Drawing for Meaning

Students develop three-dimensional skills through scientific drawings.

By Jennifer Baxter and William Banko

Drawing clarifies our thinking and expresses our ideas. We might draw ideas for a school logo, clothing design, plans for home improvement, blueprints for a bridge, or even a patent application. In science, we use drawings to show life cycles, express cause-and-effect relationships, and label parts of an object such as an apple. Scientific drawing is a three-dimensional skill that aligns with the science and engineering practice of Developing and Using Models and the crosscutting concept of Systems and System Models (NGSS Lead States 2013). *A Framework for K–12 Science Education* states, "modeling can begin in the earliest grades, with students' models progressing from concrete 'pictures' and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system" (NRC 2011).

Why Teach Drawing?

Visual representations such as drawings, diagrams, and charts help us collect, process, and understand information. Use of visual tools, such as drawings, charts, graphs, or concept maps help the brain make new connections that are necessary for long-term retention of information (Vasquez, Comer, and Troutman 2010). When students draw, they are intrinsically motivated and more engaged in learning. Drawing assists in the development of visual-spatial thinking, which allows the learner to see both the "big picture" and components of any type of learning (Ainsworth, Prain, and Tytler 2011).

The act of planning a sketch, chart, graph, or other visual representation requires metacognitive thinking skills. Students must analyze the object or idea; make decisions about which parts of the object to include or emphasize; decide where to place elements in the drawing; and make judgments about size, shape, and color. These thinking skills can be further developed with careful guidance and practice.

A single image can convey as much meaning as several lines of text. Beginning readers and English-language learners may understand the meaning conveyed by a drawing or photograph more easily than text. Images help special-needs students better understand and express information. Because drawing is a skill accessible to all learners, special needs students would need only a few accommodations. Students with physical needs or students who are visually impaired would need to use adaptive technology.

How to Teach Scientific Drawing

Introductory Sketches

Scientific sketching may be introduced prior to formal instruction by setting up an area in the classroom with plain white paper, a variety of familiar objects, and "how to draw" books. During formal instruction, emphasize that scientific drawing is *not* the same as "artistic drawing." Because students have not learned to differentiate between the two, they may add fictional scenery and details around the subject. Communicate to them that a scientific drawing represents a model of a real object or idea. It may represent the entire object or idea (e.g., green plant structures) or part of the object or idea (e.g., fibrous roots). Scientific drawings should be simple, accurate, detailed, and clear. All elements in a drawing must be evidence-based and relate directly to the object or idea being drawn.

Start with simple observational drawing of a familiar object such as a button, shaped pasta, an apple, or toy car. Observational drawing requires close examination of the details of an object, such as the physical structures of a plant or animal or the parts of a simple electrical circuit. Students use visual spatial skills to organize space in the drawing, including placement of components and their size relative to the object.

Introductory drawing lessons generally take 30–40 minutes. The first drawings should be completed as a class. The teacher models a drawing of the object with student assistance as students observe, describe, and discuss the properties of the object. As students participate in the composition of the drawing, discuss:

- overall shape; use simple shapes to represent parts of the object (e.g., circle for a head, oval for a body, or triangle for a bird beak);
- visual "sections" of the object and examine each part (top/bottom, left/right side);
- use of color, shading, blending, and texture to show details; and
- vocabulary specific to the object when describing its parts.

Demonstrate the use of a light pencil drawing for the outline, which may be easily erased and revised. Show students how to "air draw." Trace the general outline of the object in the air just above the paper before placing the pencil on the page. Then draw the outline. After completing the outline, add color using crayons or colored pencils. They are easier to control than markers when shading, blending colors, or adding texture. Markers tend to bleed and do not blend well.

Figure 1 shows apple drawings done by second- and third-grade students. If using an apple for the introductory sketch, ask:

- What shape is the apple? Round? Oval? Both? What parts are round? Which are oval?
- Is the apple one color or more than one color? Is it red or yellow? What kind of red or yellow? Bright red? Darker red? Yellow? Yellow with orange? Yellow with green?
- Are there spots, bumps, or patches of color?
- Is there a stem? Leaf? What colors?

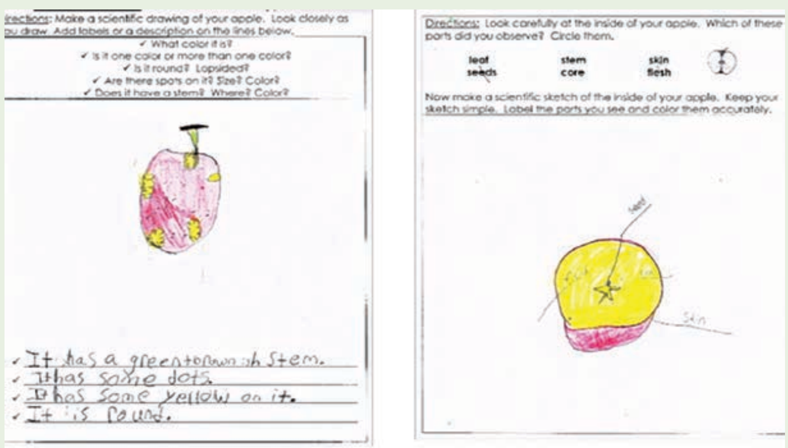
Students then draw their own apples. Have students work with partners or in small groups. Encourage discussion while drawing. Sharing observations and viewing others' sketches allows students to see multiple perspectives and refines their thinking. Use this modeled or shared drawing approach whenever introducing a new type of visual representation (diagrams, comparison, or procedural sketches).

