CLEAN IT UP!

Fifth graders focus on unique properties of matter to separate a mixture.

By Janette Smith

Young students need opportunities to develop their conceptual understanding of properties of matter. By providing students with inquiry activities, we lay the groundwork necessary for students to grasp the challenging concepts associated with learning about the periodic table in middle school. In this 5E activity (Bybee 2009), fifth-grade students assume the roles of environmental engineers to clean up contaminated soil. They are tasked with identifying unique properties of components of a mixture in order to select appropriate tools for separating these components. Development of the vocabulary word *property* as it is used in the context of matter frames the conceptual understanding that matter has unique properties that can be leveraged to separate a mixture. Once students develop a plan to separate their mixtures, they select tools such as magnets, sifters, and tubs of water to perform the task. After their mixtures are separated, the activity is extended by providing students the opportunity to find the mass of each component using digital scales. Throughout the activity, probing questions help guide the students. Opportunities to develop vocabulary are interwoven throughout this engaging lesson.

Pre-Lesson Scaffolding

As a foundational activity to the inquiry activity, familiarizing students with the word *property* as it is used in the context of matter is important. Fifth graders have heard this word used in different ways before, such as owning property, so it's important to spend some time developing the idea of *property* as it is used in describing matter. I asked students, "What is property?" One student responded with, "something that belongs to someone." I followed up with, "Property has two definitions. One is what you suggested: something we own. Another meaning of property is a characteristic of something. For example, if you have a rock, what are some things that describe the rock?" Some responses were, "hard," "sharp," and "solid." I followed up with, "These are all properties of the rock. In a way, the rock owns those descriptors, so it is related to the kind of property that you are used to."

One strategy that I have found success with for developing the concept of properties of matter is playing "The Property Game," which provides a good foundation for understanding properties. This can be done in small groups, or if you are pressed for time, it can be done as a whole class using a document camera to model the game. Basically, all that is needed are 15 or so random objects from around the classroom (e.g., glue stick, ruler, marble, clay, rock, and so on). The person who is the leader thinks of one specific property and separates the objects, making one pile for items that have the property and one pile of items that do not. The students are then asked to figure out what the property might be. In the first example, I pointed to the screw, the washer, and the paper clip and said, "These objects all have the property I'm thinking of." Students raised their hands and offered guesses. One student said, "They are all shiny." This was a good idea but not what I had in mind. I asked for more and got, "They are all silver (in color)"—another good property but not the one I was thinking of. Finally, I called on one student who said, "They are all magnetic." Bingo! After it seemed that students were comfortable with the game, they played a few rounds in small groups.

Background

This simulation of a real-life scenario puts students in the role of environmental engineers. They are tasked with separating different components of a mixture using tools designed to work well with unique properties. Given a baggie of sand, marbles, washers, and cork pieces, students decided which tools would be effective for separating their mixtures. They chose from items such as magnets, sifters, and tubs of water. To help minimize traffic and manage materials, try setting up all materials in advance in a central location, such as a table, and then assigning roles such as "materials manager."

PHOTOS COURTESY OF THE AUTHOR

Students separate components of a mixture.

Engage

Before beginning the demonstration, I showed the students a cup of water and a cup of oil. I wanted to check to make sure they were feeling comfortable with the idea of properties, so I asked, "Who can tell me some properties of water?" Some responses included, "clear," "liquid," and "wet." I then asked about properties for the cup of oil. Students responded with "liquid," "yellow," and "greasy." I felt confident that their understanding of properties was developing, so it was time to begin the activity. To set the scene for the investigation, I began by asking students what would happen if oil was poured into some water. One student raised his hand and said, "The oil will sink to the bottom." While another said, "No, I think the oil will float." It's important to ask stu-

