Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

In these two 45-minute lessons, students explore conservation of matter in closed and open systems. During the first lesson, students are challenged to predict, record, and explain changes (or not) in the mass of a bottle containing water and sugar cubes as the sugar cubes dissolve and disappear. In the second lesson, they compare the masses of bottles in two different situations in which a reaction is taking place. In one situation, the bottle is open, and it loses mass. In the other situation, the bottle is closed, and the mass remains the same.

Objectives

Students work with the following ideas and content:

- conservation of matter
- Students demonstrate understanding of this idea by explaining their observations of changes in matter and accompanying change (or lack of change) in mass. They give reasons both verbally and in writing for the observed mass relative to changes in characteristics of matter.

Correlations to NC Science Standards

National Standards to be added when adopted in North Carolina.

5.P.2.2 Compare the weight of an object to the sum of the weight of its parts before and after an interaction.

Correlations Common Core State Standards for Mathematics

5.NBT

7. Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

Brief Science Background

When energy and matter interact, things move, change form, heat up, rearrange, or change in some other way. Sometimes matter may seem to disappear altogether, for example, when something burns up. However, when matter changes in a closed system where nothing can enter or leave, nothing is added or subtracted from the total amount of material in the system. For example, if something burns in a closed system, all of the ash and gases resulting from burning remain in the system, and the weight of the system as a whole remains the same.

Part 1 — Where's the Sugar?

Materials

Materials for the whole class

- a scale accurate to .1 gram
- a 12-oz soda bottle with cap
- 2 sugar cubes
- 1 oz. cup with water
- Cartoon to be projected
- Index cards, 3"x 5" ruled

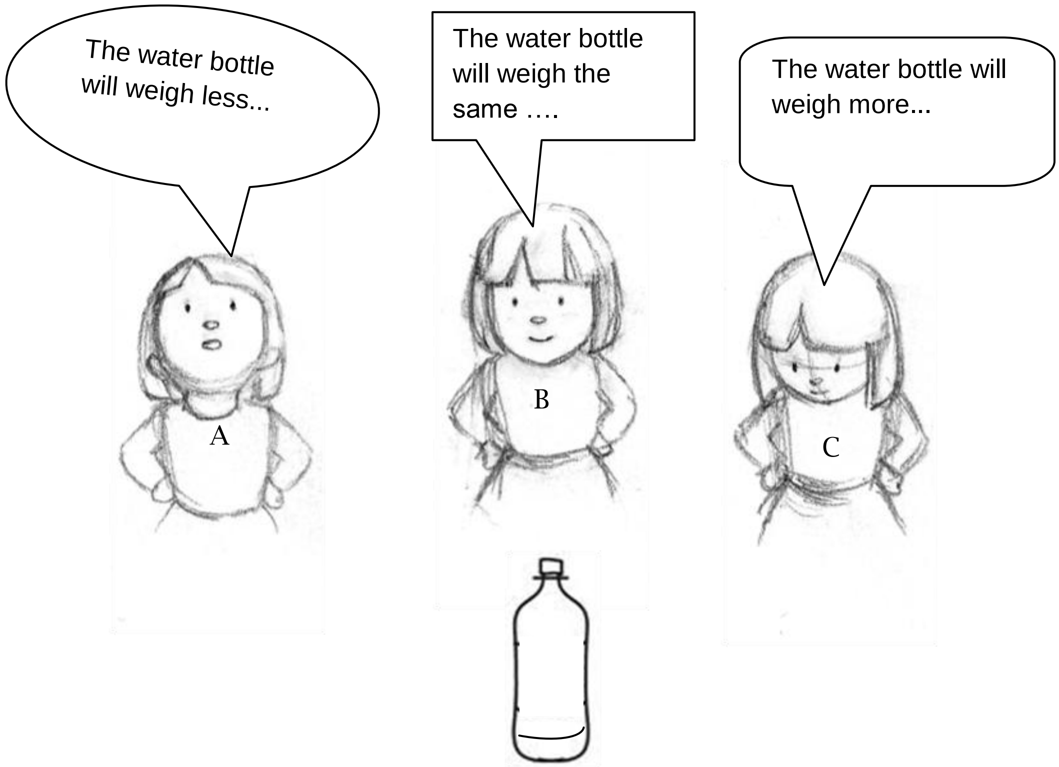
Preparation

1. Pour a few ounces of water in the bottle and weigh the water and bottle on an electronic scale.
2. Have the sugar cubes at hand.
3. If you have a document camera, you can use it to project the scale readout for all to see. Otherwise, select a student to read out the weights.

