5

EXPLORING "Watermelon and Grape"

INTRODUCTION TO THE LESSON

In this lesson, elementary students **explore** the size and weight of everyday materials and **explain** how whether an object is heavy or light for its size determines if it sinks or floats. The lesson starts by engaging and eliciting students' ideas about whether they think a watermelon and a grape will sink or float. It then provides students with experiences in making observations of the sizes and shapes of objects to describe the physical properties of materials.

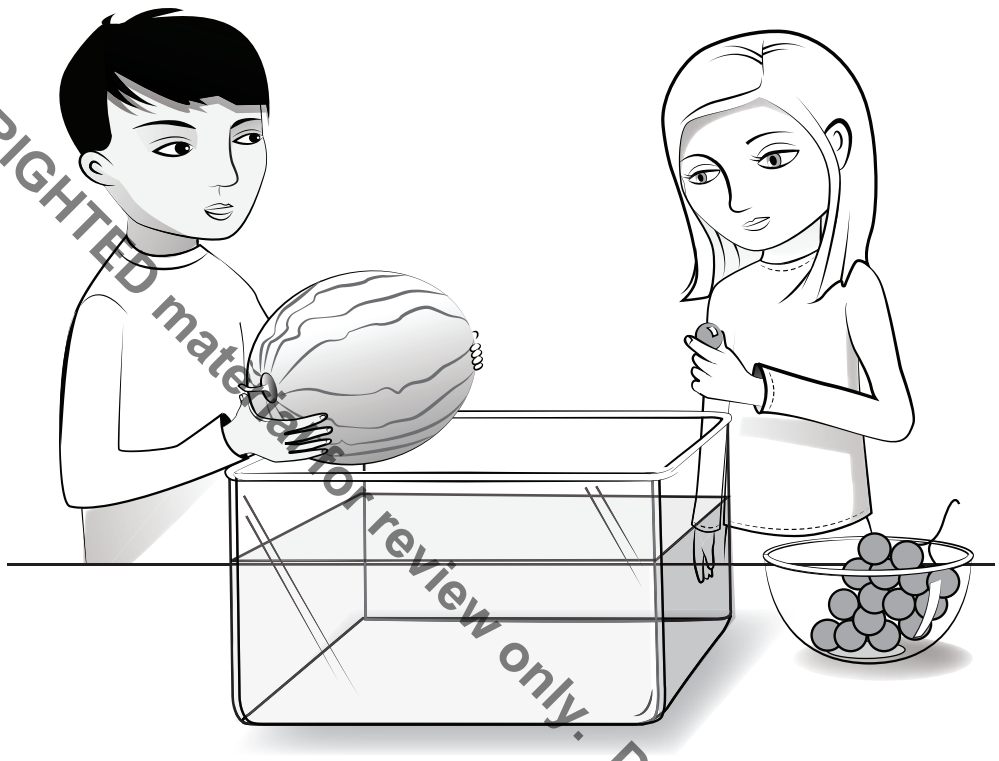
MATERIALS NEEDED FOR THIS LESSON

- "Watermelon and Grape" formative assessment probe (included)
- 10-gallon fish tank
- Eight gallons of water
- Watermelon
- Grape
- Various objects to compare and contrast, such as different-sized fruits (e.g., cranberries and a pumpkin) and other items like a marble and a weight

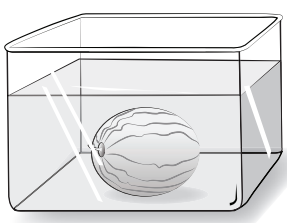
SAFETY NOTES

1. Have direct adult supervision while you are working on this activity.
2. Wear safety goggles and nonlatex aprons during the setup, hands-on, and takedown segments of the activity.
3. Quickly wipe up spilled or splashed water off the floor so it does not become a slip-and-fall hazard.
4. Keep water-filled aquarium away from electrical receptacles to prevent accidental shock.
5. Do not taste or eat food used in this activity.
6. Wash your hands with soap and water after completing this activity.

