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Using Graphic Organizers to Improve Teaching and Learning

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Students often have difficulty learning from texts and lectures because information is commonly organized in blocks or lines that obscure important relationships among ideas. This article introduces graphic ways to display information so that relationships are apparent and easily learned. For example, notice how information about the solar system's first two planets is displayed in block form in the paragraphs in Figure 1 and how information about the solar system's next two planets is displayed in linear form in the outline in Figure 2. In these examples, studying blocks or lines of planet information makes it difficult to recognize relationships among planets.

Figure 1 • Planet Information Displayed in Block-like, Paragraph Form.

Planets

Mercury is 36 million miles from the sun. Its revolution time around the sun is 3 months. Its orbit speed is 30 miles per second. Its diameter is 3,000 miles. Mercury has a rocky surface. It has 0 moons. Its rotation time is 59 days.

Venus is 67 million miles from the sun. Its revolution time around the sun is 8 months. Its orbit speed is 22 miles per second. Its diameter is 8,000 miles. Venus has a rocky surface. It has 0 moons. Its rotation time is 243 days.

Figure 2 • Planet Information Displayed in Linear, Outline Form.

Planets

Earth

Miles from Sun:	93 million
Revolution Time:	1 year
Orbit Speed:	19 miles/second
Diameter:	8000 miles
Surface:	Rocky
Moons:	1
Rotation Time:	24 hours

Mars

Miles from Sun:	142 million
Revolution Time:	2 years
Orbit Speed:	15 miles/second
Diameter:	4000 miles
Surface:	Rocky
Moons:	2
Rotation Time:	25 hours

Introducing Graphic Organizers

It is also possible to display the planet information in a more graphic form. Graphic organizers display information more visually than conventional text and outlines. They compress seemingly disjointed information and convert it into a spatial structure that is easy to read and understand. A good graphic organizer is effective because it reveals the intended message — the important relationships — with only a glance (see, for example, Alvermann, 1986; Berkowitz, 1986; Guri-Rosenblit, 1989; Jonassen, Beissner, & Yacci, 1993; Robinson & Kiewra, 1995).

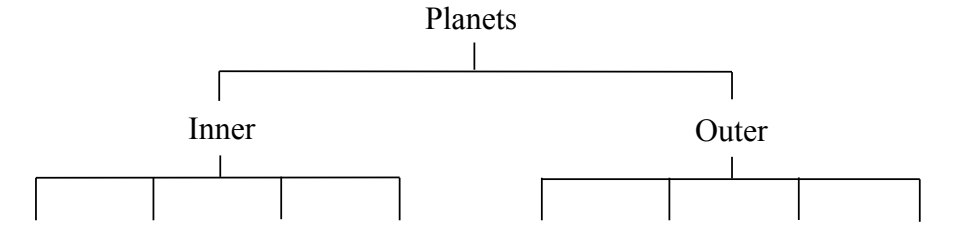
A graphic organizer of the solar system information appears in Figure 3 (see next page). This graphic organizer is superior to its block and linear form counterparts because it prompts planetary comparisons and reveals integral relationships obscured by the competing forms. With only a glance at the graphic organizer, several planetary relationships are quickly revealed: As planets are positioned farther from the sun, revolution time increases and orbit speed decreases. And, inner planets have smaller diameters, rockier surfaces, fewer moons, and longer rotation times than outer planets. Ascertaining these relationships from a text or outline is far more difficult and time consuming.

The remainder of this article a) presents research supporting graphic organizers, b) explains why they work, and c) introduces a graphic organizer system that is easy to use.

Research Supporting Graphic Organizers

According to Robinson (1998), there are four types of graphic organizers (concept maps, flowcharts, tree diagrams, and

