Identifying Physical and Chemical Changes

Morgan McKinley
Pershing Middle School

INTRODUCTION

The beginning of middle school science comprises all fields from physics to chemistry to astronomy to biology. There is a lot of ground to cover, and I would like to present a unit that provides hands-on experiments that fit into the sixth grade curriculum. One of the first objectives in middle school science is for students to understand the difference between physical and chemical changes (Houston Independent School District 1). The unit that I have developed is designed to provide numerous opportunities for students to learn this objective through hands-on experiments and activities. The unit should take approximately three weeks (seven to eight 90-minute class periods). It is also designed as the second objective in sixth-grade science, immediately following the first unit on understanding the basic difference between matter and energy (Houston Independent School District 3). Students will first start off the year developing science process skills and then move into comprehending basic objectives about matter such as atoms and molecules. This unit on physical and chemical changes will then follow.

The basic framework of this unit still centers on matter, how it's defined, how it's identified and how it's classified. Students have learned that matter is anything that has mass and takes up space and that the physical world can be divided into matter and energy (the ability to do work). Because there are interactions among matter and energy, there will be change. Matter can change in two ways. A chemical change can happen or a physical change can happen. In a physical change, the appearance or form of the matter changes, but the kind of matter in the substance does not. In a chemical change, the kind of matter changes, and at least one new substance with new properties is formed. How and why these changes occur will be one of the key assessments to the unit.

According to the National Science Education Standards, students in middle school should be able to observe and measure various properties of matter, including simple chemical changes, and use those properties to distinguish one substance from another (National Research Council 149). Focus begins to shift from just describing properties of objects to understanding that substances have distinguishing characteristics and properties from which materials are made. It should be noted that explaining atomic and molecular structure is not important for students to have a full understanding at this point. They are introduced to the terms in previous lessons, but not required to grasp the idea fully at the microscopic level. This terminology can distract from focusing on the observation and description of macroscopic features of substances and of physical and chemical changes (National Research Council 149). With this is mind, the unit focuses on the evidence students derive from careful observations to help them determine physical changes and chemical changes.

Students will first start off by writing about what they already know on changes in matter in a journal. This will help identify any misconceptions for the teacher and will give the teacher an idea about what needs to be developed further and what does not. Daily journal entries also serve as a warm-up activity that gets students immediately involved in the learning process at the beginning of the period (Freiberg and Driscoll 77). Students will also create a booklet about physical and chemical changes as they go along through the experiments. This will be more than just their daily journal entries. The booklet will be used to write and draw results and observations about their experiments and activities throughout the unit. It will provide constant visual reminders throughout the unit. The student-designed booklet will also serve as a means of assessment for the teacher. Teachers who use products of student work will be able to see immediate results and will have a curricular-based tool for measuring student learning. It is this emphasis leading away from standardized norm-referenced, paper-and-pencil tests and towards more authentic learning that will allow teachers to better monitor student progress (Lezotte 81).

I have several experiments that have worked very well to include in this unit as well as new ideas and activities about physical and chemical changes. Along with the journal entries and unit booklet, these activities will provide the opportunities students need to understand how and why matter changes.

Over the last several years of teaching, I have found that most sixth-graders love to mix things together! They seem to enjoy the idea of being real "chemists." This has been one of my favorite objectives to teach because it gives the students the opportunity to feel like they are doing science (even though there is much more to it of course). This is a great opportunity to incorporate hands-on science into the curriculum. All students have a natural curiosity, and this is one way to build on their excitement. This is just one of the reasons why it is important to teach this topic.

Teachers can be hesitant to incorporate experiments into their lesson plans because of various reasons. Limitations on time, not enough materials, and classroom management are a few of these reasons. The activities and experiments in this unit are easy to incorporate, simple to perform, and require inexpensive and easy-to-find materials. To help prepare for time determinations, teachers should do these activities first. Doing the activities yourself can help you identify possible mistakes or can provide new ideas.

