Air

An understanding of the properties of air is the basis for understanding weather. The problem for young children is that air cannot be seen because it is invisible. Its existence can only be inferred by the effects air has on objects. Air makes trees sway, feels cool on our faces, makes flags unfurl, drives sailing ships and so on. But what happens when air is still? A young child will often infer that air is not there, gone away, or does not exist. In the investigations that follow, students identify several ways in which air affects other objects and use those effects as evidence for the presence of air.

What is there between you and me?

Teaching and Learning Focus

These first investigations of weather offer a set of experiences and thoughtful discussions to help students understand that air is matter that can be experienced and measured. Some of the measurements and observations students make will be similar to those used by meteorologists to forecast the weather.

Materials Needed

- Classroom or similar space
- Classroom objects such as: chair, easel, student desk, books, sports equipment, etc.
- Photographs of objects affected by air/wind
- Ping-pong ball

Safety

This investigation is considered generally safe to do with students. However, please review it for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

To introduce students to ideas about air, they first need to realize that air is something, and that it takes up space. This first part of the investigation is designed to get them interested in learning more about air.

Place some simple objects between yourself and the group (e.g., a chair, an easel, a student desk, etc). Ask the students what lies between you and the group. As they name each item, take it away until it appears that there is "nothing" standing between you and the students. Then ask, "Is there anything else between us?" Some, maybe all, will answer that there is nothing left.

Presenting the Investigation Question

Introduce students to the investigation question: *"If air is invisible, how can we know it is there?*"

Tell students that they will be investigating this question and that at the end of their investigations, they will be able to provide reliable answers.

Have students brainstorm ideas about how to investigate this question:

1. Design an experiment that could be used to test the investigation question.
2. What materials would be needed?
3. What would you have to do?
4. What would be measured?
5. How long would the experiment take?

Assessing What Your Students Already Know

Here are some initial questions that students can discuss in groups and as a whole class:

- What is air made of?
- When do you know air is there?
- What does air make happen?

Have students report out their ideas and make a list of them. It might also be a good idea to start a list called "Questions we have about air." This list will provide further insights into what students know, and also what they feel they'd like to know. By the end of the investigation, most of these questions will probably have been answered.

Exploring the Concept

1. Give each group a piece of heavy paper or cardboard. Have them fan the cardboard back and forth. Ask them if they felt anything being pushed as they fanned. Next, give them a ping-pong ball or other light object. Ask them how they can make it move using the cardboard, but not letting it touch the cardboard. As they determine that they can fan the object, ask them to make it move more slowly, more quickly, farther or to a specific target. The intent is to let them explore the properties of moving air. Discuss their results.

2. Finally, bring out an empty toy balloon. Flop and fold it in your hand to show that it is very soft. Then blow up the balloon and have the students notice that it now feels firm to the touch. Have them discuss Why? (*They will probably conclude that the balloon is firm because it now has something inside, and that thing is AIR!*) The intent here is to show that air can have an effect on things even when it is not moving from one place to another.

Applying Students' Understanding

To assess how students have adjusted their concept of the nature of air, give them the following picture examples and ask them the question that accompanies each one:

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- What is moving the flags?
- What is holding up the parachutes?
- What is blowing the leaves here?

Revisiting Investigation Question 1

Complete this investigation by asking students to reflect on this question and how their answers may have changed because of this investigation. Air affects things, which means that it exerts a force. Realizing that air affects things will help them recognize that even though it is invisible, air is still matter.

How can you tell air is “something”?

Teaching and Learning Focus

In Investigation Question 1 students recognized that air affects other things, which is the result of the fact that it is matter. This simple procedure will help students to understand that air is "something," that is, that like all matter it takes up space and can be contained. They will learn this by seeing that air takes up the space in a cup that is inverted in water such that objects in the cup do not get wet.

Materials Needed

- Bag of fluffy cosmetic puffs or cotton balls
- Clear plastic drink cup
- Clear container big enough to hold the completely submerged cup
- Water

Safety

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

Setting the Scene

Remind students that in the last activity they found out that air affected things (e.g., by pushing or filling them.) Ask the students to consider other places where air can be found- other than around us in a room. Air can be in things, like a cup or a box that would normally be considered "empty". But if things with air in them are put in water, what happens to the air?

Presenting the Investigation Question

Introduce students to the investigation question: "*What happens to the air in a container when it is put in water?*"

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

Spend some time reviewing the results of Investigation 1 with students. They should now have at least a general understanding about air and how it occupies the spaces between objects. Ask questions such as:

- What are some things that can hold air inside them?
- What are some things that air can escape from?
- Why can air escape from some things but not others?

