We are seeing something new with modern standards: a growing commitment to the idea that learning science requires the purposeful interplay between students’ background knowledge and experiences and the simultaneously use of the skills, practices, and habits of mind laid out in *A Framework for K–12 Science Education* and the *Next Generation Science Standards* (NGSS) (NRC 2012; NGSS Lead States 2013). The combination of students existing ideas and new learning related to Standards promotes sensemaking and honors the research on how people learn (National Academies of Sciences, Engineering, and Medicine 2018). Sensemaking relates to the degree to which a science concept has personal meaning (i.e., makes sense) and helps students explain how the world works (science) or how to design solutions for problems (engineering). From an instructional design perspective, teaching for sensemaking requires favoring depth over breadth while engaging all students in “doing” science by including critical attributes (see www.nsta.org/sensemaking):

- Draws on phenomena that are meaningful to students’ lives
- Uses students’ ideas as assets for learning
- Develops conceptual understanding of science ideas using science practices and crosscutting concepts.

**What Are the Planning Considerations?**

A useful framework for promoting sensemaking includes the convergence of two independent ideas: (1) the focus of modern education on teaching for understanding and transfer, and (2) a purposeful sequence of instruction with those ends in mind (see Figure 1). In its essence, the sensemaking framework intends to help educators identify the big ideas that we want students to come to understand at a deep level (e.g., construct evidence-based claims from firsthand experiences) so that they can transfer their learning to new situations. This conception is perfectly aligned with the NGSS emphasis on teaching science through the conceptual lenses of core ideas (called Disciplinary Core Ideas [DCIs], practices (called Science and Engineering Practices [SEPs]) and crosscutting concepts (CCs) rather than fixating on factual information only. In addition, this view aligns with four critical attributes that include phenomena, science and engineering practices, student ideas, and science ideas (see www.nsta.org/sensemaking). The sequence of instruction *explore-before-explain* helps teaching place priority on students constructing evidence-based claims in the sensemaking framework. The *explore-before-explain* instructional sequence follows a modified 5E learning cycle (less emphasis on the elaboration phase) to highlight the importance of students constructing evidence-based claims.

The sensemaking framework offers planning considerations for instructional design process based on the idea that teaching is a means to an end, and curriculum planning precedes instruction. The most successful teaching begins with clarity about desired learning outcomes as well as about the evidence that will show that the targeted learning has occurred. Daily lessons that describe the planned teaching and learning activities are then developed. A critical factor in a quality unit plan is alignment—all planning considerations are clearly aligned not only to standards but also to one another. What follows is a description of the four key planning considerations for sensemaking as well as how *explore-before-explain* teaching plays out in practice for teaching K–2 students about whether objects are heavy or light for their size.
Consideration 1: Engaging Prior Ideas

In sensemaking lessons, a common phenomenon that is culturally relevant drives learning goals about content, practices, and logical thinking. Using culturally relevant phenomena (i.e., observable events in students’ lives) as the topic for evidence-based explorations increases equity, making learning accessible to all students—a key critical component of sensemaking as well as a significant advancement in contemporary cognitive science research (National Academies of Sciences, Engineering, and Medicine 2018). Students’ lived experiences provide initial insights into students’ ideas about how the world works (an essential component of constructivist theory and all learning builds on existing ideas (Bransford, Brown, and Cocking 2000)) and provide teachers valuable feedback.

Beginning a new unit is a chance to ask students questions like, “What do you notice?” and “What do you wonder?” or use the Uncovering Student Ideas formative assessment probes by Page Keeley and colleagues. Using “notice and wonder” questioning routines and the Uncovering Student Ideas probes provides a practical engagement activity for making science meaningful for all students. Both strategies for eliciting students’ ideas and experiences invites uninhibited participation (i.e., not tied to fears of assessing ideas) by eliciting students’ insights based on their experiences (“Affective Filter” Hypothesis; see Krashen and Bland 2014). In addition, neurologist and teacher Judy Willis contends that asking questions like “What do you wonder?” or having students create a rule for their thinking (a strategy Keeley and colleagues often advocate for specific probes) are the highest-yield instructional strategies because they focus the brain’s attention and set up a “need to know” (McTighe and Willis 2019). If students’ wonderment ideas and rules for their thinking are accurate, it validates prior knowledge and sound reasoning. Conversely, if their forecasting and predic-

tions are incorrect, students want to discover why and seek an explanation.

Consideration 2: Constructing Claims

Students need the opportunity to collect data, analyze it, and determine how to make sense of what the data may mean. Only when students begin to analyze data and then interpret what the analysis means about the science they are exploring do they have evidence. The practice of having students generate knowledge transforms their experience from a passive to an active meaning-making experience. For students, developing an evidence-based claim for student learning melds content with instruction that facilitates students’ construction of knowledge through an active process—the fundamental idea behind A Framework for K–12 Science Education and vital aspect of the learner-centered classroom, calling upon students’ current intellectual abilities (e.g., pattern recognition and causal relationships) (Gopnik, Meltzoff, and Kuhl 1999). Decades of studies support these assertions and have shown that students develop a deeper understanding and retain that understanding longer when they actively construct explanations (McNeill and Krajcik 2012).

