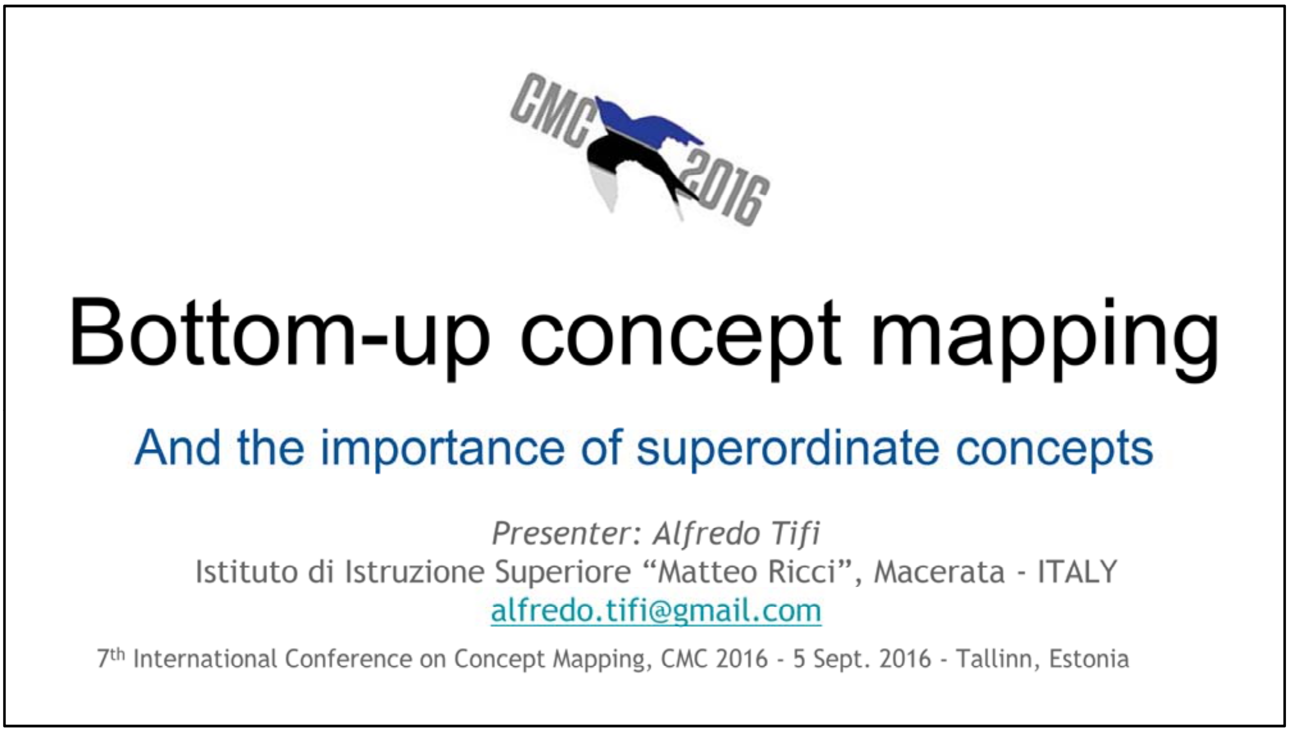


This presentation is to introduce the main **conclusions** and a sort of resumé of a series of esperiences I led with 14-15 year-old students in chemistry, whose report is chronologically described in details in the pdf article: http://cmc.ihmc.us/cmc2016papers/cmc2016-p69.pdf

Summary

Thermodynamic concepts are good examples of highly superordinate concepts.

For example, the same concept of “entropy” applies to the widest range of different contexts and to practically any transformation.

1.Superordinate concepts

Are relatively GENERAL Concepts

Are relatively ABSTRACT Concepts

Novak's definition of concept:

"a *perceived* regularity or pattern in events or objects, or records of events or objects, designated by a label"

i.e. it is relatively "general". As we will see, "more general" is not synonymous of "simpler"

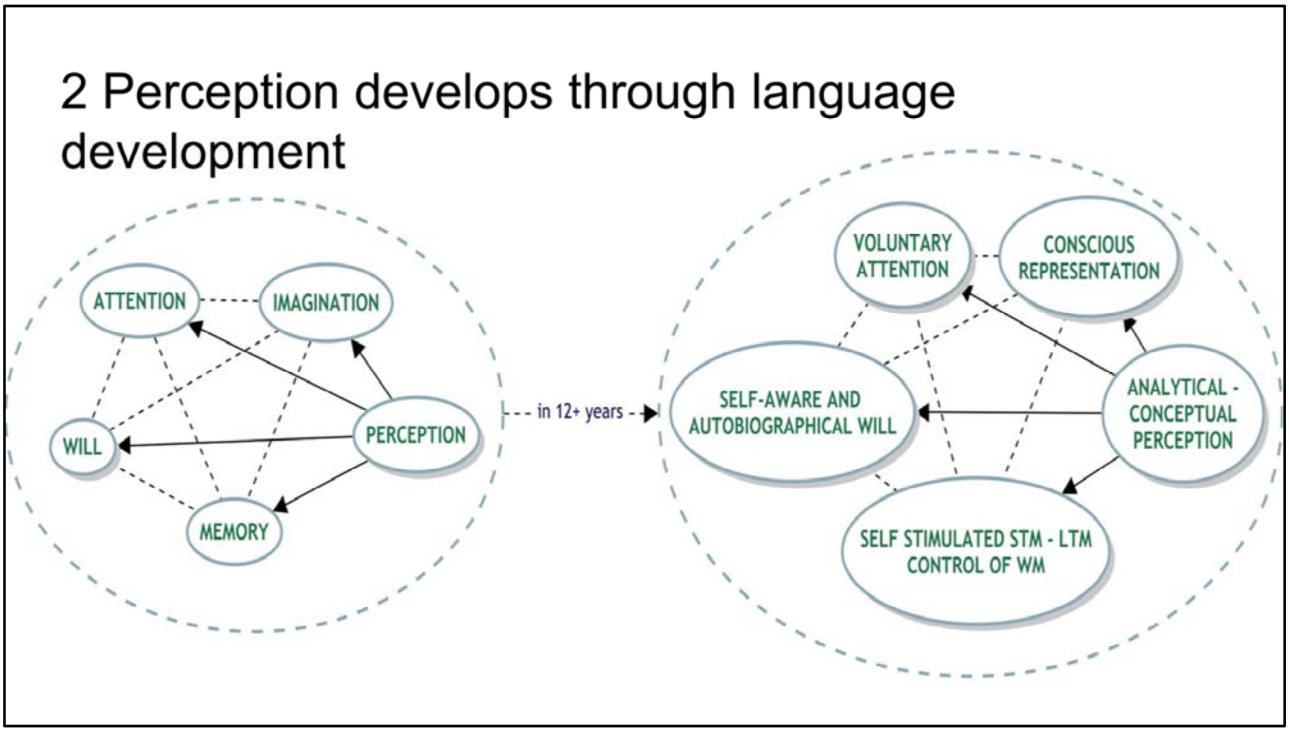
Thermodynamic concepts are also good examples of how superordinate concepts are not "constitutive" of reality, but rather they are "constructs" we can use to describe, comprehend and connect different apparently unrelated phenomena.

i.e. they are relatively "abstracted" from observation of reality. The word "relatively" is here because the concept of battery, for example, could represent a high level generalization for a two -year child. So they haven't a causal relation with phenomena, but only a tautological one:

This battery is dead < electrical potential is too low < the system has got too close to chemical equilibrium < the system cannot produce enough entropy…

These aren't causal explanations, but just different descriptions with different degrees of abstraction of the same observed event.

