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THIRD INTERNATIONAL SEMINAR ON MISCONCEPTIONS AND EDUCATIONAL STRATEGIES IN SCIENCE AND MATHEMATICS

Department of Education, Cornell University, August 1-4 1993

Plenary Sessions on Metacognitive Learning and Related Topics

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On C-maps, V-diagrams, conceptual change, and meaningful learning.

The focus of my comments is on some misuses of concept maps (C-maps) and Vee diagrams (V-diagrams or V-maps) as metacognitive tools and on the importance of recognizing the need for meaningful learning to change conceptions. By doing this, I hope to address, at least indirectly, the main questions suggested for these plenary sessions, namely : 1) What are the key problems and issues relevant to metacognition? , 2) What are major research findings that serve as foundation for improvement of metacognition? , and 3) What are promising directions for future research and application of knowledge?

The assumptions subjacent to these comments are :

* Meaningful learning underlies the constructive integration of thinking, feeling, and acting, as put by Novak and Gowin (1977, 1981, 1993) in their theories of education.

* Metacognition -- learning about learning -- facilitates meaningful learning.

* Meaningful learning is required for conceptual change.

These assumptions, in turn, are based on research findings, reported in the specialized literature, which I summarize as :

- Previous knowledge seems to be, indeed, the most important single factor influencing learning, as proposed by Ausubel and Novak (1978). A large amount of research findings on misconceptions support this claim.

- C-maps and V-diagrams are now being successfully used at all levels of instruction and in most subject matters. Several research findings, including some being presented in this seminar, suggest that these metacognitive tools facilitate learning.

- So far, conceptual change strategies based on the model proposed by Posner et al. (1982) and/or on cognitive conflict have failed to promote significant effects. After a decade of experimenting with this kind of approach, we are still idling in this respect.

In my view one key issue in metacognition is the development of metacognitive tools and strategies, that is, tools and strategies that help learners to learn about learning and about knowledge construction. Fortunately, C-maps and V-diagrams have been developed (Novak and Gowin, 1984). They are not enough, but they have a good potential to promote metacognition and to facilitate meaningful learning. However, in some cases, these instruments are being either misused or being used in such a way that their potential as metacognitive tools is not explored.

My criticisms regarding what I see as misuses of C and V-maps are as follows.

On the use of C-maps.

Umbrelalike C-maps such as the one sketched in Figure 1 are almost synoptic charts of concepts. Synoptic charts are useful for displaying a whole and its parts for instructional purposes, but they can hardly be considered an instructional innovation or a metacognitive tool.

This kind of C-map is fairly common. It is also common to hear people saying that they have used C-maps well before knowing about them. In fact, they have used synoptic charts and this previous knowledge served as anchoring idea to assign meanings to C-maps in such a way that they were

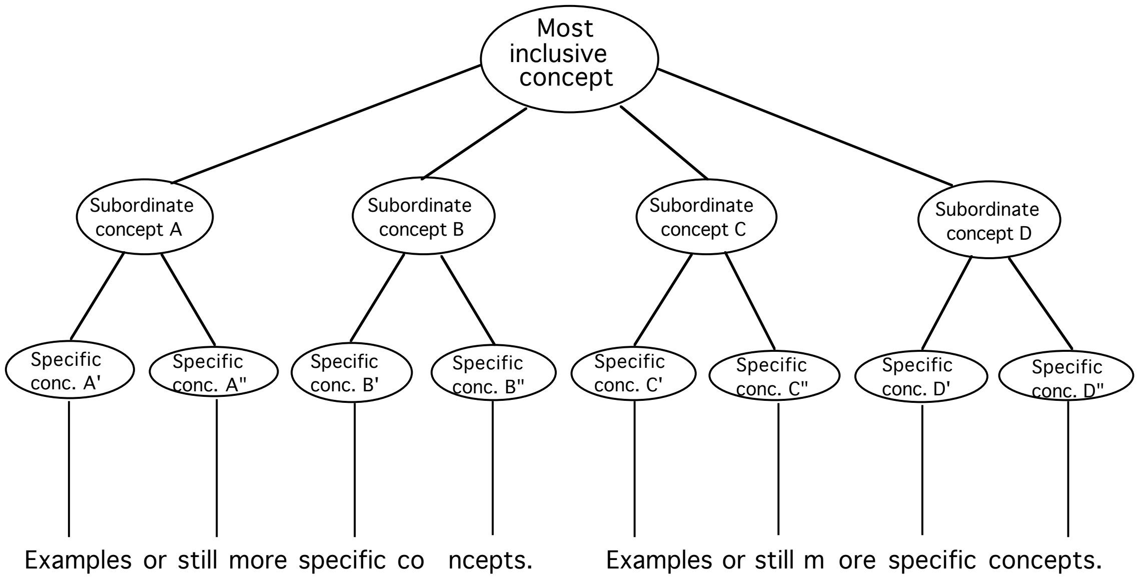

Figure 1. A schematic view of a C-map as a conceptual synoptic chart.

