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THE LONG WAY TO DEEP UNDERSTANDING

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Abstract. The goal of deep understanding is still considered – in actual educational practices - more as an ideal limit with blurred edges than as a dutiful objective for all secondary school students, especially in scientific education. This achievement, along with decisive governance and professional changes in the educational systems, would be obtainable first by the mediation of linguistic tools (signs, meanings and senses) by their rule-governed use in language – a Vygotskyan development of an individual author's action-research, and the center of this paper - then by the organization of framework, mobilization and use of scientific concepts, and finally – in a psychological, not chronological sense - through diffuse problem-solving activities. In the last three years of teaching experience in Organic Chemistry in a secondary school, within the class context of three different groups of students, different practices of problem solving and writing tasks for mediation of concept change, which could be complementary to concept maps, have been tried out and discussed from the perspective of deep understanding.

1 Introducción

In the last three years, I have tried several approaches to empower meaningful learning and understanding, through in-class and online activities (through wikis and Google docs, linked to www.divini.net/chimica), proposing practices of collaborative problem-solving, trying activities of concept-texting with students aged from 16 to 18 on a three-year course at our Chemistry technical school. These practices have been oriented – from a curricular point of view - to the teaching/learning of Organic Chemistry, a discipline characterized by a) a specific language that is visual and verbal at the same time, b) a high autonomy from other chemical disciplines, c) a strongly deductive and logical constitution, d) a strategic and problem-solving approach, e) strong but indirect bonds to experience mediated by symbols (formulas and reaction mechanisms' schemes) and f) invisible concrete-material body of microscopic objects, molecules and forces, manageable only through logical imagination as is the case with other chemistry subjects.

The individual action-research route had roughly the following development:

In 2007-08 with group A (20 students), at the first of three year course in organic chemistry, being unsatisfied of previous attempts to implement concept mapping in the course, I managed to base the whole course on collaborative problem solving, with stages at home (through shared online documents), in laboratory and in-class.

In 2008-09 group A continued to work as before to the second grade curriculum topics progressing in blocks of questions and problems (both theoretical and experimental, differentiated for the five heterogeneous collaborative groups), with important changes in managing the organization of timing and strategies to maximize the involvement of all, and the sharing of knowledge intra- and inter-group (these changes, however being interesting, go beyond the design of this review). In the same year a new freshman group of ten students ("group B") started to work at blocks of focus or "stimulus" enquiring questions that had to be answered in five lines, writing short propositions with a reduced number of concepts and highlighting the most relevant concepts. This text structure was designed to prepare subsequent concept mapping activity on the related topics; at the same time it was intended as a concept texting task having more expressive freedom than the propositional structure possessed by Cmaps, in the perspective of attempting a subsequent comparison the two kinds of conceptual writing. Also this activity was given a collaborative form, mainly online (included pair and teacher reviewing) for the sake of finalizing home study, and leaving class time for concept mapping and applications of concepts and principles.

In 2009-10 group A, arrived at the third and last year of the course, continued to apply in elaborating whole class-group shared documents (because of the reduced involvement that remained restricted to a few students) about biochemistry topics. The online questionnaire had to be initially completed in collaboration by the whole class, completely autonomously. A reviewing and enhancing contribution by the teacher was given only at the end, to yield a complete guide for studying the topic. The class group B, arrived to the second grade, after a substantially fault to collaborate in the concept texting tasks, and also to get advantages from concept mapping, was driven to a different form of questionnaire for each topic, to be answered individually (personal study diary) with possible contributes of a peer-reviewer. The objective was to give more feedback and to stimulate more changes and insights for each question and for each individual student. For the same reason the questions were more in-depth analyzed also in class discussions.