This is like Novak's definition of concept: "a perceived regularity or pattern in events or objects, or records of events or objects, designated by a label". The key concept here is perception.



The key concept here is *perception*.

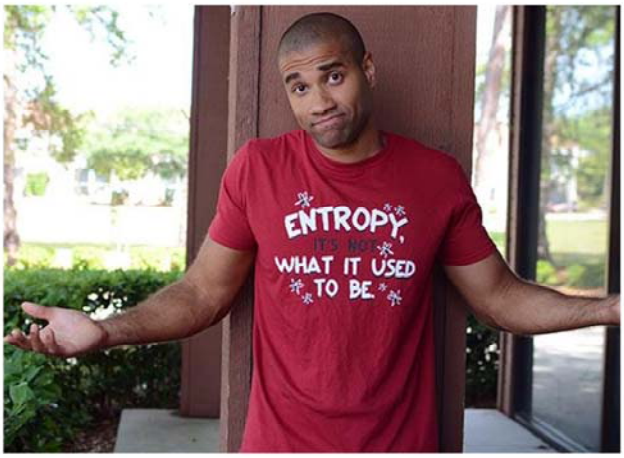
If we mean just “sensory” perception, we would be able to *perceive* only “complexes” in Vygotsky’s jargon, i.e. generalizations which are always directly related to concrete or exterior attributes of labelled real objects.

Actually, thanks to their progress in language mastery, a child slides through deeper and wider degrees of perception along their development. By improving language their *perception* undergoes important changes. The world, the “objects” in their environment undergo changes as more and more social - consensual signs enter their life - and the other components and the whole psychological system, change as well:

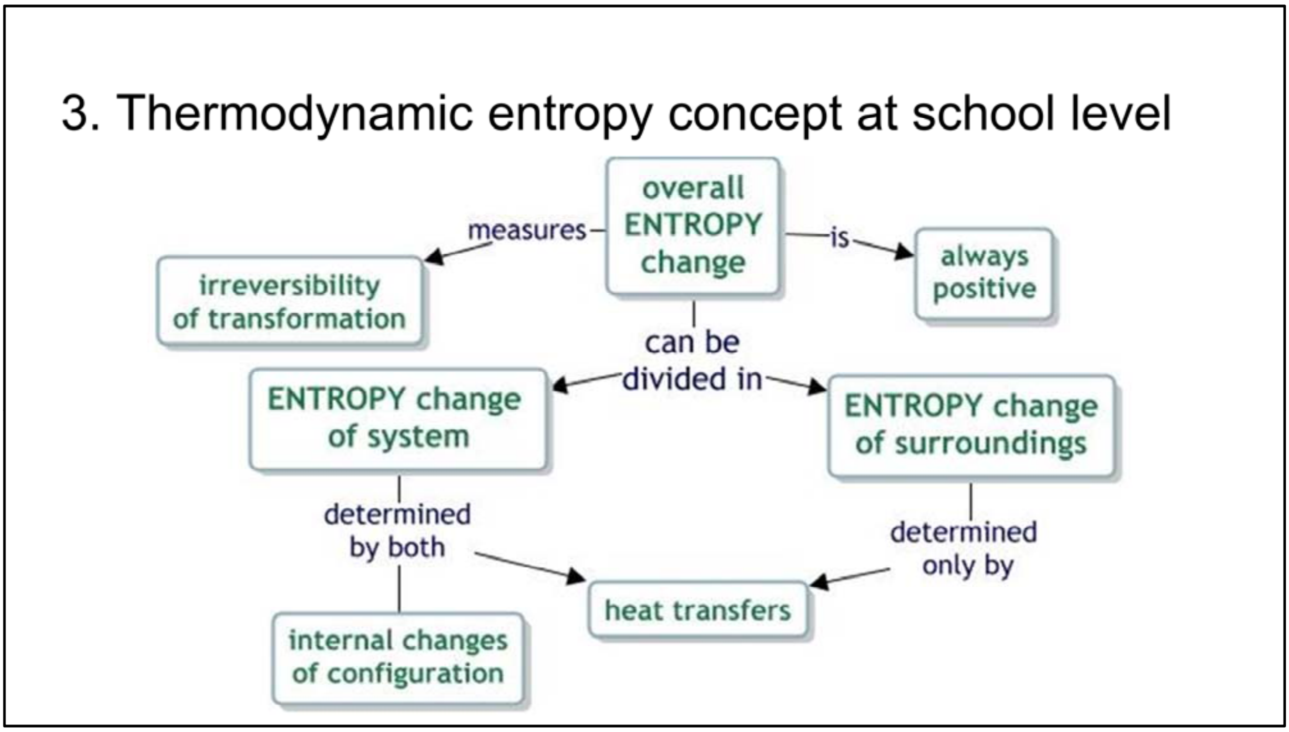
This is how the psychological system develops

So, this development brings about the great leap forward, represented by **thinking in concepts** in adolescence, which actually is my target.

PART TWO
Self-teaching experiment on the concepts of entropy



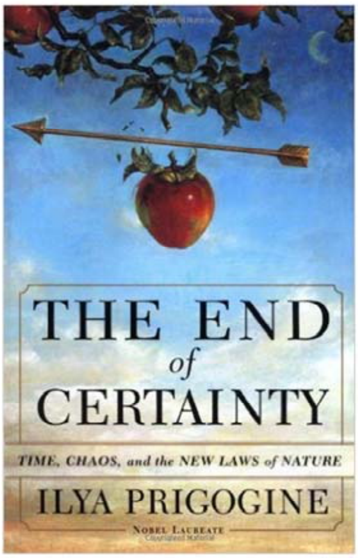
In the last August I decided to upgrade my own conception of thermodynamic entropy to suit my purpose of grasping some concepts from a book of Prigogine which I was striving to read.



This is somewhat I’ve taught for years in my courses of physical-chemistry at secondary level technical school.

An overall increase of entropy accompanies any spontaneous process, and it is given by adding entropy variations occurring in all the involved subsystems, that are “system” and the “surroundings”.

