Clouds

Introduction

Figure 1. There are many types of clouds, each associated with specific weather patterns. Credit: Bob Williams, NOAA

Before completing these investigations, it is recommended that students first complete lessons to develop a concept of air as something that moves, fills space, and exerts pressure. They should know that it has properties, like temperature and wind speed, that can be measured. Students can consolidate their understanding of these properties of air while adding clouds and precipitation to the picture.

Earth's atmosphere, so critical to its living systems, is a mixture of gases. The major components are nitrogen and oxygen. Minor components include argon, carbon dioxide, and numerous trace gases. But this list of gases leaves out one critical component of the atmosphere -- water. Besides being vital to life on Earth, water's properties make it the most noticeable of the mix of gases in the air. Why? Because it is the only substance naturally occurring in the atmosphere that, under ordinary life-supporting conditions, is found in all three states of matter-solid, liquid, and gas. Children quickly become aware of the two states of water, liquid and solid, but they may have little idea of water vapor as an invisible gas.

How can we see if water is in the air?

Teaching and Learning Focus

In this investigation, students will begin to develop their concept of clouds based upon three basic observations:

- Warm air can contain more water vapor than cold air.
- When air loses heat, some of the water in the air turns to liquid.
- As air loses heat, droplets of water collect and become visible on solid surfaces.

Materials Needed

For the class:

- Foam bucket of ice cubes and water

For each student group:

- Large glass or metal tumbler
- Water

Safety

This investigation question is considered generally safe to do with students. Please review the investigation for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

Show students a regular cloth hand towel. Tell them that you are thinking about washing the towel, but, since there is no clothes dryer at the school, you wonder how it might get dry. Ask them if they have an idea how you could dry it (some students will eventually suggest hanging it out to dry.) Ask the students where the water that makes the towel wet goes when it is hung out and it dries (some students may indicate that the water is simply "gone", while others may indicate that it is in the air.) How can we see if water is in the air?

Presenting the Investigation Question

Introduce students to the investigation question: "*How can we see if water is in the air?*" Have students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on the flipchart.

Have students brainstorm ideas about how to investigate this question:

1. What materials would be needed?
2. What would you have to do?
3. What would be measured?
4. How long would the experiment take?

Assessing What Your Students Already Know

When asked to describe a cloud, most students will portray a remote, white fluffy object in the sky, much like a floating cotton ball. Some students who have had experiences with air travel might be able to describe flying above the clouds or into clouds. Few children will think that they have ever touched a cloud or walked through a cloud.

- Ask students if they have ever been in fog. (They might be surprised to know that fog is a cloud at ground level.)
- If you live in a climate with cold temperatures, ask if they have ever seen their breath on a cold morning. (If so, they have actually created clouds.)
- Ask students if they have noticed that fog or breath seems to be wet or damp. (What they are seeing is a collection of tiny water droplets that form as water vapor turns to liquid.)

Tell students that in this investigation they will learn how to tell that there is water in the air.

Exploring the Concept

1. Give each group of students a metal cup or glass tumbler. Ask them if the cup appears to be able to hold water without leaking any to the outside. (*You might fill yours with room temperature water to verify that it is leak-free.*)
2. Pour an amount of room-temperature water into the cup, leaving room for several ice cubes that will be added next. (*It is best to have a pitcher or bowl of water sitting in the room for several minutes before beginning, to ensure that the water will not be cooler than the air in the room.*) Have students verify that the cup is not leaking. If there is any water on the outside of the cup due to spills, have them dry it off and check again for leaks.
3. Next, distribute the ice into the cup of water so that all cups are about half-filled.
4. Ask the students to observe the cup carefully for a few minutes and record their observations. (*The outside of the cup will begin to show drops of water on the surface. If the room is exceptionally dry, ask the students to blow on the side of the tumbler. Moisture from their breath will condense on the surface.*)
5. Have students discuss their observations and these questions:
   - What have you seen form on the outside of the cool cup or glass tumbler? (*Tiny water droplets.*)
   - How can you be sure what it is? (*It's wet, and it feels and looks like water.*)
   - Where do they think it came from? (*Some might connect it to the water in the tumbler. If they do so, remind them that the tumbler was tested before the experiment and found to be leak-free.*)
6. Ask students to report their conclusions about their observations of the ice-filled container to the class. (*Through careful discussion and questioning, students should be able to agree that the only place the water could have come from was the air.*)
7. Help students focus on what they have learned. They should be able to figure out that the air contains water that is invisible. But, when the air is cooled, the invisible water in the air forms liquid water on a surface. Finally, introduce students to the scientific term for this process - condensation.