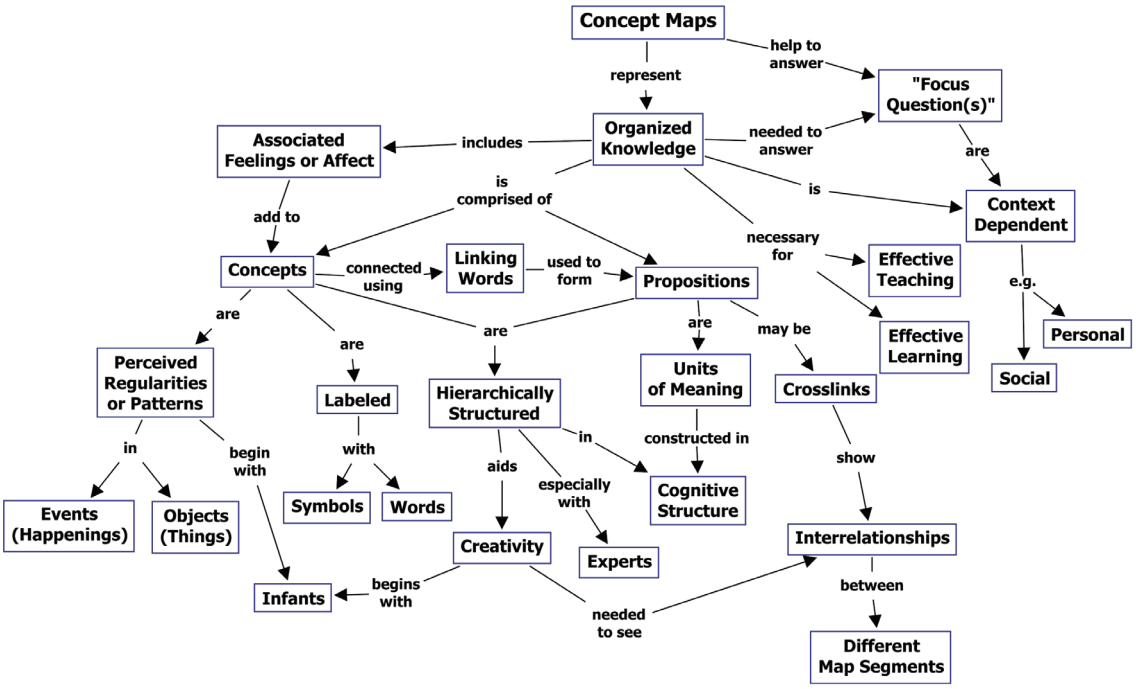
Figure 3 • Planet Information Displayed in Graphic, Matrix Form.



	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Miles from the Sun:	36 million	67 million	93 million	142 million	483 million	886 million	2 billion	3 billion
Revolution Time Around the Sun:	3 months	8 months	1 year	2 years	12 years	30 years	84 years	165 years
Orbit Speed (Miles/Second):	30	22	19	15	8	6	4	3
Diameter (Miles):	3,000	8,000	8,000	4,000	89,000	75,000	32,000	31,000
Surface:	Rocky	Rocky	Rocky	Rocky	Slushy	Slushy	Slushy	Slushy
Moons:	0	0	1	2	17	22	15	6
Rotation Time:	59 days	243 days	24 hours	25 hours	10 hours	11 hours	16 hours	19 hours

matrices), and research has generally confirmed that studying these organizers boosts learning more than studying text. Concept maps (such as that shown in Figure 4) display a concept's components (called nodes), using boxes or circles, and the links joining those components, using lines and labels. Flowcharts use arrows to display the steps in a process, such as how to dress a wound. Tree diagrams resemble an evergreen tree. They display a single concept, like president, at the top and progressively more subordinate concepts, like vice president and senator, in its widening branches below. And, matrices, like that in Figure 3, are two-dimensional classification tables that can be studied vertically by topic (in this case, planets) or horizontally by category (in this case, miles from sun, revolution time, etc.). Most of the research on graphic organizers has centered on the matrix organizer and has confirmed that studying a matrix is superior to studying a text or outline.

Figure 4 • Concept Map About Concept Maps (Novak & Cañas, 2008).



In one representative study (Kauffman & Kiewra, 2010), college students studied information about six types of wildcats that was displayed in text, outline, or matrix form. The three displays contained identical information and 78 distinct facts but expressed the information in progressively fewer words: text, 2000; outline, 367; and matrix, 244. After displays were studied for 15 minutes, three tests were administered. The fact test assessed knowledge of single facts; two relationship tests assessed knowledge of relationships among facts. One of the relationship tests measured local relationships across a single category (such as how wildcats compared in terms of weight); the other measured global relationships across multiple categories (such as how the wildcats' weight was related to their range). Results indicated that the matrix group learned more facts as well as local and global relationships than the outline or text groups. Other research studies confirm that studying matrix displays reduces learning time (Robinson & Skinner, 1996) and yields higher achievement (Kiewra, Dubois, Christian, & McShane, 1988; Kiewra et al., 1991; Kiewra, Kauffman, Robinson, Dubois, & Staley, 1999) than studying text or linear displays.

