

CHAPTER 4

Creating Visual Thinking Tools

Have you ever tried to secure a screw into a piece of wood using a hammer? Or sew a button on a shirt using a pin? Or peel an apple using scissors?

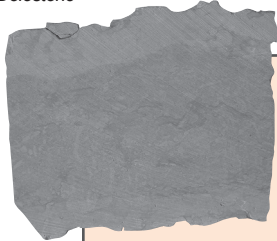
Although you may have attempted such tasks because you were desperate (or inventive), you knew that you were simply using the wrong tool for the task. On its own, each tool is a wonderful thing. The hammer, pin, and scissors are each constructed in a particular way to accomplish the task for which they were specifically designed. The hammer's design is best suited for driving the pointed end of nails into wood. The head on the pin helps it to secure two pieces of fabric together without sliding out. The sharp edges of the scissors are better for cutting than for peeling (although one of the authors of this book does admit to using them in that manner on more than one occasion).

In today's educational landscape, teachers are faced with the challenge of differentiating their instructional approaches to accommodate the diverse backgrounds and experiences of the students in their classrooms. They must select the most appropriate "tools" in order to meet those individual needs. Being able to connect what students need to know with ways for them to

use and recall this information has at times been problematic. Recent advances in brain research have shown that linking verbal or linguistic information with visual representations can improve a student's retention and increase their conceptual understanding. These visual representations can be called "visual thinking tools." How students select and create these tools and then apply them to their learning experiences can facilitate their acquisition of information. In this chapter we will look at a variety of visual thinking tools, describe how these visuals can support your science instruction, and discuss strategies for helping students recognize that advantage.

Please read the following passage. As you read, think about how you are mentally organizing the information in order to make sense of it. Then read the passage a second time and think about how you would share this information with someone who has not read the passage.

Sedimentary rock—
Dolostone



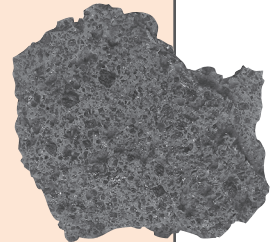
The Rock Cycle

There are three types of rocks: igneous, sedimentary, and metamorphic.

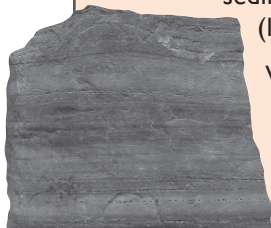
The elements that make up rocks are never created or destroyed, although they can be redistributed, transforming one rock type to another. The core, mantle, and crust of the Earth can be envisioned as a giant rock-recycling machine. The recycling machine works something like this. Molten (liquid) rock material solidifies either at or below the surface of the Earth to form igneous rocks. Uplifting occurs, forming mountains made of rock. The exposure of rocks to weathering and erosion at the Earth's surface breaks them down into smaller grains, producing soil. The grains (soil) are transported by wind, water, and gravity and eventually deposited as sediments. This process is referred to as erosion. The sediments are deposited in layers and become compacted and cemented (lithified), forming sedimentary rocks.

Variation in temperature, pressure, and/or the chemistry of the rock can cause chemical and/or physical changes in igneous and sedimentary rocks to form metamorphic rocks. When exposed to higher temperatures, metamorphic rocks (or any other rock type for that matter) may be partially melted, resulting in the creation once again of igneous rocks—starting the cycle all over again.*

Igneous rock—
Olivine basalt



Metamorphic
rock—*Quartzite*



*This passage can be found at www.rocksandminerals.com. It is also an NSTA scilink: www.rocksandminerals.com/rockcycle.htm, recommended for use in grades 5–8.

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What was this passage about? As you were reading, what were you thinking? Were you thinking, “Rocks! Ugh! I don’t understand this stuff.” Or were you (we hope!) trying to picture how the information on the three types of rocks fits together? When you read the phrase, “There are three types of rocks,” did you perhaps have a mental image of a three-column chart (Figure 4.1) for the three types of rocks?

