

Concept Mapping: some foundational theory and advice on use and application

Adapted from powerpoint presentations written and presented by Andre Daniels, Clint Braaf and Prof Louis Fourie.

What are concept maps?

Concept maps are tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts. Words on these lines can be used to specify the nature of the relationships between different concepts.

A Concept map: is a graphical display of concept names connected by directed arcs encoding propositions in the form of simplified sentences. In educational settings, concept mapping techniques have aided people of every age to examine many fields of knowledge.

Why are they useful in learning and teaching?

- to generate ideas (e.g. brain storming)
- to design a complex structure
- to communicate complex ideas
- to illustrate the relationships between different components or processes
- to aid learning by explicitly integrating new and old knowledge
- to assess understanding
- or diagnose misunderstanding

Differences between making mindmaps and concept mapping

Concept maps provide an elegant, easily understood representation of an expert's domain knowledge. They are more like webs, showing links between concepts in a more complex way, and they can allow for a range of complexity, from very simple to very complex.

Mindmaps are also useful but they tend to be more 'linear' in their representation of knowledge, and often it is difficult to show complex links between different concepts, or to communicate the meaning of the concepts themselves with a mindmap.

Figures 1 and 2 provide a graphic illustration of the differences between mindmaps and concept maps.

Figure 1: Concept map on Concept Mapping

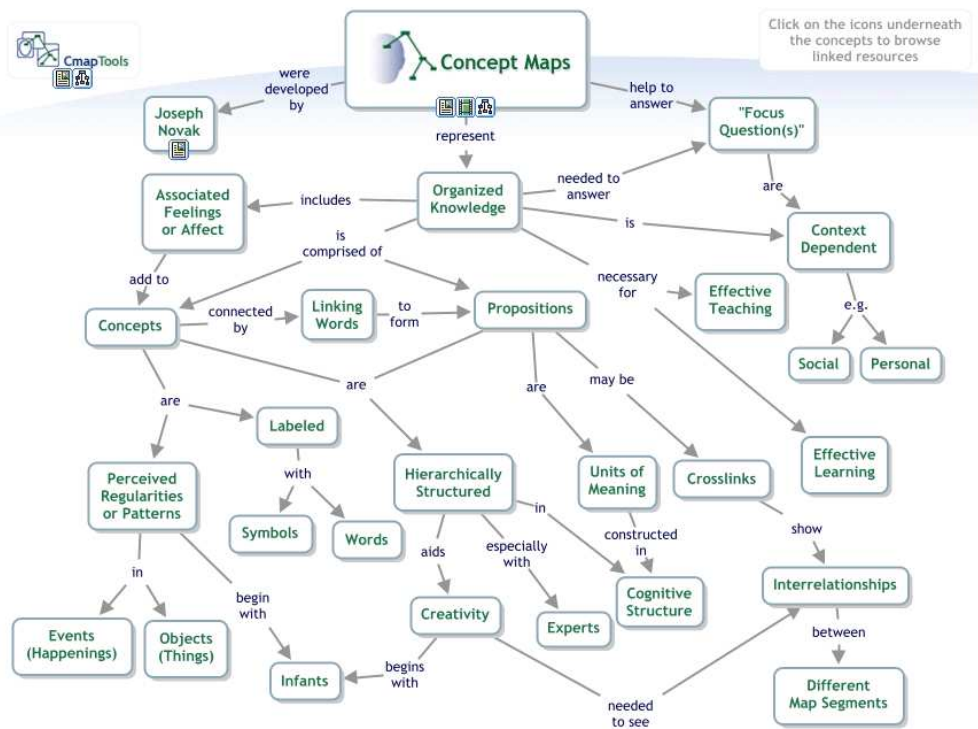
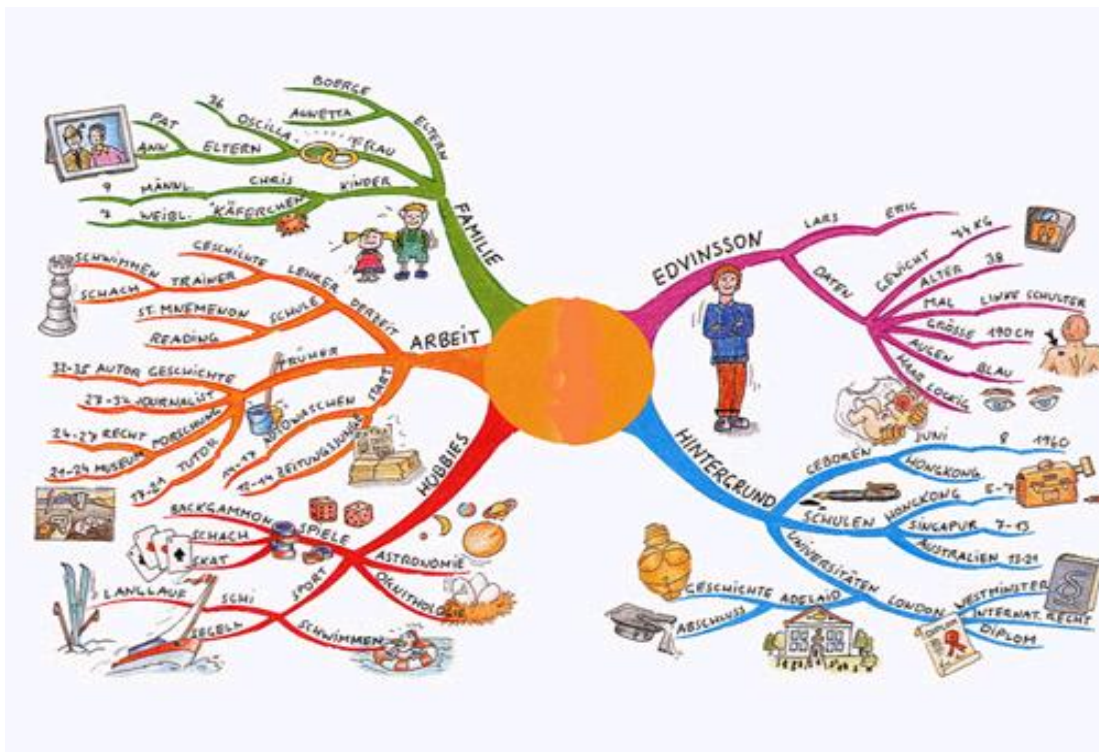