interpreted as just another type of synoptic chart (a case of derivative subsumption !).

I have used this kind of C-maps many times (e.g., Moreira 1978, 1990), but I am now critic of them. They are just classificatory schemes which tend to emphasize poor downwards relationships among concepts, overlooking important horizontal relationships and other cross linkages which are crucial for integrative reconciliation and superordinate meaningful learning. These C-maps are too reductionist. The conceptual relationships and the conceptual structure of a body of knowledge are much more complex than what we can get in a synoptic chartlike C-map.

Vertical relationships such as "is", "can be", "depends", "has", which are commonly used in this kind of map are extremely poor to represent the relationship between a pair of concepts. For example, if we use the connective "is" to relate "sky" and "blue" we form the propositon "sky is blue", which could be considered OK in a C-map but says nothing about the relationship between the sky and its blueness. In physics, this relationship would be better represented by "light scattering", which, in turn, involves the concepts of "light" and "scattering".

Another misinterpretation of C-maps is seeing or constructing them as flow charts. Some people tend to use plenty of arrows in their C-maps in such a way that one can "read" each branch that appears in the maps. Using the same example as above, we would find a C-map branch such as the one sketched in Figure 2. The branch is fine, but do we need C-maps to represent this propositional sequence of concepts?

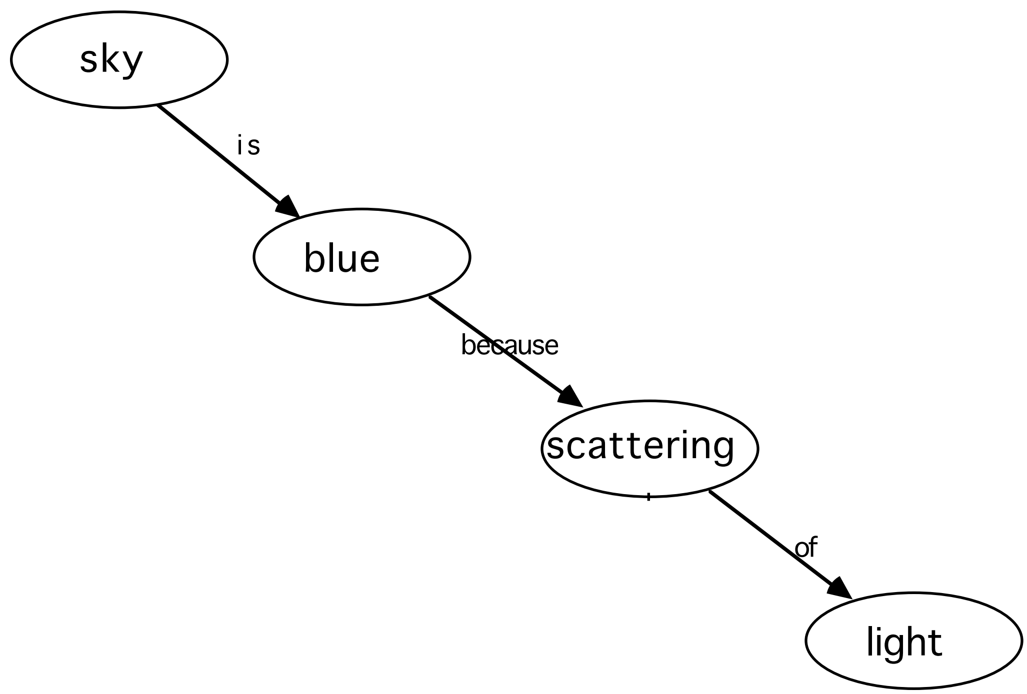

Figure 2. A fictious bra nch of a flow chartlike C- map.