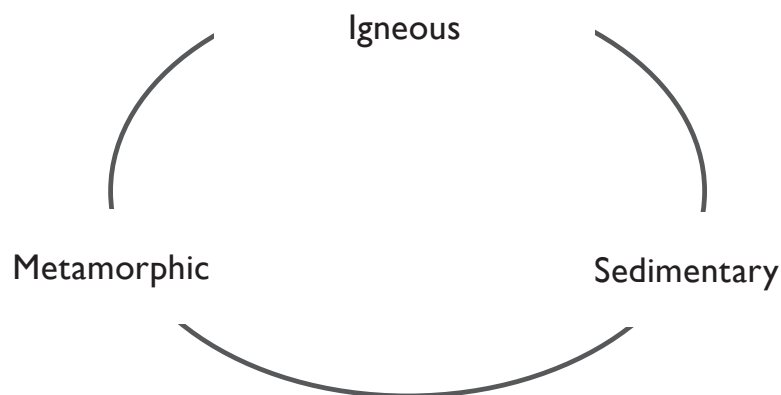
Figure 4.1 Column Heads for Chart of Three Kinds of Rocks

Igneous	Sedimentary	Metamorphic
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As you read further,

- did that mental image change because of the addition of more information, such as the phrase “rock-recycling machine?”
- did the word *recycle* indicate to you an ongoing process? If so, how did that change your initial mental image of a chart with three columns (if such an image was what you started with)?
- did you, in your mind, “see” the three types of rocks in a different arrangement, such as the flow diagram in Figure 4.2?
- did your mental image change even further as more information was added?
- how did you begin to fill in the new details about the rock types in your mind?
- how does the image in Figure 4.3 (p. 42) help organize or clarify the particular details found in the passage?
- did you consider adding arrow heads to the lines connecting the different types of rocks in order to signify motion or process?

Figure 4.2 Flow Diagram for Three Kinds of Rocks



As you reread the passage, did you add even more details and words to your mental image to make the meaning even clearer or more explicit? Did you pause to think about vocabulary words you were unfamiliar with in order to remember them? Does the placement of the words on the arrows in Figure 4.3 help clarify what action or process is occurring between each type of rock? Look at the image in Figure 4.4 for an even more elaborate diagram on the three kinds of rocks.

Figure 4.3 Flow Diagram for Simple Relationship Among Three Kinds of Rocks

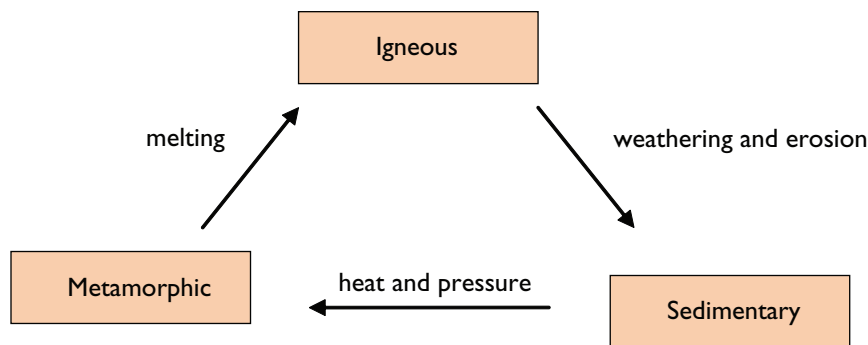
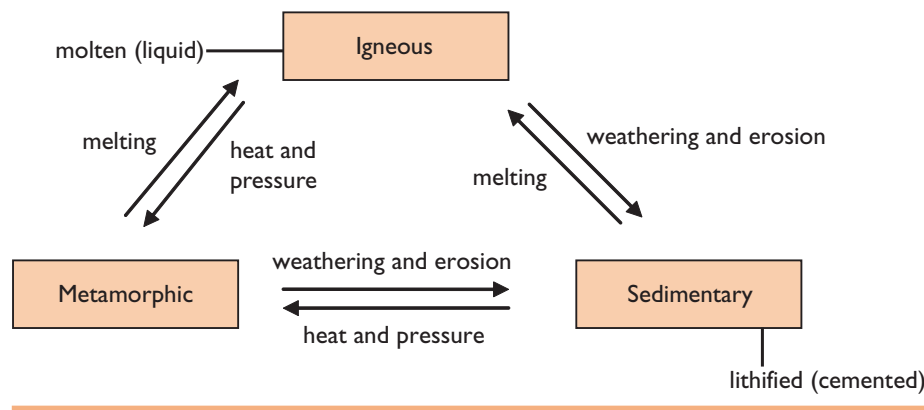