4. New concepts of transfer and production of entropy

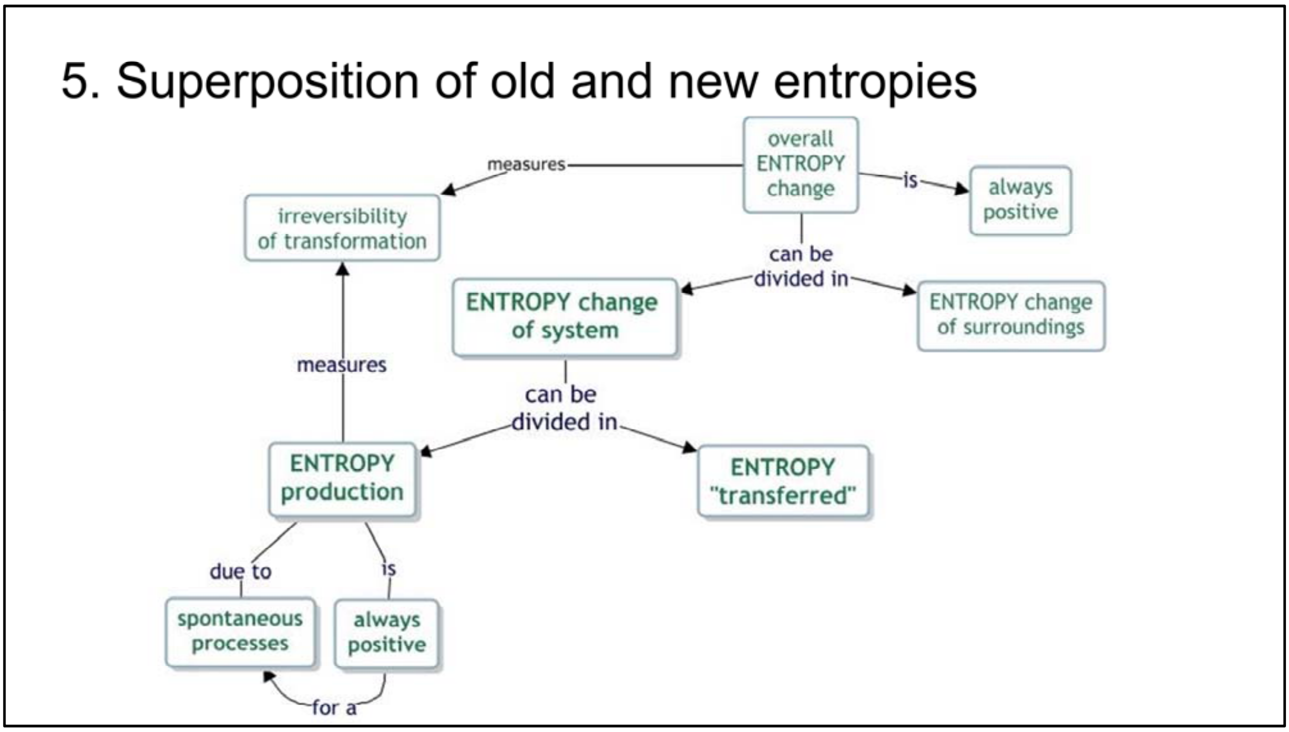


Extract from page 61

course of time. How can we extend this statement to systems that are not isolated, but which exchange energy and matter with the outside world? We must then distinguish two terms in the entropy change, dS: the first, d_eS, is the transfer of entropy across the boundaries of the system; the second, d_iS, is the entropy produced within the system. As a result, we have $dS = d_eS + d_iS$. We can now express the second law by stating that whatever the boundary conditions, the entropy production d_iS is positive, that is, $d_iS \geq 0$. *Irreversible processes are creating entropy.* De Donder went

According to the book's title, five lines at p. 61 destroyed my certainties about entropy.

The entropy change of the system was divided into entropy transferred across its boundaries and internal entropy production, and this latter was always increasing for the second law of thermodynamics.



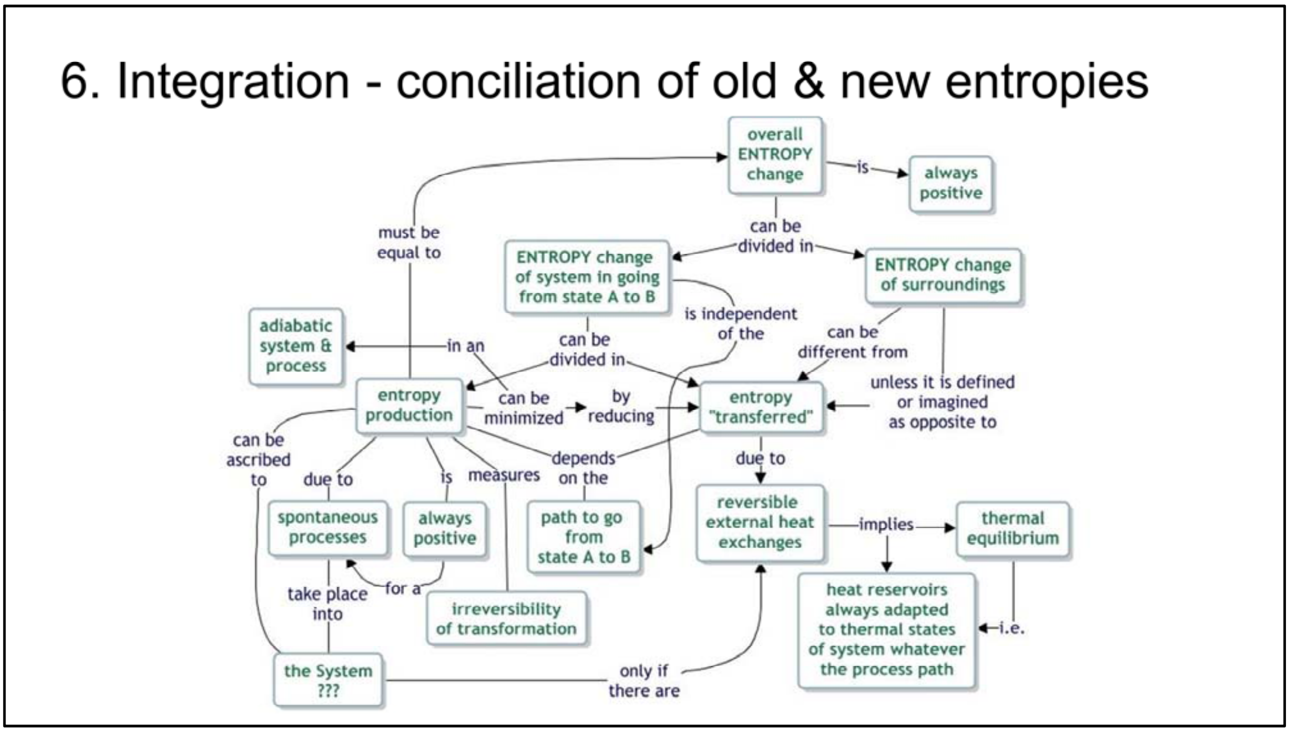
Thus, the old and the new divisions can be provisionally combined:

Showing as the “new” concept of internal “entropy production” and the old *overall change* were both expected to increase for spontaneous processes, of the same amount.