In this last school year also a new class group "C", formed by 23 students entered in the first course year. During the first school months I observed more closely the ways these freshmen students where elaborating contents, solving problems and taking notes, and I saw their habit to register only the symbolic part of class contents, their habit of writing down sequences of transformations, also imitating other mates or the teacher in doing such actions, but always in such a way that many important words (concept labels) were lacking (orally substituted with "this", "that" etc.), so that the "discourse" of the process was systematically lost. My working hypotheses to explain this phenomena was that the mastery in the use of the new terms and associated lexicon was lacking. From such observations and interpretation I tried (January - April 2010) to put in action a different form of shorter pre-conceptual writing tasks, less demanding for enquiry. This action led also to a profitable strategy and a clearer role for the introduction of concept mapping.

The time is ripe for a first evaluation of the briefly outlined old and new practices which, in these years of experimentation, were aimed to the conquest of aptitudes for autonomous learning and deep understanding.

2 Deep Understanding

There are many ways to attempt a definition of deep understanding (e.g. Wiggins & McTighe, 2005). In any case, there are a few observable indicators that distinguish the aptitudes of a small group of students within the whole population. The distinguishing mark of deep understanding relies on challenging the learning contents.

These efforts to criticize and comprehend invariably produce an autonomous change of initial forms used to represent the object. In this sense, the term "deep" stands more for "distinctly individual" and personalized than for "in-depth". Going along the general exam of deep understanding, D. Perkins in "Teaching for Understanding" (Perkins, 1997), also prefers to define "understanding" more as a «flexible performance capability to think and act flexibly with what one knows», rather than as some kind of an achieved understanding, i.e. a representation or image or a mental model that we have when we say, "I've got it". It is not guaranteed that in-depth study is apt enough to answer probing questions about fundamental, general or initial aspects inherent in a topic to satisfy the strive for understanding. This kind of thought is characterized by a stronger need for knowing "why are things as they are and not otherwise?", an aptitude that is certainly required to answer the following questions that was posed in the last school year:

Ex.1 (group "A", 3rd grade): ATP is a high-energy species, stable in water. It can be hydrolysed only by coupling the reaction with water along with some useful, non-spontaneous reaction. Why does the cell never produce enzymes that would be able to catalyze only the hydrolysis of ATP?

Ex.2 (group "B", 2nd grade): Acyl halides are the strongest acylating substances; so which substance could ever acylate a halogen to yield an acyl halide?

Ex. 3 (group "C" 1st grade): Does butane contain the substance carbon?

True deep understanding doesn't consist in "knowing the right answers" to these questions. Maybe the "right answers" have been given by the instruction process and have been meaningfully learnt by the students. Nevertheless even the most thorough instructional programme is capable of neither eliciting all possible challenging questions about a subject nor transmitting the ability to pose intriguing questions autonomously.

These questions could also be posed and answered without knowing details of the topic; what is demanded is a knowledge of the whole system and of the main relationships among its elements (such as the role of ATP as a chemical energy carrier among catabolism and anabolism in example 1), that is to say a "true" understanding of the main concepts (such as the concepts of chemical substance and element in example 3).

As an attitude towards knowing and knowledge, rather than a body of knowledge, deep understanding should emerge as a spontaneous recognition of critical aspects, resulting from non-accepting thinking, imaginative processes and the exercise of curiosity. In the second question, for example, the application of inquisitive thinking would consist in posing a searching question on how the strongest acylant of the series could be obtained, rather than accepting the information as it is from the textbook.

A critical extension of this line of reasoning is that a concept map, or other instructional tools used to promote knowledge as guides for "tuning" learner conceptions with universal scientific concepts, are unsuitable and premature for the prompting of those questions that challenge knowledge. Processes of deep understanding cannot be so "patient" that they wait for a complete systematization of subject's knowledge before moving into action. Therefore the processes of critical and imaginative thinking should start working from the very beginning of any approach to new contents. As will be discussed in section 4, a better way to match these requirements could be a controlled immersion in a propositional speech of the new language-discipline.

In sum, deep understanding corresponds to an inquisitive attitude towards knowledge, whereas its opposite is the "accepting" attitude, a mind-set that shouldn't be misunderstood for the "learning by rote". The "accepting learner" doesn't learn mechanically (at least not necessarily), but he/she never thinks that it is his/her place to question the material he/she should assimilate. He/she limits him/herself to trialing and adapting previous conceptions (meaningful learning), or simply to constructing new habits and new responses to the new stimuli involving only the new contents (rote learning). In both cases the "acceptative" learner considers him/herself as an empty vase to be filled, in exactly the same way as his/her teachers do.