Once familiar with the activities, you can learn to incorporate leading or inquiry-based questioning into the lesson. It is very easy to ask yes or no questions in lessons, and in particular it is simple to ask students if they think they saw a chemical change or a physical change. To really get students involved in their own learning, you can develop a system of questioning and probing that can lead students to develop their own comprehension of physical and chemical changes. Throughout the unit, students can use evidence from their observations and evaluation of their predictions from previous activities to help them develop their own understanding. Guiding students in their thinking and questioning creates a class culture of inquiry-based learning and exploration, skills in observation and experimental design, and practice in problem solving and synthesizing information (Harcombe 121). It is easier to incorporate as you go along through the unit.

After students observe something in an activity that is interesting to them, they can then try to explain in their own words what happened. Based on the explanation, students can then formulate hypotheses and relate it to a new situation. Some questions that they have can be answered experimentally. If they were asked to test their hypothesis through an experimental framework, the result might be different from what they predicted. Many research studies have demonstrated the power of asking students to explain the principles they are working from, the hypotheses they generate from these principles, and why their hypotheses make sense. Apparently, the process of explaining their thinking helps students deepen their understanding of the principles they are applying (Marzano 105). After an activity, teachers can ask students how their observations support their hypotheses, how their experiments test their hypotheses, and how their results confirm or disconfirm their hypotheses.

OVERVIEW OF UNIT

The activities and experiments in this unit give students the opportunity to experience physical and chemical changes through hands-on inquiry-based lessons. In "Lesson One: Gooey Gak," students mix glue, water, and borax solution to observe the creation of a new substance. Students will learn to identify a precipitate by mixing ammonia and Epsom salt solution to observe evidence of a new substance formed. "Lesson Two: Caramel" is an activity where students will change sugar both physically and chemically. In "Perfectly Pink," students will mix ammonia, vinegar and Ex-Lax to observe color change as an indicator of a chemical change. There are also several basic activities involving baking soda and vinegar, seltzer tablets and water, and cornstarch and iodine. One activity, "Lesson Four: The Baffled Baker," allows students to use what they know about physical and chemical changes to solve a mystery in which various food ingredients are mislabeled. Throughout the unit, students will make predictions and observations and will record their data in their booklets. They will draw conclusions from these observations that will help them understand the difference between physical changes and chemical changes.

In a homework activity, students will make a list of household chemicals found in their homes. They will examine the ingredients of some of these chemicals and the purpose for using each of them. This will also tie into their excitement about mixing things together. Products of the scientific process give them everyday examples. In another homework assignment, students will make observations of chemical and physical changes outside of school. For example, what happens when we cook, clean, drive, and eat. Students will make a list (about 10 examples) of various things that happen at home, identify them as either a physical or chemical change, and then explain why or how did they know. The activities and experiments in class as well as at home will be the basic framework for understanding this objective.

SAFETY CONCERNS

At the beginning of the year, one of the first things we do in class is go over safety rules. Students are required to take a quiz over basic safety in our science class. This will be used as a contract. They must make a perfect score on the quiz and have their parents' signatures on their contracts in order to participate in class. The students and parents sign the safety contracts ensuring that everyone has an understanding about the safety rules set forth by the teacher. This is especially important for this unit since we will be working with chemicals that may cause problems if not handled carefully. Although they are not life-threatening substances, some of them can cause minor or serious irritations if not used properly. Students by now know the evacuation routes in case of fire or emergencies. They know where the fire extinguisher and first-aid kits are located. They also know how to call the office in case of an emergency. During the activities and experiments, students will be required to wear safety glasses at all times. They are not required to wear lab coats, but must not wear loose clothing. Safety is mostly common sense and good behavior. Breaking the rules violates the contract, and students know that by doing so they will not be able to participate in the activities and experiments.

ACTIVITIES AND EXPERIMENTS

One activity that can be used to start the unit is one in which students observe a burning candle. It may seem simple enough, but there are a lot of important ideas that can come from making observations from this activity. Set up a candle in the classroom where everyone can see it. Have students make a list of as many observations as they can from the candle when you light it. I would let it burn for several minutes to give them enough time to make their lists. After several minutes and when the candle has changed considerably, have students share their findings with the rest of the class. Write them down on the board as you go along. Sharing them as a class will give a more comprehensive list. Students will see that the candle changes in many ways. This can start the discussion on how and why matter (such as the candle) can change. It can also help you probe their minds and lead to student self-questioning about their observations. They can use this information for future reference throughout the unit.

