

3rd Place Winner
Scientific Inquiry
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Give Me Proof: The Evidence for Chemical Change

Grade Level(s): Grades 6-8

Content Topic(s): Physical and chemical changes

Materials:

- Apple or other fruit
- Glow sticks
- Easy Bake[®] oven
- Easy Bake[®] cake mix
- Kool-Aid[®]
- Pitcher
- Clay
- Green and brown/yellow leaves
- Water
- Ice
- Safety goggles
- Vinegar
- Baking soda
- Beakers
- Standard science classroom tools, including thermometers, scales, spoons, rulers, etc.

DESCRIPTION:

Through this lesson, students increase their critical thinking skills by using inquiry to design and carry out an experiment that provides evidence changes in properties of matter. They will also classify changes as physical or chemical and support their decisions with evidence.

OBJECTIVE:

1. Students will learn to work collaboratively in a scientific setting.
2. Students will understand how to use physical and chemical properties to classify substances (chemistry).

3. Students will classify changes as chemical or physical changes (science).
4. Students will understand how to generate a question that can be answered through a scientific investigation. They will then plan and conduct a scientific investigation that includes the collection and analysis of data (science and math).
5. Students will understand how to construct a reasonable explanation using evidence (science).
6. Students will demonstrate how to write a persuasive essay (language arts).
7. Students will understand that increased comprehension of scientific knowledge and processes leads to new inquiry (science).

OBSERVATION AND BACKGROUND:

Students will use hands-on activities to examine, identify, and classify materials that have undergone a change in either of two categories – physical or chemical. After gaining an understanding of changes in matter, students will design and carry out their own investigation in order to gather evidence and prove that a chemical change takes place when baking soda and vinegar are mixed.

Properties of matter and changes in properties of matter are a focus of these lab activities. The National Science Education Standards mandate that students at this age level understand properties and changes in properties of matter. Properties and changes in properties of matter are fundamental concepts to future understanding of chemistry. These concepts are also very important and appropriate at this age level as the students observe their environment and form questions about changes in themselves and in their world. Properties and changes in properties of matter fit within the broader context of National Science “big ideas” of change, constancy, and measurement, as well as within systems, order, and organization.

As inquiry is central to student learning, students must be able to carry out investigations and to use laboratory procedures and strategies. By empowering students to design and complete investigations to answer their own questions along with being able to generate and communicate scientific explanations, a scaffolding is laid down that will serve as a foundation for future scientific inquiry.

EXPERIMENTAL PROCEDURE:

Students will participate in a multi-layered lab featuring physical and chemical changes.

Part 1: Sort it Out

Set up seven stations around the room. Students should work in groups of 3-4 and rotate through the seven stations. Each station will take 8-10 minutes. This lab can be done over a one day period (for schools with block scheduling) or a two-day period (for schools on a traditional schedule).

At each lab station, students will follow the investigation instructions. Although the specific instructions vary according to the lab activity, students will critically discuss their observations at each station. The teacher will need to type up the specific instructions for each station and tape the instructions in front of each station. The stations are as follows:

1. **Easy Bake Cake:** Students mix a bag of Easy Bake[®] cake batter with water (physical change). Students will "cook" their cake in the Easy Bake[®] oven for 6 minutes (chemical change). Students then cut the cake (physical change) and eat it (chemical change – digestion).

***CAUTION: Be aware of any food allergies. Warn students not to touch the inside of the Easy Bake[®] oven. If you do not want to use the Easy Bake[®] oven, you can have the students compare a box of cake mix with a baked cupcake.**

2. **Kool-Aid[®]:** Students mix two scoops of Kool-Aid[®] or powdered drink mix into a pitcher of water. The Kool-Aid[®] dissolves (physical change).
3. **Apple:** Students cut an apple into pieces (physical change).

***CAUTION: Use an apple corer or the teacher should cut the apple for safety purposes.**

4. **Glow Stick:** Observe an “unsnapped” glow stick. Snap the glow stick and observe any changes (chemical).
5. **Leaves:** Students examine a green leaf and leaves that have changed colors (chemical).
6. **Clay:** Students mold a ball of clay into an animal of their choice (physical).
7. **Ice:** Students place ice cubes into a cup of warm water and observe (physical).

Students must support their choice of physical or chemical change for each investigation. For example, when the glow stick is snapped, they will observe

an indicator of chemical change – a color change. The formation of a new color indicates that a new substance is being produced. Students can hypothesize as to how the liquids are kept separate in the “unsnapped” glow stick. In contrast, the clay has not been changed into a new substance. It is still clay whether it is in a ball or in the shape of an animal.

