SOS "Water Falls" – Pre-visit Lesson Teacher's Guide

Lesson Overview: This lesson plan is intended for teachers to use with their middle school students before they see the Science on a Sphere film, "Water Falls." The emphasis in this lesson will be on having students learn about the importance of freshwater resources and understanding the processes that take place in Earth's water cycle. The following NGSS (Next Generation Science Standard) will be taught and assessed through this lesson:

National Standard:
MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]

Background Information:
Water is everywhere on Earth, from high in the atmosphere (as water vapor) to low in the atmosphere (precipitation, droplets in clouds) to mountain snowcaps and glaciers (ice) to running liquid water on the land, in oceans, and underground. Energy from the sun and the force of gravity drive the continual cycling of water throughout these reservoirs. Sunlight causes evaporation and propels oceanic and atmospheric circulation, which transports water around the globe. Gravity causes precipitation to fall from clouds and water to flow across the land through watersheds.[1]

Materials:
- Assessments – 1 each per student
- Student Capture Sheet – 1 per student
- Materials for Teacher Demonstration *(See Teacher Demonstration Instructions Sheet)*

Engage:
1. Hand out the Student Capture Sheet and have students complete the Warm-up/Activator.
2. Teacher asks, "Why is water important to us?" Record answers.
3. Show Slide 3 with the "Blue Marble" (Earth image from space). Say, "Earth is sometimes called the water planet. That's because more than 70% of Earth is covered in water."
4. Students "Think-Pair-Share" the question, "What percentage of all water on Earth is available for human use?" Ask for a few responses and have kids write down their responses.
5. Show slides (slides 4, 5, and 6) that depict where freshwater is and how much of it is available for human use. Directions for completing this demonstration can be found at the end of this guide and in the accompanying PowerPoint. *(This can be done as a teacher demonstration, or as a hands-on activity.)*

[1] Authors: Achieve, Inc.; Next Generation Science Standards, Core Idea ESS2.C ; Publisher: Achieve Inc.; Copyright: 2013.

   a. *If done as a hands-on activity, it is suggested that material sets for each group are placed in a tub or box before class.*
      i. *Each group of students should have: a clear, plastic drinking cup; a small medicine dispensing cup (or similar size); and an eye dropper.*
   b. *Students follow along with the directions in the PowerPoint.*
6. Show 'The Freshwater Connection' video (slide 7) at: http://pmm.nasa.gov/video-gallery/what-is-global-precipitation-measurement.

Explore:

1. Ask, "What is a cycle." Solicit responses (slide 8).
   a. *"Very simply, when scientists talk about cycles, they are talking about sequences of events that repeat themselves. Some cycles are very simple. For example, the seasons of the year represent a cycle in that they always repeat – Winter, Spring, Summer, Fall, and then back to Winter!"*[2]
2. Ask, "More specifically, what is the water cycle?"
3. Show the following animation (slide 9). It has no narration, so the teacher can choose to use it in a number of different ways. *(The animation is three minutes long. It is not necessary to watch for the full three minutes.)*
   a. Have the students watch a few minutes without giving explanations.
   b. The teacher can add commentary about what is happening.
   c. The teacher can pause as new things are happening and ask students to say what they think is happening.

Explain:

1. Now, show the same video (slide 10), but this one has the stages of the water cycle labeled. Pause to allow students to copy the labels of the water cycle onto their diagrams. http://www.youtube.com/watch?v=iohKd5FWZOE
2. Ask, "What stages are driven by solar radiation? (i.e. Which stages require heat in order to change phase?) Students should write these on their capture sheets. (slide 11) Clicking ahead will show circles around the two terms. (Evaporation and Transpiration)
3. Have the students Think-Pair-Share this question. "We know the sun's radiation is the energy that drives the water cycle. What is the force that keeps the water moving in the water cycle?" (Gravity) (slide 12)
4. Say, "Scientists can use their understanding of the force of gravity, soil, and geology to gather data about where and how much water is in groundwater and soil. The GRACE mission uses a pair of satellites to measure variations in gravitational pull to find and measure underground water."
   a. Text on PowerPoint: The gravity variations studied by GRACE include: changes due to surface and deep currents in the ocean; runoff and ground water storage on land masses; exchanges between ice sheets or glaciers and the ocean; and variations of mass within Earth.

[2] Windows To the Universe; *What is a cycle?;* http://www.windows2universe.org/earth/climate/cycles_general.html; June 29, 2005.

   b. The underlined portion of the text refers to the water cycle portion of the GRACE mission statement.
   c. On their capture sheets, have students list the stages of the water cycle that are driven by gravity.
5. Ask, "Earlier, we talked about why freshwater is so important to humans and almost all life on Earth. Where are some places humans get fresh water?" (pumped from rivers, lakes, wells, and man-made reservoirs.)
6. Ask the students, "What is a reservoir?" Record their answers.
   a. Share this quote from a USGS web page. "As you know, the Earth is a watery place. But just how much water exists on, in, and above our planet? About 70 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. But water also exists in the air as water vapor, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers, and even in you and your dog." [3] (slide 16)
   b. Say, "The air, rivers and lakes, ice and snow, underground aquifers, and living things all act as reservoirs – they hold water that can be used at a later time. Some reservoirs are manmade so towns and cities can draw from them."
   c. Say, "Look at the water cycle diagram we labeled earlier. Where is water being stored? (reservoirs)" Help the students identify the parts of the cycle where water is stored. Students fill in the space provided on their capture sheets with this information. See presenter notes on PowerPoint or the capture sheet key.

Evaluate:

1. Students complete a mini-project in which they describe one possible path that a water molecule can take through the water cycle. They have the following choices in order to demonstrate their understanding:
   a. They may make a mini-poster with a diagram of the water cycle. (8.5" X 11" maximum)
      i. The diagram should not look just like the one we used in class. It should have the water molecule moving from one step to another.
      ii. Each step in the cycle needs to have text that describes what is happening to the molecule. This text can be 'spoken' by the drop, or written as a caption near the drop.
   b. They may make a comic strip with a molecule of water as the main character.
      i. The comic must include text that explains what is happening in each frame.
      ii. The text can be dialog 'spoken' by the drop, or written as a caption at the bottom of the frame.

   Electronic Options for students who prefer to use a computer:
      1. A Glogster poster. http://www.glogster.com
      2. Computer generated comic strip.
2. There is an optional rubric at the end of the student capture sheet.

[3] USGS, How much water is there on, in, and above the Earth?; http://ga.water.usgs.gov/edu/earthhowmuch.html

3. Administer the lesson assessment.

Extend:

1. Show the video, 'The Water Cycle – Featuring Molecule Man!' http://pmm.nasa.gov/education/videos/water-cycle-featuring-molecule-man.This video takes students through the water cycle again. But this time, improvements in technology used to study the water cycle are emphasized.
2. At the end of the video, students should explain at least one way that technology has improved over the years.

Additional Resources:

1. Article: Earth Observatory Water Cycle Overview http://earthobservatory.nasa.gov/Features/Water/
2. Video: Our Wet Wild World (GPM Overview) http://pmm.nasa.gov/education/videos/our-wet-wide-world-gpm-overview

Directions for the "How Much Water is Available" demonstration.

1. Fill the cup about 70% (Almost ¾)
   "This represents how much of Earth's surface is covered with water."
2. Fill the eye dropper from the cup, and GENTLY squirt it into the medicine cup.
   "This represents how much of Earth's water is freshwater- ~ 2.5%"
3. Use the eye dropper again to place one drop on the back of your hand.
   "This represents how much freshwater is easily accessible to us – less than 1%!"