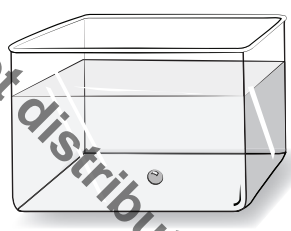
Watermelon and Grape



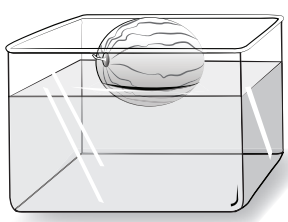
The watermelon will sink.



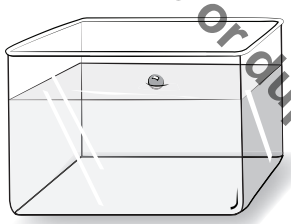
The grape will sink.



The watermelon will float.



The grape will float.



What are you thinking?

"WATERMELON AND GRAPE" PROBE BACKGROUND INFORMATION

Teacher Explanation

"The watermelon will float" and "The grape will sink" are the best answers. Although the watermelon is much larger than the grape and its felt weight is much greater, its mass-to-volume ratio (density) is less than that of a grape. Also, its density is less than that of water; therefore, it floats. The grape's mass-to-volume ratio is greater than the watermelon's even though its felt weight is much less. The density of a grape is greater than that of water; therefore, it sinks. Denser objects are heavy for their size, while less-dense objects are light for their size. An object denser than water sinks; an object less dense than water floats. Thus, it is the mass-to-volume ratio that makes a difference, not the size.

Research on Students' Ideas Related to This Probe

- A study conducted by Biddulph and Osborne (1984) asked students ages 7 to 14 why things float. The typical response was "because they are light."
- Some students use an intuitive rule of "More A–More B" (Stavy and Tirosh 2000). They reason that the larger an object the more likely it is to sink.
- Children younger than age 5 typically ignore an object's size and focus on its felt weight (Smith, Carey, and Wiser 1984).
- Piaget's studies (1973) demonstrated that children initially think of a pebble as being "light" and later describe it as "light for them" but "heavy for water." He showed that when children reach ages 9 and 10, they begin to relate the density of one material to that of another material by describing some materials as floating because they are lighter than water (Driver et al. 1994).

THREE-DIMENSIONAL LEARNING TARGETS FROM *A FRAMEWORK FOR K–12 SCIENCE EDUCATION*

Disciplinary Core Idea: *Grades K–2*: Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured.

Scientific Practices: Carrying Out Investigations, Analyzing and Interpreting Data, Constructing Scientific Explanations

Crosscutting Concepts: Patterns, Scale, Proportion, and Quantity

CONNECTIONS BETWEEN THE *FRAMEWORK*, FORMATIVE ASSESSMENT PROBE, AND *EXPLORE-BEFORE-EXPLAIN* LESSON

Before students learn how to describe materials by their measurable properties, they first **explore** and **explain** using multiple observations to describe objects. The "Watermelon and Grape" formative assessment probe elicits students' ideas on and past experiences with whether objects sink or float depending on size. The probe provides teachers with information about common misconceptions that will be challenged during the lesson. As students collect data from their **explorations**, they notice patterns in an object's felt **heaviness** and **size** and whether it sinks or floats. Next, students circle back to test whether additional objects sink or float. Finally, they begin to formulate how the "heavy or light for its size" property of an object influences whether it sinks or floats. Students' **explanations** are a direct consequence of their firsthand experi-

