Rain Gauge Activity Lesson Plan

Lesson Overview: This is an inquiry-based hands-on activity that has been created to engage students in designing and testing out a rain gauge. The point of this activity is to provide a common experience from which we can illustrate engineering concepts and skills. As the new "Next Generation Science Standards" include an emphasis on engineering skills, science teachers need some examples of lesson plans that use science content as the context for including an engineering problem. Students are given a rationale for the need to measure precipitation, and then are presented with an engineering problem: "Design and make a rain gauge that can be used to measure precipitation." They are given some easily obtainable materials and tools to use. After students have designed and made their rain gauges, they simulate rain falling, and then compare their results. The comparison of results leads to a discussion about the need for a standardized calibration system to be used to get precise measurements that are reliable. Students are then introduced to the Global Precipitation Measurement mission and learn how this mission will set the new calibration standard for measuring precipitation across the world.

Learning Objectives:

- Identify water in its three different forms on Earth (ice, rain, water vapor)
- Describe how water moves through the water cycle
- Explain the need to measure precipitation
- Use provided materials and tools to solve an engineering problem
- Realize the necessity of having a calibrated rain gauge that uses an agreed upon unit of measurement and a standardized design to ensure the reliability and validity of data collection

National Standards:

Core Idea ETS1: Engineering Design

- ETS1.A: Defining and Delimiting an Engineering Problem
- ETS1.B: Developing Possible Solutions

ETS1.A: DEFINING AND DELIMITING AN ENGINEERING PROBLEM

What is a design for? What are the criteria and constraints of a successful solution?

The engineering design process begins with

- Identification of a problem to solve
- Specification of clear goals or criteria for final product or system

ETS1.B: DEVELOPING POSSIBLE SOLUTIONS

What is the process for developing potential design solutions?

The creative process of developing a new design to solve a problem is a central element of engineering

- Open-ended generation of ideas
- Specification of solutions that meet criteria and constraints
- Communication of ideas through various representations, including models
- Data from models and experiments can be analyzed to make decisions about a design.

This is a very well written article that explains the importance of including engineering practices in the National Science Education framework-
http://www.nsta.org/about/standardsupdate/resources/201201_Framework-Sneider.pdf

Core Idea ESS2.C: The Roles of Water in Earth's Surface Processes

- Water continuously cycles among land, ocean, and atmosphere. Water is transported from one to the next via the processes of transpiration, evaporation, condensation, crystallization and precipitation, as well as the downhill flow of water over land. (MS-ESS-4)

Background Information:

The Science: NASA is partnering with the Japan Aerospace Exploration Agency (JAXA), along with several other countries, to develop and launch an international satellite mission. The mission, called Global Precipitation Measurement, will provide next-generation observations of rain and snow worldwide every three hours. To learn more about this mission, please go to http://pmm.nasa.gov/GPM. One of the reasons that it is important to know how much rain and snow are falling worldwide is because we actually only have a very small amount of freshwater available to meet the needs of our societies. Earth is widely known as the "Water Planet," but only about one percent of all of Earth's water is available to people to use. You can find out more about the importance of measuring precipitation from space at this link: http://pmm.nasa.gov/science.

The Methodology: This lesson purposely uses an open-inquiry approach. The goal is not for the students to make accurate rain gauges that have correct calibration on their first attempt. Instead the goal is to allow students to design a rain gauge and then test it out in an attempt to familiarize them with the many factors that must be taken into account when designing a tool for a specific purpose. It is important that the students are allowed to make mistakes, such as not using a ruler and making measurements from the bottom up, in order for them to have the experience of designing a tool and trying it out, and then realizing that there are certain design restraints that must be taken into account.

Materials:

- A globe
- Plastic cups (one for each small group; see though cups work best)
- Smaller cups (one for each small group; medicine cups or petri dishes work fine)
- Eyedroppers (one for each small group)
- A few ice cubes
- A wide assortment of plastic containers for students to select from (one for every pair of students: empty water bottles, soda bottles, etc. It is fine if they are not all clear and they should not all be the same size or shape for this particular activity.)
- Scissors, tape
- Both metric and standard rulers
- Measuring tape
- Plastic graduated cylinders of different sizes
- GPM PowerPoint entitled, "Making a Rain Gauge"
- Computer with Internet access (if possible)

Engage: Show the students a globe and ask them to explain what it is. Elicit student observations about what they observe and then discuss how the globe is actually a model of the Earth. Talk about why we use models and discuss what is accurate and not accurate about using the globe as a model of Earth.

Then, using the *GPM Rain Gauge Activity PowerPoint*, show them the "*Engage*" slide *(slide 3.)* Ask students to describe their observations. Help guide them to talk about seeing water on Earth and discuss the fact that is it present in different forms of matter: as a liquid (in oceans and lakes); as a gas (in clouds), and as a solid (in ice packs and glaciers such as in Antarctica and the North Pole.

Go to the next slide (*slide 4*) and have them discuss the three phases of water. Have water in cup and ice and have them identify the stages water is in. Ask if someone can give an example of water in a gas form (steam, clouds, etc.). Use to reinforce the fact that water exists in three forms on Earth. Ask students what causes water to change from one form to another. Ask them for a few examples of water changing form due to changes in temperature (i.e. from rain to snow as it gets colder).