Why Graphic Organizers Work

Why is a matrix, for example, more effective than a text or outline? Until recently, the answer was that a matrix is more computationally efficient. According to Larkin and Simon (1987), computational efficiency refers to how quickly a display allows a reader to locate important information and to accurately infer relationships. This definition, though, lacks specificity. It does not specify which factors make a display more computationally efficient. More recently, Kauffman and Kiewra (2010) explored and revealed three computational efficiency factors: signaling, extraction, and localization. *Signaling* refers to cues that boost information access. An outline's topic and subtopic organization and a matrix's column and row structure each make it easy to access a fact efficiently (e.g., Mercury's orbit speed). A text, however, does not necessarily provide such signals. *Extraction* is the process of removing critical information from less important information and setting it apart. Only outline and matrix displays extract critical text information and set it apart. *Localization* is the process of positioning related information in close proximity. All three displays are high in *topical localization* — they place information about the same topic together. For instance, information about the topic Saturn appears in the same text paragraph, the same outline section, and the same matrix column. The displays differ, however, in terms of *categorical localization*. For instance, information about the category orbit speed would appear in eight different text paragraphs, eight different outline sections, but in just one matrix row. With all the information localized in a single matrix row, relationships are easily drawn. The matrix is especially effective for comparing information across multiple categories. Returning to Figure 3, a glance across the miles from sun category quickly reveals that the planets are progressively farther from the sun. And, glancing across both that category and the orbit speed category quickly reveals that as planets are positioned farther from the sun, their orbit speed decreases. Drawing this relationship from a text or outline would require learners to select and compare facts located in 16 different locations — a most difficult task. Figure 5 is a matrix showcasing and summarizing these computational efficiency findings. As can be seen, outlines are more computationally efficient than texts because of signaling and extraction, and matrices are more computationally efficient than outlines because of categorical localization.

Figure 5 • Computational Efficiency Ratings for Text, Outline, and Matrix Displays.

Computational Efficiency	Type of Display		
	Text	Outline	Matrix
Signaling	No	Yes	Yes
Extraction	No	Yes	Yes
Localization	Topical	Topical	Topical and Categorical
Overall	Low	Medium	High

To summarize, a matrix is superior to an outline or text for displaying planetary information, and its advantage is one of computational efficiency. The matrix's graphic form signals the information's structure, extracts important ideas, and localizes related information both topically and categorically. The next section introduces a simple system for displaying any and all information graphically. This Graphic Organization System, developed by Kiewra and DuBois (Kiewra, 1994; Kiewra & DuBois, 1998), includes the matrix along with three other displays: hierarchy, sequence, and illustration.

The Graphic Organization System

The Graphic Organization System was developed to simplify and systemize the confusing array of graphic organizer methods found in the seminal research literature (see Robinson, 1998) and still popular on Internet websites today. In fact, one Internet source (Education Oasis, 2011) advocated choosing from 58 different forms of graphic organizers.

Figure 6 (see next page) is a matrix showing the four types of graphic organizers in the Graphic Organization System: *hierarchy, sequence, matrix,* and *illustration*. These four organizers mesh well with those advocated by Robinson (1998). The hierarchy is akin to the tree diagram. The sequence is similar to the flowchart. And, both classifications include the matrix. The Graphic Organization System omitted concept mapping because of its loose structure and spotty track record of success (e.g., Katayama, A.D., Robinson, D. H., Kiewra, K. A., DuBois, N. F., & Jonassen, D., 2011; Karpicke & Blunt, 2011) and replaced it with illustrations, which are integral for displaying an item's physical structure (Mayer & Gallini, 1990).

These four organizers differ with respect to organization and relationships revealed. As seen in the left-most column of Figure 6, a *hierarchy* organizes information in a top-to-bottom fashion and reveals hierarchical, superordinate-subordinate relationships. In the example, the moth and butterfly are subordinate to the superordinate insects. The next column to the right pertains to the sequence organizer. A *sequence* organizes information in a left-to-right fashion and reveals order relationships. In the example, the order of developmental stages for moths and butterflies is shown. The next column to the right pertains to the matrix organizer. As addressed earlier, a *matrix* organizes information in columns (by topics) and rows (by categories) and reveals comparative relationships. In the matrix example, the wings and color for moths and butterflies are easily compared. The right-most column of Figure 6 pertains to *illustrations*. These are organized according to location of parts and reveal positional relationships. In the example, the relative locations of the insects' body parts are shown. The following subsections address each graphic organizer type in more detail.