Striving for "deep understanding for all", on the other hand, requires the creation of an aptitude, if not a philosophy, of deconstructing – reconstructing in every case, independently of the source, but this skill has intellective-developmental requirements. At the end of his research on the development of meaning, Vygotsky quotes Wertheimer's study in talking about productive thinking (Vygotsky, 1986, p. 205):

«Really productive thought is based on "insight", i.e. instant transfiguration of the field of thought. The problem X that is a subject of our thought must be transferred from the structure A within which it was first apprehended to the entirely different context of structure B, in which alone X could be solved. But to transfer an object or thought from structure A to structure B, one must transcend the given structural bonds, and this, as our studies show, requires shifting to a plane of greater generality, to a concept subsuming and governing both A and B»

This "bridging" from A to B is only possible thanks to a corresponding system of relations of generality. In addition, the inquisitive thinking is essential to run all these processes: thanks to it X is "released" from A, i.e. the structural links connecting X and A are made weaker, and this makes other relations searchable in principle. Inquisitive thinking "searches" for alternative options and alternative structures, among which there is "B". To have a chance of relating problem X to a different sub-system B structural mobility is needed, because the conceptual system "B" – in the problem solving process - doesn't arise by strict logic, ready for use.

Inquisitive thinking, since it is flexible and generative, doesn't demand a forcibly distrustful and suspicious attitude towards information sources. It is, instead, the simple consequence of the authentic and unrestricted exercise of curiosity, in the deepest sense that Dewey referred to the "desire for fullness of experience" (Dewey, 1997, pp. 30-34), as a sort of inward need of harmonization and acquaintance with experience.

Many, if not all, of these habits are a consequence of the systematic development of curiosity, understood as the finest gift of a scientist – researcher. Curiosity empowers the students to tolerate and handle long and rigorous chains of causes and effects that are often necessary to relate two phenomena (such as to link a structural characteristic of a chemical compound to the acidic strength or solubility of the corresponding substance), instead of shortcutting the concept chain on the basis of non-significant associations.

Problem solving furnishes practical contexts where to apply, is a source of curiosity and of concept changing-mobilizing through discoveries of critical issues in knowledge (Thagard 2002, Jonassen 2006), concatenations of causal relations among concepts; the ideal "gym" to develop deep understanding aptitudes.

3 Problem Solving

The desire to achieve these gifts encouraged the extensive "forcing" of collaborative problem- solving in group "A", (see the Introduction). From this experience these conclusions have been drawn.

1. Only a few students felt themselves as competent to manipulate the material and to gather the necessary information, while tackling problems; most of them appeared to act as "secondary beneficiaries" of the resolution process and strategies, or they behaved as mere external or passive observers;
2. Even in circumstances where groups solved the problems autonomously, the process didn't activate metacognition. Students didn't show a clear awareness of having changed their perspective, of having radically changed the formulation of the problem so as to grasp its real nature, of having recognized new relations and concepts, of having discarded unsuccessful strategies. Rather, everything was done and perceived along a linear route leading directly from the premises to the solution, as if they were repeating an already known procedure;
3. Nevertheless, there were some students who were more inquisitive about knowledge by the final grade. That was good, but not enough, because too many learners remained nearly unchanged.

The first point, in the light of Vygotsky's model of development of conceptual thought, can be interpreted as admitting absence of a system of relations of generality (Vygotsky, 1986, p. 205), at least for those students that was called "secondary beneficiaries". For these students knowledge resulted mainly declarative and unsuitable for productive thinking, as to say that the task, also with adult collaboration, was too much demanding, out of the zones of proximal development (Vygotsky, 1986, p.194-5).

The second point, on the other hand, could suggest that even those students who were capable of meaningful learning, and who had developed a systematic framework of scientific concepts, didn't construct habits of enquiry (for problem solving as well as for verbal thinking), as a result of repeated problem solving activities, because this practice was perceived by them as foreign to their role as students, to their styles and aims of learning. This means, in our educational system, the waste of much unused potential in many students.