Figure 2: A mind map



Where do concept maps originate and how do they work?

Concept maps have at their heart the theory that all knowledge is built from Concepts and Propositions. Joseph Novak is widely credited as the creator of concept maps, and has been writing and researching them since the 1970s.

A concept is perceived regularity in events or objects, or records of events or objects, designated by a label: for example, Life; Cell; Blue; Ship.

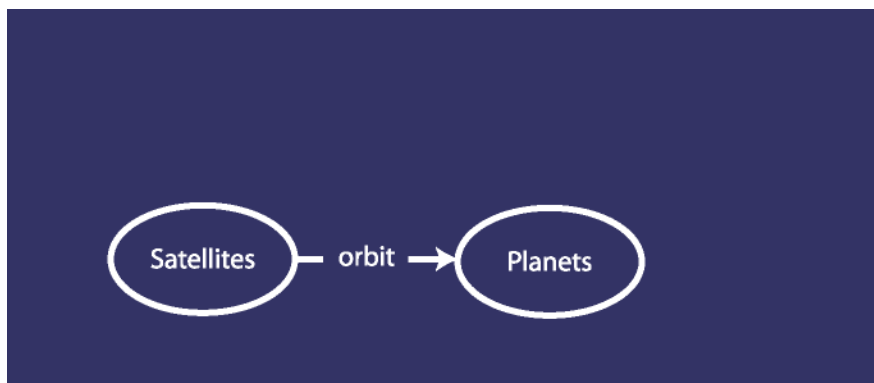
A proposition is made when two or more concepts combined to form a statement about something: a basic unit of meaning or expression: e.g., living things are composed of cells OR the ship was blue.

Thus, concept maps represent knowledge using diagrams that express concepts and propositions, and are therefore a tool to represent the structure of knowledge.