During "Lesson One: Gooey Gak," students will be given a plastic cup containing 20 ml of Elmer's (non-toxic school) Glue. I would highly recommend doing this yourself instead of having the students pour glue since it can get messy. I then give them a cup of water and a graduated cylinder and instruct them to add 20 ml of water to the glue and mix thoroughly (with wooden stick or spoon). This also incorporates the science process skill of measuring. Next, I go around making sure they are mixing and I add two to three drops of food coloring to their mixture. Again, I would do this myself to keep them from wasting the colors! The final step is to add 15 ml of saturated borax solution. This consists of dissolving borax in water and then adding a little more until it is saturated. Have this solution ready before class starts. They can use their graduated cylinders again to measure the 15 ml. Ask students to predict what will happen when the borax solution is added to the glue/water mixture. Instruct students to stir as they are adding the borax solution. Once thoroughly mixed, they can take the substance out of the container, roll it around in the palm of their hands, and play with it. The result is a new substance with new properties. Ask students to reflect on their predictions, and ask them questions about their new substance. Have students write in their booklet about their observations and what type of change occurred and why (see lesson plan for this activity at the end of this paper).

Before the next experiment, always review the previous experiment or activity. This can be done orally or as a journal question for students to answer as a warm-up. Reviewing the previous lesson or lessons gives students a chance to reflect on what they previously learned. It also helps them formulate hypotheses for future activities. Therefore, their hypotheses can be more than just predictions.

For "Lesson Two: Caramel," students will observe physical and chemical changes to sugar. Each student is given two sugar cubes and asked to make observations about one of them (including taste!) Next, they are to crush one of the cubes with their hands and identify the type of change that took place. Each student then places the other cube on a metal spoon. They are to predict what they think will happen when the spoon is placed over a flame. For middle school students, I usually have only one or two alcohol burners set up for safety reasons. Students then set the spoon over the alcohol burner and observe changes to the sugar. "Melting" (burning) of sugar is a chemical change. There is a common misconception about chemical changes when objects burn. Some students forget that matter is conserved. At this point, they do not have a formal understanding of conservation of matter. One research study indicates that students think of burning objects as "disappearing." When students observe that the sugar is no longer there, they may feel as though the heat made it vanish. As with the burning candle, a gas is one of the products, although many times not a visible one. Conservation is therefore more difficult to understand when products of chemical changes are gaseous (Driver 88-89).

A good question to ask at this point is to have students explain the difference between burning sugar and melting ice. Why is burning sugar a chemical change and melting ice a physical change? Since melted water can go back to becoming ice, a new product was not formed and therefore the water only changed form (physical change). When something burns, a chemical change occurs and the original substance(s) cannot go back to their original forms without another chemical change. The new substance created when sugar was burned cannot go back to its original form by physical means. Changes in states of matter are usually difficult for students to identify as being physical and not chemical changes.

Research shows that students often use the term chemical change to encompass changes in physical state and other physical transformations. How well they can make the distinction between physical and chemical change depends partly on their conception of "substance." If they regard ice as a different substance from liquid water, then they are likely to classify the melting of ice as a chemical change. Substances should be regarded as identical if their properties are identical when compared under the same conditions (Driver 85).

In order to help students understand that phase changes are physical only, I use a demonstration using water. They usually think of boiling water as a chemical change since they see bubbling occur. Although bubbling can be an indicator of a chemical change when a gas is formed, it is not the case when a liquid boils. Without going into convection, students can see water boil and understand the change from liquid to gas (since heat is added to the system and not another chemical). Water is a unique substance since it can be all three states relatively quickly. I show them cubes of ice and they know that it is solid water. As it is placed on the table, they can see it melt to liquid water. Since nothing new is created, it is not a chemical change. Water has only changed state and therefore retains the same properties. As I show them water boiling, they see it evaporating. Again, it is only a different state and is still water. After this, I have several water molecule models constructed from a molecular kit. The kits are available through any educational catalog or store. A "kit" can also be made using toothpicks and colored marshmallows (different colors representing different types of atoms). The toothpicks can show the bonds between atoms. I arranged them in a lattice pattern to show water molecules in ice form. I then "add heat" and show them that as they turn to liquid, the molecules are still the same. I have not created a new molecular substance. I then show how the molecules move faster and further apart when more heat is added (boiling water – liquid to gas). Again, still the same water molecules and no new substances made. This will usually help a lot of students understand that phase changes are only physical and not chemical since nothing new is being made.

