

## Lesson Implementation and Review

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Astronomy and Space Science: Fall 2019

Topic: Insolation and Seasons

Professor: Dr. Brandon Rodriguez

**Background:** I teach Regents Earth Science near New York City and one of the other teachers in the course shared a resource called Insolation and the Seasons (see attached) that she uses with her Earth Science students. This is an important topic for students to understand and they often have significant misconceptions about it. The lesson plan follows the 5E model and has students conduct experiments in class and use online astronomy simulators to collect data. The simulator is part of a collection of many astronomy simulators that allow students to manipulate the latitude of the observer or the date of observation (<https://astro.unl.edu/classaction/coordsmotion.html>). The season simulator is the most powerful tool I have seen to help students understand seasonal changes in angle and intensity of insolation (<https://astro.unl.edu/classaction/loader.html?filename=animations/coordsmotion/eclipticsimulator.swf&movieid=eclipticsimulator&width=970&height=710&version=6.0.0>).

### Lesson summary:

The lesson took 4 class periods to complete and involved some reflection being done as homework.

Lesson opener: Students are given the following set of ideas to read and they have to pick the one they think makes the most sense for why it cold in New York in the winter and warm in summer.

## Engage: Why Do Seasons Occur on Earth?

At lunch you overhear some of the kids at school talking about why it's so much warmer in New York City during the Summer than it is during the Winter. Read their ideas below and decide which one you agree with most.

Devon: "It's because the winter clouds block heat from the Sun."

Lisa: "It's because the Sun gives off more heat in the summer than in winter."

Omar: "It's because Earth's tilt changes the angle of sunlight hitting Earth."

Derek: "It's because the Earth orbits closer to the Sun in the summer than in the Winter."

Simone: "It's because one side of Earth faces the Sun and the other side faces away."

Susan: "It's because the Northern Hemisphere is closer to the Sun in summer than in the winter."

Which idea do you agree with most? Draw a diagram and write a few sentences below to explain your thinking.

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A couple of students identified Omar's explanation as the correct one but most of them thought that Derek was correct. Thinking that seasonal temperature differences are caused by the difference in distance between the Sun and Earth at aphelion and perihelion is a common misconception. We had just finished studying the eccentricity of elliptical orbits so students correctly understand that the distance between the Sun and Earth varies but the incorrectly attribute seasonal temperature differences to this variation.

Students were asked to draw a model explaining the seasonal temperature difference phenomenon.

Here are some student artifacts:

**Engage: Why Do Seasons Occur on Earth?**

At lunch you overhear some of the kids at school talking about why it's so much warmer in New York City during the Summer than it is during the Winter. Read their ideas below and decide which one you agree with most.

- Devon: "It's because the winter clouds block heat from the Sun."
- Lisa: "It's because the Sun gives off more heat in the summer than in winter."
- Omar: "It's because Earth's tilt changes the angle of sunlight hitting Earth."
- Derek: "It's because the Earth orbits closer to the Sun in the summer than in the Winter."
- Simone: "It's because one side of Earth faces the Sun and the other side faces away."
- Susan: "It's because the Northern Hemisphere is closer to the Sun in summer than in the winter."

Which idea do you agree with most? Draw a diagram and write a few sentences below to explain your thinking. I'm agree with Derek, because when Earth is closest to the Sun, it is going to be

**New York City in the Summer**



**New York City in the Winter**

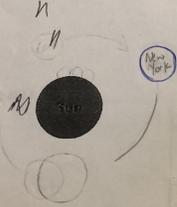


Simone: "It's because one side of Earth faces the Sun and the other side faces away."

Susan: "It's because the Northern Hemisphere is closer to the Sun in summer than in the winter."

Which idea do you agree with most? Draw a diagram and write a few sentences below to explain your thinking.

**New York City in the Summer**



**New York City in the Winter**



The further away New York is from the Sun, the colder it is.