Consideration 3: Connecting Claims To Scientific Principles

Teachers can plan for the essential scientific vocabulary and terms for concepts and processes that fill gaps and helps build more sophisticated understanding. Said a bit differently, introducing vocabulary should occur after students’ experience with phenomenon so they have a meaningful framework for understanding. Here, teachers enhance student knowledge by helping them understand the underlying scientific principles that may be inaccessible from hands-on experiences alone. This is where readings, discussions, and lectures become potent learning experiences because they create connections between ideas and students’ frameworks for understanding. The disciplinary core ideas, crosscutting concepts, and science and engineering practices from the Next Generation Science Standards (NGSS) are good places to start when identifying essential academic vocabulary and a way to make sure students’ sensemaking aligns with modern standards (NGSS Lead States 2013).

Consideration 4: Reflecting on Developing Understanding

The final consideration is creating an opportunity for students to reflect on their new conceptions of science. Students should think about what they have learned and how far they have come intellectually—that is, engage in metacognition, which has a significant effect on learning (see Hattie 2009; Bransford, Brown, and Cocking 2000). Evaluation from a learners’ perspective is a chance for them to assess how ideas
have developed and strategies that lead to more reliable and valid evidence-based claims.

**Putting It All Together: An Example**

Grab everyday materials and get ready to explore! In this task, students start the lesson with the *Uncovering Student Ideas* probe “Watermelon and Grape” (Brown and Keeley 2023; Figure 2). Next, they explore the size and weight of everyday materials to describe the physical properties of materials and explain how whether an object is heavy or light for its size determines if it sinks or floats. The final activities have student revise and elaborate on their initial ideas using crosscutting concepts and science practices to support their scientific understanding.

**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

**Exploring “Watermelon and Grape”**

**Step 1: Eliciting Understandings**

Students kick off the lesson by considering an assessment probe that asks them to decide whether they think a watermelon and a grape will sink or float (Brown and Keeley 2023). Next, have students engage in “partner talk” and share their ideas. Encourage students to explain whether they think a watermelon and grape will sink or float using their lived experiences with everyday objects as support for their thinking.

When asked to explain their thinking, students’ responses typically focus 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.”

Most students made connections to how when they “threw heavy things in the water they would sink” but “when they threw ‘light things’ in the water they would float.” Students also connected sinking and floating with whether the material had air inside like a “pool floaty.” 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 (Stavy and Tirosh 2000). For example, if an object has more weight or a greater size, students believe that it is more likely to sink.

**Step 2: Exploration of a Watermelon and Grape**

The exciting part of the prediction phase (step 2) is that students will have a chance to explore these ideas firsthand. Sometimes, the best learning comes from explorations that provide answers different from our initial thinking (i.e., provides a discrepant event). The watermelon and grape question can easily be tested using the materials in the probe and a 10-gallon fish tank of water. If a fish tank is not available, teachers can use a similar size plastic storage bin. In addition, the exploration can be done as a teacher demonstration or student-led experience. If teachers have students perform the exploration, they will need the appropriate amounts of materials (e.g., grapes for each group of two and watermelons that can be shared). (Teachers should have towels ready to cleanup spillage and prevent slip hazards). Students performed the investigation as a classroom demonstration...
using a 10-gallon fish tank. (See the teacher video resource at https://youtu.be/L_Pce6xbq7g). To the students’ surprise, the grape sank and went straight to the bottom of the tank. Next, the watermelon is placed in the tank. Most students were shocked when the watermelon did not sink to the bottom. The goal of the first exploration is to begin to develop the ideas that objects have physical properties—one of which is whether they are heavy or light for their size.

Step 3: Exploration of Additional Objects

The second exploration is less about having students identify whether objects would float or sink and geared more toward having them use new ideas and think about objects in terms of whether they are heavy or light. Students can extend the formative assessment probe and compare other fruits, including cranberries and a pumpkin. In addition, further objects can include a small marble, weight, and water balloon.

Step 4: Developing Evidence-Based Claims

After all students have collected data, have them consolidate their data into two categories, one on each half of their sheet, with the headings “Heavy for its size” and “Light for its size.” Students can draw pictures of each item tested and list whether it would sink or float under one of the headings. Using data, students can make the following evidence-based claims: (1) First, an object’s weight alone does not determine whether it sinks or floats and (2) Second, shape on its own does not explain whether an object sinks or floats. With teacher guidance, students can begin to explain sinking and floating as related to both the size and shape of an object. The culminating activity allows 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 can enable them to understand the similarities among the various floating and sinking experiences.

Step 5: Reflecting on Developing Understanding

Have students revisit the “Watermelon and Grape” formative assessment probe to explain if size and shape determine whether an object sinks or floats. Students can 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 revise their claims, prompt them 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.

Supporting Educators for Change

Teachers that emphasize sensemaking in their instructional design find the context that explorations provide engages students in science and cultivates their beliefs that they are essential agents in creating classroom knowledge (see National Academies of Sciences, Engineering, and Medicine 2018). Context affects learning and motivation. Situating all learning in students’ explorations and the resulting evidence-based claims gives meaning and purpose to all activities, including discussions, lectures, and textbook readings. The result is that students gain higher levels of sensemaking because understanding from both explorations and explanations combine to create meaningful learning experiences.

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REFERENCES


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