When doing a C-map of a research paper, for example, some people try to draw it in such a way that the paper can be read in the map. That is, the C-map looks like a schematic view of the paper, full of preferred directions. This is a distortion of the idea of C-map and a waste of its potential for meaningful learning. C-maps are useful for unveiling the conceptual structure of a paper, which is usually hidden and has nothing to do with a flow chart: concepts are not steps in a sequence of operations.

By the same token, I would say that C-maps are not organizational schemes: concepts do not have well defined hierarchical positions and their relationships are not power relationships. Conceptual hierarchies are contextual: a key concept in one context might be a secondary concept in another one.

C-maps are great for negotiating meanings, for exploring the complex conceptual relationships and for learning about learning. However, if we are satisfied with nice looking maps which are nothing else than conceptual synoptic charts, flow charts or organizatinal schemes, emphasizing poor conceptual relationships, preferred conceptual sequences or sharp conceptual hierarchies, we might be wasting all the potentiality of C-mapping for meaningful learning. As a matter of fact, we might be fostering rote learning.

Let's not fall in the trap of nice looking C-maps drawn by college professors or by second or third graders, which are just classificatory schemes or schemes that replace prose.

On the use V-diagrams.

V-diagrams were designed to help students identify the components of knowledge, that is, the structure of knowledge. The underlying idea is that since knowledge is not discovered, but is constructed by people, it has a structure that can be analysed (Gowin, 1981). By understanding how knowledge is constructed, learners may become aware of their own construction. In this sense, V-diagrams are metacognitve tools as well.

Like C-maps, V-diagrams were first used in the mid-seventies with Cornell graduate students, but are now being used in all levels of instruction and in most subject matters. The original V-diagram, as proposed, by Gowin (1981), looks like the one presented in Figure 3.