The Explore portion of the lab consisted of three parts:

- a) Collecting temperature data at the solstices and equinoxes at different latitudes using a heat lamp, thermometers and a globe (See Figure 1 below)
- b) Organizing data from a diagram showing the Earth's distance from the Sun and the average temperature on the solstices and equinoxes
- c) Using a flashlight shone on different latitudes to demonstrate the intensity of light hitting the surface of the Earth

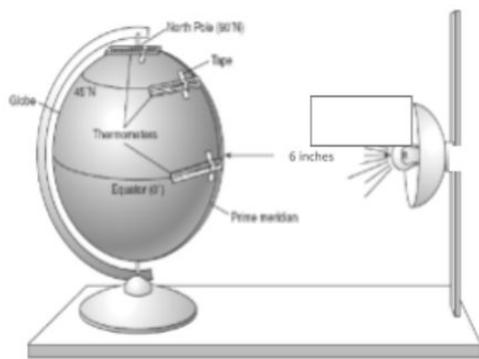
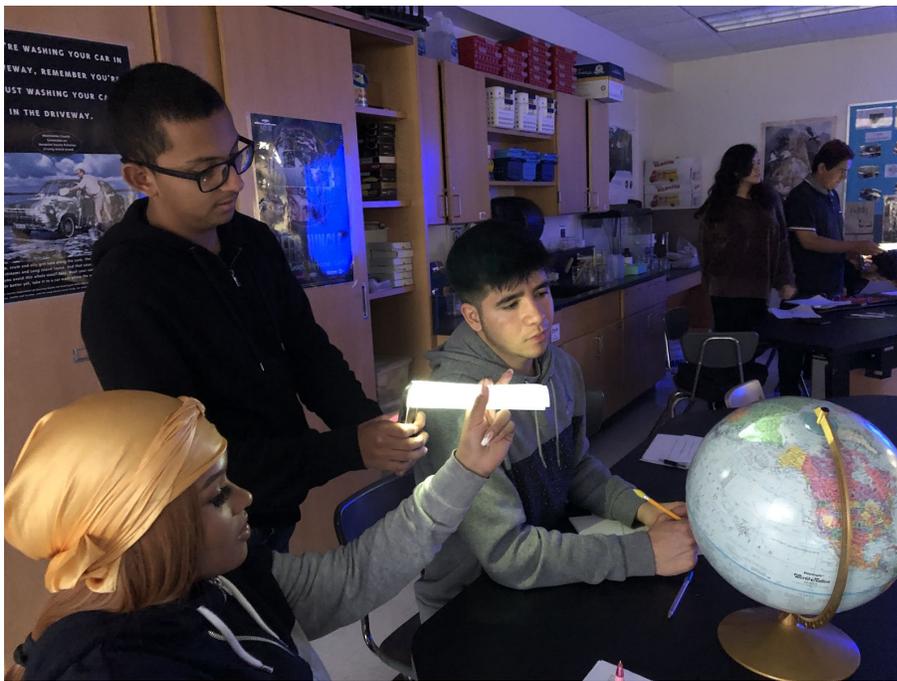
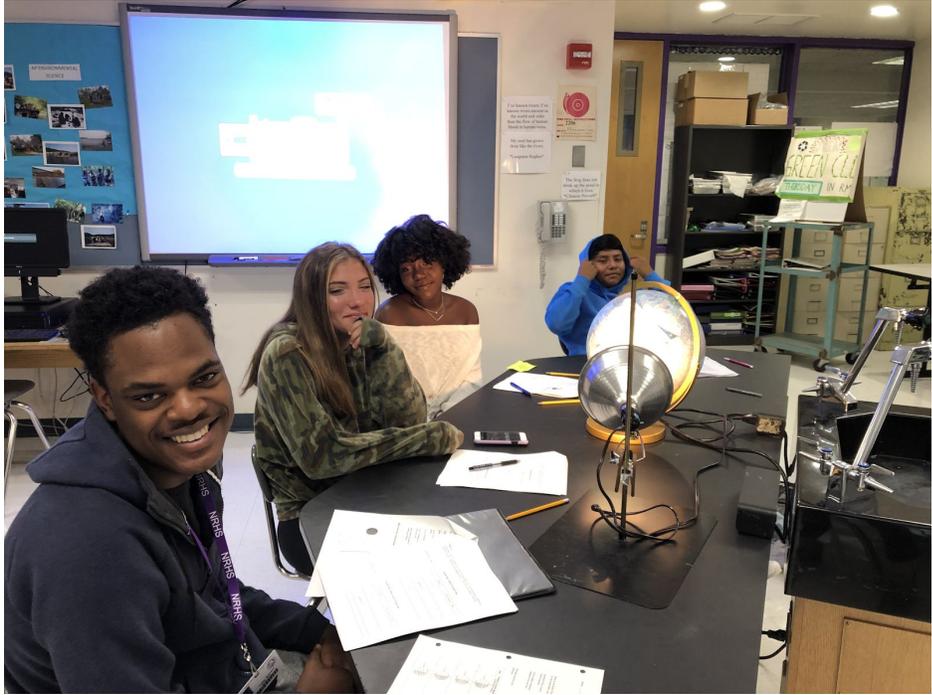


FIGURE 1

Here are some photos of students at work collecting data followed by some student data sheets:





**Part C:**

In this section, we will recreate the Sun's rays as they interact with our Earth. Observe and note the spread of light at different latitudes across the globe.