Exploring the Concept

1. Show students the materials to be used in this investigation: cotton balls, clear plastic drink cups, and clear glass or plastic water container.
2. Ask students to predict what they think will happen if they put the cotton balls in water and why? (*They would get soaked!*)
3. Now ask them what will happen if the cotton balls are pressed down into the bottom of the cup, and then the cup is put in water and why? Have students write down or draw their predictions along with the reasons for them. (*Some might answer that they would still get soaked. Others might think that the cup would keep them dry. Some might suggest that it would depend how the cup was placed in the water.*) Note: You may need to put a piece of tape across the bottom of the cup to help hold the cotton balls in place, depending on the size of the cup and the puffs.
4. Ask for suggestions on how to lower the cup into the water so that the puffs stay dry. Allow the students to write and draw pictures to describe the various ways they could try to accomplish this.
5. Have students experiment to test their predictions. (*By experimenting they will find that pushing the inverted drinking cup into the water allows the cotton balls to stay dry. However, they may not be certain of why this is so.*)
6. Have students look again at the predictions they made. Ask them to give explanations for what they have observed and whether this fits or does not fit with their predictions. (*Look for students to make the connection that air is trapped in the cup, and that's why the cotton balls stay dry.*)
7. As a demonstration, use a sharp pencil to poke a hole in the bottom of one plastic cup. Make sure the students see that there is a hole. Ask them to predict what will happen if this cup is inverted in water, just like the ones that kept the cotton balls dry. Go ahead and invert this cup into a tank of water. The students will see that the water rises in the cup, and they will see bubbles emerging through the hole. Ask how this fits with their prediction. Discuss how the hole allowed the air to escape, which allowed the water to enter.

Applying Students' Understanding

1. Ask students to find another way to show that air is in the cup (*They will find that it can be released by upending the cup and the air can be seen as it bubbles to the surface. Your students can also experiment with transferring the air from one cup to another underwater.*)
2. Have students draw pictures showing the different ways the cup was lowered into the water. They can circle the picture of the method that kept the cotton balls from getting wet. (*Alternatively, you could use the diagram below as a blackline master.)*

3. Have them consider the cup with the hole in it. What would have happened if the hole had been in a different place in the inverted cup?

Revisiting Investigation Question 2

Complete this investigation by asking students to reflect on this question and how their answers may have changed as a result of this investigation. What do they know now that they did not know before? When a container full of air is put in water, the air takes up the space in the container. If there is a way for the air to escape upward, it will leave the container, allowing the water to enter.

What can air do when it presses on things?

Teaching and Learning Focus

In Investigation Question 2 students saw the air pressing on water, keeping it out of the cup. This investigation shows students that air presses on other things, and ultimately that it presses on all things that are in the air. Understanding this provides a building block toward developing an understanding of air pressure. You could have groups do this, or you may want to do it as a demonstration using student volunteers. Be sure to try this yourself ahead of time to insure that your wood samples are thin enough. Observe all safety precautions.

Materials Needed

- 2 strips of very thin balsa wood (1.5 in x 20 in)
- Multiple page section of newspaper
- Small hammer or mallet
- Work table
- Safety goggles for you and students

Safety

This investigation question contains potential safety hazards and should always be done under adult supervision. Ensure that all safety procedures are followed. You may feel that parts of this investigation are best done as a teacher demonstration. Use of goggles is required.

Setting the Scene

Repeating (or reviewing) the activity from Investigation 2 provides a way to introduce Investigation 3. The students' attention can be focused on the water being held out of the cup. The discussion can move to the air being what keeps the water out, and from there to the idea that the air is pressing on the water. This to the realization that air presses on other things, too.

Presenting the Investigation Question

Introduce students to the investigation question: "*What can air do when it presses on things?*" 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. Design an experiment that could be used to test the investigation question.
2. What materials would be needed?

3. What would you have to do?
4. What would be measured?
5. How long would the experiment take?

Assessing What Your Students Already Know

The idea of air pressing on things, or air pressure, may be quite new to most of students. They will more likely know that contained air within a balloon, basket ball, bicycle tire, etc., pushes on the inside of these inflatables. They may even think of this as air under pressure. However, the idea that air exerts pressure on the outsides of objects from every direction is a tough concept to understand.

Spend some time reviewing Investigation 1 and 2. Remind students how air was contained with a balloon in Investigation 1 and inside the underwater cup in Investigation 2.

Ask them to consider the following questions, first in groups then as a whole class:

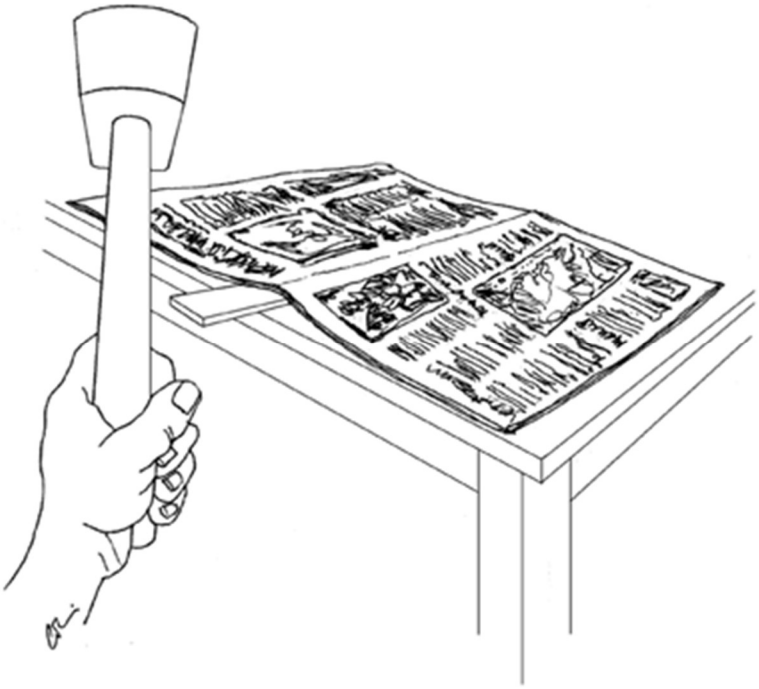
- When have you seen air pushing on things? (*Some may give air pushing on boat sails or windmills as examples, which are examples of wind movement not air pressure. Do not correct them at this stage.*)
- How do you know it was air that was pressing on things? (*Your students may come up with a range of possibilities here. Their responses will alert you to the level of understanding they currently have. Accept them without judgment at this point.*)