Procedure

1. Add 1 oz of water to the bottle. Close the bottle with the cap and place it on the scale. Record the mass of the bottle, water, and cap on a SmartBoard™ or whiteboard for the class to see.
2. Leave the water bottle on the scale and add 2 sugar cubes next to the bottle on the scale. Determine the mass and record the mass on the board or SmartBoard™ for all to see.
3. Place the sugar cubes in the water, secure the cap. Do Not Shake.
4. MATH EXTENSION
   When the sugar cubes are sitting in water in the bottle on the scale, tell students, woops! You forgot to determine the mass of the sugar cubes. Ask them to figure out from the information on the board what the mass of the sugar cubes must be. **Don't give hints; just confirm that the information on the board is enough to determine the mass of the cubes. After a minute, accept answers and show how to determine the mass of the cubes. The sugar cubes should still be visible in the bottle.**
5. Take the bottle off the scale and swirl it to completely dissolve the sugar cubes. When they have disappeared, ask students where the sugar went. Accept all answers. Ask students what they think will happen when you weigh the bottle. DO NOT PLACE THE BOTTLE ON THE SCALE. Project BLM 2, the cartoon, and ask students to read the three responses to the situation in the thought balloons.
6. DO NOT PLACE THE BOTTLE ON THE SCALE! Give each student a note card. Ask each student to individually write on the front of their note card which person they agree with: A, B, or C.

Procedure



7. Ask each student to write the quote from the person they chose on the back of the card, and add the word "because…" Then, ask each student to complete the sentence giving a reason for what they think.

6. Have students form groups by like letter. Groups should be 4-5 students. If many students choose the same letter, break them into multiple subgroups advocating for the same letter, but keep group size at 4-5. Give each group 5 minutes to agree on 3 main reasons their statement is correct. Ask them to select a speaker to report their reasons to the class.

9. After 5 minutes, have each group report, but give no indication of the correct answer.

10. Ask students to return to their seats, hold the bottle of water up and place it on he scale. Record the results. The mass should be the same as step 2 above.

11. Briefly discuss with the class which cartoon person is correct (B), but do not discuss conservation of matter yet. Students might think (correctly) that just because the sugar disappeared, that does not mean it is gone. Others might just as reasonably think that A is correct because the sugar is gone. Others might think C is correct because the sugar made the water sticky and sticky things are heavier. For now, it is enough for them to think that the sugar changed what it looked like without changing how much of it is in the bottle.

Notebook Prompt: Write a rule that explains what you just observed.

Part 1 Procedure cont.

12. Project BLM 1, the definition of the Conservation of Matter. Relate it to the exploration that students just completed, especially to their responses to the notebook prompt.

Conservation of Matter:

When matter is enclosed so that none comes in or out, if that matter is rearranged or changed, the amount of matter does not change. The amount is known by how much the enclosed matter weighs.

Part 2 — Bubbles

Materials for the Whole Class or the Teacher

- a digital scale accurate to .1 gram
- 3 effervescent tablets
- A 1-oz cup of water
- A 9-oz cup of water
- document camera
- a 12-oz to 1-liter soda bottle with cap (supplied by teacher – be sure to keep the cap)

Materials for each student

- Science notebook (to be supplied by teacher)

Preparation

1. Wash out the bottle after the previous activity. Pour a few ounces of clean water in the bottle. Turn on and "zero" the electronic scale. If you have a document camera, set it up to project the scale readout for all to see. If this is not possible, choose a student to read the mass to the class during the demonstration.
2. Break one of the tablets in half.
3. Without any water in the 12-oz bottle, practice placing the tablets in the neck of the bottle and sealing the bottle so that the tablets stay in the neck. Steps 5 and 12 of the procedure will go more smoothly with a little experience.

Procedure

This activity is designed to teach the concept of a closed system when dealing with conservation of mass. This can be a difficult idea for children.