There were two different words for the same thing? Or were these two a couple of different concepts for the same amount of change?

To conciliate that, I had to discover a mess of “*hidden and complicate distinctions”* over there: to avoid an extra production of entropy, you must produce the *real* transformation within the system and imagine *ideally reversible exchanges* towards the ambient.

Eventually, what seemed pretty plain resulted in a tricky machinery to apply to real transformations (an expert professor would say “it’s self-evident”. It wasn’t evident to me).



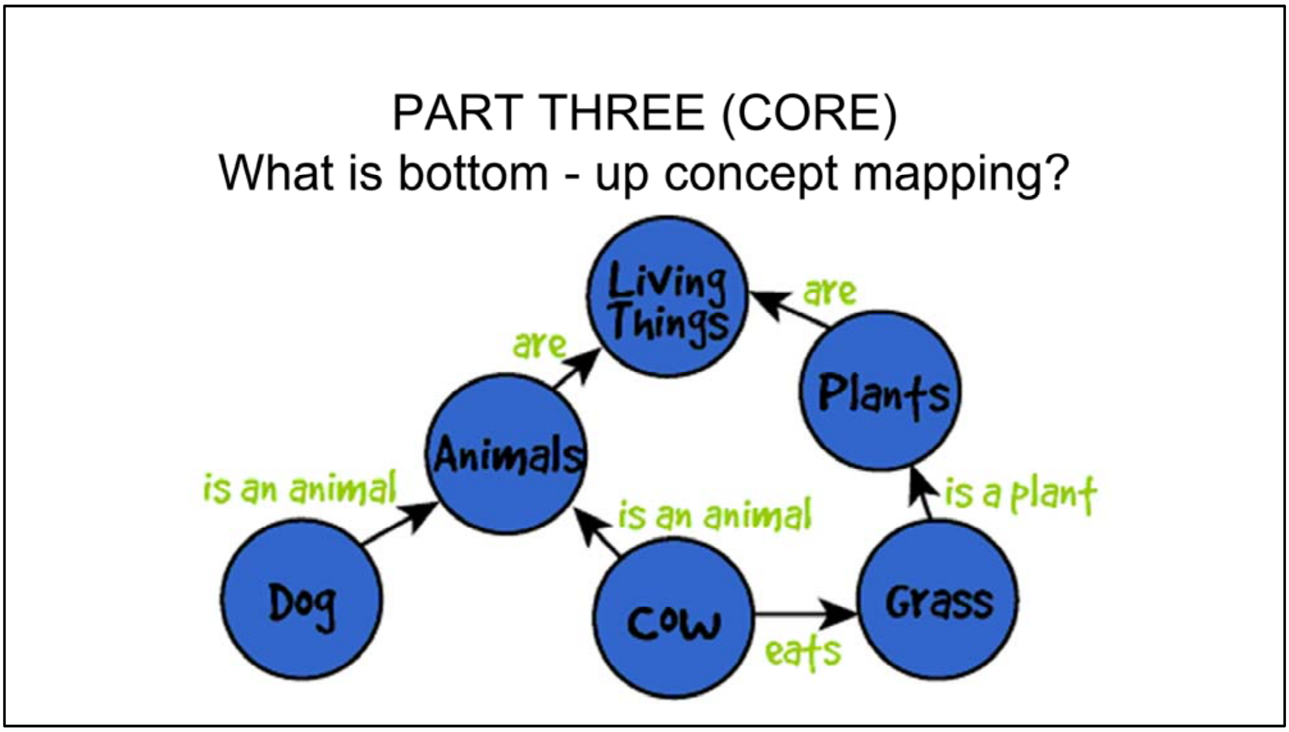
And yet, in case of further doubts about my understanding, I will need to go back and check again the problems I have already treated.

So, after the self-teaching experiment, I concluded:

7. Conclusions from the self-teaching experiment

The concrete examples are the very source of ***constraints*** and ***distinctions*** that Humans need to understand superordinate concepts

(there is an exception with mathematicians: they are maybe not entirely human because they can directly create and manage hyperordinate concepts from scratch, without any real anchorage available)



My “self-teaching” experiment served to confirm several observations I also made with students during the last school year, as these two main in next slide.

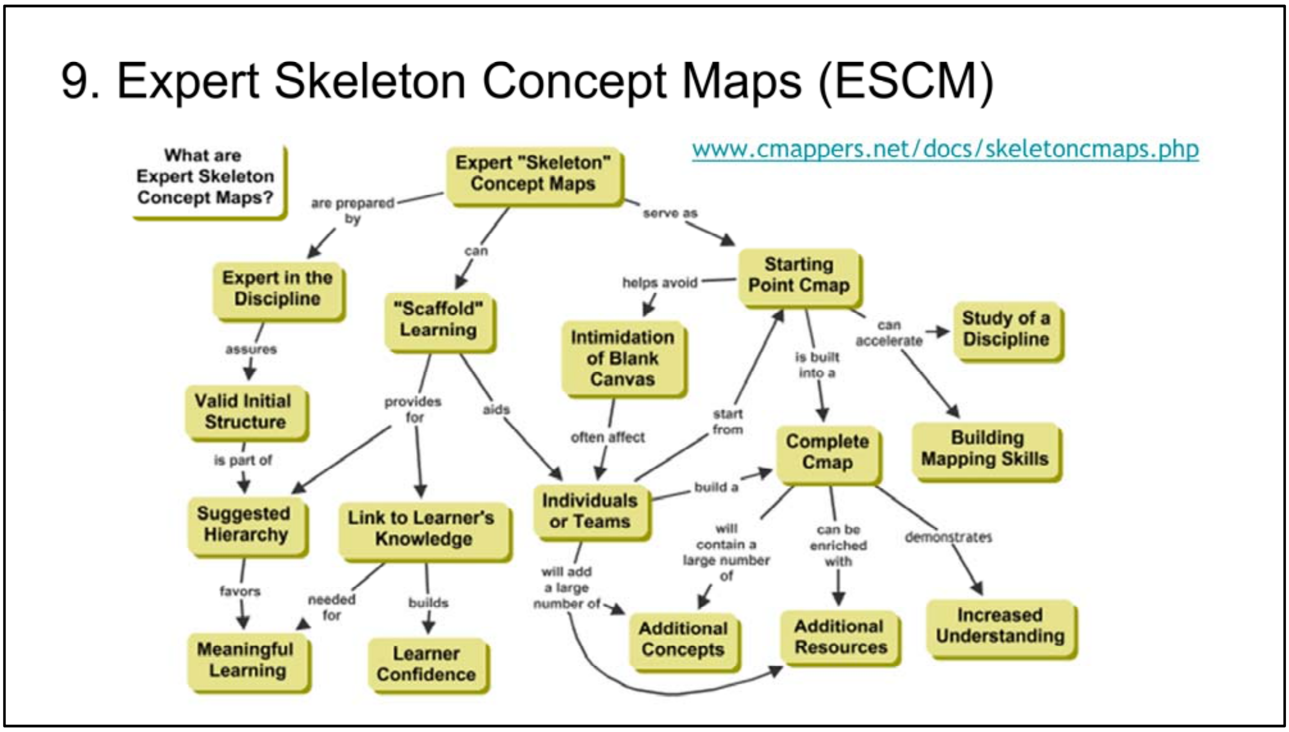
8. Observations during last school year

1. Cmaps are useful to question or monitor uncertainty, not to fix it

2. The major challenge in constructing the mastery of a multifaceted, superordinate concept, is to learn the many distinctions of it by struggling in the study of its concrete applications.