Applying Students' Understanding

To assess students' understanding, ask them what they think will happen when you put warm water in your metal tumbler. *(Empty and dry the tumbler before filling it with warm water. This time, air will not be cooled, and it will not form condensation on the surface*).

Revisiting Investigation Question 1

Complete this investigation question by asking students to reflect on "How can we see if water is in the air?" and how their answers may have changed as a result of this investigation.

How can clouds form?

Teaching and Learning Focus

In this investigation, students will begin to develop their concept of clouds based upon three basic observations:

- Warm air can contain more water vapor than cold air.
- When air loses heat, some of the water in the air turns to liquid.
- As air loses heat, droplets of water collect and become visible on solid surfaces.

Materials Needed

For each student group:

- Large jar with lid
- Supply of small ice cubes
- Quart-size zip-closing plastic bag
- Water at room temperature
- Wooden safety matches
- Small flashlight (observations work best if the viewing area is dimly lit)

Safety

Most of this investigation is considered generally safe to do with students. However, one part of it involves the use of a lit match. YOU need to demonstrate this step for the students. Review safety precautions with them carefully. To ensure all students clearly observe this event, conduct a separate demonstration at each table. You students can participate with each step except the one involving flame.

Setting the Scene

You might want to set the scene for this investigation by telling the students about this fascinating experience. (*Alternatively, you could use it at the end as a way of assessing what students have learned. They should be able to explain what happened in the cave.*)

Dr. Vincent J. Schaefer (1891-1993) is known for writing several handbooks on climate and weather. He once described an interesting experience when he and a companion were exploring a cave. They slipped through a small opening and entered a large cavern where their flashlights revealed a clear pool of water. The air felt cool, their skins felt moist and clammy, and the cave walls were wet--typical conditions for a cave. They decided to take a swim. Schaefer's friend suggested saving flashlight battery power by lighting their lanterns instead. He struck a match, and, suddenly, the whole room was filled with a dense fog. They had created an underground cloud!

You can also begin by showing the students pictures of clouds. These may be photographs, or they may be art in books or that the children themselves have drawn. Have the students share their ideas about where clouds come from, and whether they can ever disappear.

Given the possibility that some will offer that clouds from out of air, the question arises:

- How can clouds form?
- Presenting the Investigation Question
- Introduce students to the investigation question: "*How can clouds form?*"
- Have students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on the flipchart.

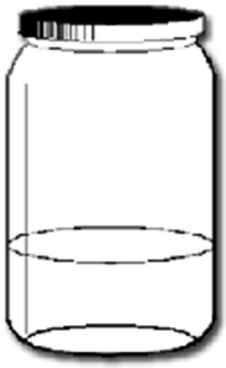
Have students brainstorm ideas about how to investigate this question:

1. What materials would be needed?
2. What would you have to do?
3. What would be measured?
4. How long would the experiment take?

Assessing What Your Students Already Know

From the last investigation, students will have a beginning understanding that air can contain water as a gas. They may, or may not be able to describe this as water vapor. Some may know that water vapor is an invisible gas. Some students may not think of the role of water vapor in cloud formation, but will believe that clouds simply travel from one place to another, so that the clouds they see simply floated in from someplace else. Keep in mind that young children respond to concrete observations and, in so doing, can misunderstand parts of scientific phenomena.

Exploring the Concept



1. Ask each group of students to carefully pour water to the depth of about an inch (2.5 cm) in the bottom of the jar. Replace the lid. (*They can use a ruler to measure the water depth.*)
2. Have students next examine the jar and its contents as they shine the flashlight. (*Water and jar should be at the same temperature. If the water temperature is too warm, or the jar too cold, condensation may form on the wall of the jar. At this point, there should be no sign of a cloud or condensation.*)
3. Now, have a student shake the jar so that the air inside is well exposed to water.
4. Ask this question for review: Does air hold water? (*Yes. We concluded that after the first activity when we saw water condense on the side of the tumbler.*)
5. Ask students to observe the jar as they shine the flashlight. Is there any sign of a cloud inside? (*No*)
6. Ask one student in each group to fill the plastic bag with ice. Remove the jar lid, and quickly place the bag of ice over the container. Ask the students to observe as they shine the flashlight. Now is there a cloud inside? (*No*)