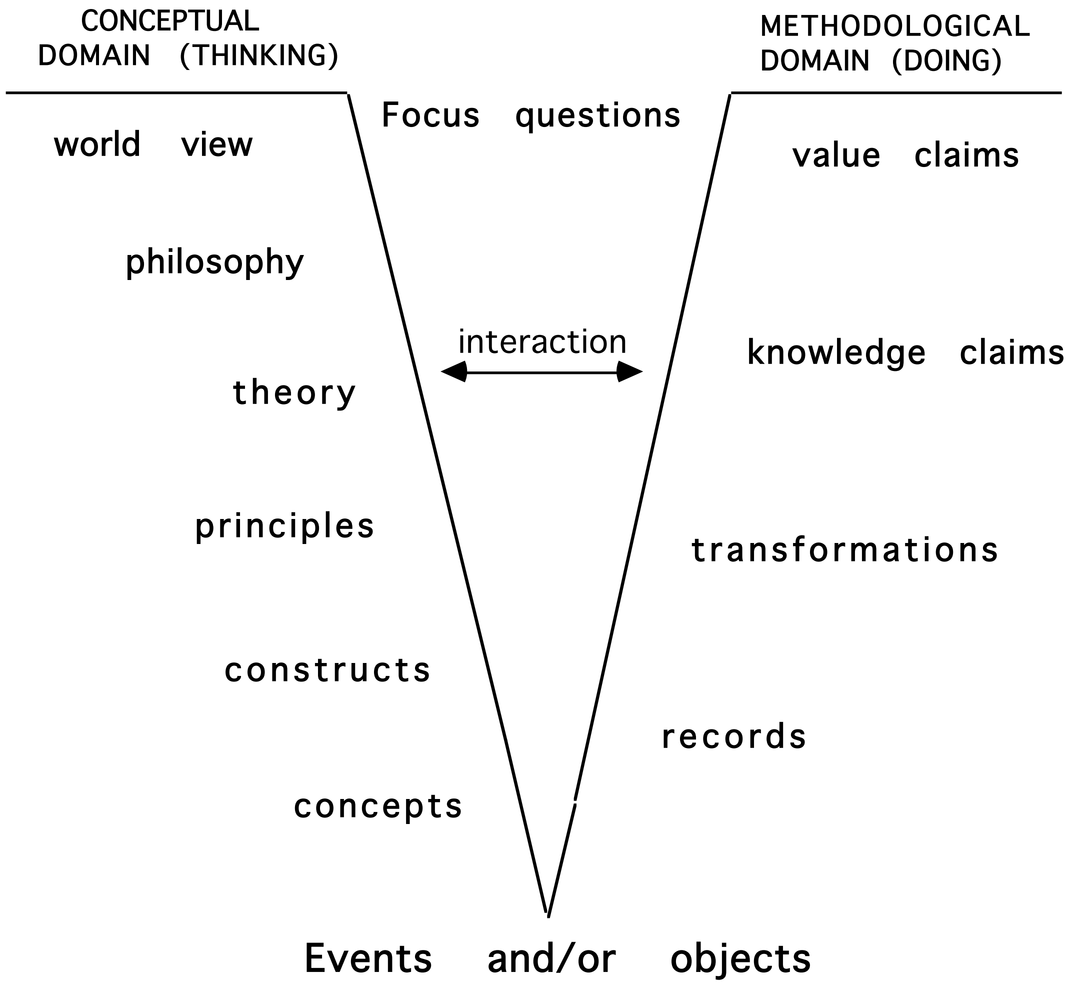

Figure 3. Gowin's original V- diagram.

Still more schematically, V-diagrams may be sketched as in Figure 4.

However, many teachers and students are interpreting and using the Vee as a questionnaire to be filled, such as the one represented in Figure 5. This view trivializes the Vee and misses its main points: the interaction of thinking and doing in knowledge construction and its convergence on events and/or objects about which research questions are formulated. By missing the permanent interaction between the left and right sides of the Vee, teachers and students tend to interpret the right side as a sequence of steps which ends up in some discovery. That is, they might see the right side as the

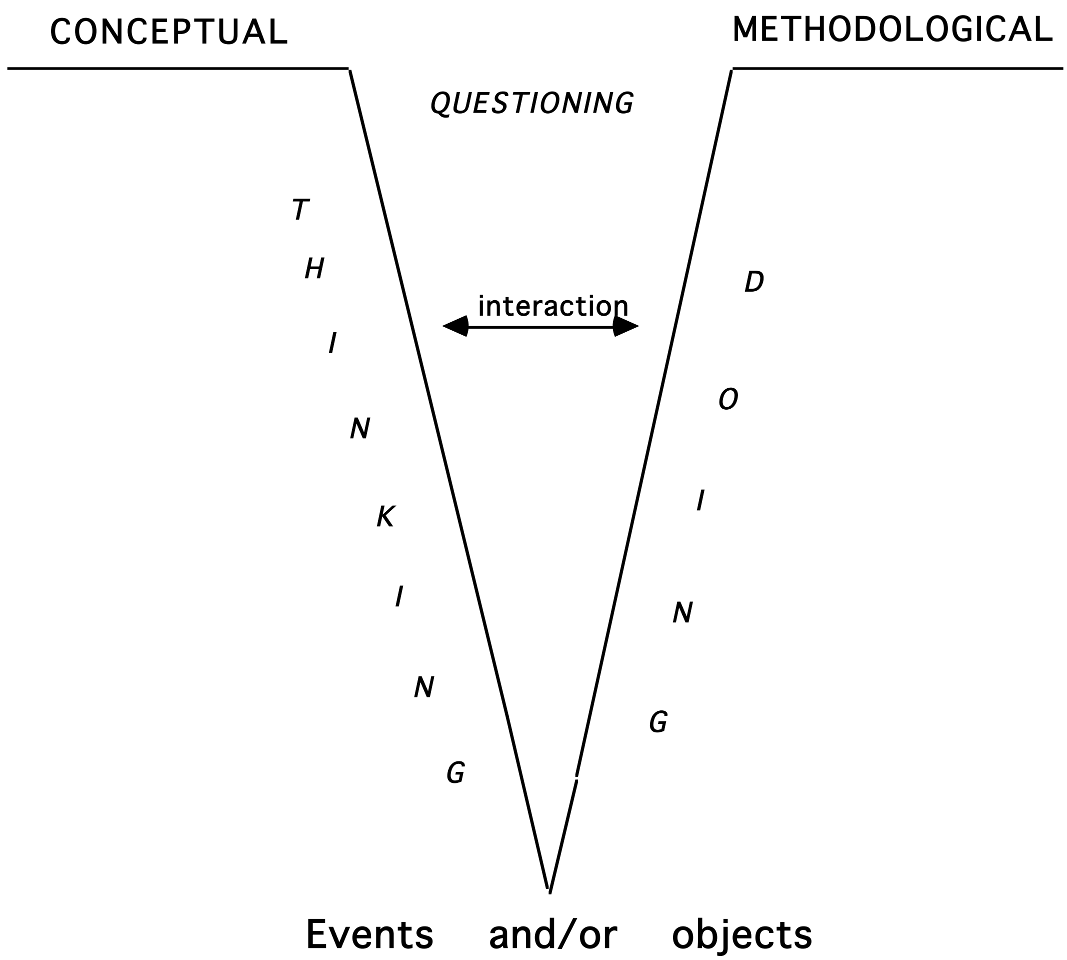

Figure 4. A more schematic view o f Gowin's Vee.

