, which is also referred to as one astronomical unit (AU). During the Equinoxes the distance between the Sun and the Earth is 149.6×10^6 km and the night is the same length as the day all over the world. The Perihelion and the Aphelion are both Solstices, meaning that they are the longest and shortest days of the year. The Perihelion occurs in the winter and is the shortest day of the year and is also called the Winter Solstice. The Aphelion occurs in the summer, also called the Summer Solstice, and is the longest day of the year.

Methods:

1. Locate the center of the flat platform (round table).
2. With the help of a construction compass, draw a round circle on the table using the marker. You may want to lay down a large paper on the table to avoid drawing on the table surface. (The circle represent the path followed by the earth as it revolves round the sun, shown in the figure by the red dotted line).
3. Place the torch/flashlight near the center of the table, be sure to offset it slightly to account for the Aphelion and the Perihelion. Ask the students what the torch/flashlight represents. [Answer: The sun revolved around the sun, the torch/flashlight represents the sun]
4. Choose two points A and B on one of the drawn circle to represent the aphelion and the perihelion respectively. Use the figure below as a reference. Note that, The earth's revolution (orbit of the earth around the sun) brings it close to the sun and far from it,

alternately, being nearest during the Perihelion in December and furthest during the aphelion in June.



5. Place the globe at point A, direct the torch light towards the globe. Using the tape measure the distance covered by the light from the torch to the globe in position A (note that the distance from the torch/flashlight to point A should be longer than the torch/flashlight to point B).
6. Now place the globe at point B and measure the distance covered by light again. It might be useful to create a table, like the one given below, on the blackboard to write down the results. This would be a good time to ask the students about their observations of the strength of the light that reaches the globe when it is in position A compared to position B. Did they notice that the light seems brighter when the globe is at position B compared to position A?

Point #	Distance from point to torch/flashlight	Amount of light reaching the point
A (Aphelion)		
B (Perihelion)		

Calculations:

For meteorological purposes, the sun is assumed to be a point source, which means that its size is small compared to the distance the radiation goes. The intensity of the radiation at a point (E) is inversely proportional to the square of the distance (d) of the point from the source i.e

$$E \propto \frac{1}{d^2},$$

Note: This formula may also be written as $E=k/d^2$. The quantity of the sun's radiation reaching the earth's surface is known as the solar constant (k). The solar constant, S_o, has a mean value of 1360 J m^{-2} s^{-1} and fluctuates by about 1 to 2% per year. Therefore k is the solar constant. For this demonstration, k will be the amount of light produced by the torch. Since we are using the same light source (torch/flashlight) for the entire exercise we can use to original equation of $E \propto 1/d^2$.

Discussion:

Ask the students to summarize what was performed during the lesson plan. Opened ended questions like this should encourage students to contribute in the discussion. [Possible Answer: we started by drawing the Earth's orbit around the sun on the paper, we placed the torch/flashlight in the center and the globe along the Earth's orbit. Then we compared the amount of light that reaches the globe at different locations around the orbit.]

Follow up the previous question by asking students what they learned during the demonstration. You may want to allow multiple students to answer this question as their answers may vary.

Ask the students to explain what is important about the Earth's orbit around the sun. How long is one revolution? [Answer: A revolution is when the Earth makes a complete orbit around the Sun. This is important because the distribution of daylight and nighttime hours depends on where the Earth is in its orbit.]

Ask the students to explain what is important about the Earth's rotation. How long is one rotation? [Answer: The Earth rotates around an imaginary axis that runs from the North Pole to the South Pole. This axis is tilted 23 degrees and is the reason that we experience season and other variations in weather each year. One rotation is 24 hours, or one day.]

Finally, ask the students based on their observations and calculations which point (A or B) did more energy from the Sun reach the Earth? [Answer: when the Earth is farther from the Sun, like at point A of the Aphelion, the energy from the Sun that reaches the Earth is less than when the Earth is closer, like point B of the Perihelion.]