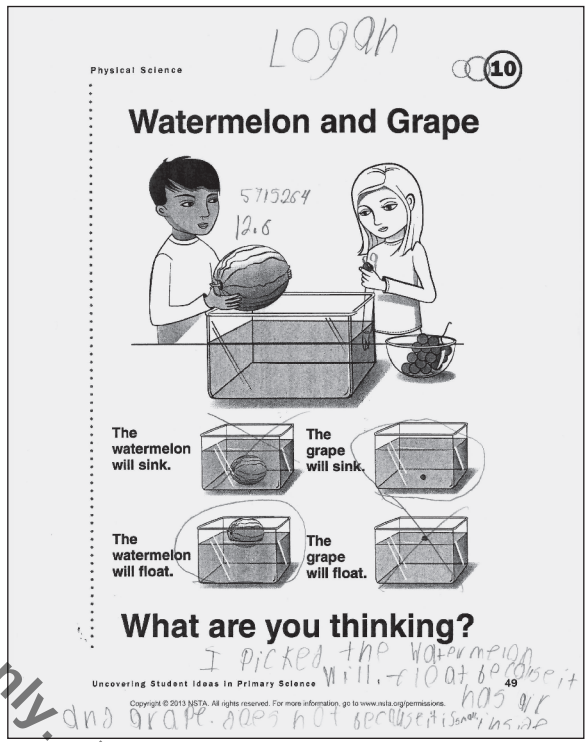
ences. With teacher guidance, students can develop a more profound concept of physical properties, including many different observations considered in tandem. At the end of the lesson, students revisit the formative assessment probe to explain that sinking and floating are based on an object's weight in relation to its size.

VIGNETTE: EXPLORING "WATERMELON AND GRAPE"

The lesson started with the *Uncovering Student Ideas* probe "Watermelon and Grape" (Keeley 2013, pp. 49–52). The probe specifically asks students whether they think a watermelon and a grape will sink or float. The ideas were attractive to students, and nearly all thought the watermelon would sink and the grape would float. When asked to explain their thinking, students' responses focused on using the object's weight to determine whether it would sink or float. For example, Harry explained, "The watermelon will sink because it's heavy." Interestingly, one student thought the watermelon would float and the grape would sink. Logan said, "I picked the watermelon will float because it has air inside and the grape does not because it is small" (see Figure 5.1).

Thus, Logan based his prediction on thinking about the materials inside a watermelon versus a grape. The probe's purpose was to elicit student ideas about sinking and floating and see whether they could substitute a prediction with a rule for their thinking. Therefore, engagement time was not about the correctness of students' ideas, but rather how they logically supported their predictions. The probe revealed a research-identified commonly held intuitive rule, known as "More A–More B," in which students reason if there is more of one thing, then there is more of another. For example, if an

Figure 5.1. *Student's Idea About Why a Watermelon and a Grape Will Sink or Float*



object has more weight or a greater size, students believe that it is more likely to sink.

Next, with ideas in mind, it was time for students to explore whether the watermelon and grape would sink or float. We performed the investigation as a classroom demonstration using a 10-gallon fish tank. (See the teacher video resource at https://youtu.be/L_Pc6sxB_gI). First, the grape was placed in the tank. To the students' surprise, the grape sank and went straight to the bottom of the tank. Next, we placed the watermelon in the tank. Most students were shocked when the watermelon did not sink to the bottom. However, they were torn on whether the watermelon was sinking or floating. They associated floating with being completely suspended on top of the water, although they could see water between the watermelon and the bot-

tom of the fish tank. For example, Harry noticed that the watermelon did not sink to the bottom and was only partially submerged. Described a bit differently, half of the watermelon was below the water's surface. Students were perplexed as to why the grape sank and the watermelon floated. Harry claimed that he had done the investigation before and this is not what he had found. Thus, students' conceptions were persistent, and they resorted to explanations that justified their initial ideas despite having data as evidence to the contrary.

Next, we set out to do some additional tests. The goal was less about having students identify whether objects would float or sink and geared more toward having them think about objects in terms of whether they are heavy or light. The exploration focused on the idea that weight and size alone do not determine whether objects sink or float. First, students extended the formative assessment probe and compared other fruits, including cranberries and a pumpkin. They compared the relative heaviness of the objects, and then predicted whether each would sink or float based on what they had learned from the "Watermelon and Grape" investigation. Students closely compared the grape and cranberry. While nearly the same size and similar in shape, many thought the cranberry would float because it was "lighter." Students were less sure about comparing the pumpkin and watermelon but believed they felt the same and commented that the pumpkin should float like the watermelon. Then students watched the demonstration and saw that the pumpkin floated like the watermelon. Thus, the experience added further evidence that weight alone does not determine whether an object sinks or floats.