We might translate the latter point with top-down concept mapping: **progressive differentiation**, and so on.

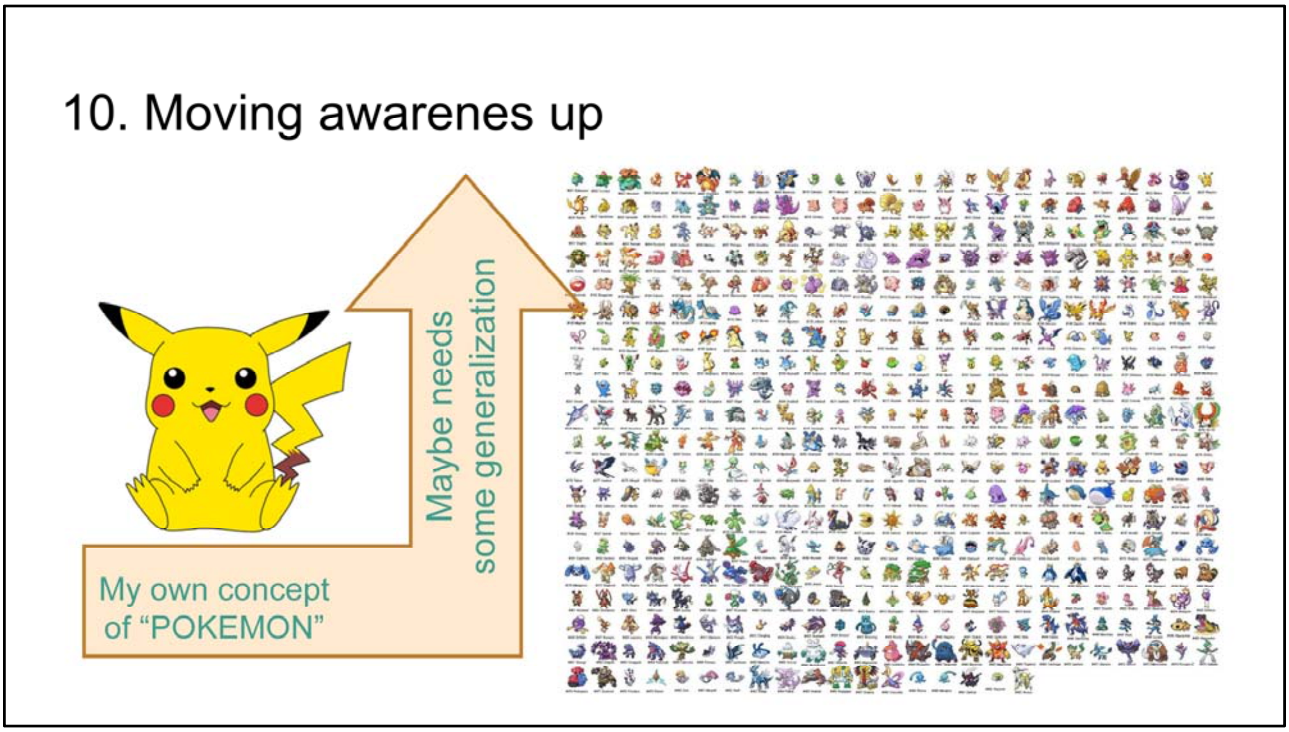
These reflect how our cognitive structure is organized from general to specific and the sequence in which we should teach new content starting with the more general and then progressively distinguishing that, as we go to the more specific. And, this is indeed one of the most important Ausubel’s legacies.



Also ESCM (Expert Skeleton Concept Maps) are an extraordinary tool, as advanced organizers, to help classes to coordinate this top-down movement.

Look up to the left part of this cmap from www.cmappers.net/docs/skeletoncmaps.php

(I don't agree with the bottom right part because not always "completion of a cmap demonstrates increased understanding of root - superordinate concepts)

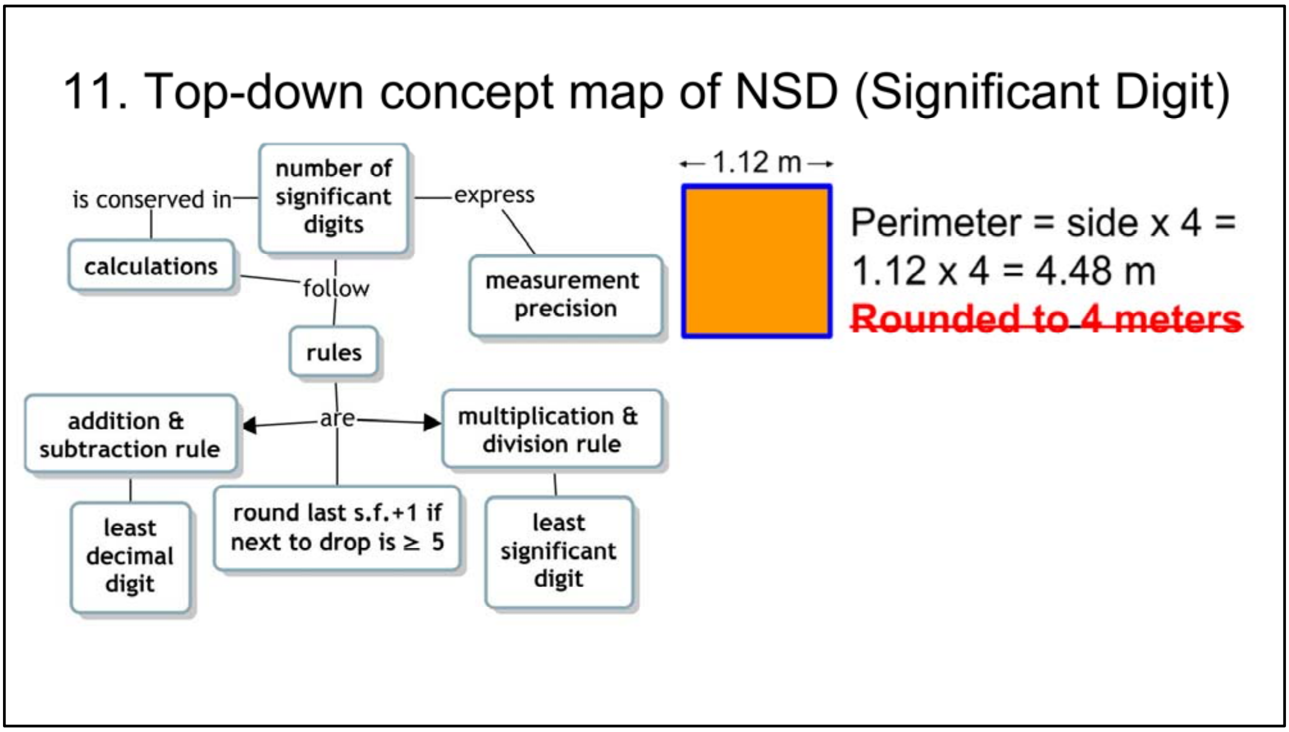


But the structure of knowledge is even more complicated than this

For example, my top-down progression was helped by a good mastery in the general concept of entropy. I had a tight "anchorage" on that, to pick up another term from Ausubel's theory.