The action-research operative response was to prepare both – and simultaneously – the conditions for practicing problem posing-solving and a different distribution of the problematic approach to knowledge as a continuous and more affordable - but not exclusive - practice. By systematically disseminating many simple problems, to be solved individually or with the help of the teacher, from the very beginning of the study of the discipline, it could be enough to avoid both nurturing inert knowledge and confirming the standpoint of students who consider themselves as content reproducers. At the same time I argued that problem solving and cognitive conflict are not always enough to prime conceptual change because, as maintained by Jonassen (2006), they need to be mediated by some knowledge-building activities, as outlined in the following section.

4 Concept Texting - Mapping

So that instances of learned knowledge can be effective enough to solve problems, each concept has to be "conceived" as a set of logical and meaningful connections with other concepts: superordinated, subordinated and coordinated, and objects of individual, concrete experience, as part of a system of meanings, rather than as a word that can be remembered only within a sequence of words, as could be a definition learnt by rote. This is what Vygotsky considers as a well developed scientific concept. But this cannot be attained by direct teaching (Vygotsky, 1986, p. 150). On the other hand Vygotsky (1986, p. 192) was aware that «Not even separate concepts as such could exist; their very nature presupposes a system [of meanings]», and consequently: «In the acquisition of scientific concepts the system must be built simultaneously with their development.» For organic chemistry it could be added, among the structures to be built simultaneously, a body of concrete experience with material stuff (substances) and "pseudo-concrete" experience with invisible objects (atoms and molecules), and their symbols (e.g. formulas). In fact this equipment should substitute the tacit apprehension (spontaneous concepts) on everyday life objects which in Vygotsky's theory constitutes an important resource to the "upward way" to scientific concepts[1] .

Under these theoretical and factual pre-conditions, standing the evidences of difficulty to effective use of concept mapping gained from past experiences, resolute in the tenet that not only conceptual thinking is necessary to solve problems, but also, by converse, that real cases and problems are the best pregnancy and cradle of concepts (in opposition to proposals exclusively based on “verbalisms”), in 2008-2009 – I started to assign enquiring focus questions to be answered - in shared online docs - with short texts (e.g. five lines) by groups of three students. As already pointed out in the Introduction, these assignments were somewhat similar to Cmaps for the propositional structure, limited number and highlighting of concepts in every proposition, and focusing of the knowledge domain upon the question. This writing task, being characterized by higher expressive freedom compared to inexperienced concept mapping, was expected to prepare students to true concept mapping activity. The following is one of the first examples, how it resulted after several hints and changes by peer and teacher reviewing:

Focus Question: What are the characteristics of carbon that allow it to form so many compounds?
Answer + revision (italics): Carbon is a notable element for several reasons. ~~Its different forms include one of the softer (graphite) and one of the harder (diamond) known substances.~~
Deleted because the focus implies a discussion based on the (following) atomic - electronic properties of carbon atoms, not on the physical properties of the substances.
Moreover, carbon has a high affinity for making chemical bonds with other light atoms, including carbon itself, thanks to its small dimensions and tetravalence, arising from the four external electrons that allow it to form strong single or multiple bonds (a property that is called “desmalusogenia” it’s the first time I see this word!!!), always reaching a stable octet. Silicon has this property in a very reduced form, because its atoms are larger and the Si-Si bonds are weaker. These properties allow the existence of over ten million carbon compounds.
(Underlined words or groups of words were identified by the students group as concepts, after several revisions.)

Similar concept texting questions were assigned to focus on a) relevant points about the topic to be studied (as in the example), b) specific critical aspects, c) issues to be solved, or d) a hint to further investigation into a topic. The information base materials were the textbook, assigned reading, websites or free research.

