Activity 3.1 Making Simple Weather Instruments: Barometer, Anemometer, Thermometer, Psychrometer, Precipitation Gauge

Teacher Background

Weather instruments work because of the way the world works. A barometer functions because air has weight and therefore exerts pressure. A thermometer works because a liquid expands when warmed and contracts when cooled. In this Activity, students will make some or all of the five weather instruments detailed below and will see the principles behind their operation.

3.1.1 Air Pressure and Barometers: The first barometers, invented by Evangelista Torricelli in 1644, consisted of a glass tube with an open end. The tube was placed in a container of mercury, open end down, and attached to a ruler. As air pressure increased, it pushed down on the surface of the mercury causing it to rise inside the tube. Since the measurement was recorded using the attached ruler, meteorologists still record pressure in inches of mercury. Mercury barometers are bulky; today most barometers are aneroid and use a thin metal container with some of the air removed thus making it more sensitive to air pressure. A spring-like device keeps the can from collapsing. As the pressure changes the volume of the container changes. This change is registered on a barometric scale. The balloon barometer students will build models aspects of such aneroid barometers. The water barometers in the Suggested URLs more closely resemble Torricelli's original, without the mess, expense and risk of using mercury.

3.1.2 Using an Anemometer to measure wind speed: a basic anemometer consists of 3-4 light weight cups which can rotate freely on a vertical spindle. The anemometers seen on NOAA's balloon-launching or tornado-chasing vehicles in the video are admittedly more high-tech than this but share substantially the same design. Anemometers are more accurate at heights greater than surrounding buildings or in an open field. It's also difficult to get an accurate measurement on very calm days or when there are intermittent gusts. On such days, the Beaufort scale can be used to estimate wind speed. To determine the direction of the wind you need a wind vane. The wider tail resists the wind more than the nose, thus moving the nose of the wind vane in the direction from which the wind comes. Thus when we say there's an easterly wind we mean that the wind is blowing from east to west.

3.1.3 Measuring Temperature with a Thermometer: temperature is a measure of the energy of molecules. When molecules are heated they spread further apart, causing the liquid in the thermometer to expand in volume and rise. Mercury thermometers are more accurate than alcohol, but alcohol does not freeze until temperatures of -129 degrees Celsius. This simple instrument uses colored water.

3.1.4 Using a Psychrometer to record Relative Humidity: psychrometers work because evaporation causes cooling. A psychrometer has two thermometers. One gives the "dry bulb" reading. The other is wrapped in cheesecloth, or uses a wick which is then dampened, giving the "wet bulb" reading. To find the relative humidity you swing the two thermometers until they reach a stable level. You then record both the dry and wet bulb readings. Using a table you can then find the relative humidity. To make this Activity work you will need inexpensive manufactured thermometers. Don't try and have students swing the apparatus they build in Activity 3.1.3 around the room!

3.1.5 Making a simple Precipitation Gauge: these measure the amount of rain or snow that has fallen. You can use any container with a flat bottom and straight sides to record the amount of precipitation. The opening of the container should be the same size as the bottom. A clear jar makes it easier to read the amount of rainfall, but in strong winds the jar can be blown and broken unless you carefully anchor it. Your rain gauge should be placed in the open, away from buildings, or under a tree in order to obtain an accurate measurement. Snow can be measured by simply using a ruler. Make sure you choose a location where you are not measuring extra accumulations caused by wind drifts. Use an empty inverted soup can (watch out for jagged edges!) to take a "core sample," making sure you get the total height of the snow that fell. Bring your sample inside and let it melt. This will tell you how much rain would have fallen in that time if the temperatures had been warmer.

These instruments are *not* intended to collect weather data with the same precision as professional instruments. However, students will enjoy collecting data with "their" instruments, will find a rough correspondence between their data and that obtained with "real" instruments, and will have a much greater appreciation of the weather, the science behind it and how we measure its daily changes. A direct experience of "wind speed" or "relative humidity" will give new relevance to these words when students hear them in a weather report. It also allows you to connect a student's natural fascination with how things work to the lives and times of the inventors of the instruments. (See Activity 4.3, Making a Weather and Climate Timeline.)

Objectives

Students will build simple weather instruments which use the same principles found in the instruments used by professional meteorologists.

Students will relate how and why these instruments work to fundamental scientific principles, i.e. air has weight, liquids expand when heated.

Students will contrast the accuracy of their instruments and data with professional instruments and data by comparing the two sets of measurements over a period of time.

Engage

If your school has a weather station, take students to see it, and have them name the different instruments. Ask how they work. Accept all answers, and have them note the various scientific principles suggested in their WEATHERlogs. Explain that while these instruments are professionally made, they can make simple versions which will let them record some of the very same phenomena. If you do not have such a weather station, ask students where the data they see on TV or read in the newspapers originates: have them list instruments and how they work, and proceed as above. Students will also see many instances in the LFSTORM videos where researchers use more sophisticated versions of what they're about to build. For example, in program 1 they'll see a snow gauge high in the mountains of Utah, anemometers on the decks of ships, and an instrument pack recording temperature, pressure, relative humidity and wind speed and direction being flown beneath a balloon as part of NOAA's Intermountain Precipitation Experiment, IPEX.

Explain/Explore
Procedure
The procedures for making each instrument are detailed in 5 separate worksheets, one instrument. Additional information and alternative construction plans for each instrument are provided in the URLs suggested. We suggest you review these worksheets and the Standards Correlation sheet before beginning the Activities, and sample the URLs to see if any of the alternate procedures would better suit your circumstances.

As in Section 2, you can implement 3.1 at a *series* of activity stations so students rotate through each instrument-building activity in turn. Or each student can select a weather phenomenon to measure, and then build and use their instrument, and report back data and learnings to the class. Depending on resources, Activity 3.1 can be implemented with individual students or in teams.

Expand/Adapt/Connect
As suggested on the worksheets, have students use their instruments for a predetermined period of time (1-2 weeks). Have them make a chart in their WEATHERlogs comparing results obtained with their instruments with those found in local newspapers or online.
Either as part of Activity 3.2 or as a stand alone, have them note correlations between observed weather conditions (sun or cloud, rain or wind) and the phenomena they can now measure with their handmade instruments. Again, assign a 1-2 week period.
Go online and research the inventors who first developed such instruments. This will also prepare them for Activity 4.3 Making a Weather and Climate Timeline.
At the LIVE FROM THE STORM website, under WHO/SITE tours, see if they can find pictures of weather instruments at work.

Suggested URLs
These two sites provide much more than information on barometers: associated with these two URLs you'll find a whole suite of other simple instruments and procedures. Many more URLs are listed on the Student Worksheets for Activity 3.1.

http://sln.fi.edu/weather/todo/barometer.html
Water Barometer: The Franklin Institute: Franklin's Forecast

http://www.schools.ash.org.au/paa/instruments.htm#airbarom
Air Barometer, from the AMS Project DataStreme affiliate