Figure 4.4 Flow Diagram for Complex Relationships Among Three Kinds of Rocks



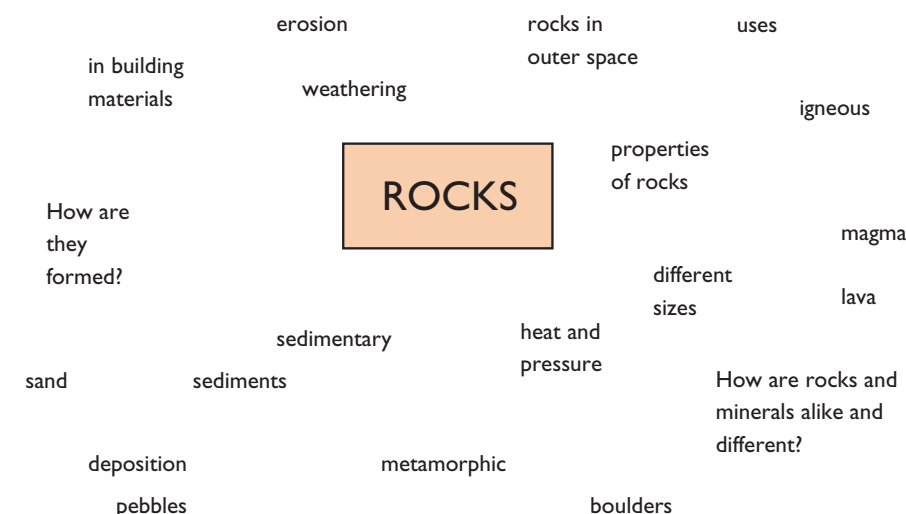
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Types of Visual Thinking Tools

By developing visual thinking tools, such as charts and diagrams, students acquire formats for recalling, retelling, or making meaning from written text. As adults, we tend to create such mental pictures intuitively as we read information. Creating these mental pictures helps us organize facts and details as we seek to find an organization or pattern to the words and their meanings. Many students who struggle in school do so because they fail to detect the patterns that link their everyday learning experiences together. Caine and Caine (1994) have described the brain as a “pattern detector.” People who fail to recognize patterns are bound to struggle to organize the massive amounts of sensory input bombarding their brains each day—and so they are often unable to link the input to something meaningful or significant.

Visual thinking tools help us create the patterns that our brains need to facilitate our learning and thinking. The three main types of visual thinking tools are brainstorm webs, graphic organizers, and concept maps. Each of these tools helps transform words, thoughts, and ideas into visual representations for organizing, translating, and transmitting our thinking. These tools can vary from simple line drawings sketched on scrap paper to highly organized and structured diagrams.

Figure 4.5 Brainstorm Web



Brainstorm Webs

Brainstorm webs are ways to generate and categorize a multitude of ideas and thoughts. They can be used to list attributes, definitions, or facts that are usually related to a single concept or theme. As their name implies, they can be most useful when generating fresh ideas quickly and are especially useful in the creative/development phase of a project where many ideas can be generated without evaluation or critique. Although they do present a model of organizing the information, their physical appearance tends to be unstructured and randomly constructed. This “chaotic” array can be confusing to students at first. The example in Figure 4.5 (p. 43) depicts the random nature of the brainstorm web.

Simple Graphic Organizers

Graphic organizers are visual tools that allow the viewer to detect patterns in information and organize them to facilitate the viewer’s understanding. (In Chapter 5 we look at the three-dimensional graphic organizer, a more complex organizer than discussed here.) Graphic organizers are a common tool among teachers and are used across disciplines because of the graphic organizers’ simplicity and commonality in function. Figure 4.6 shows a graphic organizer used to present the main idea (sedimentary rock) and its corresponding supporting details.