Comparison of a similar object may be introduced at this point. If the initial object was an apple, introduce an orange. Again, use student assistance while modeling but spend less time with the new object. The goal is to gradually give the students increasing responsibility for analyzing the details of an object and recomposing them as accurately as possible. Observational drawings may continue throughout the year. For comparison purposes, students might draw the initial object again at the end of the year to see their growth.

As students grow proficient and efficient with sketching, include it as a regular part of lessons and activities. With practice, sketching then becomes a strategy that students can use to help them process and communicate understanding of an idea or concept.

FIGURE 1.

Apple drawings.



Pairing Topics With a Visual

Certain topics are represented better with specific visual formats. Table 1 shows a progression of suggested pairing for *Next Generation Science Standards* topics and types of visual representations.

Diagrams are the basis for many visual representations. A *diagram* shows the parts of an object (e.g., simple electrical circuit) or parts of a bigger idea (e.g., water cycle). Labels of the diagram should not crowd the drawing and should connect to the parts of the diagram with straight-line segments only. Avoid arrowheads, as diagonal lines can be difficult for younger children to draw.

Scientific drawings can also show sequence, process, or cause-and-effect relationships. Steps in a process may be represented by multiple panels, each showing subsequent steps. Use line segments, double lines, lines with arrows, or wavy lines to represent motion, cause and effect relationships, or before and after relationships.

Change over time, life cycles, or growth of an organism can be represented by repeating the main illustration over several panels while adding or changing elements. Figure 2, drawn by a second-grade student, shows the same playground tree drawn through all four seasons.

Charts and tables show observational data. Use single words and short phrases for headings and labels. Provide a basic chart shape for younger students to complete. The eventual goal is for students to organize and compose their own charts using spatial organization and use concise language to communicate data.

Revisions and Evaluation

As students gain confidence in their sketching abilities, introduce revision. Students draw an explanation for a question posed at the beginning of a unit of study or inquiry (e.g., *How does the water cycle work?* or *How does a tadpole change into an adult frog?*). As the inquiry progresses, students either make revisions to original drawings or create new drawings to better explain the question using supporting evidence. The teacher might use sticky notes with questions or comments about details or vocabulary to guide students through revision. A final drawing is made at the end of the unit to reflect a thorough explanation of the initial question (Krajcik and Merritt 2012).

Drawings and other visual representations help determine the accuracy of students' learning and avoid misconceptions. Collect drawings from several students (or the entire class). Look for consistency in representation of the idea. For example, if the topic is a simple electrical circuit, the battery, bulb, and wires should all be present and easily identifiable. If the topic is the flow of energy through a food chain, arrows should point toward the organism that is receiving energy.

FIGURE 2.

A playground tree throughout the seasons.

TABLE 1.

Topics and visual representations.

	Grades K–2 Suggested Standards and Type of Drawing	Grades 3–5 Suggested Standards and Type of Drawing
LS1: Structures and Processes	Grade K: Living/Non-living (comparison drawing) Grade 1: Life Cycles (growth/change over time panels)	Grade 3: Life Cycles (growth/change over time panels) Grade 4: Vertebrates/Invertebrates (comparison diagram) Physical Structures (diagram)
LS2: Ecosystems and Interactions	Grade 2: Food Chains (sequence)	Grade 5: Food Webs (diagram)
LS3: Heredity	Grade 1: Parent/Offspring (comparison diagram)	Grade 3: Inherited/Learned Traits (chart)
PS1: Matter and Interactions	Grade 2: Properties of Matter (observational drawings) Grade 2: Matter and Phase Changes (cause/effect)	Grade 5: Properties of Matter (observational drawings) Grade 5: Composition of Matter (diagram)
PS2: Forces and Interactions	Grade K: Forces and Collisions (cause/effect)	Grade 3: Forces and Collisions (cause/effect)
PS3: Energy	Grade K: Effects of Sunlight (cause/effect)	Grade 4: Energy Transfer (process/change over time)
PS4: Waves	Grade 1: Sound and Vibrations (diagram)	Grade 4: Sound Waves amplitude and wavelength (diagram)
ESS1: Earth's Place	Grade 1: Moon phases (sequence)	Grade 5: Sky Patterns (change over time)
ESS2: Earth's Systems	Grade K: Daily Weather (chart) Grade 2: Fast and Slow Changes (cause/effect)	Grade 3: Types of Severe Weather (comparison chart) Grade 3: Water Cycle (process/sequence) Grade 4: Weathering/Erosion (process/sequence) Grade 5: Earth Spheres (system diagram/comparison)
ESS3: Earth and Human Activity	Grade K: Basic Needs/Habitats (diagram)	Grade 5: Earth's Resources (comparison chart)
ETS1: Engineering Design	Grade K: PS – Sunlight/Warming Structure (diagram) Grade 1: PS – Communication Design (diagram) Grade 2: ESS – Preventing Erosion (multiple diagrams)	Grade 3: ESS – Hazardous Weather Design Solution (diagram) Grade 4: PS – Device to Convert Energy (multiple diagrams)