So, there can be *distinctions* in which our awareness needs a move in the opposite direction, that is from **bottom-up**.

This is my concept of pokemon. But, a rapid web mining i've done insinuated in me a suspect, that I would like to add some distinction and higher category or superordinate concept about it. Going back to school, the most general - introductory characteristics of a topic are often given for discounted by students and teachers because relevant applications and drill are based on lower level concepts. But, if you bump into unfamiliar cases, the understanding of the rationale could require an enhanced level of awareness in some superordinate concept.

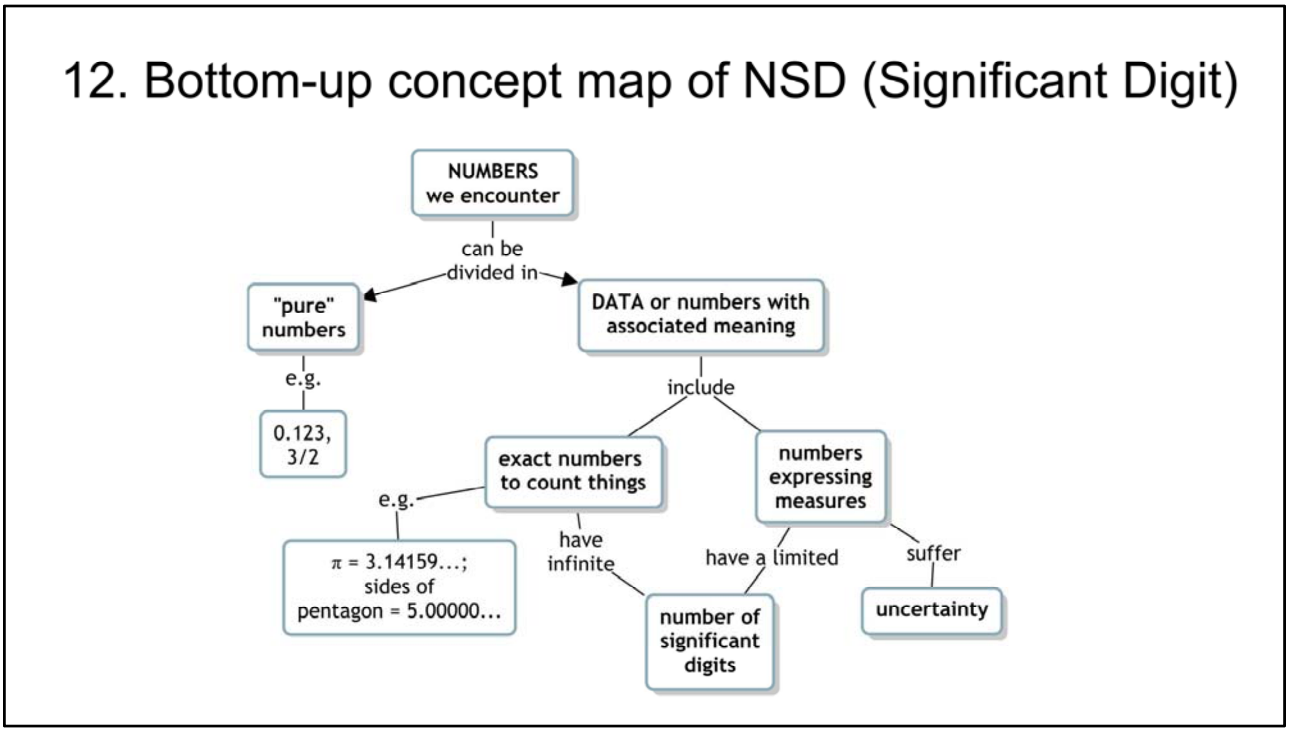


This is a top-down cmap which synthesizes the context of application of rules of calculation with measures. The root concept, as the is given for discounted here.

For example a student applying the least significant digit rule for multiplication, when seeking the perimeter of a square from the lenght of its side, may obtain a wrong result:

This often happens because they haven't got a conceptual grasp of the number of significant digits (NSD). Their level of generalization of this concept is only based on the superficial appearance of the numbers, not upon their meanings: three figures in the first (1.12), one figure in the second (4), the unseen error. The number of figures were not associated to the concepts of information, precision, uncertainty of these data.

Once I was aware of the source of these and similar errors, I constructed and used the following cmap,



a bottom-up cmap to help them differentiating the different kinds of data, while posing several examples in which the mechanical application of textbook rules would have led to possible errors.

This cmap goes from the “number of significant digits” upwards and helps the students to acknowledge that, on the one hand, there are data with infinite precision - with no uncertainty - as the number of sides of a square, and on the other hand, there are data with uncertainty, that are the results of measures.

After testing the class again, I did find indeed that the students’ errors were sensibly reduced.

I can say that this bottom-up concept map was necessary to scaffold the *true concept* of “significant digit” (true in the sense of Vygotsky).

Now, there are two more things to point out about this experience.

13. Two things to point out about NSD experience

1. Full awareness is up to teacher first

2. The generalization through discovery is not effective when students are at the generalization level of *complexes*

… awareness is up to teacher first 2. I attempted a different solution to this problem in the past, even in one of my textbooks. The effectiveness of the practical rule of NSD can be easily demonstrated doing tests with a pocket calculator. By changing just one unit in the last significant figure of one term of the operation, you can see which figures in the result remain the same (these are significant figure) and which ones undergo great changes and, for this reason, they are not significant and we must drop them. BUT this solution based on “discovery” didn’t work. Experimenting why, when and how the rule worked, didn’t help them to get a better grasp of the concept of “**significant**” for the figures. So they **remained tied to the rote application of rules**. This could be explained admitting that **the generalization through discovery is not effective when students are at the generalization level of complexes** . So, in one next experiment, in order to construct a tough concept of “significant digit”, that is the very crucial, limiting concept in this topic, I will try to merge the scaffolding of superordinate concepts *and* the experimental discovery.