dents why they think the way they do when they make predictions in order to reveal their thinking and any misconceptions. When prompted with, "Why do you think the oil will float?" The student responded with, "I've seen that happen in my salad dressing; I think it is just lighter than water." I replied with, "That's a great observation. The mass of an object definitely plays a role in whether or not something will sink or float. But what about a log? Have you ever seen a log floating on water? Is a log light?" After students discussed this idea for a few minutes in their groups, I introduced the idea that mass is one property that determines if something floats, but volume also should be considered. I said, "Remember, volume is how much space something takes up. Since a log has a large mass but also has a large volume, it is able to float. This combination of mass and volume makes up a property called *density*." Referring back to the salad dressing, I rephrased to say, "The salad dressing is less dense than water, causing it to float on top of the water." Next, I raised the clear plastic cup of water so everyone could see and slowly poured in the oil. The oil appeared to sink down into the water a little and then settled on the top of the water. (A side note: I tried to put food coloring in the oil to make it easier to see, but the food coloring didn't mix with the oil very well. In fact, when I poured in the food coloring–oil mixture, some of the food coloring sunk to the bottom, which might have confused students. Next time, I will color the water! This is a good reminder of why we need to try things before we teach them.) Next, we discussed how one property of oil is that it floats on water. This was a good segue to a video on oil spills (see Internet Resources). A quick clip of the oil-rig explosion in the Gulf of Mexico was shared, and we discussed what the environmental engineers had to consider before cleaning up the oil. Students concluded that properties of water and oil must be considered to come up with a solution to separating them. Since oil floats, the video showed booms used to contain the oil on the surface of the water. We also discussed the possibility of burning off the oil since oil is flammable and water is not.

Explore

To provide students with a realistic application, students assumed the roles of environmental engineers challenged with cleaning up some contaminated soil. Students were divided into groups of four using prearranged table groups. Students wore safety goggles so they could avoid getting sand particles in their eyes. I then showed them a bag of mixed materials (cork pieces, marbles, washers, and sand) and told them that two of the substances in the bag, the marbles and the sand, were hazardous materials that they needed to separate from the mixture. Like the oil spill, properties of the substances should be considered when separating. Before students got to work, they worked on an activity sheet requiring them to list properties of each separate component of the mixture (see NSTA Connection for the activity sheets). At first, students were a little slow to get started on this part; I think if I had done the first one with them they would have been clearer on what to do. I ended up circulating the different groups and asking questions to get them started.

Students clean up contaminated sand.

Once students had their properties listed, their next step was to determine the tools they would need to separate the mixture, keeping the properties in mind. This can be done in several ways, depending on how much of a challenge your students need. You could ask the students which tools they would like to use to separate the mixture. Or, if your students need more prompting, you could show them a variety of tools to choose from, such as magnets, bowls of water, sifters, paper plates, paper towels, and so on. You can choose to display the variety of tools on a table or not, depending on the needs of your students.

Once students had a plan for separating the mixture, they worked together in the same groups to write the details on page 2 of the activity sheet. One thing that was emphasized was that students should carefully consider the order that they separate the mixture. I've done this activity before, and inevitably, someone will dump everything into the water first. This makes the sand virtually impossible to separate with the sifter. I used a variety of probing questions while they were planning to try to avoid this common error. I asked, "What are you planning to do first?" If they responded with "Dump it all in the water so the cork would float." I responded with, "What will that do to the sand?" They then realize that the sand will be wet and hard to put through the sifter. I

did have some extra baggies of mixtures on hand in case any of the groups made this mistake.

The students enthusiastically worked together to separate their mixtures. They seemed to really enjoy using the different tools to separate each item. Most groups began with the sifters and dumped the whole mixture into them. One group chose to use the magnet first to retrieve all the metal washers. Once the sand was separated, many groups dumped everything into the tub of water to get the cork to float. One group was excited to learn, "Hey, my magnet works in the water!" It didn't take long for students to separate each item. One group didn't even use the tub of water and picked out the pieces of cork and marbles by hand. I asked them, "If this was 10 acres of mixture, what would be the problem with your technique?" They responded, as I had hoped, with: "That would take forever!"

To extend the activity, I had the students find the mass of each component on a digital scale. I did have to give a quick tutorial on how to tare the scale so that they could use the little plastic lid as a bowl to contain each component. They found the mass of each component in grams and then answered a few more math questions related to ordering the masses and doing some basic calculations to answer another question. It is important to note that each group had varying amounts of each component, so mass calculations for each group would vary. Depending on the level of your students, students could also be challenged with finding the percentages of each component of their mixture. This could be related to the real-world scenario by telling students that the contaminants needed to be stored, so it is important to know how large of a storage container would be needed. If students know that a certain size container can hold a specific mass of marbles or sand, they would know how many containers they would need.

