Session 3

Physical Changes and Conservation of Matter

In everyday life, observations that things "disappear" or "appear" seem to contradict one of the fundamental laws of nature: Matter can be neither created nor destroyed. This session explores various manifestations of the law, and builds on the particle model of matter to explain physical changes.

The Video

What happens when sugar is dissolved in a glass of water? When a pot of water on the stove boils away? Do things ever really "disappear"? The video opens with children in the Science Studio observing a common magic trick in which matter *seems* to disappear. As they try to follow the button that vanishes from their field of vision, the ideas they express about "where things go" become the recurrent theme as they and other children explore what happens to matter through a series of physical changes like melting, mixing, and dissolving. Which principles of the particle model apply to these changes?

We continue in the Science Studio where two students investigate the principle of conservation of matter using building blocks and the evaporation of alcohol, and other children grapple with the reversibility of physical changes.

Technicians Ark Pang and Peter Schuerch introduce us to the desalination of water, a real-world application of the separation of solutions. We then visit the Benjamin Banneker Charter School in Cambridge, Massachusetts, where Rosinda Almeida's second graders are exploring the effect of heat on the dissolving process. The session ends with a puzzle—how can the volumes of two liquids that are mixed together and shaken *decrease*, while their weight remains constant before and after the shaking?

Learning Goals

During this session, you will have an opportunity to build understandings of the following concepts:

- Matter is neither created nor destroyed during physical changes.
- Physical changes rearrange, but do not change, particles.
- Under everyday conditions, physical changes are reversible.

On-Site Activities

Getting Ready (60 minutes)

Activity One—Problem Set and Reading Discussion (20 minutes)

1. In a small group, review the answers from the problem set for Session 2.
2. To prepare for this session, you were asked to think about instances in everyday life where matter seems to disappear. Share the lists you made with a partner.
3. With your partner, review and discuss each other's particle model concept maps. Referring to the Novak article and your journal entry, share the decisions you made for cross-linking key concepts on your map. Discuss how this activity affects your thinking about the particle model of matter.

Activity Two—Physical Changes (20 minutes)

1. In Session 2, the particle model of matter was introduced as a way of explaining changes of state such as evaporation, condensation, and boiling. With the whole group, brainstorm which principles of the model might be used to explain what happens in mixing and dissolving.
2. With your partner, review the process by which bubbles form when water is boiling. Be specific about what they are and where they come from.
3. In Session 2, we saw a drop of food coloring spread out in a beaker of water without being stirred. Do you think this is a demonstration of a physical change or a chemical change?

Activity Three—Conservation of Matter (20 minutes)

1. Share your ideas about conservation with the whole group. What does it mean to say that matter is conserved?
2. With a partner, discuss how you predict conservation of matter might fit into your concept map for the particle model.

Watch the Video (60 minutes)

As you watch the video, think about the following focus questions:

1. What is the definition of a physical change?
2. The children in the Science Studio express the belief that a change of state also involves a change in weight. How do their ideas compare with yours?
3. In Rosinda Almeida's classroom, the lesson seems to convince most of the students of the effect of heat on dissolving. Do you agree with their conclusions?

On-Site Activities, cont'd.

Going Further (60 minutes)

Facilitators: Distribute the Session 3 materials.

1. With a partner, try the following experiment:
   a. Fill three beakers or cups with water.
   b. Take three more cups and put a tablespoon of sand in one, salt in another, and sugar in a third.
   c. Put one of the cups of water on a gram scale, along with one of the cups of either the salt, sand, or sugar, and weigh them, recording the weight.
   d. Now take those two cups off the gram scale and pour the sand (or salt or sugar) into the cup of water and stir.
   e. After you have mixed thoroughly, take a magnifying glass and look closely at the mixture. Share what you observe with your partner.
   f. Before putting both cups back on the scale, predict whether together they will weigh the same, more, or less than when they were weighed the first time.
   g. Re-weigh the two cups together and record the weight. Discuss with your partner what you think is happening.
   h. Repeat the same process with the salt and sugar.
   i. With the funnels and filter paper provided, try to separate each of the mixtures. With the magnifying glass, look at the water that filters through the paper. Discuss with your partner how they are the same and different.
2. Evaporation and filtration are two ways in which physical changes are reversed in the video. Is there a way to recover the food coloring from the water discussed in Activity Three of Getting Ready? Discuss your answers with a partner.
3. In the video, the ability of fish to breathe in water is given as an example of a gas dissolving in a liquid. In the whole group, brainstorm additional examples of dissolving that do not involve solids.