Most students have experienced mixing baking soda and vinegar from elementary school. They know that when the two are added, bubbling occurs. How is this a chemical change? First of all, heat is not added like in the water demonstration. I then explain to them that in this case, bubbling is an indicator of a chemical change and that a new substance is made. How do they know? Bubbling is indicating a gas formation. For "Lesson Three: Chemistry in a Bag," I give them each a plastic bag with baking soda in one corner of the bag. I next give them a little bit of vinegar in a small paper or plastic cup. They are instructed to place the cup inside the bag, but not to mix the two. Then, they are to seal the bag, pushing out the air inside getting as much air out as they can. Once it is sealed, then they can pour the cup over and let the two mix. As bubbling occurs, so does the formation of carbon dioxide. They can "see" this as the bag inflates. They can now see and feel the formation of a new substance.

After the water demonstration with the molecules, I then have models of acetic acid (vinegar) and sodium bicarbonate (baking soda) to show them. I tell them that when these two are mixed, a chemical change occurs. I then take a carbon atom and two oxygen atoms off and put them together to make a molecule of carbon dioxide. I take one hydrogen and two oxygen atoms off to make a molecule of water and the remaining product is sodium acetate. I tell them that when the two are mixed, these are the resulting products. They now have a visual showing new molecular substances resulting from the mixing of baking soda and vinegar. This visual shows them that a chemical change has taken place. It is not important that they memorize the chemical formulas, but that they know that the atoms are rearranged to make new molecules of new substances resulting from a chemical change involving two reactants.

Another indicator that a new substance was created is the formation of a precipitate, a solid that settles out of a liquid. Precipitate formation is an easier way to show a chemical change since students have an easier time seeing a new substance. For this activity, students need 100 ml of a saturated solution of Epsom salts in a beaker. As with other activities, I usually have this made for them and they can just measure the amount they need. Next, they measure 200 ml of ammonia using a graduated cylinder and they add the ammonia to the Epsom salts solution. After a several minutes of observation, they begin to see the white layer precipitate forming at the top of the beaker. Since ammonia has a strong odor and can burn if inhaled, both students and teachers need to take the appropriate precautions. Have students cover their noses when working with ammonia if masks are not available. Other than this safety precaution, this is a simple way to show a new substance being formed when two liquids are mixed together. The solid that has resulted is a new product with different properties from the two reactants.

An alternative precipitate reaction can be demonstrated using silver nitrate (aqueous) and salt water (sodium chloride). When the two are mixed, the brownish-colored precipitate, silver chloride, forms. The brownish color is easier to see compared to the white precipitate from the ammonia and Epsom salts reaction, but the silver nitrate may not be as readily available as the others. It can be ordered through most scientific or educational catalogs.

Rusting is another indicator that a chemical change has taken place. Most students are familiar with this process and can draw on their own experiences for this type of change. This reaction takes more than one class period to observe, so it can be used for long-term set-up in which students make daily observations. Steel wool or nails can be used for several different activities. After making predictions, students simply add a piece of steel wool or a nail to a cup of water and record their observations during the first day. They can then make observations each class period for the next several days. Iron will react with oxygen to form iron oxide. This new product indicates that a chemical change has taken place.

This is a great time to incorporate student ideas into the curriculum. Have groups of students design experiments to test for rusting of various metals. They can set up different stations with different materials and test their hypotheses. There are many questions that can be asked and can even lead to possible science fair topics. Will steel wool rust faster in regular water or salt water? Does rusting occur faster in colder temperatures or warmer temperatures? These are just a couple of ideas that students can use. If possible, they may even be used to teach difference parts of the experimental design process such as hypothesizing, controlling variables, using multiple sets of data, and interpreting results. If students are setting up an experiment, it is important that they are able to explain the results of the experiment. They should be able to decide if their hypothesis was supported or not or if they need to conduct additional experiments to generate and test an alternative hypothesis. Using a structured experimental format allows students to apply their understanding of important content. It also requires students to reflect on and use a broad range of knowledge related to the topic. Collecting evidence to support a hypothesis will strengthen their understanding.

