Concept Mapping

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CONCEPT MAPPING

Concept maps are node-and-link diagrams that represent the key-terms and relations among terms within a set of materials. *Concept mapping* refers to the activity of creating a concept map. There are a variety of ways to create concept maps, but all share common elements: People construct concept maps by identifying key terms or ideas, placing those key terms in nodes, drawing lines that link related terms, and writing a description of the nature of the relation along the link. Figure 1 shows an example of a concept map created by a college student while they read a text about the composition of blood. No sophisticated tools are needed to create concept maps – pencil and paper will suffice – but several computer programs have been developed to aid in the creation of concept maps. Concept mapping is done in educational settings in a variety of ways, from students creating concept maps as they study on their own (e.g., while they read a textbook) to teachers and students constructing maps as a collaborative classroom activity. Concept mapping may be used for wide variety of purposes, including creative brainstorming, note-taking, outlining, and – the focus of this article – as an activity intended to promote learning. Concept mapping enjoys widespread popularity in educational settings and among the general public.

Concept Mapping and Related Techniques

Concept maps bear a surface resemblance to semantic networks developed in cognitive psychology in the early 1970s. Such network models depict semantic knowledge as a set of interconnected nodes and assume that when one idea or concept is activated, the activation spreads throughout the network to other related notes. Concept mapping was developed as a pedagogical tool by Joseph Novak in the late 1970s. The original intent of concept mapping was to track students' conceptual change over time. For example, a student's knowledge about the composition of blood may change over the course of a semester-long anatomy class, and such changes would be reflected in the changing organization of concept maps produced by the student at different points in the semester. An assumption behind concept mapping is that when learners express their knowledge on a concept map, they express more, or express knowledge differently, relative to what they would express on a different assessment.

Concept mapping shares similarities with other mapping techniques, all of which can be considered types of *graphic organizers*. In a technique known as *knowledge mapping*, students create node-and-link diagrams, just as they do in concept mapping, but must use a pre-defined set of relations to do so (e.g., "part", "type", "example"). There is not universal agreement about whether concept maps and knowledge maps are functionally similar activities, and no direct comparisons exist in the literature. *Mind mapping* is another technique that also involves representing knowledge in a node-and-link diagram, but mind maps typically center around a single concept (node) with several associated images and ideas radiating from this central node. Likewise, causal maps and flowcharts represent knowledge in node-and-link diagrams. While concept maps may represent cause-and-effect relations, concept mapping is generally considered to be different from mind maps, causal maps, and flowcharts.

Evaluating Concept Maps

A great deal of debate has focused on the most meaningful and informative ways to evaluate students' concept maps. Perhaps the most straightforward way to assess a concept map is to tally the number of *idea units* represented on the map, where an idea unit is a proposition that expresses an idea or concept. For example, in the map in Figure 1, "blood is composed of plasma" was scored as one correct idea unit. Evaluations of concept maps can become considerably more sophisticated than this simple example, when one begins to consider the number of nodes, the number of links, and the overall organizational structure of links on a map. In a map like the one in Figure 1, nodes exist in different levels of a hierarchy, and students may identify *cross-links*, where a node in one section or level of a map is linked to a node in a different section or level. The presence of cross-links on a student's map is though to represent relatively deeper knowledge and insight about a domain.

Claims about Concept Mapping

The chief claim about concept mapping is that concept maps improve learning, but many additional claims about concept mapping have appeared in the literature and popular media. Concept mapping has been proposed to stimulate brainstorming and the generation of new ideas, aid in creativity, improve metacognitive monitoring (the self-assessment of one's own knowledge), enhance critical thinking, and serve as an effective note-taking technique. Many of these claims have not been thoroughly examined in experimental or quasi-experimental research, for instance, by comparing a concept map condition to a plausible control condition and determining whether concept mapping improves the outcome of interest (such as idea generation or metacognitive accuracy). All of the claims mentioned here are plausible, and perhaps true, but without more thorough research no firm conclusions can be drawn.

One claim that has been examined in experimental research is that concept mapping improves students' affect, self-efficacy, and motivation. A 2006 meta-analysis of concept mapping research identified 6 papers that examined these outcomes, all of which reported positive effects of concept mapping. This represents promising support for the effectiveness of concept mapping in promoting students' affect, self-efficacy, and motivation, but given the relatively small number of studies in the literature, further exploration is certainly warranted.

Mechanisms of Concept Mapping: Why Should Concept Mapping Promote Learning?

