Rain Gauge Experiment

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 go outside and 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 clouds)
- Explain the need to measure precipitation
- Discuss the fact that freshwater resources are vital to life
- 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
- Communicated 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*

Background Information:

The Science: NASA is partnering with the Japanese Space Agency (JAXA) along with several other countries, to develop and launch an international satellite mission that 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 that is available to meet the needs of our societies. Earth is widely known as the "Water Planet", but only about 1% of all of Earth's water is available to us to use for our needs. 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 as the goal here isn't for the students to make accurate rain gauges that have correct calibration on their first attempt, but rather to allow them to attempt 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
- A cup about 70% filled with water
- An empty cup
- An eyedropper
- A few ice cubes
- A wide assortment of plastic and metal containers for students to select from
- 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)
- Watering can to use to simulate rain

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 lesson PowerPoint*, show them the "*Engage*" slide *(slide 3)* and ask them 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. Have water in cup and ice, and have them identify the stages water is in, and 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, and ask the students what causes water to change from one for to another. Ask them for a few examples of water changing due to changes in temperature.

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% 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. Ask if salt water is good for plants and if we can drink it to stay healthy. Ask if they think more water on Earth has salt or is "freshwater". Then say "If you imagine that all the water on Earth is in this cup- covering 70% 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. Tell the students that are how much water is freshwater, and the rest has salt in it. Add some salt to the cup, and ask if that would taste good, and reinforce that we need freshwater, and not salty 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, because most of it 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- and tell them that is how much freshwater we have that we can share with everyone in the whole world- and so we have to try to keep track of where it is and how much we have to share.

Explain: Ask if anyone has ever tasted rain or snow, and ask if they think it is freshwater or salt water. Use the water cycle plastic model to show the water cycle, and point out that the rain is freshwater because the salt stays behind in the ocean. 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 the mountain-, which is water in which form? (solid). Some goes down into streams, some stays on the land- we call that "surface runoff", and other goes underground- which we call "groundwater". Some waters plants and when they drink it and then get hot, some of that water turns into water vapor- we call this "transpiration". This keeps happening over and over, and so we call that the "water cycle".

Extend: Now we are going to try to make something that we could use to measure how much precipitation in the form of a liquid- what would we call that? (rain) is falling in a certain place. Say we wanted to find out exactly how much fell in our yard in one day. We need a tool to use to measure the amount of rain that falls- this is called a "rain gauge". So, we will give you some supplies and you will work with two partners and make a tool that could be used to measure rain. Give them the materials to work with and circulate to answer questions, but guide them to try out their own ideas. When everyone has finished, take some water in a few squirt bottles and simulate rain, and let them compare what their measurements were. Show the video about how GPM will measure precipitation.

Evaluate: Guide them to think about how they could get more precise measurements. Also have them talk about why it might be important to measure precipitation. Review with them the phases of liquid, and see if they can figure out what causes water to move from one phase to another (heat being added or taken away). Hand out the water cycle droplets for them to keep, and use it to review the water cycle. Show them the GPM mission on the other side, and show them the little drop of water that represents fresh water, and see if someone can explain that. Also point out the shape of the droplet and share why it is shaped that way.