The resulting answers (as home assignments) to these questions was often a mixture of text sequences duplicated from the Internet (as happened in the example) or from the textbook, going frequently out of focus; when the sentences were authentically produced by a student, they often needed radical revision or, at any rate, recasting. Even if were given hints or precise reasons for their errors, students were often unable to cope with the assignments by themselves. Once completed, after several revisions with students’ contributions, the texts were flimsy recognized as correct, *but rarely the students were observed in making use of meanings that corresponded to the content of the texts*. At the beginning of this trial about the possible employments of similar

writing compositions, I was believing that a sort of straight passage, from the concepts and propositions of the edited answers to a concept map setting, could be possible. But the first results were disappointing: Cmaps weren’t influenced by the text formulated by the same students. Singling out of proper concepts from the text resulted a hard task for the students and, above all, useless for the following concept mapping activity. Provided that students hadn’t enough familiarity with concept maps and most of the focus questions were actually more specific than the one in the example, concept mapping session about the general topic was postponed after the completion of the textual applications on the same topic. But, once more, the results were unsatisfying.

These findings could be interpreted thanks to a model of meaning change of scientific concepts based on Vygotsky’s theory (Vygotsky, 1986, chapter VI, p. 197). Thought processing of new information and ideas (primary product) produces utterances that can be captured as sentences in written language or possibly communicated orally in class (secondary product) - and this increases awareness even if the learner has yet little or no control of the concepts involved. Eventually, the sentences (in verbal thought and in written speech) can be elaborated, changed and combined, repeatedly reformulated in different contexts under adult expert collaboration and control, to attain enough consciousness to be able to autonomously produce acceptable propositions (tertiary product). This three-step process form just the first stage in the “race” to consciousness and control of meaning. Without control it would be very hard to seek a flexible conceptual organization as in a concept maps (quaternary products). Now, in the light of this route of scientific concepts development, we conclude that most often the learners stopped at the first stage (strictly individual) of arbitrarily transforming thought into a textual production, without any reinforce from the social context. We shouldn’t be surprised if concepts and conceptual organization didn’t emerge from this spontaneous written language,

[1]The building up of this latter should be indeed a well rooted task in the first period of secondary school science education, but actually the majority of older students cannot rely on it.

nor if the words in it weren't applied properly in concept maps. Finished text compositions were not at all representative of the actual level of understanding of the students. Moreover, in December 2009, by close observation of the results of a class-work in class "C", I was triggered to realize the phenomena of "lacking words" (see Introduction) in all interpersonal students' explanations-communications as for oral reports and written class notes.

These points became clearer and clearer as I went through the experiments until, finally, I decided that textual assignments should have been given a different format and scope, more focussed on speech facilitation[2] . These tasks can be accomplished by describing a known transformation, a molecular structure or its properties, or by decoding some symbolic information into words and vice versa[3] .

Here follow some examples of speech facilitation assignments:

1. Write a sentence that explains how ammonia can be transformed into ammonium ions, using these terms: proton, conjugated acid.

2. Describe what happens in this transformation, using appropriate terminology

3. Hydrogen bromide protonates 1,3-butadiene in its C1 carbon, generating a secondary carbocation. Write down a complete scheme for this transformation.

4. Describe in detail the mechanism of aspirin synthesis from salicylic acid and - as an acylant – acetyl chloride instead of acetic anhydride.

5. Describe in detail the arrow-movements of electron couples that lead the base structure of imidazole to other resonance limit structures.

Writing and reading in class, decoding symbols and encoding words in symbols, imply that objects are labelled and rehearsed by their words, a bottom-up task that gradually transforms these words into precise meanings. Problem solving implies a very different task, somewhat reversed: from a generalisation of the problem (bottom-up) to the selection of necessary meanings or concepts (top-down). The awareness that a concept is necessary to deal with a problem, always expands its meaning and makes it more accurate. Hence some queries are not purely linguistic, as in the following examples which contain a simple problem in addition to the textual assignment (anyway, problem requests are easily distinguishable from textual demands):

6. An unsaturated hydrocarbon C4H6 doesn't react with sodium amide. But, when it reacts with hydrogen and Lindlar catalyst it yields an alkene. Describe with words and schematize the reaction occurring to the hydrocarbon with dihydrogen.