Color change can sometimes be a difficult indicator of a chemical change. Adding food coloring to water is not indicating a chemical change, although some students may think so. Again, this is one the most common misconceptions regarding changes in matter. Several studies have indicated that students describe various physical transformations as being chemical, especially ones in which the color of a substance changes (Driver 85). It is a misconception that I have experienced in my own classroom also. One possible demonstration to show a physical change with color involves adding food coloring to ice and to water. First, add a few drops of food coloring to a beaker of water. Students will quickly observe the food coloring diffusing in the water. Next, drill a hole into an ice cube. Put a few drops of food coloring into the hole. Students will observe that the food coloring does not diffuse throughout the cube. When asking why, students may think that the reason is because the ice is solid and therefore more dense. Since ice is less dense than liquid water, this is not the explanation. In liquid water, there is more energy and the movement of the molecules allows the food coloring to diffuse throughout the liquid water. This may help them understand that by mixing the two together, there is no new product being made, and therefore it is only a physical change.

The key to understanding a chemical change is to know that a new substance is being made. There are many indicators that can be used as evidence, but the only sure way is the formation of a new substance with new properties. Color change can indicate a chemical change. To demonstrate this, I use the “Perfectly Pink” experiment for the students. The first step in this activity is for students to take an Ex-Lax tablet, crush it into a powder, place it in a small beaker and mix it with 125 ml of water. The supernatant liquid is an indicator solution. Next, they measure 500 ml of water in a large beaker and add five ml of ammonia. In two small beakers, they place five ml of Ex-Lax indicator solution and in a third they measure 25 ml of vinegar. From the large beaker, they take 100 ml and add it to the first two small beakers, make observations, and record what happens. Then students take these solutions and put them back into the large beaker and make observations. After this, students pour 100 ml of the large beaker into the third smaller beaker with just vinegar. After making observations, they pour this back into the large beaker and record their observations for the final time. During this, students can see that chemical changes occur with some surprising changes in color.

Another color change activity involves water, food coloring, and bleach. In this activity, students measure a small amount of water (200 ml), add food coloring, and mix. Then they are to measure a small amount of chlorine bleach in another beaker (10 ml). Students should be careful not to get bleach on their clothes, hands or face. They are then to add the food colored water to the bleach and observe what happens. This is a good way to show the difference between a color change that is physical (food coloring and water) and a color change that is chemical. It is also one that they can use for their household chemicals activity later on in the unit.

One of the final experiments (also designed as an assessment since students will need to understand the difference between the types of changes already) is where they are given a mystery to solve called the "The Baffled Baker." It is a short story about a donut baker who has not labeled his salt, powdered sugar, baking soda or cornstarch properly. Students will need to test each kitchen ingredient to figure out which one is which. They are first given all four of these ingredients as their known substances. They have a data table to record physical properties of each substance such as color and size and shape of grains (they have hand lenses to use). Also, they will add water, iodine, and vinegar to each and observe chemical changes, if any, which occur when mixed. When iodine is added to baking soda, salt, sugar, etc., it makes the substance appear yellowish-brown in color (physical change). When it is added to cornstarch it becomes purplish-black in color (this can be identified as a chemical property of cornstarch). Next, they are given the unknowns, the un-labeled ingredients from the bakery. They perform the same tests to determine which ingredient is which. You will need to have all of the materials in small cups or chemical trays if available. I usually have them work in groups on this experiment. Also, they only need small amounts of each ingredient to test (this will keep the activity from getting too messy and will make clean-up much easier). To make this lesson more challenging, I usually add a couple of other white powders such as baking powder, granulated sugar, and flour. Some ingredients are easier than others to identify, but with six or seven, it becomes increasingly challenging for sixth-graders. This experiment tests their observation skills as well as their knowledge about using properties to identify physical and chemical changes.

There are two assignments for this unit that students will need to work on at home. This can be done near the end of the unit or in the middle. I usually give them a couple of weeks to do both during the unit. Both are designed to go together.

