Inquiry project: Weather Forecast

In this lesson students will build a simple barometer and use it to record data of air pressure over two weeks, in order to understand the ways in which air pressure is related to weather conditions and use this understanding to make predictions about the weather.

Learning Goals

At the end of this project, students will be able to:

- Build a simple barometer
- Understand how a barometer works
- Understand the relation between air pressure and weather conditions
- Make predictions regarding future weather based on the air pressure data they collected
- Read weather maps including isobars, low and high pressure areas and warm and cold fronts

Background Information

Unlike other smaller planets like Mercury, our Earth is big enough to create a gravitational pull to stop gases from escaping and thus creating an atmosphere. Without it, life would not be possible, as all living things depend on air for survival. Plants transform air carbon dioxide into glucose through the process of photosynthesis, while both plants and animals use air oxygen to break glucose molecules in the process of cellular respiration. Moreover, Earth's atmosphere prevents solar radiation from escaping the planet, in a phenomenon known as the greenhouse effect, which makes Earth's temperature suitable for life. Without atmosphere, the Earth's average temperature would be closer to zero Fahrenheit that the approximately 60 degrees F that it is now.

Earth's atmosphere extends about 300 miles above our heads and therefore we are constantly pushed down by a large mass of air, even if we are not usually aware of it. At sea level, Earth's atmosphere is pressing against us with a force of 14.7 pounds per square inch. The reason why we do not collapse under that pressure is because the air inside our bodies balances it out. Atmospheric pressure is measured in inches of mercury ("Hg) in weather reports, while meteorologists use the metric unit of millibars (mb). The average air pressure at sea level is 1013.25 millibars or 29.92 inches of mercury. As we go further away from the Earth's surface, air pressure decreases, as there is a lower density of air molecules, most of which are held close to the earth's surface by gravity.

A barometer is an instrument that measures air pressure at a particular location. The first barometer was created in 1643 by Evangelista Torricelli and used a long glass tube, open at one end and closed at the other, with a mercury-filled reservoir. The height of the column of mercury in the tube indicated air pressure, as the weight of the mercury

column balanced the atmospheric force exerted on the reservoir. High atmospheric pressure forces the mercury higher in the tube, while low pressure lets the column go down to a lower level.

Air pressure is one of the main factors that influence weather conditions. Air moves from zones of high pressure to low pressure zones, originating winds. The greater the difference of pressure between a high pressure zone and a low pressure area next to it, the stronger the winds generated. Moreover, winds take with them clouds and thus make the sky clear. Hence, zones with high air pressure levels are more likely to have nice weather. On the contrary, a low pressure area attracts winds and clouds, increasing the likelihood of bad weather.

Weather maps include different features that students must learn to read in order to be able to interpret them (see Go Wild in New York City, page 32), including:

- High and Low pressure centers, marked with a blue "H" and a red "L", respectively: They indicate the location in which air pressure is the highest or lowest relative to its surroundings.
- Isobars: Lines which connect points of equal pressure on a weather map.
- Warm Front: Indicate the zone in which a warm air mass is replacing a cold air mass. When a warm front passes through, the air becomes warmer and more humid than it was before. Represented by a solid red line with semicircles pointing towards the colder air and in the direction of movement.
- Cold Front: Indicate the zone in which a cold air mass is replacing a warm air mass. When a cold front passes through, the air becomes colder and dryer than it was before. Represented by a blue solid line with triangles along the front pointing towards the warmer air and in the direction of movement.

Development of the activity

1. Warming-up

As an introduction to this activity, discuss with students the following questions:

- How do we know whether tomorrow will be a rainy or a sunny day?
- What are the different ways to find that out?
- How do meteorologists predict weather conditions?

Write students' answers on the board, and ask them to record their responses on their journals. At the end of the project, students will revise their former answers and extend or correct them according to what they have learned.

Also, bring copies of a New York City weather report and a weather map from the newspaper (see for example http://www.nytimes.com/mem/weather.html) and ask students to identify which elements of the report and map they understand and which

others they don't. Make a list on the board of the unknown concepts (such as zones of low pressure, isobars, etc.) which, will be addressed during this project.

2. Theoretical introduction

Students must understand several concepts that before building the barometer and making predictions. Explain that Earth is covered by a gas atmosphere and mention its different layers and its composition (see Go Wild in New York City, page 28.) Discuss the fact that air has weight and therefore exerts a pressure, which we can measure. Talk about how much weight we support over our shoulders even if we do not realize it and why our bodies do not collapse under external pressure (see Background Information.)

Explain that air pressure decreases with height, and connect that with what happens to us as we climb a mountain, when we feel dizzy because air pressure diminishes and thus less oxygen reaches our cells, and how climbers must take a time to adapt their bodies to low air pressure conditions and also use special devices to provide them with oxygen when they go to the summit.

Finally, tell students the relation between air pressure and weather (see Background Information section) and discuss how air moves from high to low pressure zones generating winds. Discuss that the level of air pressure is one of the factors that allow scientists to forecast weather conditions. Propose students to build a barometer, an instrument to measure air pressure, in order to make their own predictions of local weather conditions.