Hierarchy

Figure 7 shows an example of a hierarchy about clouds. The hierarchy reveals the superordinate cloud types — cirrus, cumulus, and stratus — and their (subordinate) subtypes. Think about any subject, and hierarchical relationships abound. In science, a hierarchy might display the various systems on one level (e.g., digestive, nervous, endocrine…) and each system's main parts (e.g., mouth, esophagus, stomach… for digestive) on the next level. In English, a hierarchy might display certain types of literature on one level (e.g., prose, poetry, and drama) and their subtypes (e.g., short story, novelette, and novel for prose) on the next level.

Figure 6 • The Graphic Representation System.

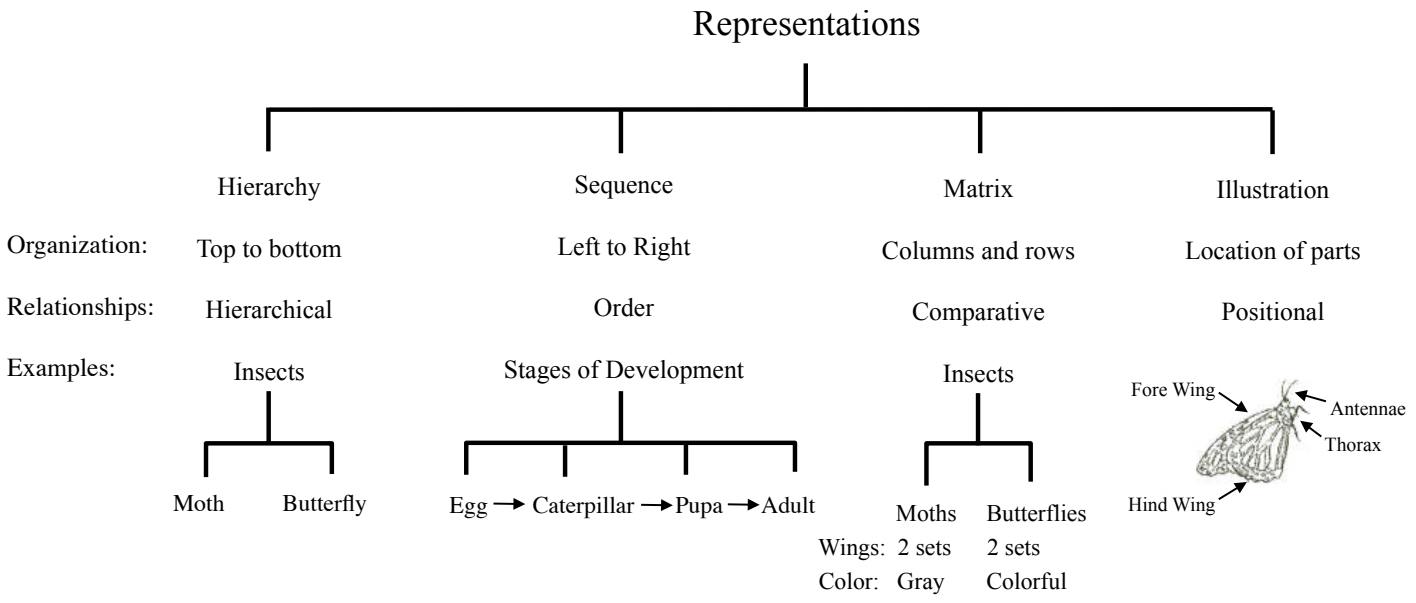
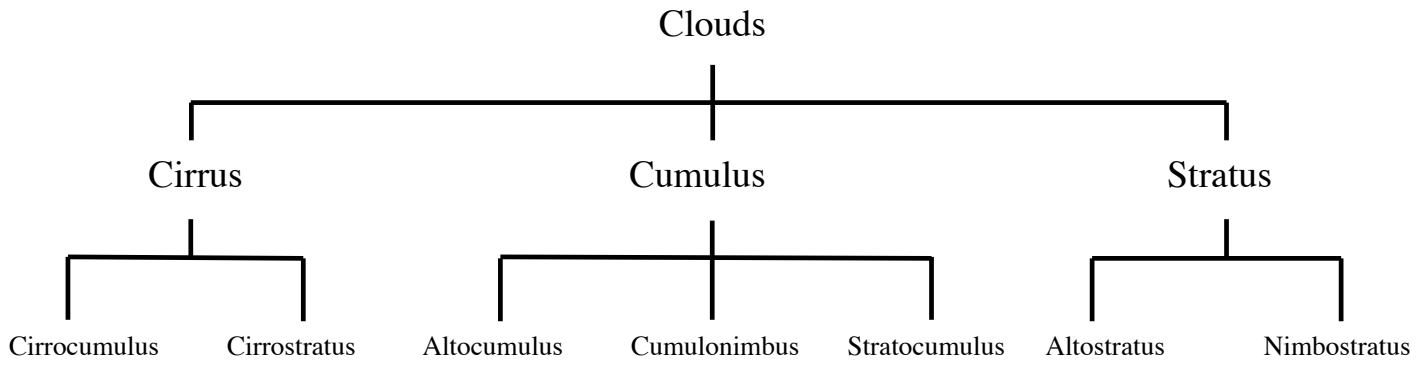