The first activity is for the students to make a list of chemicals found in their home. Most are relatively easy to find, but our cabinets, closets, garages, and drawers are filled with chemicals that are important in our everyday lives. They are products of the scientific process designed to make our lives better in some way. Students are given a data table, and their job is to list a product in one column and list its ingredients in another column. They can use medicine, foods, cleaners, polishes, pet products, etc. The important part is not for them to memorize or even be able to pronounce some of the names of the chemicals, but to know that the process of changing matter by mixing things together can lead to products that improve our daily lives. Some chemical products are new, and some have been around a long time. Most people take these products for granted. Hopefully, at least some students will get a better appreciation for the science behind various products in our lives and may one day want to become chemists themselves.

The second part of their assignment is to identify changes that occur in our homes, too. For example, when we eat, cook, and clean there are changes that are happening. Students are given a data table to fill out for their "Household Changes" activity. They are to make a list of 10 changes that take place at home (or on the way to school). Next, they will check either the "chemical change" column or the "physical change" column for each change they identify. Finally, they will need to answer the question, "How did you know?" in the final column. I usually give them a couple of examples to help them get started. For instance, when you are making a salad, is it a chemical change or a physical change? After students respond that it is a physical change, I ask them why. Students will say that you are just cutting up vegetables and not making something new and therefore results in a physical change. Is burning wood in a fireplace a chemical or physical change? Students will respond that it is a chemical change, since burning is always creating new substances. The activities for home give students a chance to use their own experiences from home or from their community and bring personal meaning into their learning.

For each activity and experiment, students will have to answer questions about how they knew a physical change or a chemical change occurred. Since observation is an important part of interpreting evidence, students will need to keep accurate records about each activity and experiment. This will also be kept in their booklets as they go along for a visual reminder. The booklets can be a great way to assess their understanding as you go through the unit. I have them make notes, write detailed observations, and even have them draw and color what happens in each activity. Drawing and coloring gives them a visual about each experiment and since color is important evidence for some changes it can be just as important to record.

The completed booklet on changes in matter is a great way to have students take ownership in their work. At the end of the unit, students can then share their findings and ideas. It gives them the chance to discuss with the others what they have been exploring and learning. When students are comfortable sharing their work, they become more enthusiastic about science (Atkinson and Fleer 26-27).

Throughout the unit, students will incorporate different parts of the experimental design and how it leads to an understanding of scientific knowledge. The most important premise for me has always been the evidence. Far too many times students base decisions without really thinking them over. Gathering evidence gives students the opportunity to make sense of the world around them. Activities in science can be interesting and important to them. When they are actively engaged, students can therefore establish a knowledge base for understanding science. They can experience the richness and excitement of knowing about and understanding the natural world. They can use appropriate scientific processes and principles in making personal decisions. Everyone has opinions and predictions, but I feel that it is important for students to make informed decisions. This doesn't necessarily have to be just in science class, but in their everyday lives as well. The processes in science help students become more scientifically literate, an important characteristic beyond the classroom.

LESSON PLANS

Lesson One: Gooey Gak (45 minutes)

Purpose

Objective SCI 6.1 – Demonstrate that new substances can be made when two or more substances are chemically combined and compare the properties of the new substances to the original substances.

Science Concept: The student knows that substances have physical and chemical properties.

Materials (Per groups of two students)

- 20 ml Elmer's glue (prepared by the teacher – plastic container is preferred)
- Graduated cylinder
- Water
- Craft stick
- Food coloring
- 15 ml saturated borax solution (prepared by the teacher)

Procedure

1. Read the questions in the observation section. Answer them in the journal.
2. Measure 20 ml of water in the graduated cylinder.
3. Add the water to the white glue in the container and mix thoroughly with the craft stick.
4. Add two or three drops of food coloring to the mixture and stir.
5. Add 15 ml of borax solution to the glue and water mixture. Stir immediately!
6. After a few minutes, remove new material from the container and roll around in hands or table.

7. Let the material rest on the table for a few minutes.
8. Record observations and questions into journal.

Questions (to be answered in journal)
1. What did you notice about your materials before you mixed them? What were their properties?
2. What did you notice when you mixed the water and glue? Describe the properties of this mixture.
3. What do you predict will happen when the borax solution is added?
4. What did you notice when you added the borax solution? What this what you predicted? Describe the properties of this material. Where the properties similar or different to the original substances? Was this a chemical change or a physical change? Explain.