Authentic assessment should be used by the teacher as the investigations are being conducted. The teacher should circulate among the groups as the investigations are occurring. Formative assessment should occur during as the teacher walks around and instruction should be modified as the teacher assesses student learning in an on-going manner by continually interacting with each group. For example, if the feedback to the teacher indicates that students are having difficulty with indicators of chemical change, this should be reviewed while the investigation is occurring.

Students can present their conclusions to the other students in another teacher's science class. (Scientists must be effective communicators!) Students will also document their results and turn in their lab notebooks at the completion of this activity for formal grading.

Part 2: Proof that a chemical change occurred.

(National Standard: Using science as an argument and explanation).

The teacher will invent a story/scenario describing someone's confusion regarding the mixing of baking soda and vinegar. I use a story in which a shipping company is not permitted to ship items that can chemically react on the same train. The shipping CEO is insisting that a shipment of baking soda and vinegar can be shipped together. The students' job is to design an investigation that proves a chemical reaction occurs when baking soda and vinegar are mixed. This is a new way of exploring chemistry for many students as it requires them to really stretch their thinking.

Allow students to work together (in the real world, scientists often collaborate), consult outside resources, ask for tools, etc. Explain to students that when scientists solve a problem in the outside world, they use all of these tools. The only condition should be that they cannot seek the teachers' input. This prevents students from seeking an answer from the teacher without trying. The teacher can and should ask probing questions and circulate among groups, while encouraging students to seek their own solutions.

Students will need to design an experiment that answers the question, “Do vinegar and baking soda undergo a chemical change when mixed together”? They will need to present their final product as a lab report with a problem

statement, hypothesis (prediction), materials list, procedure, data table and graph(s), analysis, and reflection. As this will be student-designed, the procedures may all look different, but the general format is as follows:

1. **Problem:** What are you trying to solve/answer?
2. **Hypothesis:** Use an “If _____, then _____ because _____” format. A hypothesis might be, “If baking soda and vinegar are mixed, then a chemical reaction occurs because bubbles indicate that a new substance (gas) has been produced.”

Most students have seen the reaction of baking soda and vinegar and know that it bubbles and foams. They may not know that there is a temperature change (decrease) and a change in smell. The indicators of a chemical change should be discussed prior to this activity.

3. **Materials List:** Students should list the quantity and type of each material that they will use. Safety goggles should be on each group’s list.
4. **Procedure:** These will differ from group to group. Encourage students to come up with ways to gather multiple forms of evidence. For instance, they might measure the temperature of the solution before and after mixing (temperature change); observe bubbling and foaming (production of a gas); and smell the mixture before and after.

***CAUTION: Make sure students know to “waft” a solution when smelling. In addition, make sure that students wear safety goggles during their experiments. Procedures should include the necessary steps, repeated trials, controlled variables, and recorded data.**

5. **Data:** Students should create a data table and record their results. In addition, each set of trials should be graphed.
6. **Analysis:** Students will analyze their data and report their findings.
7. **Reflection:** Students should report any inconsistencies, further questions, difficulties, thoughts for future experiments, and real-world applications.

Students should then incorporate their findings into a persuasive letter. In the example story, students would write their letters to the CEO of the shipping company outlining the evidence supporting the fact that vinegar

and baking soda undergo a chemical reaction. This component can be coordinated with language arts teachers in that persuasive writing skills are a common learning objective for middle schools.

ANALYSIS:

Use the following discussion questions to enhance students' understanding of the experiment:

- What were the benefits to designing your own experiments? What were the difficulties?
- Reflect upon your learning – what stands out the most for you?
- Does a temperature change always indicate a chemical reaction? What about boiling water?
- What additional investigations can you carry out if you had unlimited funding and/or equipment?
- Do you feel that you have enough evidence to support the statement, “Vinegar and baking soda undergo a chemical reaction when combined”? Why or why not?
- Have each group share their evidence and conclusions. Which are the most powerful? Why?

MODIFICATIONS OR EXTENSIONS:

Extension 1

Challenge your students to design an inquiry-based presentation for younger students based on their learning during this activity.

Extension 2 (for special needs students)

These activities are great for physical and/or cognitively challenged students as the tools are self-selected. For instance, a student with limited fine motor skills may not be able mix the vinegar and baking soda, but another student can waft the air towards him/her.

In the first part, “Sort it Out,” students can verbally describe the physical or chemical change. In Part 2, give students an investigation that already contains a procedure and requires the student to take down data and make observations.