Figure 7 • Cloud Hierarchy.



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Three guidelines for creating effective hierarchies include:

1. Construct hierarchies from top to bottom so that superordinate-subordinate relationships are clear. Later, you will see that this structure is essential for extending hierarchies into matrices.
2. Include all levels. A hierarchy is more accurate and informative when it displays all the important levels of information. If Figure 7 had only its bottom level, then it would appear that there were seven distinct types of clouds instead of three main types, each with subtypes. This guideline is more than cosmetic. The multilevel hierarchy suggests that certain cloud subtypes (e.g., cirrocumulus and cirrostratus) share common features because they stem from the same cloud type (i.e., cirrus).
3. Certain *alert words* signal that information is organized hierarchically. Be alert for words that signal hierarchical relationships such as: *parts, types, components, characteristics, groups,* and *levels*.

Sequence

Figure 8 shows an example of a sequence for the mathematical process of adding mixed fractions. This sequence is multi-level and shows that there are four phases and nine total steps involved in adding mixed fractions.

Sequential information is common in any subject area. Scientific laboratory procedures are sequential, as are periods of history and events in a story.

Three guidelines for creating effective sequences include:

1. Create sequences from left to right and place arrows between steps. Again, you will soon see that this structure is essential for extending sequences into matrices.
2. Include all levels. Just as some hierarchies have multiple levels, some sequences do, too. The multi-level sequence in Figure 8 is preferred to a single-level sequence displaying just the nine steps because the former groups the nine steps in meaningful ways (e.g., there are three steps involved in changing mixed fractions to improper ones) and simplifies the process (by showing that the nine steps can be grouped into four simple phases).
3. Certain *alert words* signal sequential relationships, such as: *steps, phases, stages, process, develop, first, later,* and *next.*

Matrix

Figures 9 and 10 (see next page) show matrix examples. Figure 9 is an extension of the cloud hierarchy previously shown in Figure 7, and Figure 10 is an extension of the adding mixed fractions sequence previously shown in Figure 8. In both cases, the matrix is formed by adding categories down the left side (e.g., appearance and example) and by adding details within the matrix cells.

The opportunity to use matrices to compare two or more topics abounds across subject areas. Already you have seen matrices used to compare planets, information displays, graphic organizers, clouds, and steps for adding mixed fractions. They might also be used for comparing historical periods, fictional characters, developmental theories, types of symbiosis, real and rational numbers, and types of soccer alignments.

Three guidelines for creating effective matrices include:

1. Create matrices by extending hierarchies and sequences. All hierarchies and sequences can (and are likely to) be extended into matrices. This is done by adding categories down the organizer's left side and adding details within the matrix cells at the intersections of topics (e.g., cloud names) and categories (e.g., height, appearance, and associated weather). There can be multiple categories in a

Figure 8 • Adding Mixed Fractions Sequence.

