Learning by Visualizing

> *Visualization is the process of making an external spatial representation of information. Visualizing is a useful strategy for discovering structure and organizing information efficiently.*
> Schwartz, Tsang, & Blair, 2016, p. 277

Visualizations include diagrams, pictures, charts, graphs, flow charts, matrices, concept maps, Venn diagrams, maps, and other external representations of information. The learning benefits of visualizing include:

1. Students structure and organize information systematically. Organizing information provides a framework students can use to interpret and integrate new information with their prior knowledge.
2. Students can process verbal and visual information separately in two channels. This "dual coding" provides two ways to retain and recall information.
3. Visualization can help distribute cognitive load. As students learn new complex verbal information it is easy to become overloaded. Creating a visualization results in an external, stable, concrete representation of the information. This reduces cognitive load so the student can focus on specific parts of the information and not try to process all of it at one time.
4. Learning strategy for practice testing and elaboration. Students can use visuals for practice testing and self-explanation and elaboration. For example, Students can recall a matrix from memory or try to explain or elaborate verbally the information represented in a concept map.

Concept maps and matrices are two types of visualizations that have been well studied. Both can be effective learning strategies (Fiorella & Mayer, 2015; Robinson & Kiewra, 2002).

Concept maps are external representations of information in a format of nodes and links. In this framework, nodes represent concepts and links indicate how concepts are related or connected to each other. The example below illustrates a concept map organized hierarchically.

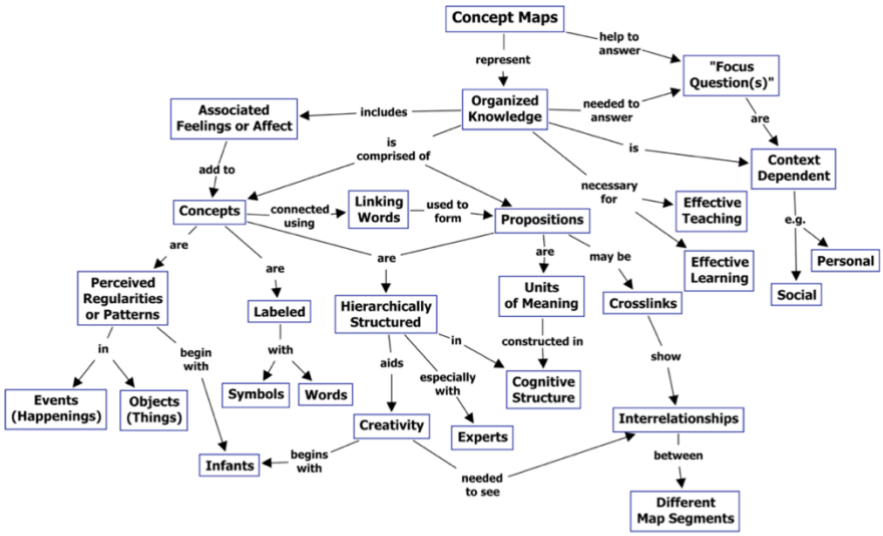

Figure 1. A concept map showing the key features of concept maps. Concept maps tend to be read progressing from the top downward.

Source: Novak, J. D. & Cañas, A. J. (2006)

Concept mapping can be an effective learning strategy in many subject areas. College students who are taught and prompted to use concept mapping consistently outperform students who only take notes (Fiorella & Mayer, 2015).

Using concept mapping effectively.

1. Creating a concept map is not an intuitively obvious activity. It is most effective when students receive some degree of training and practice to become familiar with making viable maps.
2. A key feature is that students create their map to represent the structure and organization of the topic. Maps that are randomized set of nodes and links with no discernible organization are not effective learning devices.
3. Use concept maps for studying. Students can use their maps as a basis for practice testing and elaboration. In practice testing students try to recall the nodes and links from memory, without looking at the map. Practice testing will strengthen their memory of the material and also help students identify gaps in their knowledge (Practice Testing Refresher). Alternatively, students can use their map to support self-explanation and elaboration. In this case, the student elaborates on the relationships between nodes and links and fills in details not included in the map. Elaboration expands students' understanding of the topic and also helps them identify areas they do not understand very well (Self-Explanation Refresher).

A matrix is an external representation in which information is organized into a table or grid. The table systematizes a large amount of information. A typical matrix table lists concepts in a top row or first column and then criteria or characteristics of interest in either the top row or first column. Then relevant information is inserted into each "cell" in the matrix. For example, the matrix below lists the planets in the solar system across the top of the table. In the left column are characteristics of planets. The cells contain the specific information related to each planet.

Planets

	Inner				Outer				
	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Miles from Sun:	36 million	67 million	93 million	142 million	483 million	886 million	2 billion	3 billion	3.5 billion
Time to Revolve Around Sun:	3 months	8 months	1 year	2 years	12 years	30 years	84 years	165 years	250 years
Diameter (miles):	300	8,000	8,000	4,000	89,000	75,000	32,000	31,000	1,000
Surface:	Rocky	Rocky	Rocky	Rocky	Slushy	Slushy	Slushy	Slushy	Rocky

Figure 3. Solar system matrix.

Source: Robinson, D. H., & Kiewra, K. A. (1995)

Similar to other visualizations, a matrix is a way to organize and condense a large amount of information into a format that is easy to navigate. To illustrate, a study presented undergraduate and

graduate students diagnosis problems. They had to use the new information to diagnose patients. Before doing the diagnoses, all the graduate students created a visualization, a matrix that organized and condensed the information. They used the matrix as their reference and never referred back to the original information. In contrast, 82% of the undergraduates started diagnosing the cases immediately by working from the original information sheets. The researchers surmised that graduate students were more likely to create matrices spontaneously because of their experience organizing research data (Martin & Schwartz, 2009).

Using matrices effectively.

1. Although students encounter examples of matrices in curriculum materials, they may need training and practice to make matrices. Instructors might do this by giving students passage that contains a lot of information about a topic and then asking students to propose a matrix format that would organize and condense it. Instructors can also assign students to create matrices for specific material in the course.
2. Use matrices for studying. Similar to concept mapping, students can use matrices as a basis for practice testing and elaboration and self-explanation. Students can practice test in two ways. One is to try to replicate the entire matrix from memory. The second is to start with the headings of the top row and left column and then recall the information for each cell in the matrix. Practice testing will strengthen their memory for the material and help identify gaps in their knowledge. Students can use their matrix to support self-explanation and elaboration. In this case, the student explains and elaborates on the information in each cell. Elaboration expands students' understanding of the topic and also helps them identify areas they do not understand very well.

References

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