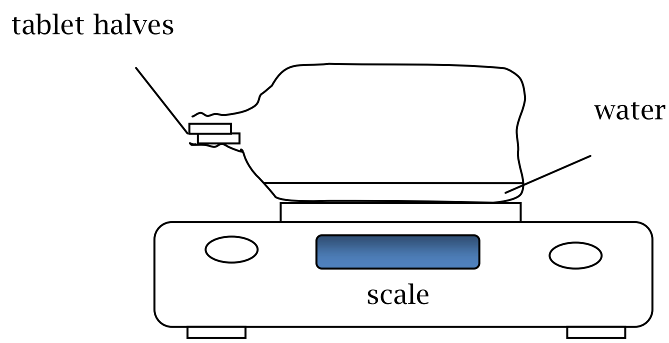
1. Ask students to remind you what the law of conservation of matter says and inform them that we will continue to explore conservation of matter today.
2. Add water to the bottle and place on the scale – no cap. Show (or report) the mass to the class. Record the mass where everyone can see it.
3. Keep the water bottle on the scale and place 1 effervescent tablet (broken in half) next to the bottle on the scale. Read the new mass and record it where everyone can see it.

Part 2 Procedure cont.

4. Say that, in a minute or so, you will put the tablet in the bottle with the water. However, before you do that, you want everyone to see what happens when these tablets get wet. Drop an effervescent tablet in the 9-oz cup of water and either put the cup and fizzing tablet under the document camera or circulate around the room so that students can see it.

   Notebook Prompt: predict what will happen to the total mass of the bottle and its contents when the effervescent tablets are placed in the water. Give a reason to support your prediction. **Most students will predict the mass to remain unchanged like the sugar cube, and as conservation of matter would suggest.**

5. Place the bottle on its side on the scale, and place the two halves of the effervescent tablet in the neck of the bottle. Be careful not to drop either of the tablet halves into the water inside the bottle. Confirm that the mass is still unchanged. Do not use the cap (keep the cap out of sight).



6. Turn the bottle upright and watch the mass for 2 minutes. After two minutes, the effervescent tablet's reaction will be complete. Have a student read the scale out loud as the mass decreases. Lift the bottle from the scale, swirl it a few times, and gently squeeze and release the sides of the bottle. **The gas in the bottle comes from a chemical reaction between the tablet and the water. The gas is heavier than air, so a little squeeze helps push a little more of it out of the bottle.**

7. Place bottle back on scale record the mass. **Over the time of the reaction, and after squeezing, students should see mass decrease by about .5 grams.**

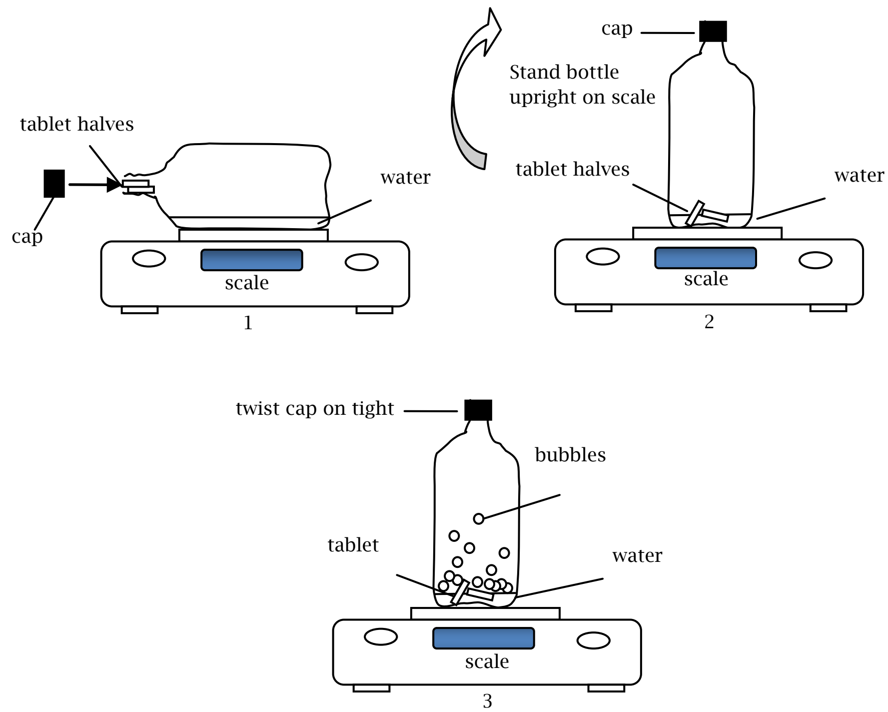
8. Ask students to explain what might account for this loss of mass? **Do Not guide students to understand what has happened.** Share with the class that this example does not seem to follow the Conservation of mass rule. Explain that we will revisit this and provide an explanation after we do one more experiment.

