O
bserving how objects
sink or float in water
is an elementary pre-
cursor to developing
explanations in later grades that in-
volve 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 predic-
tions 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 ob-
servable properties and that differ-
ent properties are suited to differ-
ent 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 im-
portant for elementary students to
have multiple experiences describ-
ing 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 ob-
ject 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 fac-
tors 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.
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
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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References