Figure 4.6 Main Idea and Supporting Details Graphic Organizer

Main Idea	Details
Sedimentary rock forms in layers from deposited materials	Results from erosion of other types of rocks
	Examples include sandstone, limestone, and conglomerate
	Uses include construction, energy, art

It should be noted that although these visual tools can help students see the relationships among parts of a whole or make comparisons between groups of objects, they tend to be limited to specific content tasks associated with skills—for example, comparing and

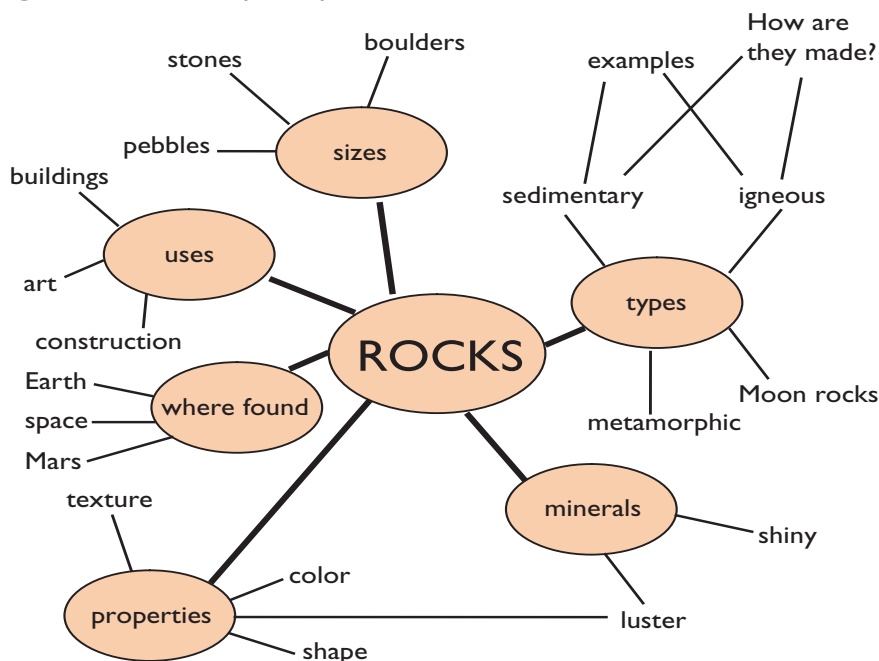
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contrasting or identifying main idea and details. Sometimes, these visual tools are precomposed frames in which the student just fills in missing information; using visual tools in this way reduces students' interest and motivation. The frames may provide the structure lacking in brainstorming webs but at the same time they limit the creativity of the user. For these reasons, they should be used sparingly.

Concept Maps

Concept maps communicate complex interrelated ideas and relationships built around a single concept, but they can be overwhelming to students when it comes to describing or making use of the information they contain. A concept map is a special type of synthetic web diagram in which the cells (or nodes) identify main ideas flowing from a central theme or concept; lines are used to link supporting information together. These links can be labeled and include arrowheads that can provide directionality to the viewer, but the lines sometimes add to the complexity of the visual. In Figure 4.7, the concept map provides better organizations than the brainstorm web but can appear random and confusing to the casual observer.

Figure 4.7 Concept Map



Visual Thinking Tools and the Brain

As researchers continue to learn about the brain and how it works, our use and creation of visuals in the classroom becomes ever more important. Recent research (see, for example, pp. 5–7) indicates that the brain, mostly through its visual receptors, is constantly processing incoming bits of information—trying to make sense of it, to assess its importance, and to assign some relevance to it. This processing involves the complex interactions of emotion, attention, and relevance. The role of emotion in student learning can best be summed up by a quote from the PBS series *The Secret Life of the Brain*: “The brain is not a thinking machine, but a feeling machine that thinks” (Hyerle 2004, p. 26). This quotation underscores how emotions can influence the processing of information. Information processing is obstructed by stressful conditions as the body’s natural response mechanisms work on the fight-or-flight reaction: Do I prepare for battle or do I prepare to flee? Neurotransmitters in the brain activate the limbic system, which is responsible for action, and not the cortex region, which is responsible for planning, rational thought, and decision making. The fight-or-flight response is useful for survival, but not for learning.