Between Sessions

Homework (* = required)

* Reading Assignment

Stavy, R. (1987). "Acquisition of conservation of matter." *Proceedings of the Second International Seminar on Misconceptions and Educational Strategies in Science and Mathematics,* Vol. I. J. Novak. Ithaca, Cornell University: 456-465.

As you read, think about what this article suggests about the particular challenges that elementary school students face in "acquiring" the concept of conservation of matter.

* Physical Science Problem Set

(Suggested answers are listed in the Appendix.)

1. In the Session 3 video, a distinction is made between boiling (a physical change) and burning (a chemical change). On a particle level, how would you describe the difference between boiling and burning?
2. At the end of the Session 3 video, equal amounts of alcohol and water are combined and then shaken in a container, resulting in a liquid with less volume but the same weight as before the alcohol and water were shaken. Is this an example of a physical or a chemical change?
3. An iron rod is sealed inside a mold that is put in a high-temperature furnace. The rod melts inside the mold and turns into liquid. The hot liquid iron is then allowed to cool until it becomes a solid rod again. The new rod is then removed from the mold. What difference do you think there is between the original rod and the new rod? Explain your answer.
   a. The new iron rod is lighter than the original rod.
   b. The new iron rod is heavier than the original rod.
   c. The new iron rod is the same weight as the original rod.
   d. The iron rod is lighter when it's a liquid than when it's a solid.
   e. The weight of the rod depends on how long the iron took to cool.
4. A copper wire is heated and turned into liquid. After a while, it cools down and becomes solid again. What changes do you think have taken place? Explain your answer.
   a. The copper turned into another metal after melting.
   b. Some of the copper turned into another metal after melting.
   c. A large amount of copper turned into another metal after melting.
   d. The solid is still all copper.
   e. There is not enough information to answer the question.

Between Sessions, cont'd.

* Ongoing Concept Mapping

Using what you have learned in Session 3, develop a concept map for conservation of matter and physical changes. Include the following concepts:

- Conservation of matter
- Dissolving
- Suspensions
- Melting
- Closed system
- Clouds
- Weight
- Physical changes
- Mixing
- Heat
- Reversibility
- Open system
- Number of particles
- Evaporation

When you are finished, make connections between this map and the one you completed for Session 2.

Guided Journal Entry

Sessions 1 and 2 focused on the nature, states, and properties of matter, and established the principles of the particle model. In Session 3, we began to investigate what happens when matter interacts with other matter, and introduced a "law" that governs the behavior of matter under a wide range of everyday conditions. In your journal entry, reflect on how each principle of the particle model relates to both physical changes of state and the law of conservation of matter. Are some principles more important than others?

Guided Channel-TalkPhysicalSci Posting

To many of us, the idea of the conservation of matter (or conservation of weight) seems almost self-evident, and many examples are very clear: If you cut a piece of sculpting clay into four chunks, the sum of the weight of the chunks is equal to the weight of the original piece. However, in this session, we've seen that many children do not apply this same thinking to more abstract ideas such as melting and dissolving. Think of some examples of physical and chemical changes where you think your students would predict that the object's weight would not remain constant.

Design a lesson that uses analogies to take your students from easily accepted examples of mass conservation to one of those more difficult situations. For example, start by weighing clay before and after it is cut into chunks and then ask how this is similar to and different from weighing ice before and after it melts. For what grade students would these activities be appropriate? Discuss your lessons on this week's Channel-Talk.

Textbook Reading Suggestions

The following are suggestions for several reading topics that may provide additional background and enrichment information. These topics are likely to be addressed in any college-level physics or chemistry textbook.

- Conservation of matter (and energy)
- Solutions
- Colloids
- Homogenous substances
- Physical changes
- Suspensions
- Pure substances
- Heterogeneous mixtures

Between Sessions, cont'd.

* Preparing for the Next Session

For "Getting Ready"

In this session, we've developed a definition of physical change that includes both macroscopic and microscopic criteria. Before the next session, look for examples of what you think might be classified as chemical changes. Is a chemical change simply anything that is not a physical change? Jot down your examples, along with a reason you classified them as chemical changes, and bring them to the next session.

Materials Needed for Next Time

- Plastic soda bottles
- Vinegar
- Block or pieces of metal, wood, plastic, and clay
- Baking soda
- Balloons
- Gram scales

Graduate Credit Activities

Continue your work on the annotated bibliography and action research project.