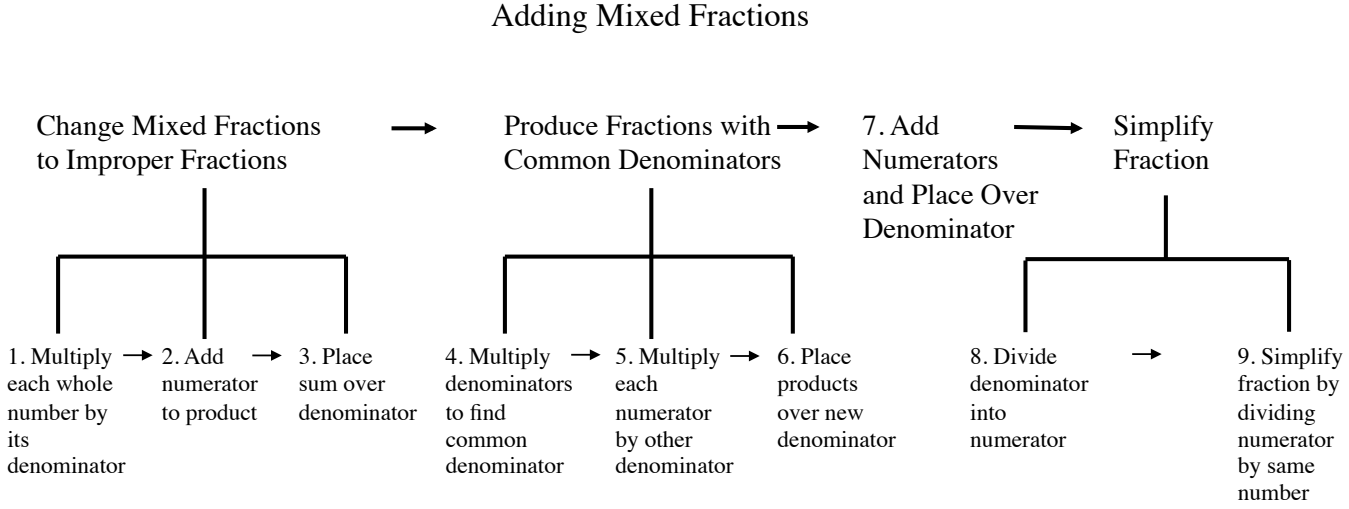

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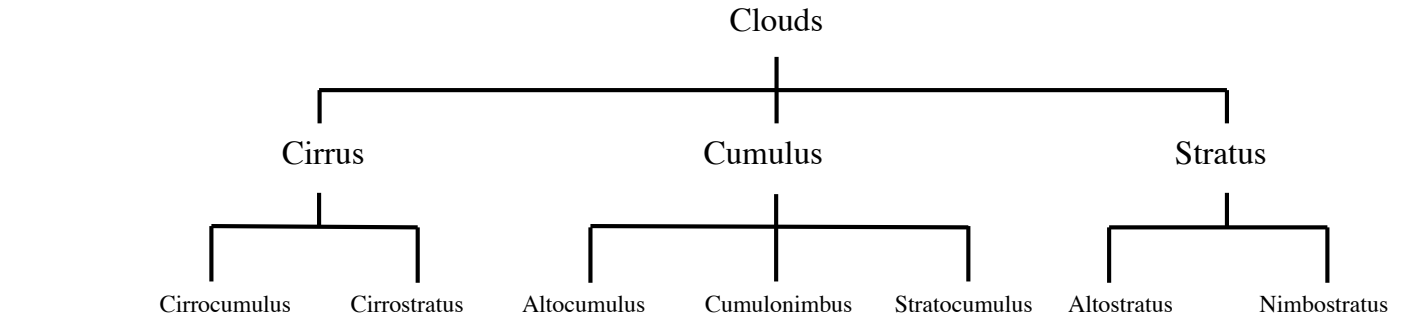
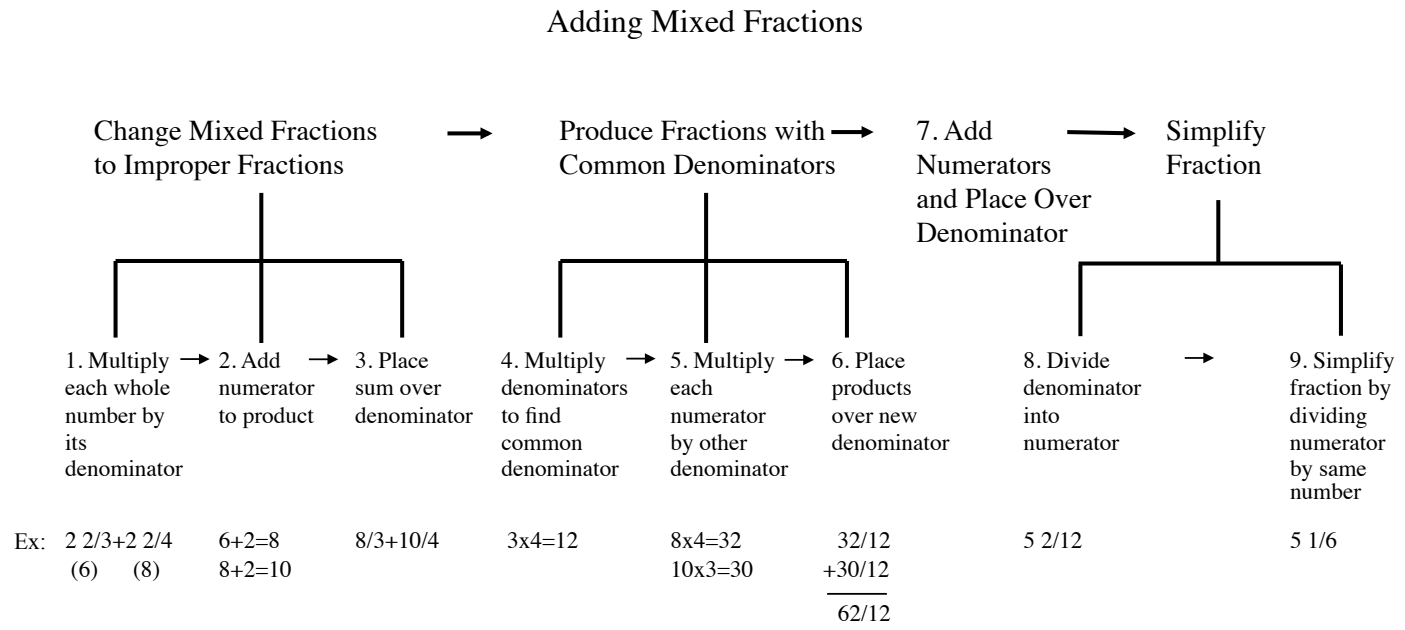
Figure 9 • Cloud Hierarchy Extended into a Matrix.