As information pours in through our senses, the brain works to make meaning of it. The brain tries to organize, evaluate, and analyze the importance of the information. Once the brain determines that the input is necessary and has some emotional importance attached to it, the conscious process of information storage begins. The short-term (working) memory “chunks” these incoming bits of information together to keep the working memory from becoming overloaded by the constant stream of data. The construction of visual tools helps the brain actively string this incoming information together by forming patterns. These patterns help mark neural pathways that are needed for long-term retention. Gerlic and Jausovec (1999), who investigated the cognitive processes in learning information, observed that explicit engagement of students in the creation of nonlinguistic representations stimulated and increased activity in their brains. Thus we can conclude that students who create their own visual thinking tools are building the mental capabilities of pattern recognition essential for helping them make meaning of—and retain—the information they are learning.

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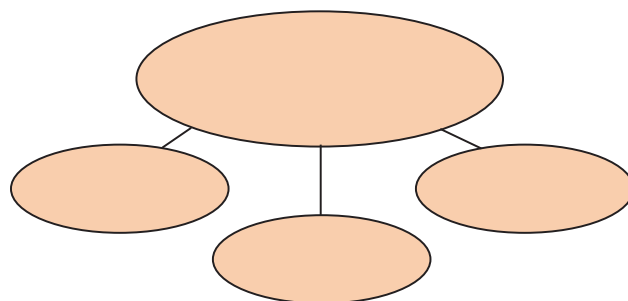
Applications for Teachers and Students

Look back at the introductory passages in “The Rock Cycle” (p. 40). Which of the graphic organizers below (Figure 4.8 or Figure 4.9) would be best for developing the skill of identifying the main idea and supporting details based on the information in the passage? Complete the graphic organizer that you think is best for organizing the information. (You will probably find that the organizer you choose does not provide enough space to completely “recompose” the information you read. Just go as far as you can with the given boxes or ovals.)

Figure 4.8 Graphic Organizer–Chart

Main Idea	Details

Figure 4.9 Graphic Organizer–Bubble



Students can develop their reading skills by using the structures in these graphic organizers to indicate the relationship between the main idea and the details in a paragraph or longer piece of writing. Younger students in particular will need explicit instruction to understand the purpose of the organizers.

Once students understand how to use a graphic organizer to organize information, teachers should encourage them to create whichever structure—that is, the chart or the bubble—works best for them. Graphic organizers help students by providing structure for organizing new information; at the same time, however, using premade charts can restrict students' creativity and active engagement in a task. Simply putting information into the organizer does not make students active participants in the meaning-making phase of learning nor does it encourage them to feel that the task is important or relevant. The emphasis should be on *creating* the chart or bubble, not on its completion. A teacher who is in the habit of using premade frames for students to complete reduces the emotional connections and the sense of relevance necessary for a student's brain to move knowledge into long-term memory, where learning occurs. Marcia Tate put it best in the title of her book: *Worksheets Don't Grow Dendrites* (Tate 2010).

Now create your own graphic organizer. On a blank sheet of paper, visually organize the information from the passage on the rock cycle (p. 40). Afterward, think about how this visual tool helped you describe the processes involved in the rock cycle. Think about the words you used to describe your thinking as you were creating this visual map. How did these words reflect what you know?

Summary

Brainstorm webs, graphic organizers, and concept maps have been important tools for classroom teachers for the past 30 years. Teachers find that these visual tools promote classroom discussions and conversations in which students use words that reveal their thinking processes—always helpful information for teachers, particularly for formative assessment. From the students' point of view, the tools provide a frame of reference for them

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to reflect on what they already know. This metacognitive step of reflection allows the student to regulate the processing of the vast number of bits of information being taken in and to make the necessary connections among facts, feelings, and the purposes for knowing. Such reflection helps students become positive and confident about their knowledge and learning.