9. Tell the class we will do the experiment again, this time we will add a cap.

10. Add water in the bottle, secure the cap, and place on the scale. Record the mass for the class to see.

11. Keep the water bottle on the scale and add 1 effervescent tablet broken in half next to the bottle on the scale and determine the mass. Record the mass for the class to see.

Part 2 Procedure cont.



12. Place the bottle on its side and place the two halves of the effervescent tablet in the neck of the bottle. Secure (seal) the cap to the bottle. As you do this, avoid dropping the tablets into the bottle and water (keep them in the neck). Stand the bottle up. After bubbling is complete, confirm that mass is unchanged.

13. Turn the bottle upright (give the cap an extra turn to be sure it seals). When you do this, the tablets will fall into the water and fizz. Watch the mass for 2 minutes, or until the tablet halves stop fizzing. The mass should remain unchanged.

14. Ask the students to describe how the second time was different from the first time. Ask how they might account for the mass remaining unchanged this time. **Explain that the effervescent tablet and water react to produce an invisible gas. Emphasize that gases, even though they are invisible and seem to float, actually weigh something.**

15. Tell students you are going to remove the cap, and you wonder what will happen to the mass after you do that.

    Notebook Prompt: predict the mass of the entire system after the cap is removed and then placed back on the bottle.

16. When students finish writing, ask students to listen carefully, then remove the cap. Ask them to describe what they hear. Ask them what they think made that sound. Hold the uncapped bottle up and gently squeeze and release the sides. Place the cap back on the bottle and put the capped bottle back on the scale to weigh it. **Mass should decrease by about .5 grams.**

    Notebook Prompt: Explain what could account for the missing .5 grams?

Part 2 cont.

Wrap-Up

1. Emphasize the difference between open and closed systems with regard to conservation of matter (mass) as follows: **Where no matter can enter or leave a system (closed system), mass remains the same even if matter changes form. If matter can leave or enter (open system), mass can change. Here, a solid became an invisible gas (CO2) that left the open system (no cap) and stayed in the closed system (cap on).**
2. Ask students what escaped, and why they think the bottle weighed less after you removed the cap (they have already dealt with this in the notebook prompt at step 16). **The open system weighed less because some carbon dioxide escaped. The carbon dioxide gas weighed something. When it left, it took some weight with it.**
3. Ask students how much they think the carbon dioxide gas weighed

Guided Practice

Marla has a soda in an unopened bottle and she weighs it carefully before she opens it. She shakes the bottle vigorously and opens it to hear a whoosh of gas escaping. She says she is going to weigh it again now that she's opened it, but before she does, she asks that she and her friends predict what the mass be. She asks her two friends, Michael and Chris, what they think the mass will be. Here are their predictions:

- Marla – The mass will stay the same because the same amount of soda is still in the bottle.
- Michael – The mass will increase because letting out the air allows the soda to expand which will make it weigh more.
- Chris – The mass will decrease because the gas being released had mass.

Respond to each incorrect person. In your response, explain why you think they are wrong so that it might convince them that you are correct.

Answer Key

Colin missed the fact that the whoosh was gas leaving the bottle, and that everything, even gas, has weight. Therefore, the bottle lost weight.

Michael has mixed up the idea of size (the soda expanding) and weight.