7. An enole having four carbon atoms transforms spontaneously into an aldehyde. Find a possible enol structure and describe the transformation only by means of words.

This kind of speech facilitation work strategy was applied intensively, both orally and by writing, in the period January-April 2010, in class and in personal online portfolios called "Student's knowledge building yard" shared documents, especially in group C (see introduction), where the results were more encouraging, in terms of problem solving skill and conceptual mastery in independent assessments trials, for those students who applied significantly. The purpose of these activity is to permit a sort of jargon's learning by imitation, with a progressive increase of

[2] Also the correct way to pass from concept texting to concept mapping gained a new planning, as we'll see at the end of this paragraph.

[3] The latter is a particularly relevant work, because students are prone to manipulate, to add or to transform symbols, without associating them with the respective words, thus binding their usage to experience and appearance only. Even if their symbolic "mute" manipulations can be viewed as logical (by the students and the teacher), they don't make any sense of them. This hinders any chance of making any generalizations and of exporting the related concepts raising from the immediate experience. The success that students sometimes report, thanks to these rote manipulations (this would be a consequence of assessments that verify mechanical ability to reproduce actions and contents), ultimately takes them further away from verbal and conceptual thought.

consciousness until the students will be able to act autonomously. An intention for the future is to introduce similar written speech activities where disciplinary jargon will be analogously played to set up reasoning clusters by imitation (explaining instead of just describing).

However, first of progressing with other developments, it is important to pause on a further important aspect that theoretically supports the speech facilitation strategy for knowledge building.

When Vygotsky (1986, p.197) tell us that single concepts couldn't exist if not being part of a system of meanings, he refers only to the upward way to scientific concepts. But there is indeed another reason that is clearly pointed out by Jonassen (2006)[4] and that, on the other hand, is perfectly compatible with the distinction among "meaning", and "sense" outlined by Vygotsky in the transition from external to inner speech (Vygotsky, 1986, Thought and Word, pp. 244-5)[5] :

«The sense of a word […], is the sum of all the psychological events aroused in our consciousness by the word… Meaning is only one of the zones of sense, the most stable and precise zone. A word acquires its sense from the context in which it appears; in different contexts, it changes its sense. Meaning remains stable throughout the change of sense.»

This quote confirms that the system of concepts and its stable relations among meanings (as could be a concept map or a glossary) would never be sufficient to recreate the body of tacit consciousness that give us a grasp on the real world; and suggests that a rich assortment of different contexts, where to "play" pattern of words, concepts-in-use (Jonassen, 2006) from the "speakers dictionary" - in the speech facilitation task - should be the privileged route to interiorize those not-writable rules of the language game (Wittgensten, quoted in Jonassen).

These issues, by the way, support the idea that the processes of meaningful learning of an almost completely abstract subjects (as organic chemistry) sums up the developments of mother language, mainly by immersion, and of a second language, provided that upward shift of meaning (as subsuming cases into grammar or conversation rules) and downward formation of tacit sense (e.g. getting used to idiomatic phrases and contextual-colloquial expressions) are both strictly needful.

Another recently experimented writing task (in group C) was summary composition. From the first results I realized that this task could be more useful if assigned (in the quick form) as soon as a certain topic or sub-topic was outlined, rather than at the end of its course. In fact such summaries permitted also to observe inclusive concepts' organization, when these structures were still fluid and it was possible to set out a correction.

Students had between 15 minutes (to prepare the discussion in fifty-minute's classes) and half an hour (as part of final classworks including exercises and problems too) to write down a detailed and complete essay about a particular segment of study. Texts about a class of reactions, in the half an hour summary, were between 100 and 500 words with 20-40 words per sentence (the highest number of words was used to explain reaction mechanisms). I derived concept maps from some representative students' texts (those texts with the higher variety of frequent errors, or with interesting and original organization), with the dual purpose of introducing concept maps and discussing students' work (see e.g. Figure1). I was surprised by how was easy to converted the students' text compositions into Cmaps, without loss of detail, but with a neat simplification in text structure, making the conceptual organization clearer, effective and useful to discuss the most common errors. Many compositions showed relevant faults in the organization of superordinate, top level concepts. These errors were very recurrent, even though they obviously weren't in the Cmaps that I had previously prepared and presented as preliminary guides or as surveys for final topic synthesis. This kind of error in categorization showed that a prolonged focus by students on a specific sub-topic improved the understanding of that topic, but, at the same time, altered the understanding of the sub-topic's role in the general structure. From the written compositions other misconceptions and gaps also emerged.