	Cirrocumulus	Cirrostratus	Altocumulus	Cumulonimbus	Stratocumulus	Altostratus	Nimbostratus
Appearance:	Small puffs, round, white	Thin, white, sheet like	Grayish-white w/ one part darker	Large white w/ flat top	Low, lumpy, gray	Covers sky, gray or blue-gray	Covers sky, dark gray w/ ragged base
Elevation:	High	High	Middle	Low-High	Low	Middle	Low
Weather Patterns:	Fair & cold	Precede rain or snow	Precede thunderstorms	Heavy rain, snow, hail, lightning, and tornadoes	Light precipitation	Form ahead of storms w/ continuous precipitation	Continuous precipitation

Figure 10 • Adding Mixed Fraction Sequence Extended into a Matrix.



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matrix, as seen in Figure 9, or just one, as seen in Figure 10.

2. Order topics and categories optimally. Not all matrices are created equal. Two matrices containing identical information but differing in the ordering of topics, categories, or both can produce differences in the learning of facts and relationships (Kauffman & Kiewra, 2010; Kiewra et al., 1999). For example, examine the two simple matrices shown in Figure 11 (taken from Kauffman & Kiewra, 2010; see next page). The organization of Matrix 1 makes the inherent relationships apparent with just a glance: Wildcats with louder calls weigh more and have longer life spans than wildcats with softer calls. And, jungle cats are solitary, whereas plains cats live in groups. Meanwhile, these relationships are obscured in Matrix 2. Related information is not well localized within topics or categories.

Figure 11 • Two Matrices. (Matrix 1 is better because its superior ordering of topics and categories makes relationships apparent.)

Wildcats Matrix 1

	Tiger	Lion	Cheetah	Bobcat
Call:	Roar	Roar	Purr	Purr
Weight:	450	400	125	30
Life Span:	25	25	8	6
Habitat:	Jungle	Plains	Plains	Jungle
Social Behavior:	Solitary	Groups	Groups	Solitary

Wildcats Matrix 2

	Cheetah	Tiger	Bobcat	Lion
Habitat:	Plains	Jungle	Jungle	Plains
Weight:	125	450	30	400
Social Behavior:	Groups	Solitary	Solitary	Groups
Call:	Purr	Roar	Purr	Roar
Life Span:	8	25	6	25

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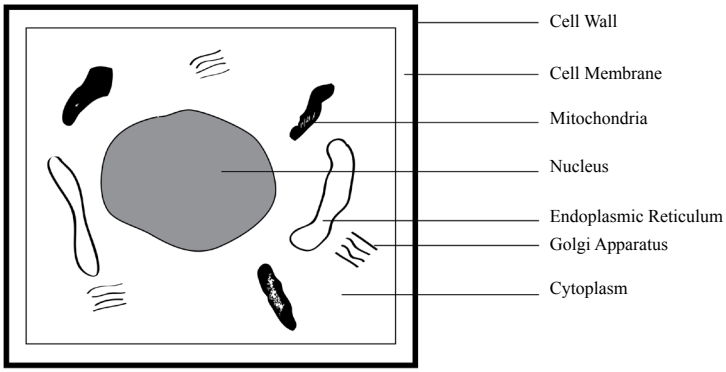
3. Certain *alert words* signal comparative relationships, such as: *compare, contrast, whereas, similar, different,* and *alternative.* Be alert, too, for adjectives that suggest potential comparative relationships. When reading about *two-stage* mechanisms, you might assume that there are also single-stage mechanisms and compare the two. *Early* settlers might be compared with late settlers, *radical* viewpoints with rational ones, and *cryo*surgery with other surgical methods.