It is worth considering why concept mapping should be expected to promote learning. Although there is a fairly extensive research base on concept mapping, few studies have targeted the underlying cognitive processes that learners might engage in when they create concept maps. In the basic cognitive science literature, it is well established that a combination of *relational* and *item-specific processing* supports effective and durable encoding. Relational processing refers to tasks in which learners consider how items are similar to one another, whereas item-specific processing refers to tasks that emphasize how items are distinctive, unique, or different from one another. When trying to learn new information, engaging in both relational and item-specific encoding is a recipe for a robust mental model of the material.

Concept mapping would seem to emphasize relational processing by focusing on how terms are similar to one another and how ideas fit together within an organizational structure. The concept map shown in Figure 1 appears to provide a clear depiction of the overall relational structure of the text. It is possible that concept mapping also promotes distinctive or item-specific processing; perhaps this would be especially true when learners create cross-links or links that emphasize the distinctiveness of terms within categories. Unfortunately, the literature is sparse when it comes to discussion of possible encoding mechanisms that concept mapping might afford.

One recent study, reported in 2015, examined the effects of concept mapping on relational and item-specific knowledge and suggested that some concept mapping activities may be detrimental to item-specific encoding. Standard concept mapping instructions emphasize that learners should form many relations among items. As a consequence, learners may create overloaded categories in which too many terms become linked to higher-level category nodes. Ultimately, the creation of overloaded categories hurt learning performance relative to other study strategies that also encouraged organizational or distinctive processing.

Does Concept Mapping Promote Learning?

The simple question of whether concept mapping promotes learning is not so simple after all, because "concept mapping" is not a single prescribed activity. Concept mapping can be done in a variety of ways. For example, students might study a concept map as an advance organizer before a lesson, perhaps one created by a teacher or one that accompanies a text. Students might create maps while reading, or they might create them after they have read something (as a retrieval practice activity). Students might create maps on their own or in collaboration with other learners. And students might engage in concept mapping activities that offer varying degrees of support. For example, they might have access to a "node bank" that contains the key-terms to be used on a map; they might be given a portion of a map and asked to fill out the remainder; or they may engage with an adaptive computer program that assists learners as they build concept maps (e.g., the Betty's Brain intelligent tutoring system).

The most extensive analysis of the effectiveness of concept mapping was a 2006 meta-analysis that identified 55 experimental and quasi-experimental studies of concept mapping and knowledge mapping. In general, concept mapping produced positive effects on measures of student learning. The largest effects were observed in studies that compared concept mapping to relatively passive control conditions, like listening to material in lecture format. Studying concept maps produced small but positive effects on learning relative to studying by reading texts or outlines. In studies that compared concept mapping to other active control conditions (e.g., creating an outline rather than simply reading an outline), concept mapping showed even smaller but, nonetheless, positive effects on learning. In short, concept mapping tends to benefit learning, but the size of the effect depends on whether concept mapping is compared against passive or more active control conditions.

Future Directions

As noted earlier, concept mapping remains very popular in a range of educational and applied settings. However, many of the central claims about concept mapping require further research and investigation. Many studies have shown positive effects of concept mapping on learning, but there is a continuing a need to identify the most effective ways to structure concept map activities to support effective encoding and promote learning.

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See also

Further Readings

Biswas, G., Segedy, J. R., & Bunchongchit, K. (2015). From design to implementation to practice a learning by teaching system: Betty's Brain. *International Journal of Artificial Intelligence in Education.*

Blunt, J. R., & Karpicke, J. D. (2014). Learning with retrieval-based concept mapping. *Journal of Educational Psychology, 106*(3), 849-858. doi:10.1037/a0035934

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82*(6), 407-428. doi:10.1037/0033-295x.82.6.407

Grimaldi, P. J., Poston, L., & Karpicke, J. D. (2015). How does creating a concept map affect item-specific encoding? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*(4), 1049-1061. doi:10.1037/xlm0000076

Hunt, R. R. (2012). Distinctive processing: The co-action of similarity and difference in memory. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 56, pp. 1-46). San Diego, CA: Elsevier Academic Press.