**Instructions:**

Hold a flashlight parallel to the floor, 3-6 inches away from the globe, and point the light at all latitude points listed in the table below. Notice the concentration and intensity of the light and record your observations below. The lights in the room can be dimmed to notice the effects further.

| Latitude | Observations of the Spread of Light                   |
|----------|---|
| 90°N     | Its less bright but covers more area                  |
| 45°N     | A bit more brighter but covers less area              |
| 0°       | Very bright but covers a bit of area of only          |
| 45°S     | less brighter than the equator but it covers more are |
| 90°S     | very bright but covers way more area.                 |

1. Do you think the amount of light coming out of the flashlight changed?

No

2. Where on the globe was the light most concentrated (least spread out)? Why do you think that is?

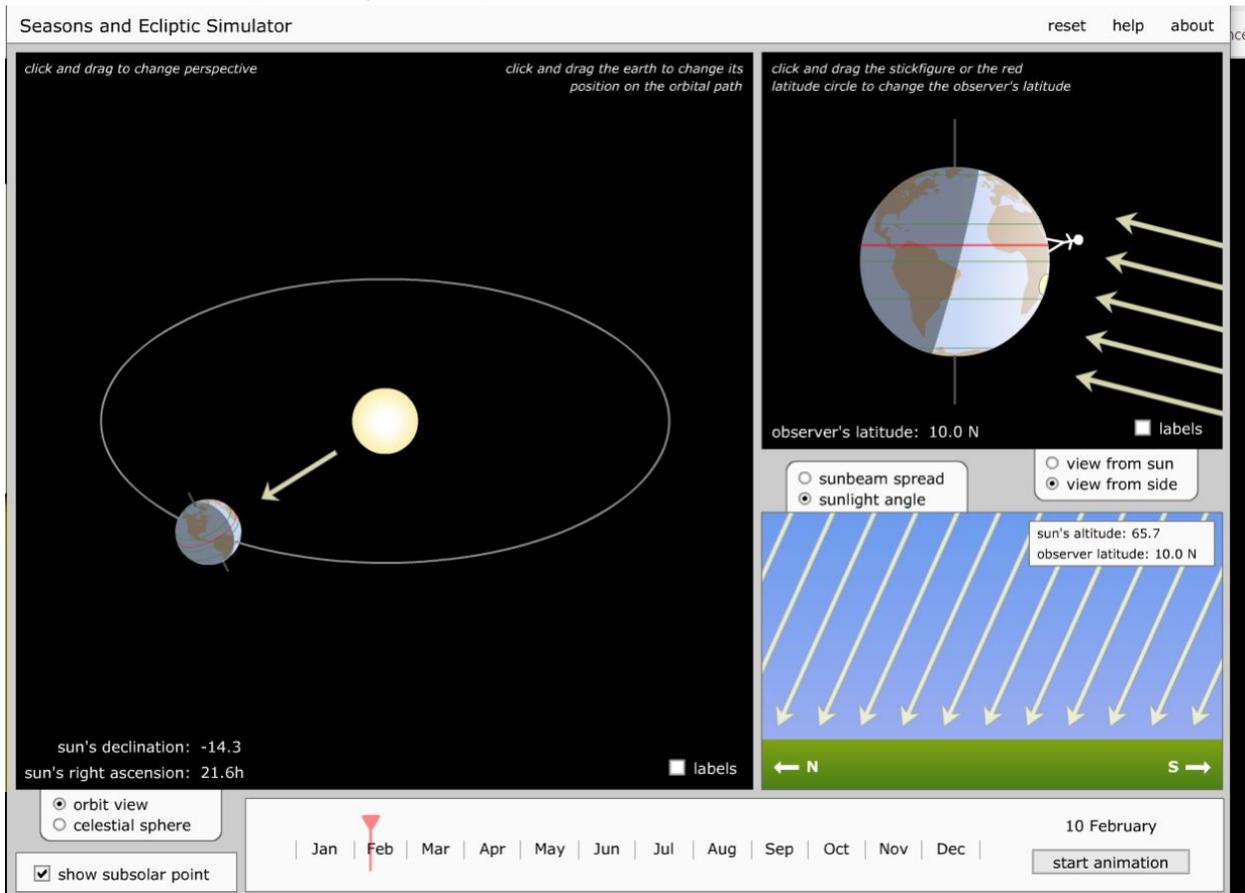
At 0°, At the equator

3. Where on the globe was the light least concentrated (most spread out)? Why do you think that is?

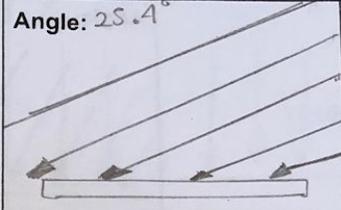
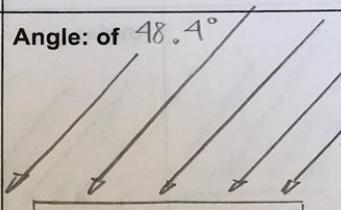
At the up <sup>North (90°)</sup> and down south 90°

Students are revising their thinking to understand that the intensity, angle and duration of sunlight hitting the surface of the Earth at different latitudes creates the uneven warming of the Earth. They still need to understand the importance of the tilt towards or away from the Sun as the factor that creates the most extreme seasonal differences. Students examine and analyze graphs of average monthly temperature data from Melbourne, Australia; Quito, Ecuador and New York City, USA. NYC and Melbourne are at approximately the same distance from the equator but north and south of the equator. Students find the fact that they are looking at data for New York City interesting and they also enjoy learning about additional international locations. One student asks, “So you could just travel and constantly avoid winter?” Bingo!

The final tool that puts together all of the students’ understanding up to this point is using the Seasons simulator (see image below).