Illustration

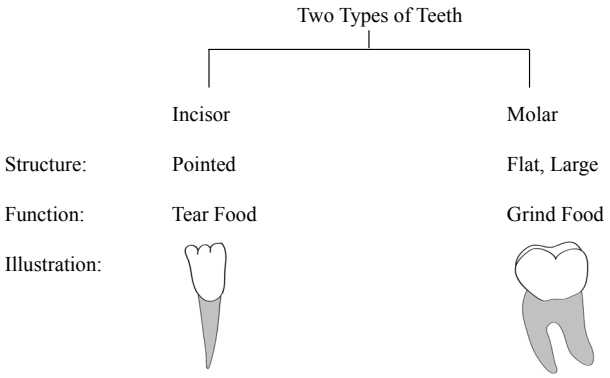
An illustration pictorially represents what something looks like. It often shows parts of something and the relative position of those parts. Figure 12 shows an illustration of cell parts. Illustrations can also be embedded in other organizers as shown in Figure 13 — a matrix that compares two types of teeth and includes illustrations of them.

Figure 12 • Cell Parts Illustration.



Illustrations are useful across subject areas. Consider how helpful it would be to see smooth versus seriated muscle, an isthmus versus a peninsula, a medieval sword, complementary angles, an offside position in soccer, and a knight fork in chess.

Figure 13 • Matrix with Illustration Embedded.



Three guidelines for creating effective illustrations include:

1. Keep it simple. Illustrations are replicas, not exact copies. Include only the details needed, and don't worry about how realistic things look. The illustrations in Figures 12 and 13 are sufficient for their purpose of showing major parts and general appearance.
2. Use labels and captions to explain illustrations. Place labels and captions near their referents to aid localization.
3. Certain *alert words* signal that illustrations are useful. Be alert for *names of things* — dorsal fin, gills, and scales; *appearances of things* — blue, pointed, and smooth; and *locations of things* — above, inside, and center.

Research Supporting the Graphic Organization System

The Graphic Organization System just described has proven to be effective when compared to concept mapping (Katayama et al., 2001). Students either studied a series of graphic organizers (hierarchies, sequences, and matrices) or a series of concept maps along with a text about abnormal behavior. In one experiment, the graphic organizer group outscored the concept map group by 20 percentage points on a test measuring hierarchical relationships and by 12 percentage points overall across a variety of tests. Moreover, 100 percent of students studying graphic organizers reported that their materials were "easy" or "very easy" to understand. Just 38 percent of concept map users made this claim. In fact, 46 percent reported that their concept maps were "very difficult" to understand. In summary, the Graphic Organization System is simple, systematic, and effective. It is simple because it contains just four organizer types, each displaying a unique type of relationship. It is systematic because organizers can be combined to display more complex relationships. It is effective because research confirms the benefit of matrices and the system as a whole.

Conclusion

Conventional displays such as text and outlines often obscure relationships among ideas. Graphic organizers — visual displays that compress seemingly disjointed information and convert it into an easily read structure — make it easy to draw relationships among ideas. Using the Graphic Organization System, recommended here, is simple and effective. There are just four organizer types (hierarchy, sequence, matrix, and illustration), and each displays a particular kind of informational relationship (superordinate-subordinate, order, comparative, and positional, respectively). Moreover, the organizer types can be combined systematically to reveal more complex relationships. And, as discussed throughout this article, research confirms achievement gains over text, outlines, and concept maps.

Teachers should design instruction based on graphic organizers. For example, teachers can provide a graphic organizer with spaces for note taking to increase lecture note taking and facilitate the organization of noted ideas. Teachers can also provide completed organizers like those shown throughout this article. And, teachers can advocate and demonstrate how to study organizers so that relationships are easily spotted and learned. More information for educators about the Graphic Organization System and its applications can be found in the book *Teaching How to Learn* (Kiewra, 2009).

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