Explore: Ask your students if there is more water or land on Earth, and talk about how Earth is often called the "Water Planet." Talk about why water is important for life, and let them offer some examples. Take a cup and explain that if the cup were a model of the surface of Earth, then 70 percent of the surface would be covered with water. Ask what the water in the ocean tastes like and help them understand it has

salt in it. Have a brief discussion about the differences between salt water and freshwater and which of these most living things need for their survival (*slide 5*).

Ask if they think more water on Earth is saltwater or freshwater. Then say "If you imagine that all the water on Earth is in this cup- covering 70 percent of Earth's surface. Let me show you how much is freshwater, which is what living things need to survive." Take an eyedropper, and invite a student to come up and take out one eyedropper of water. Have the student put it into the medicine cup. Explain that this little amount of water demonstrates the small amount of Earth's water that is freshwater. Add some salt to the cup, and ask if that would taste good. Reinforce that we need freshwater, and not salt water, to meet our needs. Then tell the students that even the little bit of water in the medicine cup isn't available for us to use. Most of Earth's freshwater is either ice in glaciers (explain what a glacier is), ice caps (like where it is almost always frozen in the North Pole) or deep under ground where we can't get to it.

Finally, invite a student to come to the medicine cup and use the eye-dropper to take out one little drop. Then tell students that the one drop is how much freshwater we have that we can share with everyone in the whole world. We have to try to keep track of where it is and how much we have to share. If you have time, let each small group of students try this activity to reinforce the concept that very little of Earth's water is freshwater. It will only take a few minutes and generally students are amazed by the small amount of freshwater that is readily available to us. (*Slide 6*)

Explain: Use a water cycle plastic model (if you have access to one but it is not essential) and/or the next slide (*slides 7*) to show the water cycle. Point out that rain is fresh water because the salt stays behind in the ocean during the evaporation process. There is not narration for this video clip, so you can talk through the diagram and animation.

Go through each part of the water cycle and explain the names of the processes. Stop from time to time and have the students fill in the blanks: liquid water from the ocean gets warmed by the ___ (sun) and turns into a _____ (gas), which we call evaporation. It goes up into the sky, or atmosphere, and may become a _____(cloud). We call this condensation. When the cloud becomes too full of moisture, or water vapor, then it either ____(rains) or ____(snows). We call this precipitation. The precipitation falls back down to the Earth, and some may become snow on mountains, which is water in which form? (solid). Some goes down into streams, some stays on the land, called surface runoff. Other precipitation goes underground, which we call groundwater. Some precipitation waters plants and when they drink it and then get hot, some of that water turns into water vapor through a process called transpiration. This keeps happening over and over, and so we call that the water cycle.

Show the students the short video entitled, "The Freshwater Connection" on *slide 8*. You will need Internet access to show this video. If you don't have Internet, you can download it ahead of time by going to this link (and http://pmm.nasa.gov/education/videos/gpm-freshwater-connection) downloading it ahead of time.

Extend: Explain that now that they understand the importance of precipitation in providing us with freshwater, they will use their engineering skills to design and test an instrument that measures how much rain is falling. (*Slide* 9) Give them the materials to work with and circulate around the class to answer questions. Guide them but encourage the students to try out their own ideas. This activity works well when students work with a partner. The goal is for the students to work collaboratively to try to design their instrument. Students may be frustrated by this task. Often they will begin to consider how to calibrate their rain gauge.

This is an engineering activity and the expectation is that some degree of trial and error often occurs when engineers need to make something for a specific purpose. If time and weather permits, you may want to take them outside and use a watering can to simulate rain. Then they can collect data and compare it (*extra slide*). Then the students can use that information to help them with the final questions about design.

Evaluate: Guide them to think about the design consideration questions on *slide 10*. Show the short video (2:01) on *slide 11* entitled, "For Good Measure". Students could write directions for designing and making a rain gauge as a formal assessment. They could also write a paragraph explaining how science and engineering work together to help us learn ore about our natural world.

Extension Activities:

- Have students make another rain gauge using the design constraints that they developed during this lesson. Have them find a way to set these up at their homes. This will create an entirely new design challenge as they experiment with ways to make the gauge stand up, withstand weather, etc. Have the students collect precipitation for a week. Have them bring their rain gauges back filled with rainwater (if you use plastic water bottles with caps, they can put the cap on for transporting their gauges) and compare their measurements. Discuss why their results may differ.
- Find out the average amount of precipitation for your area and figure out how to model this. You can use smaller water bottles for monthly data or 2-

liter soda bottles for yearly data. Students will need to explore various websites to get the precipitation data, and will need to figure out how to use graduated cylinders and do conversions to fill the bottles with the accurate amount of water.

- Do the activity above but use different regions of the world and compare the amount of precipitation they receive per year.
- Design an instrument to measure precipitation in the form of snow.
- Put up a rain gauge at your school. These are very inexpensive (~$30.) and you can report the data and compare data across the country. Go to the CoCoRaHS site below to learn more. http://www.cocorahs.org/Content.aspx?page=CoCoRaHS_Schools
- Go to the Global Precipitation Measurement mission's Education site at http://pmm.nasa.gov/education/ and explore the resources we have for students and teachers.