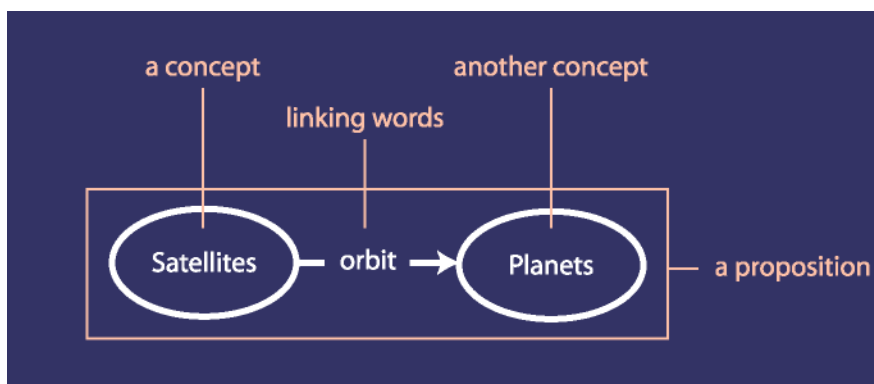
Anatomy of a concept map:

These three pictures represent the way a concept is built in a map. The linking words or phrases are essential, as you can see, because without the relations created by them, our knowledge would not “cohere”.

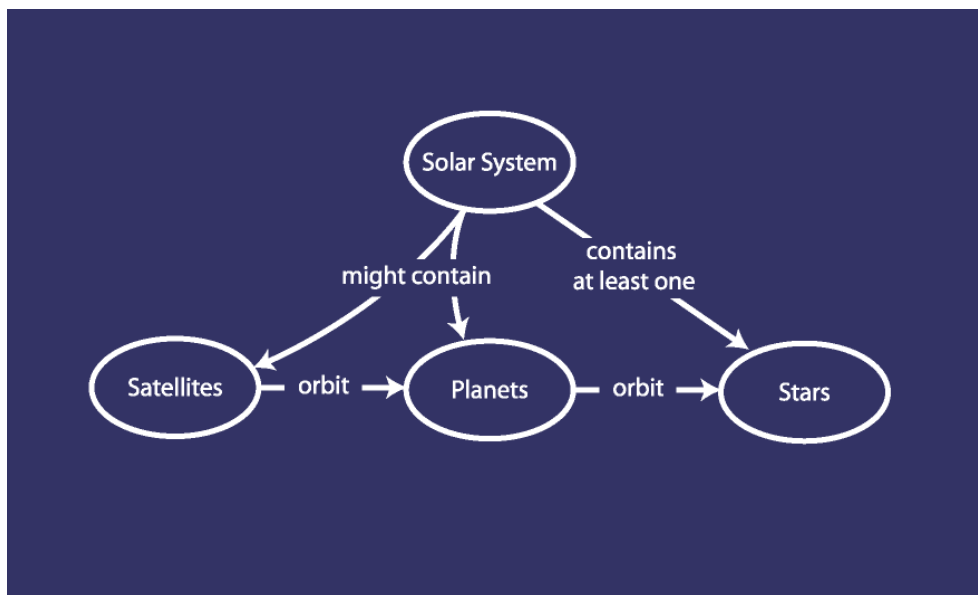
1.



2.



3.



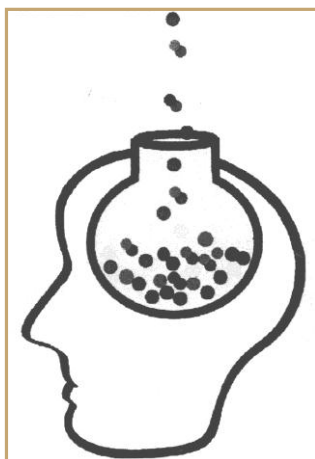
The theory of learning used by concept maps

Concept mapping draws heavily on the theory of learning proposed by David Ausubel. This theory started from his stance that: 'If I had to reduce all of educational psychology to just one principle I would say this: The most important single factor influencing learning is *what the learner already knows*. Ascertain this and teach him accordingly'.* [David Ausubel (1968)]

Key to this theory of learning is the proposition that in the process of meaningful learning, people construct meanings for concepts and propositions based on experiences, building up their knowledge structure. A clear distinction is made between rote and meaningful learning, here, and the students' prior and existing knowledge is more actively utilised to make sense out of the new knowledge they are learning.

In the more traditional conception of teaching and learning, the student tends to be conceived of as an empty vessel needing to be filled with the knowledge held by the teacher or lecturer as 'expert' (see figure 3). Learning is demonstrated through the ability to memorise and repeat – 'rote' learning.