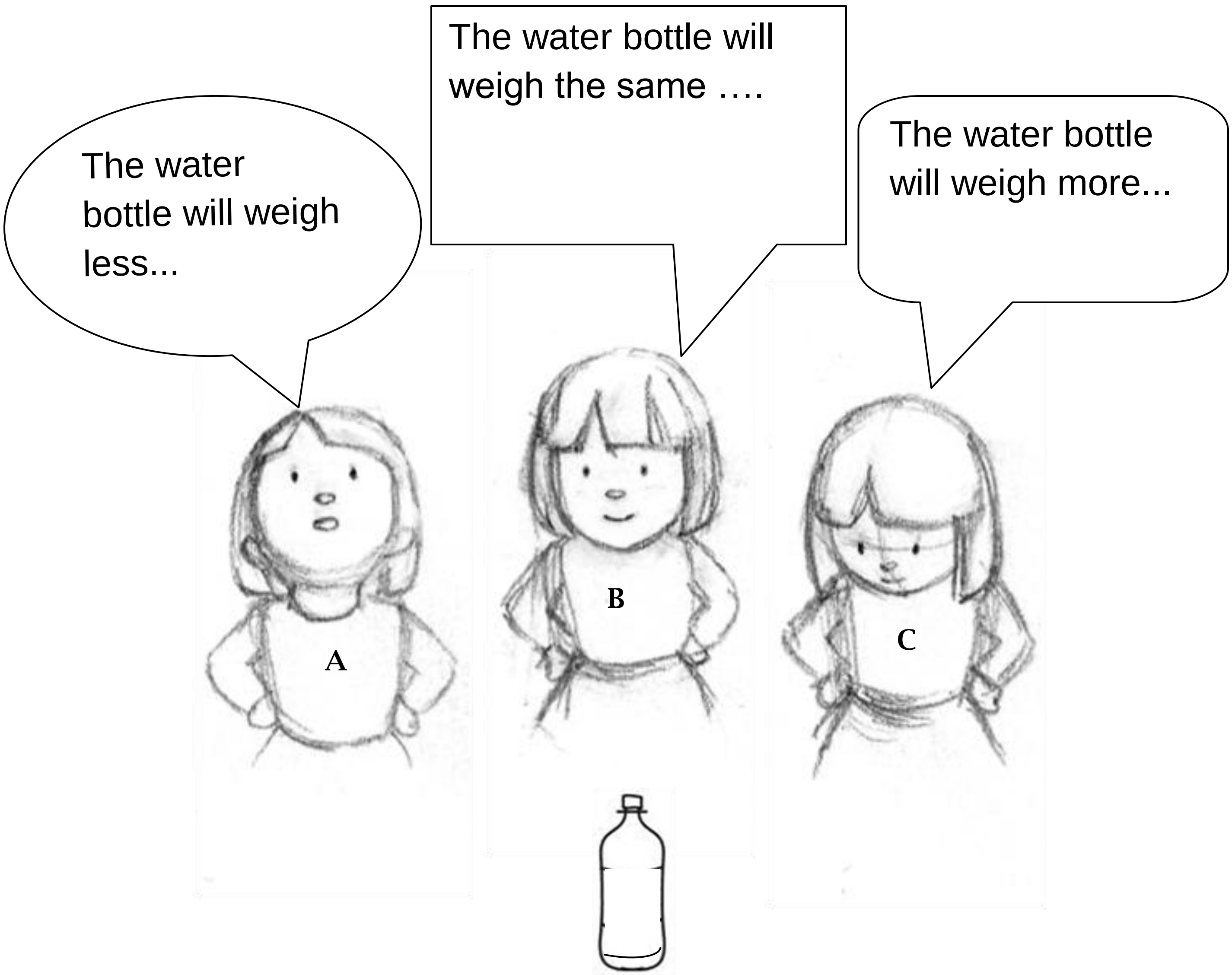
Chris is correct. The gas that came out in the whoosh is matter, and because of that, it has weight.

BLM 1

Conservation of Matter:

When matter is enclosed so that none comes in or out, if that matter is rearranged or changed, the amount of matter does not change. The amount is known by how much the enclosed matter weighs.

BLM 2


The water bottle will weigh less...
The water bottle will weigh the same ….
The water bottle will weigh more...
A
B
C

Appendix

Common Student Preconceptions About This Topic

When students see material disappear, they are likely to assume that it is gone. For example, it is difficult to imagine that all of the matter in a piece of wood still exists after it burns. In particular, students who consider gases to be weightless are unlikely to conserve mass in reactions that involve gases. This idea is related to the fact that children build their idea of mass from noticing how objects differ in the way they press down. Children learn to feel the weight of objects and compare them by felt weight. As a result, students tend to estimate mass from an object's size and appearance. Surprisingly, introducing the particle theory of matter sometimes further confuses the issue. Where a student imagines that a material is composed of very small particles spread out in space, with each particle having a negligible weight, it can seem to be less dense and be interpreted as less heavy. The confusion here is tied to the difficulty in imagining the vast number of molecules or atoms that comprise a small piece of ordinary matter.