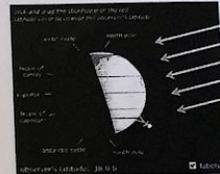


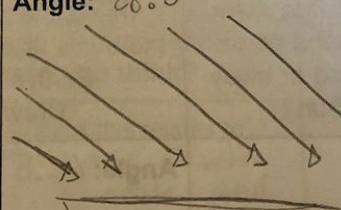
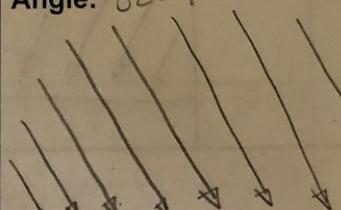
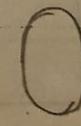
Students can change the latitude of the observer and date of the year. Students use the simulator to record the angle of the sun and the “spread” of the sunbeam during the solstices and equinoxes.

|          |                   |  |   |
|----------|-------------------|--|---|
| Dec 21   | Away from the Sun | Angle: $25.4^\circ$<br>    |  |
| March 20 | neither           | Angle: of $48.4^\circ$<br> |  |

City: Melbourne, Australia

Latitude:  $38^\circ\text{S}$



| Date    | Earth's Tilt<br>Look at the left side of the sim screen. Is the north pole tilted toward or away from the Sun? | Angle of Sun's Rays<br>What is the angle at which the Sun's rays are hitting the Earth's surface?<br>Draw them! | Spread of Sun's Rays  |
|---------|--|---|---|
| June 21 | away   | Angle: $28.5^\circ$<br>     |  |
| Sept 22 | neither  | Angle: $52.9^\circ$<br>     |  |

Students found this tool to be incredibly useful to visualize concepts that seem abstract: the tilt of the Earth, the angle of the Sun and the intensity of light hitting the Earth.

The final Elaborate part of the lesson has students use the data they have collected and their observations to answer some novel questions about the connection between latitude, tilt of the Earth and seasonal temperature changes.

Overall, I found this lesson to have clear instructions, meaningful activities and the sequencing helped build knowledge and create meaning for students. I will continue to use this lesson for years to come. The only improvement I would make would be the formatting of the sections labeled Think-See-Wonder. There was a lot of extra space that my students didn't know what to do with. In terms of incorporating "authentic space data," the simulator allowed them to attach a quantitative value (angle measurement) to a phenomenon usually described qualitatively as more intense/direct or less intense/direct. Being able to record the angle of insolation is much more concrete for students.

Thank you to Laura Rodriguez for sharing this lesson.