empirical-deductive view of the scientific method. This view is highly criticized today , on epistemological grounds, and should not be stressed in instruction. Probably, we are dealing again with a case of derivative subsumption: the scientific method as theory-independent inductivist recipe is a well established meaning for knowledge production in the cognitive structures of many teachers and students; naturally, they tend to assign a quite similar meaning to the right side of the Vee, ignoring the interaction with the right side. In addition, unfortunately, the diagramatic disposition of the left side, going up from records to knowledge and value claims, might reinforce the inductivist view of the scientific method which we are now trying to overcome in instruction.

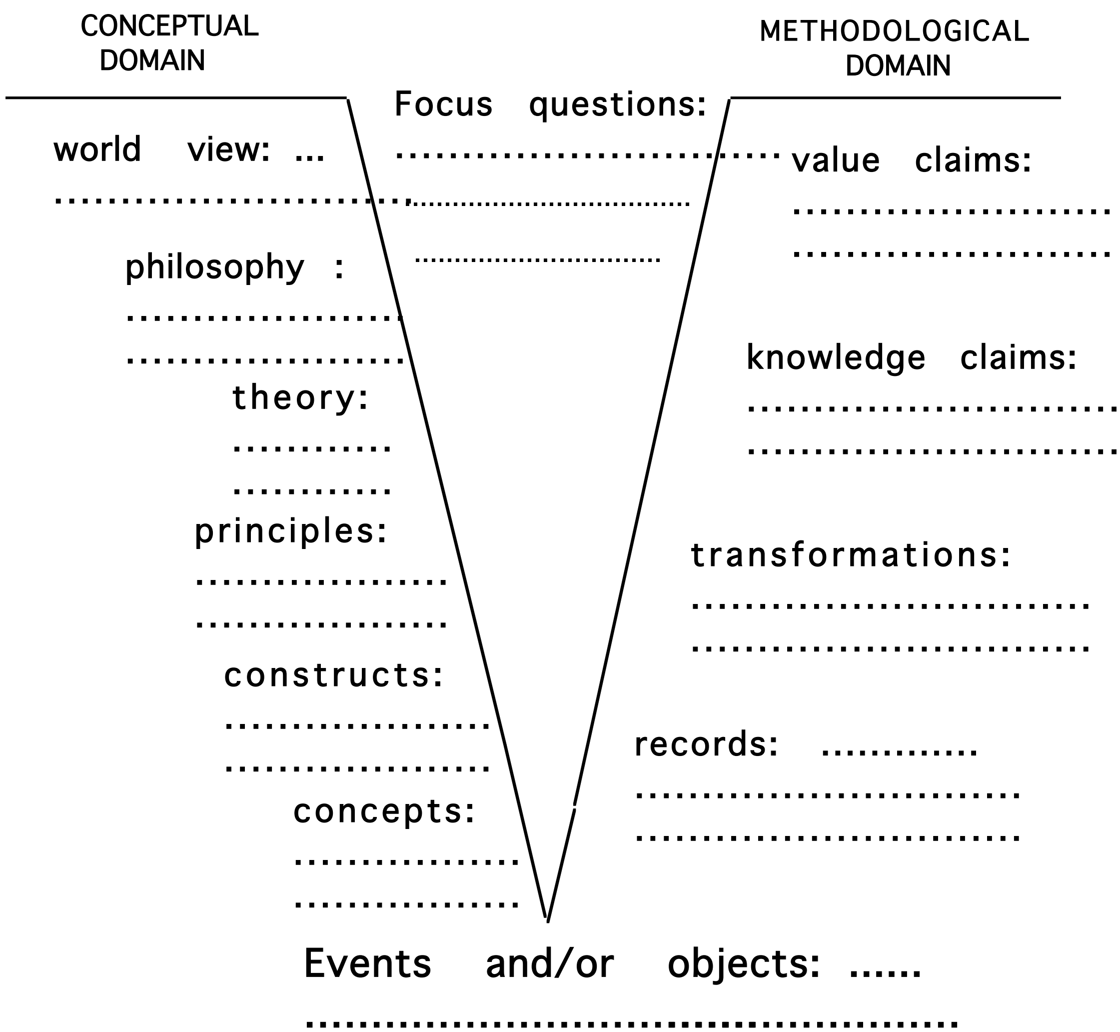

Figure 5. The V-diagram seen as a questionnaire.