Explain

For these types of explorations, I find the most effective way to begin the explanation portion is to have students share what they did. I began by asking, "What did you decide to separate first?" One group said, "The sand." I followed up with, "What unique property did you keep in mind when separating that?" Students said, "It's tiny and can fit through the sifter." I continued this line of questioning and asked if any groups did it differently until every group had shared their plan. Once students have shared their experiences, it's usually a good idea to introduce related vocabulary. I decided to share definitions for *homogeneous* and *heterogeneous* mixtures since this seemed to relate to our activity. If students have internet access, give them a few minutes to investigate definitions for homogeneous and heterogeneous and write them on the board. I wrote the following "*homogeneous mixture*: a mixture whose components are evenly distributed throughout the mixture and *heterogeneous mixture*: a mixture whose components are unevenly distributed throughout." We then discussed which type of mixture they worked with today, and students easily identified their mixture as heterogeneous. Coming up with a homogeneous mixture was a little more challenging since it is difficult to determine if the components are evenly distributed. Students came up with the idea that if they had the same numbers of each color of the same kind of candy, they could mix them together to create a homogeneous mixture.

Elaborate

To bring the activity back to the idea of environmental cleanup, students were asked how they think soil gets contaminated in the real world. This led to a discussion of illegal dumping, pollution, and acid rain. Next, students were asked why it would be important to clean up contaminated soil. The discussion concluded with the idea that contaminants in soil eventually seep into drinking water or end up in the soil where farmers grow our food.

Evaluate

Finally, to see if students could apply what they had learned, students were given a written assessment (see NSTA Connection). The assessment provides students with an opportunity to transfer their learning from separating mixtures to a new situation. The evaluation includes the following scenario:

> *You've been out at your grandpa's farm jumping around in a haystack. After you get finished playing, you realize that your metal necklace made of nickel has fallen off your neck while you were playing. You know the necklace is somewhere in the haystack, but you need to find an efficient way to find it.*

As in the activity, students are provided with space to identify unique properties of both the hay and the necklace. They follow this with a plan for separating the two. For an additional challenge, students are tasked with finding a different strategy than their first response. A grading rubric is also provided (see NSTA Connection).

Conclusion

Although this activity can be done in one science period, it really is a great culmination to the idea that all matter has unique properties. Providing a real-life scenario to

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

5-PS1 Matter and Its Interactions
www.nextgenscience.org/dci-arrangement/5-ps1-matter-and-its-interactions
The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation	**Connections to Classroom Activity** *Students*
5-PS1-3 Make observations and measurements to identify materials based on their properties.	• determine unique properties of different components of a mixture, then use these properties to separate a mixture.
Science and Engineering Practices	
Planning and Carrying Out Investigations Using Mathematics and Computational Thinking	• develop a plan to separate a mixture. • choose appropriate tools to separate components of a mixture based on their unique properties. • weigh and calculate percentages of each component of the mixture.
Disciplinary Core Idea	
5.PS1.A: Structure and Properties of Matter • Measurement of a variety of properties can be used to identify materials.	• determine unique properties of each component of a mixture.
Crosscutting Concept	
Scale, Proportion, and Quantity	• determine percentages of each component of a mixture based on weight.

apply this knowledge shows students the relevance of their learning. This experience could also help to expand the students' views of engineering and perhaps pique their interest in engineering careers. In addition, this activity provides the scaffolding they will need for their future learning about the properties of matter. This activity helps develop the concept that all matter has unique properties. In their future science learning, students will learn that each element has a specific location within the periodic table based on its unique properties. ■

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Internet Resources

Oil Spill Video Clip
http://video. scholastic. com/services/player/bcpid1842760475?bctid=86097427001

Ted Ed Video on mixtures
www.youtube.com/watch?v=Vt7lN4QPU0k

NSTA Connection

Download the activity sheets and grading rubric at *www.nsta.org/SC0417*.