3. Building the barometer

Explain how a barometer works before having students build it in small groups. Prepare in advance the following list of materials per group of students:

- Glass narrow-neck bottle
- Drinking straw (transparent)
- A rubber or cork stopper (must fit in the neck of the bottle)
- Water
- Color dye
- Permanent marker
- Students' journals

Ask students to:

- Insert the straw into the bottle.
- Fill the bottle with water about half-way full and add color dye to it.
- Perfectly seal the neck of the bottle around the straw using the rubber stopper or a cork.
- Check that the end of the straw is immersed in the water, and that the water level in the straw is above the top of the bottle.

4. Using the barometer

To see how the barometer works, ask students to blow air into the straw and see what happens with the water level. They will observe that, as air pressure increases (i.e. as they blow), it pushes water down the straw. And on the contrary, when external air pressure decreases, the air inside the water pushes water up the straw.

The second step is to calibrate the barometer. To do that, students will mark the water level on the straw with a permanent marker and check the newspaper or the Internet (for example, on www.nytimes.com/mem/weather.html or on www.weather.com) the local air pressure. Then, they will write on the straw the pressure value next to their mark. That point will serve as a reference point for future measurements. Ask students to record in their journals the date and air pressure level, as well as the temperature, wind and general weather conditions (sunny, cloudy, rainy, etc.) To finish calibrating the barometer, students will mark the water level inside the straw during at least 3 subsequent days, always checking the air pressure level with the same source. Make sure to place the barometer where the temperature is constant, as temperature changes may also affect water level.

5. Weather forecasting

Students will use their barometers to record air pressure levels on their journals during a week, while also recording the local temperature, wind and general sky conditions. After the week, each group will present their results to the rest of the class and discuss general patterns that they find on their data, such as any relation between air pressure and:

- Temperature
- Humidity
- General sky conditions (rainy, cloudy, clear)
- Wind speed

During the second week of the project, students will continue measuring air pressure levels with their barometers, but this time they will use their data to forecast weather conditions. For example, data recorded on Monday will serve to make a prediction for Tuesday, and so on. Students will check their predictions on Internet or the newspaper, as well as through their own observations of the sky, and record whether they were correct or not on their journals. They will repeat the procedure during the whole week. Finally, each group of students will present their predictions and discuss their results with the rest of the students. It is important to note here that weather forecasting is a very complex procedure that includes multiple factors, air pressure being only one of them. Students must know this in order to not feel disappointed if their predictions are not totally accurate. One possibility to avoid that is to focus students' predictions only on general sky conditions, which are more directly related to air pressure levels.

6. Reading weather maps

In the second part of the project, introduce the basic features of weather maps such as zones of low and high pressure, isobars and warm and cold fronts (see Go Wild in New York City, page 32 and the Background Information section) and ask students to search for weather maps on the internet and practice reading them. Useful websites for this are:

- Current sea level pressure contour plot: Unisys
  http://weather.unisys.com/surface/sfc_con_pres.html

- Current weather conditions map: National Weather Service. Hydro meteorological prediction center
  http://www.hpc.ncep.noaa.gov/

- National Weather Map: New York Times
  http://www.nytimes.com/weather/

Discuss with students how weather maps tell us about the present and future weather conditions of different parts of the country. Students will have to select 2 areas of the country and use the weather map to make a prediction of the likelihood of rainy/ windy/ nice weather, and, as homework, check it and explain whether they were right or wrong and why.

To conclude, ask students to revise their original responses to the questions posed at the beginning of the project, and correct or extend them. Ask them also to include new questions that this project posed to them and mention other things that they would like to learn about in relation to this topic.

Assessment

This project provides various opportunities to assess students' learning (see Learning Goals) in formative and summative ways. Student's skills and conceptual understanding can be assessed through:

-Students' performance in the construction of the barometer (formative)
-Students' journals (formative)
-Students' presentations of results and their contribution to the whole class discussion (formative)
-Students' homework (summative)
-Students' revision of their original responses (summative)

Extensions

As a follow up of this activity, students can investigate past weather conditions in New York City and compare them to present data, creating a chart of, for example, temperature variations during the last decades (see Go Wild in New York City, page 34, for extreme weather conditions in the city).

Students can build a more complex weather station including a hygrometer, a rain gauge, a wind indicator and a compass and research how these parameters affect weather conditions (see Go Wild in New York City, page 34). Different groups of students can focus on one of these factors and investigate it in depth, becoming "experts" that later teach other groups about what they learned in a final presentation. If available, a guest meteorologist can be invited to the presentation and answer students' questions about the topic.

Finally, students can also learn the ways heat generated in New York City affects the weather and causes air pollution, and investigate how they can reduce air pollution by building a green roof or lowering their energy consumption (see Go Wild in New York City, page 35).

Connection to New York City Standards

This activity addresses the following NYC Performance Standards for Middle School Science:

S3a Earth and Space Science Concepts: The student produces evidence that demonstrates understanding of weather and climate

S5b, c and f Scientific Thinking: The student:

b. Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena
c. Uses evidence from reliable sources to develop descriptions, explanations and models
f. Works individually and in teams to collect and share information and ideas

S6a to d Scientific Tools and Technologies: The student:

a. Uses technology and tools to observe and measure objects, organisms and phenomena
b. Records and storage data using a variety of formats
c. Collects and analyzes data using concepts and techniques in Mathematics Standards 4
d. Acquires information of multiple sources

S7a, b, d and f Scientific Communication: The student:

a. Represents data an results in multiple ways
b. Argues from evidence
d. Explains a scientific concept or procedure to other students

f. Communicates in a form suited to the purpose and the audience