An additional criticism that I now have regarding the original V-diagram, as proposed by Gowin, is that it overlooks the "feeling" and "contextual" components of knowledge construction. That is, similarly to meaningful learning, knowledge making is the result of the constructive integration of **thinking**, **feeling** , and **acting** (doing) in a **context**. (This should not be surprising since knowledge making is a case of highly meaningful learning.) Knowledge is made by human beings whose thinkings and doings cannot be separated from their feelings. In addition, the kind of knowledge they make depends on the embedding context.

These features of knowledge construction are overlooked in the original Vee. Of course, in research papers and other intellectual products authors usually do not report their feelings or some indicators of them. The context usually is not clearly reported either, but, in this case, inferences might be possible. Thus, when unpacking documented claims we might be not able to identify the feeling and contextual components of knowledge making. Nevertheless, this should not be a reason to present learners a diagram emphasizing only the thinking and doing components. The point is that although, in most cases, feelings and contexts cannot be identified or inferred they are always present in knowledge making.

Thus, in instruction we could start with a more general Vee before going into the thinkings and doings, which are more easily found in the process of knowledge construction. In Figure 6, I propose an alternative view of the Vee which might be useful for such a purpose.

On conceptual change.

My final comments are on conceptual change. I have recently done a study for the influential Spanish journal "Enseñanza de las Ciencias" concerning its first ten years (Moreira, 1993). In this study, I found that about 40% of the research papers, published in the 1983-1992 period, are concerned with students misconceptions and conceptual change. Nevertheless, no major research findings were reported in this field. Results were, at most, modest.

Probably, this is true for research in science education as a whole in the last decade. Most recent research studies in science education are on conceptual change and are based on the model proposed by Posner et al. in 1982 and/or on cognitive conflict.

According to Posner et al., favorable conditions for conceptual change are based on dissatisfaction with the existing conception and on the plausibility, intelligibility and fruitfulnes of the new (contextually accepted) conception.

Cognitive conflict strategies are based on the commonly accepted view that "cognitive accomodation requires some experience that would invoke a state of disequilibrium, dissonance, or conflict in the student. This view
implicitly assume that a conflict between the existing conception in the