Figure 3: traditional concept of teaching and learning



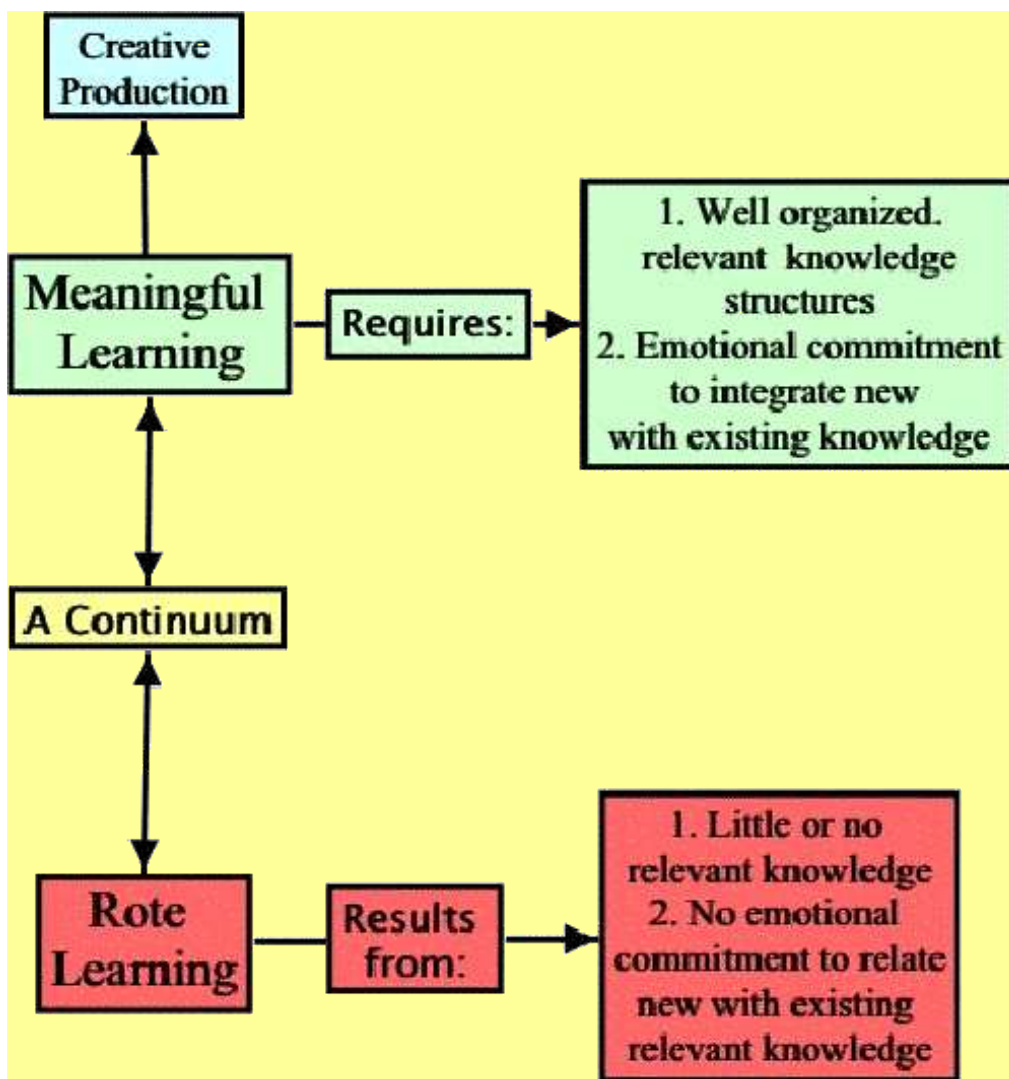
By contrast, Ausubel argues that meaningful learning involves changing one's current knowledge as a result of the comprehension of new knowledge. This process is called "assimilation" and there are four fundamental processes that lead to assimilation:

1. Progressive differentiation of concepts and relations over time.
2. Superordination of concepts under more general, more inclusive concepts.
3. Subsumption of new concepts into existing, more general concepts and propositions.
4. Integrative reconciliation to achieve coherence and consistency over time.

In order to assimilate and make sense of new knowledge, students must have opportunities to use what they already know to make sense of what they don't yet know, and fit that new knowledge into existing frameworks, and adapt and change these over time. 'Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures' (Novak & Gowin, 1984).

This difference between rote and meaningful learning is illustrated by figure 4, below.