Further objects were added to the students' investigation, including a small marble, weight, and water balloon. Students immediately thought both the marble and weight would sink, basing their explanation on a difference between these materials and the fruits tested. They believed that these objects did not have water in them and thus would sink. Students' conceptions were verified, as both the marble and weight sank. Students were less sure about the water balloon. Most thought it would sink because the water balloon felt heavy. Some students thought the water balloon would be suspended in the middle of the tank because, as they explained, "it was water just like the water in the tank."

Explanation

The Explain phase began with students' evidence-based claims described during class discussions. They had two similar experiences that served as evidence for their claims. First, students consolidated their data into two categories, one on each half of their sheet, with the headings "Heavy for its size" and "Light for its size." Next, they drew pictures of each item tested and listed whether it would sink or float under one of the headings. Students made the following evidence-based claims: First, an object's weight alone does not determine whether it sinks or floats. Students could support this claim with the watermelon and pumpkin versus the grape and cranberry. Second, shape on its own does not explain whether an object sinks or floats. Students' claims were supported with evidence that even similar-shaped objects like apples, avocados, and tomatoes differ in whether they sink or float. With teacher guidance, students began to explain sinking and floating as related to both the size and shape of an object. Aiden explained that a "small object that feels heavy will sink like a small rock." While students could do most of the evaluation activity independently, they needed help in regard to the watermelon and pumpkin. All students thought these two objects were heavy and did not have a frame of reference for whether they were heavy for

their size. Still, Charlie remarked that even "really big objects can float if they are really big in size as the watermelon."

Thus, students were starting to think about heaviness in a relative sense and realizing that not all objects perceived to be heavy float in water. The culminating activity allowed students to see patterns across the different experiences as evidence that shape and size do not determine whether objects sink or float. Having students summarize all their experiences on one sheet allowed them to understand the similarities among the various floating and sinking experiences.

Evaluation

Students revisited the "Watermelon and Grape" formative assessment probe to explain that size and shape determine whether an object sinks or floats. Students were able to support their **scientific explanation** with evidence that small objects that are heavy for their size, like a grape, will sink and large objects that are light for their size, like a watermelon, can float. Encourage students to think using relative comparisons, as they need a frame of reference for considering whether an object is heavy or light for its size. While students revised their claims, they were prompted to think about sinking and floating based on observations such as size, shape, and materials that make up the object rather than just one factor alone.

Possible Further Elaborations

- Have students predict and explain whether a tiny piece of material will sink or float versus a large piece of material. You might demonstrate with a tiny speck of soap versus a bar of whole soap, for example. (Do not use Ivory soap, which floats!)
- Have students test materials that are more porous, like a sponge or a cube with holes in it, to extend their thinking about how air and space might affect sinking and floating.
- An additional probe that can be used to further *explore-before-explain* or formatively check students' understanding is "Sink or Float?" (Keeley 2013, Model Lesson 4 in this book).

REFERENCES

Biddulph, F., and R. Osborne. 1984. Pupil's ideas about floating and sinking. Paper presented at the Australian Science Education Research Association Conference, Melbourne.

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas*. London: Routledge.

Keeley, P. 2013. *Uncovering student ideas in primary science: 25 new formative assessment probes for grades K–2*. Arlington, VA: NTSA Press.

Piaget, J. 1973. *The child's conception of the world*. London: Paladin.

Smith, C., S. Carey, and M. Wiser. 1984. *A case study of the development of size, weight, and density*. *Cognition* 21 (3): 177–237.

Stavy, R., and D. Tirosh. 2000. *How students (mis) understand science and mathematics: Intuitive rules*. New York: Teachers College Press.