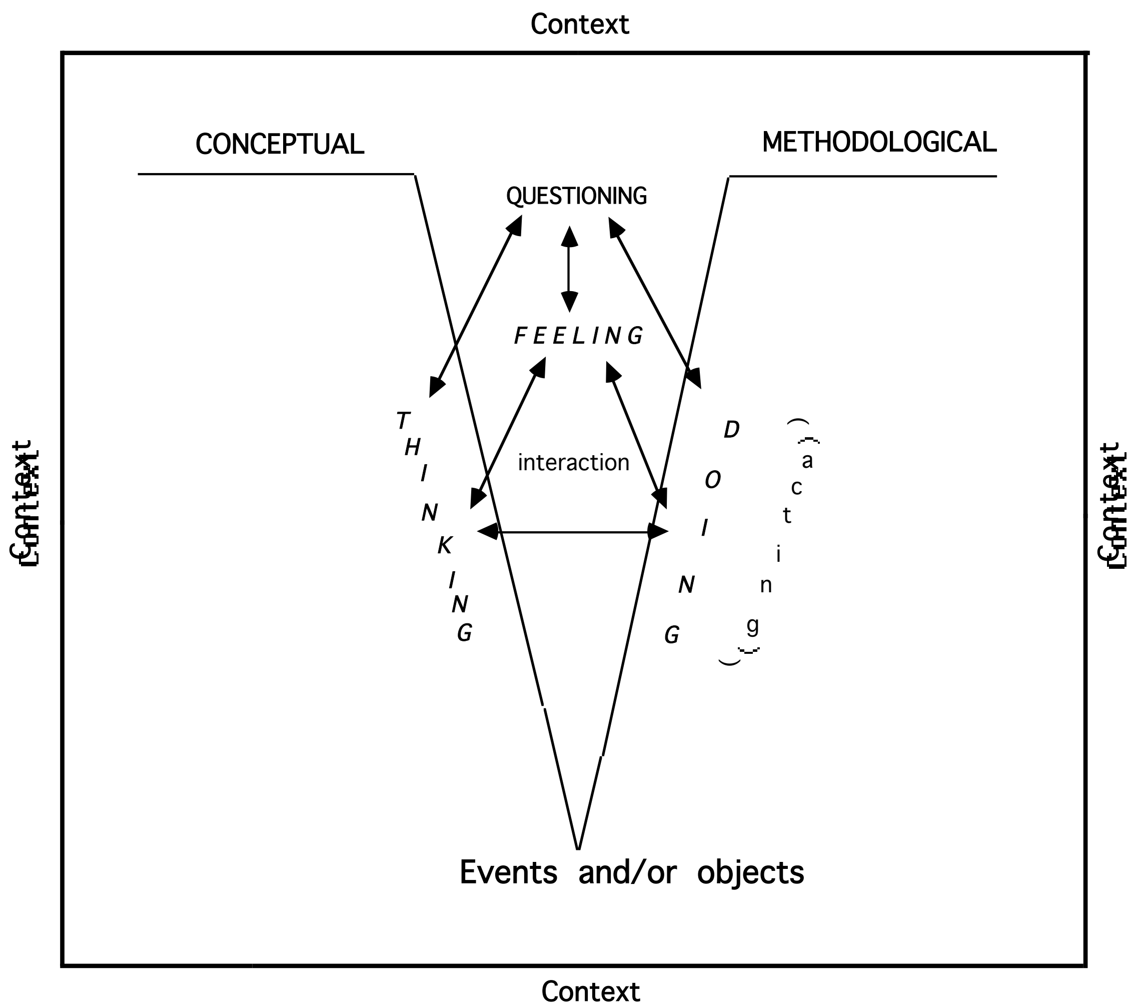

Figure 6. A V-diagram including the feeling and contextual components of knowledge making.

learner's cognitive structure and the new (scientifically accepted) conception would arouse the natural tendency to regain a state of equilibrium, and that this would lead to a cognitive accomodation appearing as an immediate conceptual change" (Nussbaum, 1989, p. 537).

These appealing models, which are compatible and/or complementary, originated, in the last decade, a large number of research studies on conceptual change, but it seems that we are still at the same point. Of course, conceptual changes have been reported in different subject matters and in different levels of instruction.

However, the persistence of the "old", "erroneous", "alternative" conceptions, depending on the situation, or on the context, is disturbing and disappointing for most teachers and researchers.

My point is: the problem with the cognitive conflict model or the model proposed by Posner et al. is that they suggest conceptual change as replacement of one concept by another in the learner's cognitve structure. Or, at least, they they are interpreted by most teachers and researchers in terms of this kind of replacement.

In my view, this type of conceptual change does not exist. By the way, I am talking about changing meaningfully learned alternative conceptions. I am referring to those "resistant to change" alternative conceptions such as the "proportionality between force and velocity" instead of force and acceleration, heat as "caloric" instead of energy transfer, or seasons "depending on the earth-sun distance" instead on their relative positions. Since these meanings are product of meaningful learning they are not eraseable. It is an illusion to think that a cognitive conflict and/or a new plausible, intelligible, and fruitful conception will lead to a replacement of an alternative meaningful conception. When conceptual change strategies are successful , in terms of meaningful learning, what they do is to add new meanings to the existing conceptions, without erasing or replacing the already existing meanings. That is, the conception becomes more elaborate, or richer, in terms of the meanings attached to it.

According to Ausubel and Novak's principle of assimilation the situation is as follows:

New, potentially meaningful idea a	_________	Related to and assimilated by	_________	Established idea A	______
___ Interactional product a'A'	__________	Dissociable into a' ----A'	_________	Reduced to the more stable idea A'	

That is, the final stage of the subsumption and obliterative subsumption processes is the modified subsumer. It is modified in the sense that it now has meanings which are residues from its original meanings and the additional subsumed meanings.

From this point of view, conceptual change, in the sense of replacing meanings does not exist. Meaningful learning is not eraseable; once meanings are meaningfully internalized (that is, substantively and nonarbitrarily) they stay forever in the learner's cognitive structure. It seems that each individual has its own cognitive history which is personal and non-eraseable.