Figure 4: difference between rote and meaningful learning



To sum up this section: concept mapping is underpinned by a constructivist epistemology holds that knowledge is a human construction and evolves over time, as opposed to a positivist epistemology holds that knowledge derives from empirical observation and is “unfettered” by varying human ideas over time. Thus concept maps can help students to:

- Decrease their focus on memorisation
- Increase their self-regulation strategies
- Increase and focus their own motivation
- Recognise the need for transfer of knowledge between contexts

The benefits of using and making concept maps for both lecturers and students

With students: concept maps can be taught and made:

- In order to assess existing knowledge prior to beginning a teaching/learning session;
- As a reflective practice to create and make explicit mental linkages surrounding a concept; and/or
- As a group exercise to improve group problem solving
- To review problem-solving options
- To summarise understanding and identify misconceptions
- To evaluate student progress
- To evaluate course/program outcomes

With lecturers: in thinking about your curriculum, concept maps can help you to:

- Map out the key concepts you want to teach and the links and relationships between them
- Map out the points within the course at which you want or need to assess your students and how the assessment links to what you are teaching and they are learning
- See at a glance where there are gaps in the learning process, and where there are very dense areas that may need to be further unpacked for your students
- See at a glance how the different parts of your course fit together

For BOTH: the process of drawing the map:

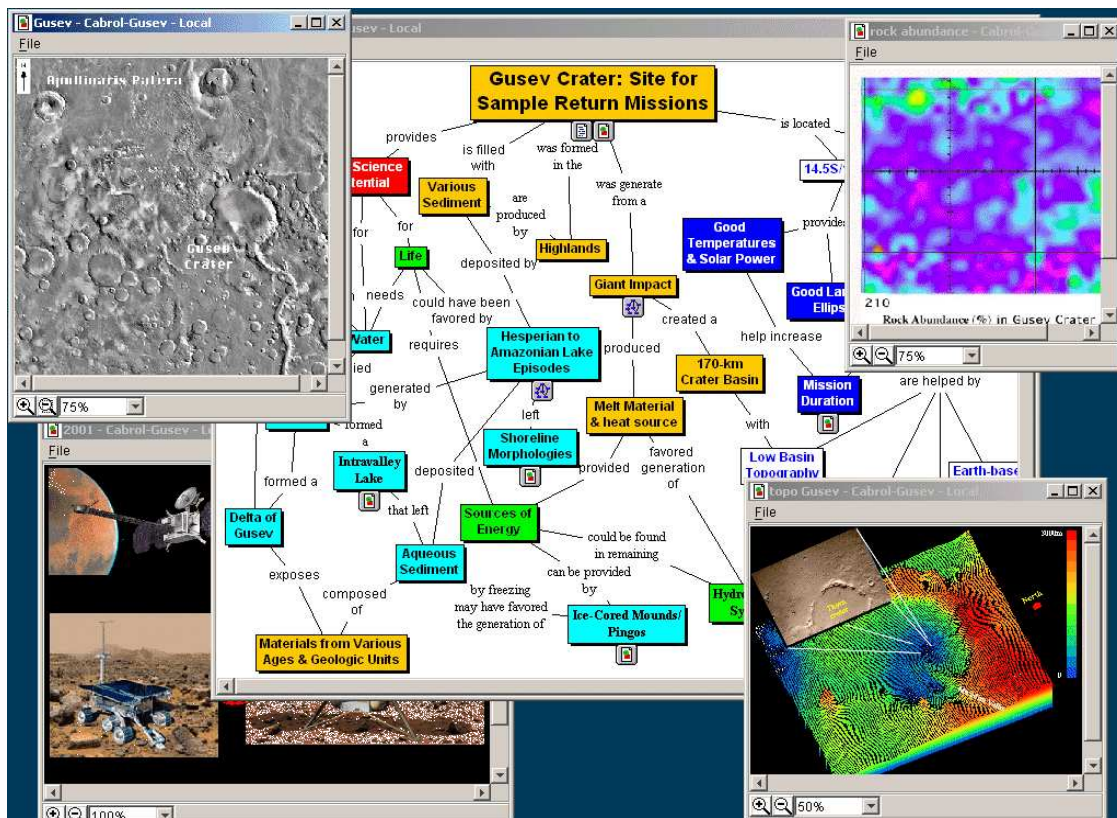
- Helps the designer understand the domain
- Is a creative process – new discoveries are made as the map is drawn
- Makes the links between concepts and propositions clear, and thus the meaning-making and knowledge construction process is made more visible and more tangible
- Shows the designer the gaps as well as the links, so can promote further learning, action and understanding