Evaluate students' sketches based on how clearly they represent the topic, not on artistic ability (see NSTA Connection for a rubric for K–2 students and one for students in grades 3–5). Both students and teachers may use the rubrics. Introduce rubrics and expectations as soon as possible. Although they tend to rate their own sketches highly at first, students will become more critical of their own work over time.

Figure 3 shows four sketches of a butterfly pupa. The first sketch (from left) is scored 4 out of 4—it is clear, clean, and appropriately labeled. The second is scored 3—all parts are labeled but not all are in the correct places. The third example from left is scored 2 due to smudges, erasures, and incorrect and missing labels. The fourth is scored 1 because it is not in color and has no labels.

Adding Language to Drawings

Including a written language component provides opportunities for students to connect science concepts with K–5 English Language Arts Standards for informational reading, writing, speaking and listening, and language. Ownership of written responses is important for all learners, but especially with the youngest, whose language is developing. Con-

FIGURE 4.

Students describe activities involving magnets and light refraction.

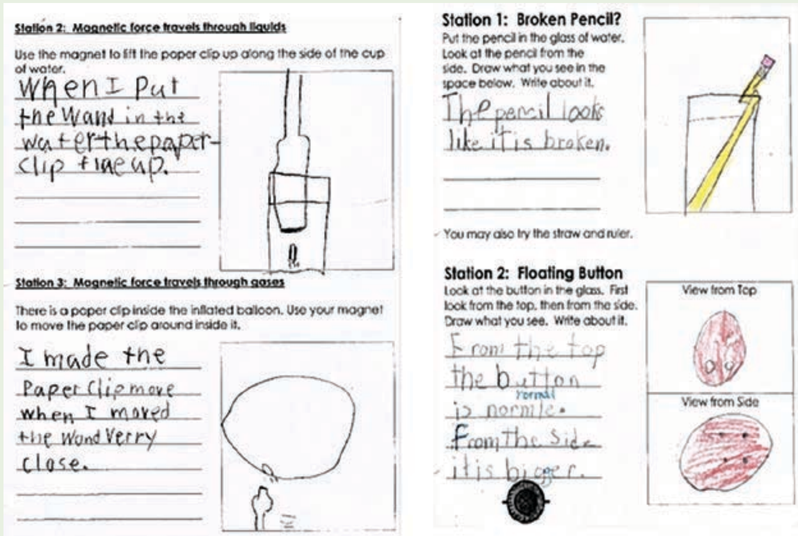


FIGURE 3.

Butterfly pupa sketches.

versations rich with topic-specific vocabulary and a word bank maintained throughout the unit may be used as a resource for written explanations or descriptions of drawings.

When students have a better understanding of written conventions, modeled sentences or sentence starters may be used. Responses should always be in complete sentences. Figure 4 shows single-sentence observations of activities involving magnets and light refraction, completed by a third- and second-grade student, respectively. Use language specific to each type of drawing. Observations or descriptions should include specific sensory vocabulary or comparisons. Figure 5 shows a second-grade description of daphnia. When writing cause-and-effect descriptions, have students use transition words: *because*, *due to*, and *if…then*. Steps in a process or procedural writing should include: *first*, *next*, *last*, *finally/last*, or *before/after*. Explanations may include: *one reason is*, *another reason is*, and *finally*.

Writing language-specific responses in science transfers to other areas of learning. *Narrative responses* may describe how an organism responds to stimuli or what happens when a pan of salt water evaporates. *Expository responses* describe a procedure using details from sketches, charts, or graphs to support the main idea. *Persuasive responses* use evidence from visual representations to support a claim, opinion, or conclusion about an idea or prediction about a future event.

Conclusion

Our brains are "wired" to process, understand, and store visual information. Students who are taught from a young age to comprehend and represent ideas through visual representations learn to use a variety of images to clarify and communicate ideas. They develop higher-level thinking skills that transfer to all areas of learning.

Scientific drawing is a three-dimensional skill. Creating models through simple drawings allows students to gradually progress to more complex expressions of ideas and processes, a skill which continues to develop throughout formal education, and even further into their daily lives. ■

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FIGURE 5.

Second grader describes daphnia.