Assessment
Check for student understanding in their journals. Make sure they are writing observations about the properties at each step. Check for explanation of chemical change.

Lesson Two: Caramel (45 minutes)

Purpose
Objective SCI 6.1 – Demonstrate that new substances can be made when two or more substances are chemically combined and compare the properties of the new substances to the original substances.

Science Concept: The student knows that substances have physical and chemical properties.

Materials (per student)
- Two sugar cubes
- Metal spoon (other options include aluminum trays or plates, aluminum weighing trays)
- Two paper towels
- Magnifying lens
- Alcohol burner (one or two per classroom)

Procedure
1. Make and record observations about the sugar cube (yes, this includes tasting) in the journal.
2. Wrap one cube in a paper towel and crush. Open towel and record observations again.
3. Using the other paper towel, wrap the end of the spoon.

4. Put another cube in the spoon and carefully place over the flame of the alcohol burner.
5. After it melts and changes color, remove the spoon and let cool. Record observations.

Questions (to be answered in journal)

1. What were your observations about the whole sugar cube?
2. What were your observations about the crushed sugar cube?
3. Compare the properties of both whole and crushed cube. Were they similar or different?
4. What do you predict will happen to sugar as it is placed over the flame?
5. What were your observations about the sugar cube when it was being heated and afterwards?
6. Is crushing a sugar cube a physical change or a chemical change? Explain.
7. Is melting a sugar cube a physical change or a chemical change? Explain.
8. How is melting sugar different than melting ice? In your explanation, describe the changes that occur in each.

Assessment

Check for understanding in student journals. Make sure they understand that crushing the cube is a physical change only and that the properties of the whole cube are the same as the crushed cube. Make sure they understand that melting sugar is a chemical change and that the new substance has different properties than the original sugar cube.

Lesson Three: Chemistry in a Bag (45 minutes)

Purpose

Objective SCI 6.1 – Demonstrate that new substances can be made when two or more substances are chemically combined and compare the properties of the new substances to the original substances.

Science Concept: The student knows that substances have physical and chemical properties.

Materials (per student)

- One Ziploc baggie
- A small plastic or paper cup
- About one to two spoonfuls of baking soda
- About 10-15 ml of vinegar

Procedure

1. Put one or two spoonfuls of baking soda into the Ziploc bag.
2. Pour about 10-15 ml of vinegar into the small cup.

3. Record observations about each substance into journal. Describe each substance's physical properties.
4. Carefully set the cup of vinegar in the bag. Be careful not to spill it.
5. Gently squeeze as much air out of the bag as you can and zip it closed.
6. Now holding the outside of the bag, knock the cup over so that the vinegar mixes with the baking soda.
7. Observe what happens and record in journal. Be sure to feel the bottom of the bag as the two substances are mixed.

Questions (to be answered in journal)
1. What were your observations of the two substances before they were mixed? Describe the physical properties of each.
2. Predict what will happen when the two substances are mixed together.
3. What were your observations after you mixed the two substances? Was this what you predicted?
4. Was this a physical change or a chemical change?
5. If you think it was a chemical change, how do you that a new product was formed?

Assessment
Check for student understanding in journals. If the bags were closed properly, then the students should have observed that the bag expanded. They should note that bubbling occurs as the substances are mixed. This is the evidence for a chemical change. The carbon dioxide gas is one of the new substances formed from the reaction. They may also note that the bag becomes cold to the touch when they are mixed.

Lesson Four: The Baffled Baker (One hour)

Purpose
Objective SCI 6.1 – Demonstrate that new substances can be made when two or more substances are chemically combined and compare the properties of the new substances to the original substances.

Science Concept: The student knows that substances have physical and chemical properties.