Exploring the Concept

1. First, have everyone put on the safety goggles. Lay one of the strips of balsa wood on a table edge with about a third of its length sticking out from the table top.
2. Ask students to predict what they think will happen when you strike the protruding length of wood with the hammer or mallet. Have them write or draw this on paper and also write the reasons for their predictions. (*Some may think that the wood will break. Others might suggest that it will flip up into the air.*)
3. Give the protruding wood a firm tap with the hammer, and it should flip the whole piece into the air. (*You might want to do this step to avoid the wood flying too far.*)
4. Ask for ideas about breaking the wood in two pieces using the hammer. (*Some will suggest that if you hold your hand down on the part lying on the table, you can break the protruding piece off with a hammer stroke. Have a volunteer hold the piece down firmly while you tap off the end.*)
5. Now, using the second strip of balsa, show the students that you are going to cover the part of the strip lying on the table top with just 3 sheets of newspaper.
6. Have students first discuss and then predict what will happen when the wood is struck by the hammer or mallet. They should draw or write down their predictions and also give the reasons for them. (*They may predict that the paper will tear or that*

the paper will work like hands to hold the wood down so that just the protruding end will break off.)

7. Hit the wood with the hammer or mallet. (*The air pressure on the paper holds down the wood on the table enough so that the end can be lopped off with the hitting stroke.*)
8. Have students look again at their predictions. (*Did what happened confirm or refute their predictions? Do the explanations for their predictions appear to be valid or not?*)



9. Set three books in a stack on the table. Then, place the balsa wood on top of the books so that one end protrudes as it did off the bare table. Set the newspaper on the other end of the balsa. In this case, the paper will be above the table (*although it is likely to sag down enough to touch the table.*) Have students predict what will happen if you hit the balsa now, and then do it. (*The balsa wood should flip the paper up without breaking.*) Explain that in this case, the air was pressing down on the paper as it did before, but because there was also air below the paper, the air pressure was also pressing upward, so the pressure was balanced on both sides. When the newspaper is smooth on the table, there is only air pressure on top, which is enough to hold the wood down such that the end is broken off.

Applying Students' Understanding

Ask students to make a drawing of this setup that resulted in the successful break and, using arrows find a way to show what happened and why. (*What you are looking for is them showing arrows pointing down onto the surface of the newspaper to represent the air pressure*.)

Revisiting Investigation Question 3

Complete this investigation by asking students to reflect on this question and how their answers may have changed because of this investigation. What do they know now that they did not know before?

When air presses on things it exerts a force that can hold things down. That force can be balanced in all directions if there is air all around the object as it was when the balsa wood was on the stacked books. Air can also hold things to a ceiling or wall when the right kind of device is used (e.g., with suction cups).

Reflecting on Air

1. Immediately following the investigations above, ask students to share their drawings.
2. Begin with the cup investigation and confirm that everyone drew or circled the same arrangement. (*If different arrangements were chosen, ask someone to repeat those arrangements to test the wetness of the material in the bottom of the cup.*)
3. Ask the students to explain why the straight down approach worked while the others did not. Coach the students as they respond until everyone gets the idea that the cup was filled with "something" that kept the water from getting to the puffs. What might that something be? Ask the students to label this space on the drawing as "Air".
4. Have students reflect on the wood, mallet and paper experiment. Ask them how air is involved in what happened. (*They should be able to conclude that the air acted like hands holding down the wood. You might need to explain that the newspaper allowed for even more air to push down since a bigger surface was involved.*)
5. Ask students to add an arrow to their drawing labeled with the word "air" to show that air was responsible for holding down the wood on the table.
6. Finally ask the students what they have learned about air. (*A concept map would be an ideal way to organize their understanding.*)

Linking to Weather

As a result of their observations and experiences, students should be ready to understand that, although they live "ON" Earth, they live "IN" air. They may need your help in beginning to understand that the weather conditions they experience, the ones that scientists measure and track, are actually air or atmospheric conditions that we refer to as weather. The properties of air that have been addressed in these activities (i.e. that air is matter; exerts force on things, takes up space and exerts pressure) are just some of the properties that influence weather.