7. Tell the students that YOU will do the next step. Tell them that you will come around to each group in turn. While the bag of ice stays on top of the container, strike a safety match. Remove the bag of ice and lower the lighted match into the container. (*Be careful to hold it in a horizontal position so that you don't burn your fingers.*)
8. Blow out the flame, so that the match begins to give off smoke, some of which will go into the jar. After a few seconds, let the match drop into the water and quickly replace the bag of ice over the top. Ask the students to observe carefully as they shine the flashlight on the jar. Now is there a cloud inside? (*Yes!*)
9. Next, have each student group review what has happened. Ask them to think about the observations they have made and try to find an explanation for the "cloud" forming. These questions may help:
    - What did shaking the container do to its contents - water and air? (*It allowed the water and air to mix, thereby causing more water vapor to form in the air - or evaporate.*)
    - What did the ice pack do? (*Cooled the air to the point where some of the water vapor is ready to change from a gas state into a liquid state - or condense.*)
    - What did the smoke from the match do? (*The smoke produced from the match contains tiny particles upon which water vapor can condense into tiny water particles - just like it did on the side of the glass tumbler in Investigation question 1.*)

(Some students might say that they are only seeing smoke from the blown-out match. You can ask them how that possibility might be eliminated. (*Light a match, put it out so that it produces smoke and drop it into a jar of water--both jar and water at room temperature--without the previous shaking and without the bag of ice.*))

10. Ask students if the experiment helped anyone to explain the cave story. Have them consider at what point our container was most like the cave chamber before the cloud appeared. (*The jar was most like the cave after the jar of water was shaken to mix water and air and after the air was cooled with the ice pack. The smoke from the match put thousands of tiny particles into the air above the water. These acted like the wall of the cup. Each one gave liquid water a place to gather when the air was cooled*).

Applying Students' Understanding

To assess how students' understanding, ask them what they think will happen when you place warm water in your metal cup. (*Empty and dry the cup before filling it with warm water. This time, air will not be cooled, and it will not form liquid condensation on the surface.*)

Revisiting Investigation Question 2

Complete this investigation question by asking students to reflect on "How can clouds form?" and how their answers may have changed as a result of this investigation.

Revisit the Concept of Clouds

After helping students to understand the nature and composition of clouds, you can make a smooth transition to a discussion of precipitation. A thorough understanding of the physical conditions favoring various forms of precipitation is probably beyond the scope of the elementary science curriculum, but what they investigate here will provide some building blocks for this to happen at a later stage.

Here are some questions for students to consider (with explanations in italics):

- Ask the students what would happen inside a cloud as droplets became larger and larger. (Soon, they would be too heavy to remain suspended in air. Slowly, at first, the droplets begin to fall toward the Earth. When larger droplets catch up with smaller droplets, they combine and begin to fall even faster. Soon large drops form and fall to the ground as rain.)
- Ask students how snow, sleet and hail might form. (If raindrops fall through very cold air near the Earth's surface they may freeze. Then we get little grains of ice pellets or sleet. Snowflakes, however, form inside the clouds themselves when conditions are right for crystals to form. Hailstones travel downward through a cloud and pick up a coating of water that freezes on the surface, before being carried upward by strong drafts within the cloud. The hailstone will fall again, picking up another layer of ice, and be carried back up the cloud again, growing a bit each time, until it finally is too heavy for the draft to carry it upward. At that time, it falls to the ground.)

After developing a concept of clouds, you can show students pictures of all of the various types of clouds in the sky. Learning to observe these clouds and relating them to specific weather conditions is an interesting extension of this investigation. There are many excellent books and tables displaying all of the various cloud varieties. Many of these resources are available on the Web, for example the National Oceanic and Atmospheric Administration (NOAA).

You may also wish to have the students add information about cloud type and cloud cover to their daily weather journals.

Digging Deeper

Clouds and Precipitation
Raindrops are formed when the cloud droplets grow big enough to fall out of the clouds. Most of the rain that falls in the winter, and even a lot of it that falls in the summer, is from

melting of snowflakes as they fall through warmer air. Rainfall is measured by the depth of water that falls on a level surface without soaking in. Rainfall is measured with a rain gauge. A basic rain gauge is nothing more than a cylindrical container, like a metal can, with a flat bottom. The only problem is to get an accurate measurement of the depth of water that has fallen. Accurate rain gauges are arranged so that the water that falls into the container is funneled into a much narrow container inside. That way, the height of the water is magnified, and is easier to read.

If you live in a part of the United States where it snows in winter, you can easily measure the snow depth with a ruler. The best time to make the measurement is right after the snow stops falling. The measurement can be tricky, because wind can blow snow from one place to another. The best place to measure snow depth is on level ground far away from buildings and trees.