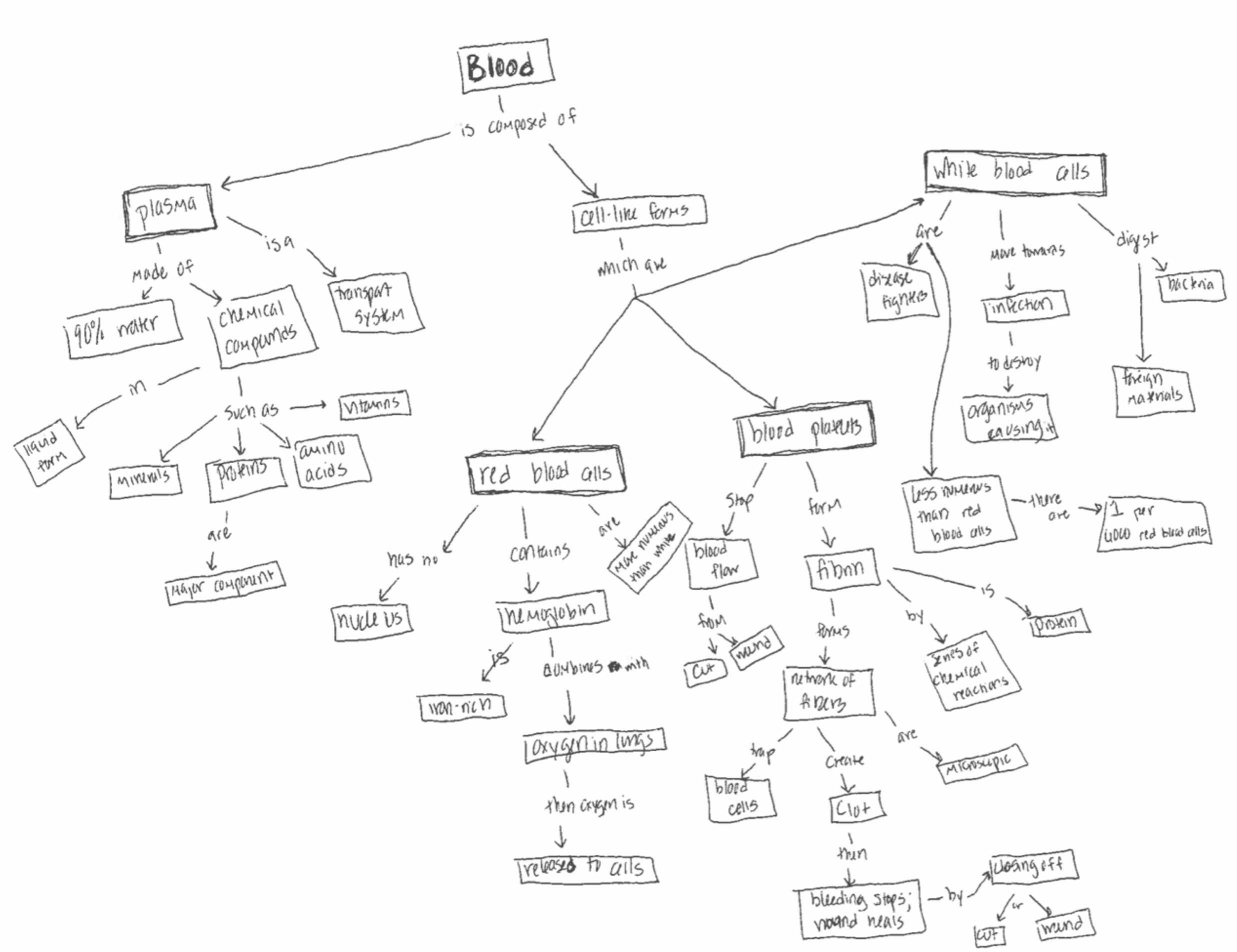
Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*(6018), 772-775. doi:10.1126/science.1199327

Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research, 76*(3), 413-448. doi:10.3102/00346543076003413

Novak, J. D., & Cañas, A. J. (2006). *The theory underlying concept maps and how to construct and use them*. Technical Report. Institute for Human and Machine Cognition, Pensacola FL.

Ruiz-Primo, M. A., & Shavelson, R. J. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching, 33*(6), 569-600. doi:10.1002/(sici)1098-2736

Figure 1


Blood
is composed of
plasma
made of
90% water
chemical compounds
in
liquid form
such as
vitamins
minerals
proteins
amino acids
are
major component
is a
transport system
cell-like forms
which are
red blood cells
has no
nucleus
contains
hemoglobin
is
iron-rich
combines with
oxygen in lungs
then oxygen is
released to cells
are
blood platelets
stop
blood flow
from
cut
wound
form
fibrin
forms
network of fibers
trap
blood cells
create
clot
then
bleeding stops; wound heals
by
closing off
cut
wound
are
microscopic
by
chemical reactions
is
protein
white blood cells
are
disease fighters
less numerous than red blood cells
there are
1 per
red blood cells
move towards
infection
to destroy
organisms causing it
digest
bacteria
foreign materials