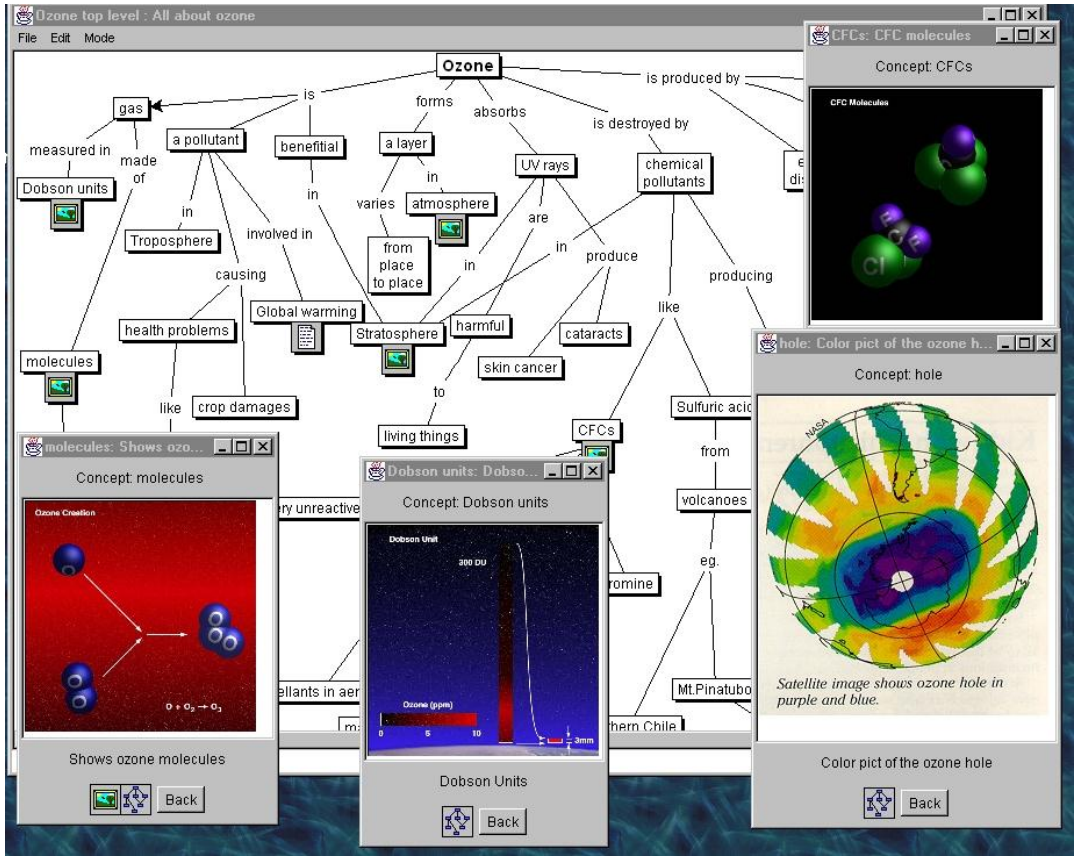
How to make a concept map (on paper or using the Cmap tool)

Select or Focus on a theme and then identify related key words or phrases. What is the central word, concept, question or problem around which to build your diagram or concept map? What are the concepts, ideas, descriptive words or important questions that you can associate with the main concept, topic, question or problem?