A conception (subsumer) might be seen as an evolving cloud of meaningfully acquired meanings in such a way that no one is eliminated; they are always present, at least in a residual form. However, "accepted" and "unaccepted" meanings are consciously discriminated according to one's level of expertise in the context of the subject matter. For example, physicists and physics teachers know that one possible (but scientifically unaccepted) meaning of heat is the caloric (a sort of fluid) interpretation. They also know that one alternative meaning (but contextually unaccepted) of the relationship between force and motion is the proportionality between force and velocity. In the same way, most people know that the seasons depend on the relative position between the earth and the sun, but they also know that some people think the seasons are dependent on the earth-sun distance. That is, they have this (unaccepted) meaning in their cognitive structure as well.

In all these cases, and in any other we can imagine, both accepted and unaccepted meanings are present in the conception being utilized but users are able to discriminate between the contextually.

Thus, our cognitive structures might be interpreted as structures of conceptions, each of which is full of meanings, both accepted and unaccepted. Speaking of science, we could say that scientifically educated people are those that share scientifically accepted meanings and consciously discriminate them from those unaccepted in the context of science. Furthermore, speaking of beginners, in any field of instruction, when they first learn the contextually accepted meanings their alternative meanings are still more stable and dominant. As meaningful learning proceeds, the conception evolves and discriminability increases; however, established meanings are not replaced or erased: they might become increasingly less used, or not used at all, but they are still present in the evolving (and richer) conception, perhaps "hidden" in some residual meaning.

Several years ago, Joan Solomon (1984) said that "meanings which underlie alternative frameworks cannot be obliterated, even if they are at odds with science, because they are continuously reinforced by everyday speech" (p. 277). She also talked about the coexistence of "two domains of knowledge" and that pupils' ability to **discriminate** (emphasis added) between them in physics is indicative of their success in learning this discipline.

David Schuster's presentation (1993), in this meeting, proposes that "an alternative instructional strategy is to enrich conceptual understanding along with metacognition, by considering situations holistically and deliberately bringing in the multiple related concepts, terminologies and modes of thinking involved, including learner's existing everyday notions, accompanied by conscious conceptual **discrimination** (emphasis added). The title of his presentation is suggestive: "From 'misconceptions' to 'richconceptions'. "

My ideas about non-eraseable meanings, richer conceptions as clouds of coexisting accepted and unaccepted meanings, the level of discrimination between them as an indicator of meaningful learning, and conceptual change as conceptual evolution, were developed independently of those from Solomon and Schuster, but I am glad to find support for my views in their papers.

Probably, much more people are thinking in the same lines and, probably, this is a sign that it is time to abandon the term "conceptual change" and models that suggest it as "conceptual replacement". It is time to realize that **conceptual evolution** and **meaning discrimination** are more promising ideas because they do not imply changing concepts or meanings. On the other hand, they do imply meaningful learning. That is, since alternative conceptions arise from meaningful learning, the evolution of these conceptions from "misconceptions" to "richconceptions", as proposed by Schuster (1993), can only be the result of meaningful learning strategies.

Giving new meanings (and, perhaps, new concept labels) to the concept of conceptual change and the consequent shift in research efforts might be the most promising direction for future research in the field of knowledge of which this seminar is all about. My previous criticisms to C-maps and V-diagrams are along the same line of reasoning. Commonly held views of conceptual change, C-mapping, and V-diagramming are wasting their potential for meaningful learning and perhaps, inadvertently, promoting rote learning.

Classroom facilitation of meaningful learning is a major objective, if not the major objective, of research in science teaching and of instructional and curricular development in science education. We all agree that meaningful learning is important. We all agree that our instructional efforts should be, as much as possible, toward the meaningful learning extreme of the meaningful-rote learning continuum. Probably, most of us also agree that metacognition facilitates meaningful learning. Then, why not explore the potentialities of C-maps and V-diagrams as instructional and metacognitive tools for meaningful learning? Why using C-maps as synoptic charts, flow charts or organizational schemes ? Why using V-diagrams as questionnaires ? It does not make sense. These tools must be used as new instruments, within a new perspective of the teaching and learning process in which meaningful learning and its facilitation are central. The main value of C and V maps are their potential for negotiating meanings and the achievement of shared meanings. Let's try to explore this potential and forget about old classificatory schemes. Let's try to think conceptual change in terms of acquisition and discrimination of meanings and forget about replacing conceptions, a view that reminds us of the old behavioristic approach of installing and extinguishing behaviors in the learner's repertoire.

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