14. "Complexity-of-representation-or-simplicity-of-thought" 1/4

*"some high-flying students who clearly have an excellent understanding of a subject (along with some subject experts), have been observed to construct **smaller maps** (that score less) than many of their less expert colleagues who score more simply by including more stuff"*

(Kinchin's Blog 2015)

http://srheblog.com/2015/11/27/complexity-of-representation-or-simplicity-of-thought/

Professor Kinchin reported in his blog:

15. “Complexity-of-representation-or-simplicity-of-thought” 2/4

*“sometimes students **simplify** their understanding as they develop more expert-like thinking“*

(Dowd et. al 2015)

Dowd, J.E., Duncan, T. and Reynolds, J.A. (2015) Concept maps for improved science reasoning and writing: Complexity isn’t everything.
CBE – Life Sciences Education, 14: 1 – 6.

Then, quoting Dowd (2015)

16. “Complexity-of-representation-or-simplicity-of-thought” 3/4

*« I feel this observation is linked to observations of expert teachers who are able to make the most complex information accessible to their students, not by ‘dumbing down’ as some less expert teachers would have us believe, but by **simplifying**. It is not the same thing...*

And, Kinchin again,

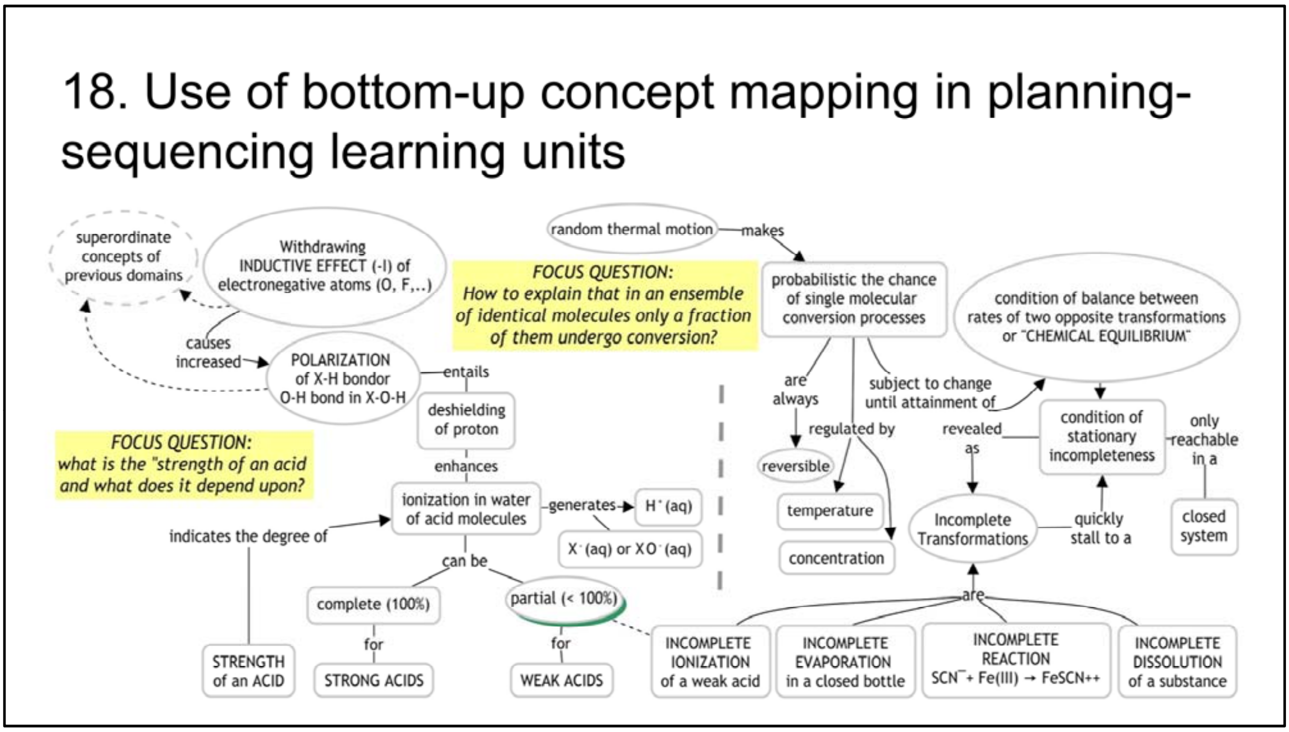
17. “Complexity-of-representation-or-simplicity-of-thought” 4/4

… So when a teacher says, “it’s just too complicated for the students to understand”, this translates as, “I lack the skills to ***simplify it*** *for my students – possibly because I have never thought about it* ***deeply enough*** *to clarify it in my own mind. »*

(Kinchin’s blog, Ibid.)

I agree with Kinchin that to simplify is a necessity to enhance the deeper. But I suspect that the “*high-flying*” students rather have a better ability in self-focusing superordinate concepts, and that they relate these to a wider collection of concrete instances or everyday knowledge, by themselves. Their ability to synthesize would be a consequence of these aptitudes.

What is more important in any case, in concept mapping, downwards or upwards, is to focus on the very most general few concepts and to make these meaningful through concrete examples, study of cases and so on. It is impossible to understand abstract concepts, to construct a mental system of scientific concepts, by just mapping relations among these abstract concepts.

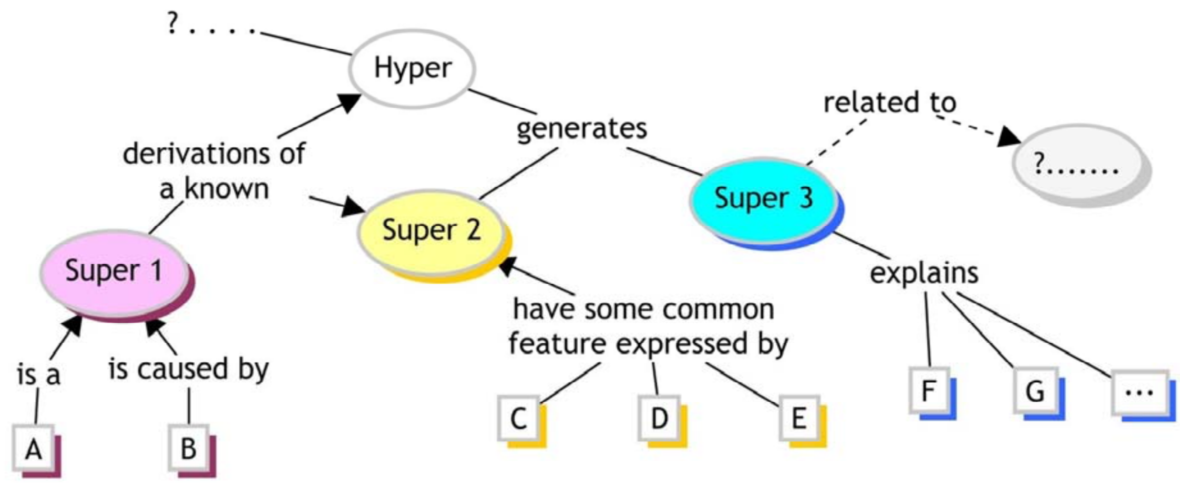


Finally, there is another important situation in which bottom-up concept mapping and the use of the obtained concept maps is useful as an advance organizer: In planning the sequence of learning units, the key concepts of a previous unit can be profitably connected to the new key concepts by means of a superordinate concept.