[4] Jonassen reports from Wittgenstein: «concepts become meaningful in their rule-governed use in language. The rules that govern their uses are called language games, which govern the acceptable uses of words.»

[5] See also Vygotsky's concepts of "first child's word as a whole sentence meaning" (1986, p. 219), "tendency toward predication of inner speech" (p. 236, p. 243), "agglutination of words in a sense" or "influx of sense as flowing of sense from a word into another" (ibid., p. 246).

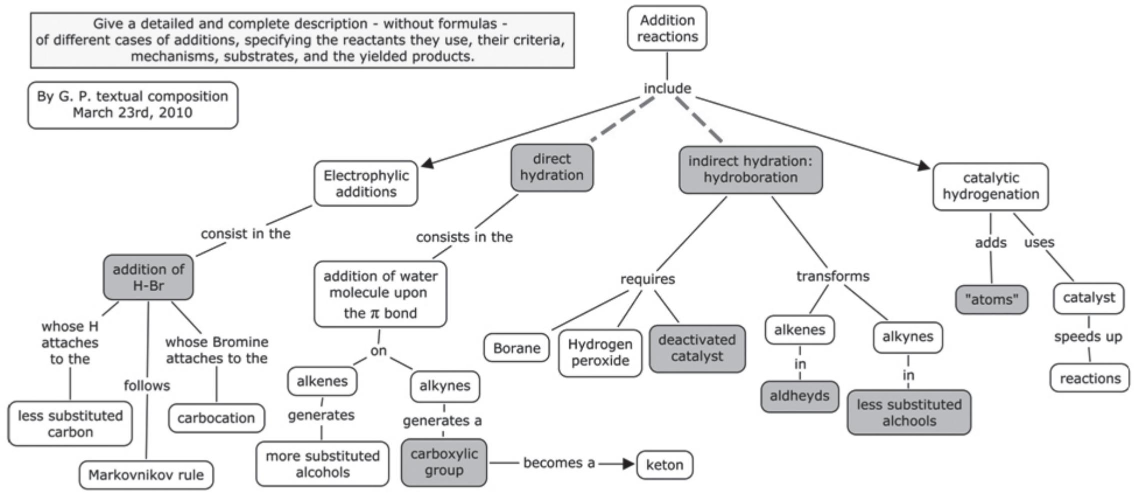

Figure 1. The text by G.P. transformed in Cmap. Two types of hydration reactions (sub-types of Electrophylic additions, dashed connection lines) have been considered as having the same rank (i.e. of a different nature) of Electrophylic additions, besides a series of errors (in gray)

Written texts presented a higher rate of complexity and revision which could not have been matched by rigidly connected Cmap structures even in longer class time (the expert cmapper is actually the one who is able to revise the blocks in a Cmap substantially and quickly, with the help of suitable software). Nevertheless, I decided that moving towards concept maps had been important because:

1. Skilfully constructing Cmaps (taking a comparable amount of time to that for textual composition) would enhance self-criticism and metacognition.
2. The opportunities for comparison and sharing of ideas enhance inter- and intra-group criticism, while paper textual summary essays provided less scope for interaction, especially during their construction.
3. In concept mapping the organization task is more relevant than in writing short-medium length texts. Students pay more attention to the organization of the most inclusive levels of a Cmap than they do in a normal text, avoiding the observed “unbalancing” effect[6].