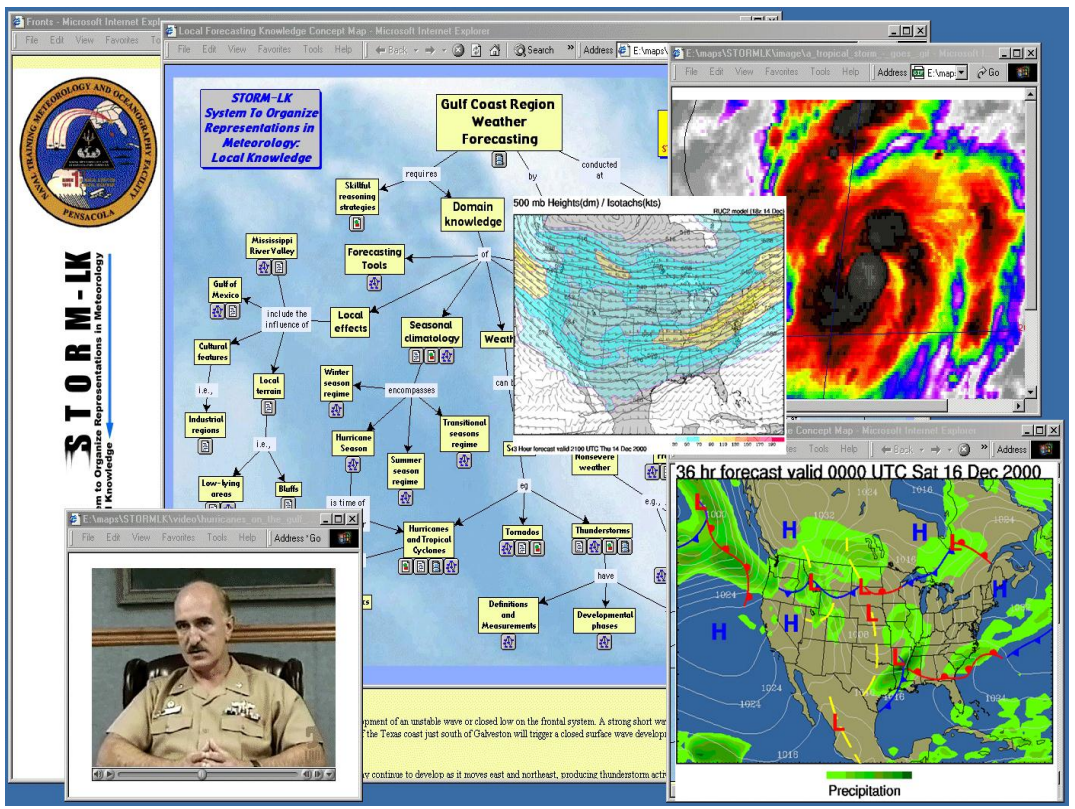
- Rank the concepts (key words) from the most abstract and inclusive to the most concrete and specific.
- Cluster concepts that function at similar level of abstraction and those that interrelate closely.
- Arrange concepts in a diagrammatic representation.
- Add linking lines and where appropriate label lines with a qualifying word or phrase.
- Groups of people can work together on a concept map - this is a good way to "brainstorm" a problem or idea.

Examples (from Prof Fourie's presentation at T&L retreat in March 2012):





C-maps used to externalise tacit knowledge at the Oceanography and Meteorology Training Facility, NAS Pensacola (Coffey et al., 2002).



Useful References

- Cañas, A.J., Leake, D.B. and Wilson, D.C. Managing, Mapping and Manipulating Conceptual Knowledge. AAAI Workshop Technical Report WS-99-10: Exploring the Synergies of Knowledge Management & Case-Based Reasoning, AAAI Press, Menlo Calif, (July 1999).
- Cañas, Alberto J., Roger Carff, Greg Hill, Marco Carvalho, Marco Arguedas, Thomas C. Eskridge, James Lott and Rodrigo Carvajal. 2005. Concept Maps: Integrating Knowledge and Information Visualization, *Lecture Notes in Computer Science*, 3426/2005, 181-184, DOI: 10.1007/11510154_11.
- Derbentseva, Natalia, Frank Safayeni & Alberto, J. Cañas. 2007. Concept maps: Experiments on dynamic thinking, *Journal of Research in Science Teaching*, 44: 3, 448–465.
- McDaniel, Elizabeth, Brenda Roth & Michael Miller. 2005. Concept Mapping as a Tool for Curriculum Design, *Issues in Informing Science and Information Technology*. Available from <http://2005papers.iisit.org/l42f49McDa.pdf>.
- Moen, Ed M. J. C. & Kerst Th Boersma. 1997. The Significance of Concept Mapping for Education and Curriculum Development, *Journal of Interactive Learning Research*, 8: 3-4, 487-502.
- Novak, J.D. The theory underlying concept maps and how to construct them. The Institute for Human and Machine Cognition. Available from <http://cmap.coginst.uwf.edu> .
- Novak, J. D. (1998). *Learning, creating, and using knowledge: Concept Maps as facilitative tools in schools and corporations*. Mahweh, NJ: Lawrence Erlbaum Associates.