Drawing to Learn in Science

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Should science learners be challenged to draw more? Certainly making visualizations is integral to scientific thinking. Scientists do not use words only but rely on diagrams, graphs, videos, photographs, and other images to make discoveries, explain findings, and excite public interest. From the notebooks of Faraday and Maxwell (1) to current professional practices of chemists (2), scientists imagine new relations, test ideas, and elaborate knowledge through visual representations (3–5).

However, in the science classroom, learners mainly focus on interpreting others’ visualizations; when drawing does occur, it is rare that learners are systematically encouraged to create their own visual forms to develop and show understanding (6). Drawing includes constructing a line graph from a table of values, sketching cells observed through a microscope, or inventing a way to show a scientific phenomenon (e.g., evaporation). Although interpretation of visualizations and other information is clearly critical to learning, becoming proficient in science also requires learners to develop many representational skills. We suggest five reasons why student drawing should be explicitly recognized alongside writing, reading, and talking as a key element in science education. We offer distinct rationales, although in practice any single drawing activity will likely rest upon multiple justifications. Both old and new technologies offer exciting opportunities. We conclude by highlighting important questions yet to be answered and key future research to extend teachers’ and learners’ use of drawing.

Drawing to Enhance Engagement

Many students disengage from school science because rote learning and traditional topics reduce them to passive roles (7, 8). Reformers advocate more interactive, inquiry-based learning (9). Surveys of teachers and students indicate that, when students drew to explore, coordinate, and justify understandings in science, they were more motivated to learn than from conventional teaching (10). The use of drawing caters to individual learner differences, as a drawing is shaped by the learner’s current or emerging ideas and knowledge of visual conventions.

Drawing as a Learning Strategy

Effective learning strategies help learners overcome limitations in presented material, organize their knowledge more effectively, and integrate new and existing understandings; ultimately, they can be transformative by generating new inferences (25, 26). Drawing can be one such effective strategy (6, 27).

Emerging research suggests drawing should be explicitly recognized as a key element in science education.
For example, asking learners to read a text and draw what they have understood requires them to make explicit this understanding in an inspeckable form ([28], see fig. S1 in supporting online material [SOM]). Unlike other constructive strategies, such as writing summaries or providing oral self-explanations, visual representations have distinct attributes that match the visual-spatial demands of much of science learning. Moreover, visual representation has been shown to encourage further constructive strategies (29). Inventing representations (including drawings) acts as preparation for future learning, because it can help students discern key features and challenges of new tasks (30).

**Drawing to Communicate**

Scientists draw to clarify ideas for colleagues, students, and the public (2, 5). In externalizing private knowledge more permanently, visual representation is one way to enable broader dissemination (4). Through drawing, students make their thinking explicit and specific, which leads to opportunities to exchange and clarify meanings between peers (31). Where learners generate and publicly share their representations, they learn by critiquing the clarity, coherence, and content of what they and their peers have drawn (32). These windows into student thinking can serve teachers in diagnostic, formative, and summative assessment (33, 34) (fig. S2).

**Current Programs and New Directions**

Various programs featuring drawing are now in progress (22, 23, 35). The Role of Representation in Learning Science (RiLS) project (36) is an exemplar showing how, through hands-on activities and a variety of multimodal representations in which drawing was featured, students were able to reason about particle distribution. For example, a student justified the selective nature of his animation of particles in evaporation thus: “I was just focusing on what they do, not representing other things like shape and size—they are very, very tiny.” RiLS teachers have noted that their students engaged much more in class, discussed at a higher level, and performed better in their workbooks (36). Analysis of test results showed stronger outcomes than in previous studies using comparable methods (37). Further research is now needed to establish explicit connections between drawing used in this way and learning.

Although there is growing evidence of the benefits of drawing to learn science, many unanswered questions remain. One active arena is exploration of how learning with new technologies can benefit from drawing. Learners can draw to help them understand what they are seeing in complex visualization environments (38). Drawing can be the way learners create models and interact with a system (39, 40), or their freehand sketches can be automatically marked to provide timely feedback (41). Technology is also broadening our concept of drawing as learners create animations (42) or use cameras and clay models on drawn backdrops to generate 1-s stop-frame movies of science processes (43).

We also need to research the fundamental mechanisms of drawing to learn. What skills do you first need to develop in order to best take advantage of learning by drawing? Perhaps some topics are sufficiently difficult to draw that attempting to do so is counterproductive. A further important research area concerns how teachers can best support their students to use drawing alongside writing and talking in the classroom. However, what is clear is the growing interest in drawing as it reflects new understandings of science as a multimodal discursive practice, as well as mounting evidence for its value in supporting quality learning.

**References and Notes**

44. The authors are affiliated with RiLS.

Supporting Online Material

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