Moreover, I foreseen a possible strategy to carry students to become concept mappers along these three stages (already applied up to the begining of the second stage, in group “C”, until the school year term):

First stage. Once a short text composition has been worked out by the students, some of their most representative texts are transformed into Cmaps by the teacher in front of the class. The teacher express first the fundamental criteria for concept mapping, as the students engage with the vision of the growing Cmap and of the original text written by their peers, side by side. As soon as the Cmap has been completed, the teacher will open a critical session about the meanings that are implied by the Cmap. Apart from the obvious conceptual task, this approach will help the students to identify themselves as Cmappers and begin to prepare them for the imitation of criteria for good concept mapping (see, for example, Figure 2).

Second stage. The students write down a very short text composition on a simple topic (10-15 minutes) and then encode it as Cmap. In this case they may be free to make changes, provided these will be highlighted in the Cmap. Then, the teacher will open a critical discussion as in the 1st stage, based only on the Cmaps, and will leave the checking of the agreement between text and Cmaps to later. This will give the opportunity for meta-cognition involved in the transformation of text to a Cmap in a subsequent class. This experience should be repeated until every student is able to faithfully transform a text into a Cmap.

Third Stage. Students write their “essay” straightaway in the form of a Cmap. Some of the students’ Cmaps un-

[6]Moreover, the scaffolding structure of general concepts can be easily transferred in “daughter” Cmaps about different sub-topics, while understanding of the main structure should remain stable even if those sub-topics will be slowly developed and/or enhanced in time.

dergo oral verbalization (without criticism), and then a "mean quality" Cmap is chosen to be revised and optimized collaboratively by the whole class. Every student should decode that common Cmap as a text and add the personalized essay-text to his/her portfolio. This final stage could remain as a consolidated habit in the development of the conclusive part of every topic (e.g. weekly). The task of selecting a mean Cmap to revise collaboratively could be assigned to different cooperative groups, offering a further possibility of comparison and discussion of the group-Cmaps.

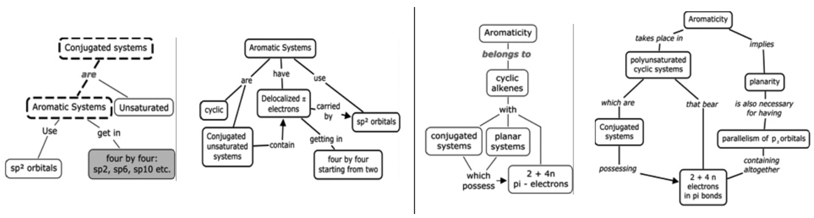

Figure 2. Examples of first stage development in passing from concept texting to concept mapping (April, 2010). First and third are Cmaps converted from students' texts (by L.F. and V.V.) answering the question: "Which criteria should be satisfied by a hydrocarbon to be an aromatic one, and which properties will be distinctive of it?" Second and fourth Cmaps are as they appeared after critical discussion in class

5 Conclusions

A lot of work needs yet to be done in order to understand how to improve true concept changing, i.e. how to make those changes that result from critical discussion in the class socio-cultural context (as the changes shown in Fig. 2), correspond to true metacognition and to actual changes of the structure of meaning, at least for the students more directly engaged in the discussion.

A recent research of Hilbert and Renkl (2008) has indicated that worst learner «had significantly worse verbal abilities than learners in the cluster with the best learning outcome», confirming that the "concept texting" tasks outlined in the previous paragraph, but also a generalised improved methodology in relating learning to written verbal language in all disciplines (even in mathematics!) are a pre-condition for successful application in concept mapping and for its effectiveness as a tool for learning mediation. The preference for written text in the initial speech mediation is also grounded in Vygotsky's research (1986, pp.180-182):

«Written speech is considerably more conscious, and it is produced more deliberately than oral speech... Even its minimal development requires a high level of abstraction… Written language compels the child to act in a more intellectual way»

The mastery of meanings and senses of a disciplinary speech and lexicon is, in turn, an evident precondition for successful problem solving and any kind of productive thought, as the ones entailed in deep understanding. So we can agree to a golden rule for linguistic facilitation as:

If you want your students to assimilate a new concept, assure yourself that they have first faced a sound written speech task about the group of related concepts.

6 Acknowledgments

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