Using the P-E-O Technique

By Page Keeley

Observing how objects sink or float in water is an elementary precursor to developing explanations in later grades that involve an understanding of density and buoyancy. Beginning as early as preschool, elementary students engage in activities that encourage them to predict whether an object will sink or float when placed in water, and then test their predictions by making observations. Core Idea PS1.A from *A Framework for K–12 Science Education* (NRC 2012) states that by the end of grade 2 students should know that matter can be described by its observable properties and that different properties are suited to different purposes. Children often base their predictions about whether an object or material will float or sink on the observable properties of the object they are testing such as its size, felt weight, heaviness for its size, or shape. Therefore it is important for elementary students to have multiple experiences describing the properties of objects and materials, predicting whether they will float or sink, supporting their predictions with explanations that use the properties of the objects or materials as evidence, and testing their predictions.

The "Solids and Holes" probe (Figure 1) is designed to find out whether students think a solid object will float differently if holes are poked all the way through it (Keeley, Eberle, and Tugel 2007). In a study by Grimillini, Gandolfi, and Pecori Balandi (1990) of children's ideas related to buoyancy, they found that children take into account four factors when considering how objects float: (1) the role played by material and weight; (2) the role played by shape, cavities, and holes; (3) the role played by air; and (4) the role played by water. All of these factors have been revealed in students' responses to this probe when using the P-E-O formative assessment classroom technique (FACT) (Keeley 2008).

To begin the P-E-O probe, the teacher provides students with a solid block of material that floats in water (e.g., wood, Styrofoam, or a piece of orange peel). Each block of material is the same size and shape. Students place their material in a cup of water and observe how it floats.

Children are continually developing ideas and explanations about their natural world. Many of these ideas come from their daily interactions with natural phenomena. Others come from ideas they pick up through the media, other students, and adults. Some of these ideas are consistent with the science children are taught; others differ significantly from scientific explanations. Many of these ideas will follow students into adulthood if they remain hidden from the teacher and unresolved. The challenge for teachers is to find ways to elicit these ideas and then use appropriate strategies to move students' learning forward. The *Uncovering Student Ideas in Science* series, published by NSTA, provides K–12 teachers with a source of highly engaging science questions that link instruction and assessment and target key ideas in the standards. These questions, called formative assessment probes, are used to expose students' preconceptions; encourage evidence-based explanations, talk, and argument; and monitor students' progress in achieving conceptual understanding. Combined with various formative assessment classroom techniques (FACTs), probes not only assess where students are conceptually, they also promote learning and inform effective teaching. This is the essence of formative assessment. Each month, this column features a probe and describes how elementary science teachers can use it with effective strategies to build their formative assessment repertoire and improve teaching and learning in the elementary science classroom. See NSTA Connection for more background on using formative assessment probes.

P-E-O begins with a prediction (the "P" part of P-E-O) that draws upon students' prior knowledge and experiences. Students predict what they think would happen if holes were poked all the way through the material as shown on the illustration in the probe. Students select their prediction from each of the answer choices provided on the probe and write an explanation (the "E" part of P-E-O) to support their reasoning.

In small groups or as a whole class discussion, students share their predictions and engage in the scientific practice of argumentation to defend their reasoning. The teacher listens carefully for evidence of understanding or misconceptions related to how objects float. For example, most students select (A) it will sink, based on their knowledge of what happens when a boat gets a hole in it. Other students will choose (B) it will barely float, with the reasoning that the water fills in the holes and weighs it down. Some students choose (D) it will neither sink nor float (it "flinks"!) due to their belief that the water will fill the holes and start to sink the object and then air will get into the holes and it will rise upward, repeating the cycle. After students have had an opportunity to share their thinking, they may reconsider their initial ideas and change their prediction based on the plausible arguments of others. The next step is to launch into an investigation to test their initial or revised predictions by making observations. This is the "O" part of the P-E-O probe.

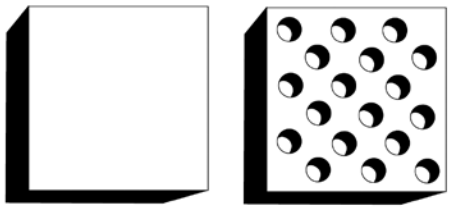
Students are provided with tools and safety instructions for drilling or poking holes in their material (or the teacher can provide them with a new block with holes already made for them). Students place their hole-ridden object in the water and observe. Be prepared for students who will not accept what they observe. The idea that an object that has holes in it will sink is so strongly held that some students are convinced that there are not enough holes in the object or the holes are not big enough! Instead of correcting them or ending the investigation and giving students the answer, let the students make more or bigger holes. Eventually they will see that the material still floats the same way as it did before the holes were poked through it. This leads to the most important part of the P-E-O probe—revising an explanation when observations do not match the prediction. Now students work together in small groups and as a class to come up with an explanation that supports the observation. Eventually some students will recognize that all they did was take out some of the material and change its shape. It was still the same floating material. It is at this point that the teacher can build on the students' revised explanation to explain why the hole-ridden material floats the same way as the solid material and does not sink like a boat, partially sink, or "flink" (as described by the distracter answer

Figure 1.

"Solids and Holes" formative assessment probe.

Solids and Holes

Lance had a thin, solid piece of material. He placed the material in water and it floated. He took the material out and punched holes all the way through it. What do you think Lance will observe when he puts the material with holes back in the water? Circle your prediction.



A It will sink.

B It will barely float.

C It will float the same as it did before the holes were punched in it.

D It will neither sink nor float. It will bob up and down in the water.

Explain your thinking. Describe the "rule" or reasoning you used to make your prediction.

choices). The air in the hull of a boat or in a hollow object is replaced by water when a hole is punched in it, thus making it sink. Boats and hollow objects include air and a solid material. The material students tested did not contain air and only involved one material. (Note: Later, when students learn about density in middle school, they will learn that the mass-volume relationship stays the same when holes are punched through a solid material).

What makes the P-E-O strategy an important technique for formative assessment is that it provides teachers with insights into the misconceptions students hold prior to engaging in inquiry that are then used to facilitate the learning process. It also promotes learning through a process of conceptual change that involves important scientific practices that will make up the highly anticipated *Next Generation Science Standards* such as planning and carrying out investigations, analyzing and interpreting data, constructing evidence-based explanations, and engaging in scientific argumentation to defend one's ideas. As you look through the probes in the *Uncovering Student Ideas in Science* series, identify ones that can be used with the P-E-O technique to provide a constructivist approach to using the scientific practices for support of students' conceptual understanding.■

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NSTA Connection

Download the "Solids and Holes" probe at *www.nsta.org/SC1301*. Read the entire chapter and the introduction to *Uncovering Student Ideas in Science: 25 Formative Assessment Probes* (volume 1) in the NSTA Science Store (*http://bit.ly/vaihtZ*).