Materials (per group)
- Eight small cups (or chemical trays if available)
- One spoonful of each of the following:
  - Powdered sugar
  - Salt
  - Baking soda
  - Cornstarch
- Other ingredients can include:
  - Baking powder

  - Granulated sugar
  - Flour
- One bottle of iodine
- One small bottle of water
- Vinegar
- Hand lens

Procedure

1. Explain to students that their help will be needed to solve a mystery. The fictional baker can be incorporated into a short story in which he has mislabeled his ingredients needed to make donuts.
2. Give them the four known ingredients and have them test physical properties of each. They can write their data in a table format. Physical properties include color, grain size, shape, taste, odor, etc. They may use a hand lens to help them.
3. Next, give them water, iodine, and vinegar. They are to test the chemical properties of each of the four ingredients.
4. Once finished, give each group the unknowns. These are the ones that the baker did not label properly. Based on their previous results, students are to decide which unknown is which ingredient.
5. Data and observations are to be recorded in their journals or booklet.

Questions (to be answered in journal)

1. What were the unknowns? Was this as you predicted?
2. Explain how you used a physical property to identify one unknown ingredient.
3. Explain how you used a chemical property to identify one unknown ingredient.
4. Why is it important to label chemicals?
5. What chemical changes occurred during your experiment?
6. How can the baker use the knowledge of understanding chemical and physical changes to help him in his business?

Assessment

Check for understanding in journals. Questions 2,3 and 5 specifically test student knowledge about physical and chemical changes. They should be able to identify baking soda and vinegar as a chemical change and can identify taste, odor or grain size for physical properties of the ingredients.

ANNOTATED BIBLIOGRAPHY

Works Cited

Atkinson, Sue and Fleer, Marilyn. *Science with Reason.* Portsmouth, NH: Heinemann, 1995.
This book provides stories from actual teachers (elementary and middle school) on their strategies for teaching science and from seeing science from a child's perspective.

Driver, Rosalind, et al. *Making Sense of Secondary Science*. New York: Routledge, 1997.
Since this book is research-based, I think there are numerous ideas conveyed from several chapters that are helpful. It is broken down into different content areas and shows what children's conceptions of various topics are and how they perceive these subjects. One part shows how students look at conservation of matter when describing physical and chemical changes.

Freiberg, H. Jerome and Amy Driscoll. *Universal Teaching Strategies.* Needham Heights, MA: Allyn & Bacon, 1992.
This book gives teachers at all grade levels tips and strategies to use such as timing, questioning, management, and beginning and closing activities.

Harcombe, Elnora. *Science Teaching/Science Learning*. New York: Teachers College Press, 2001.
This book shows teaching strategies in the science classroom, including questioning and teaching for understanding.

Houston Independent School District. *CLEAR Curriculum*. Houston, Texas: Houston Independent School District, 2003-2004.
State-required objectives and strategies for sixth grade science.

Lezotte, Lawrence. *Learning for All*. Okemos, MI: Effective Schools Products, Ltd., 1997.
Correlates and strategies for building schools to become more effective in the next generation.

Marzano, Robert, et al. *Classroom Instruction that Works.* Alexandria, VA: Association for Supervision and Curriculum Development, 2001.
Research-based strategies for increasing student achievement.

National Research Council. *National Science Education Standards.* Washington, D.C.: National Academy Press, 1996.

The standards for science education in the U.S. This book outlines teaching, professional development, content and assessment standards upon which the state derives its objectives.

Supplemental Resources

Hazen, Robert M. and James Trefil. *Science Matters.* New York: Doubleday Publishing, 1991.
An outstanding guidebook for science content. Explains everything from quantum physics to evolution to plate tectonics in a simplified way that everyone can understand.

Sample Lesson 7: Physical/Chemical Changes. 1999-2004. CAST. 1 Feb. 2004. <http://www.cast.org/udl/PhysicalChemicalChanges902.cfm#procedure>.
This site provides a few demonstrations on physical and chemical changes.

Smile Program Chemistry Index. 2004. Science and Mathematics Initiative for Learning Enhancement. Feb. 2004. <http://www.iit.edu/~smile/cheminde.html>.
This is one of the most comprehensive lesson plan sites. There are numerous chemistry activities and experiments, including several about physical/chemical changes. This is where I got a few ideas on lessons for this unit.

Gore, Gordon. *Experimenting with Physical and Chemical Changes*. New York: Trifolium Books, Inc., 2001.
This book is specifically designed for this objective. Many hands-on activities and experiments.