This merge of two concept maps try to represent the alternative way I tried last year to introduce the concept of dynamical equilibrium from a bottom-up perspective (the generalization to the right), starting from a single known specific instance of incomplete transformation (incomplete ionization of acids, on the left side).

This method also agrees Bruner's spiral or recurrent method, inasmuch the same abstract concept is cyclically treated in connection with more palatable concepts. In other words, dynamic equilibrium in chemistry is superordinate to several chapters of chemistry, then it should be treated several times from a qualitative and bottom-up point of view, before transforming it in a top-down mess of dull quantitative calculations.

19. WRAPPING WORDS UP 1/2

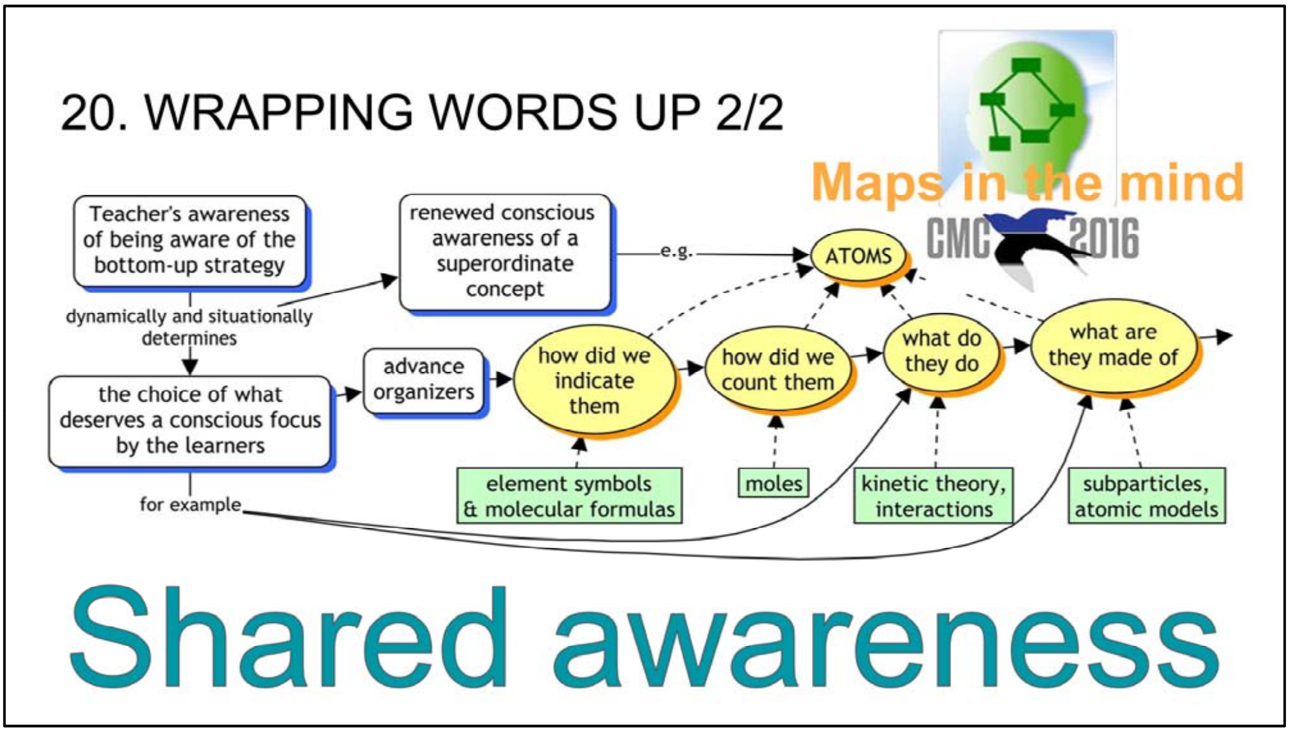


You see here an idea of bottom-up concept mapping. It represents a generalization of several possible upward movements of conscious awareness of a *skilled teacher or expert learner*, that have also been called “superordinate learning” by Ausubel and Novak.

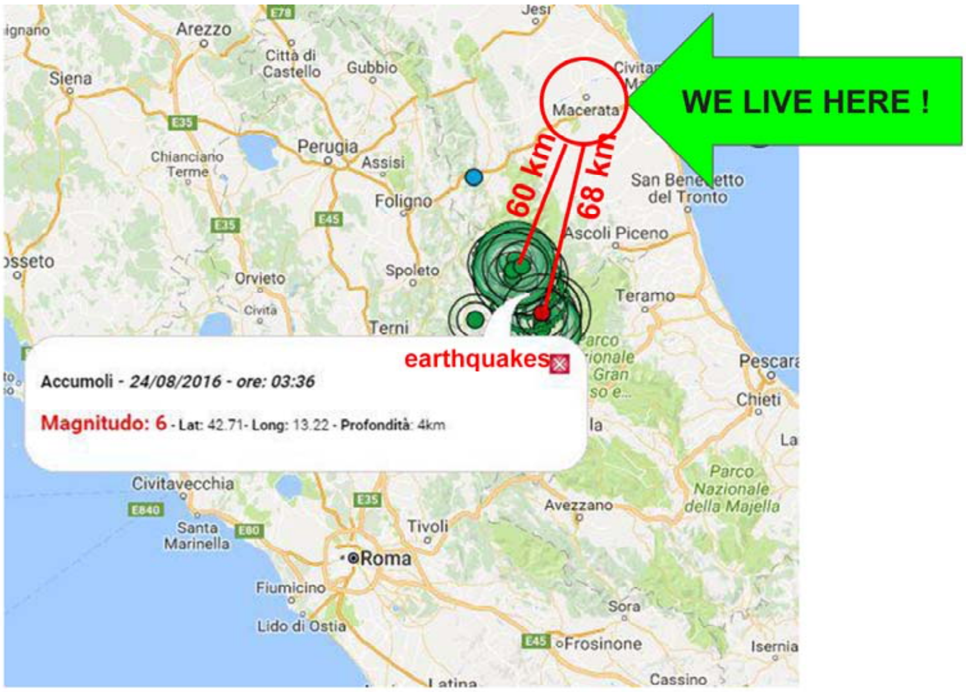
...

But, my aim was to show how much important is to make the mediator aware of this task, in order to be able to transfer their awareness to the majority of “low flying” students and to make their own superordinate learning possible.

The following cmap, for example,



shows how to scaffold a superordinate idea of “atom” by sequencing learning units in the “**shared awareness”** of the bottom-up and dynamic development the “**maps in the mind”** of the beginner learners in chemistry, as for the beginners in *conceptual thinking*.



This latter map of Italy is just to reassure you about what makes me and my family to feel relatively safe with an earthquake in our province.

Thank you for your attention.