WHY CONCEPTS, WHY MEANINGFUL LEARNING, WHY COLLABORATIVE ACTIVITIES AND WHY CONCEPT MAPS?[1]

(¿Por qué conceptos? ¿Por qué aprendizaje significativo? ¿Por qué actividades colaborativas? y ¿Por qué mapas conceptuales?)

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Abstract

In this paper, we discuss the central role of concepts in human comprehension and cognitive development. Then we argue that teaching situations should facilitate the meaningful learning of concepts, and that collaborative activities are important for this. Finally, some examples of concept maps are given and concept mapping is proposed as a strategy to promote conceptualization from the standpoint of the meaningful learning theory.
Keywords: meaningful learning; concept maps; collaborative learning.

Resumen

En este trabajo, se destaca inicialmente el papel central de los conceptos en la comprensión humana y en el desarrollo cognitivo. A continuación, se argumenta que las situaciones de enseñanza deben facilitar el aprendizaje significativo de los conceptos y que las actividades colaborativas son importantes para eso. Finalmente, se dan ejemplos de mapas de conceptos y se propone el mapa conceptual como estrategia para promover la conceptualización en la perspectiva de la teoría del aprendizaje significativo.
Palabras-clave: aprendizaje significativo; mapas conceptuales; actividades colaborativas.

Why concepts?

We can answer this question by stating that without concepts there is no comprehension and no cognitive development, because human beings live in a world of concepts.

Gérard Vergnaud (1990; Moreira, 2002), an internationally recognized neopiagetian psychologist and researcher in mathematics education, believes that conceptualization is at the very center of cognitive development. It is the cornerstone of cognition. Therefore, one must pay attention to the conceptual features of the schemes and to the conceptual analysis of the contexts in which learners develop their schemes in school or outside it. Vergnaud believes that a concept can be defined by three sets: a set of situations that grant meaning to this concept and that will constitute its *referent*; a set of operational invariants (thought categories considered pertinent; propositions considered true in relation to reality; relationships) on which depends the operationality of a given concept and which comprise its *signified*; and a set of symbolic representations that form its *signifier*. There is a dialectical relation between concepts and situations: they provide meaning to concepts, nevertheless concepts are necessary to deal with them. The more situations the learner can master the more he/she conceptualizes, and while he/she conceptualizes the learner becomes more capable of mastering more complex situations. Vergnaud's proposal is known as the conceptual

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fields theory. A conceptual field is a set of complex problem-situations whose domain requires mastery of different kinds of concepts.

Concepts are also a fundamental element in David Ausubel's meaningful learning theory (2000) since, in his view, the comprehension of new knowledge and non-mechanical problem-solving depends, to a great extent, on the availability of superordinate concepts (for the subordinate acquisition of new concepts) and of subordinate concepts (for the superordinate acquisition of new concepts) in the learner's cognitive structure (op.cit., p.2). Ausubel states that concepts are categorical ideas or generic propositions represented by unique symbols. Except in the case of very young learners, most of individuals words (with the exception of proper nouns) which are usually combined to form propositions, represent concepts instead of objects and/or specific situations (op.cit.,p. 80). When we say that words in propositions represent concepts, we actually want to say that concepts have names and that in this way they can be more easily manipulated and understood. As abstractions, concepts represent just one of the many possible ways to define a class of objects or events and do not have real existence in the physical world. However, they are real in psychological terms since they can be grasped, perceived, understood, and used as if they had a life of their own (p.89).

Ausubel maintains that there are essentially two ways of learning concepts: by *concept formation* and by *concept assimilation*. The first one, which is common to preschoolers, is a spontaneous and intuitive process based on psychological processes of discriminative analysis, abstraction, differentiation, generalization and hypotheses testing. The second way of learning concepts, which is typical for older children, adolescents, and adults, is characterized by processes in which new concepts are acquired through interaction and, particularly, through the anchorage of these new concepts in others that already exist in the learner's cognitive structure. In childhood what commonly prevails is concept formation, but as the first concepts are acquired through this process, they can be used as a support for the acquisition of new concepts by assimilation so that in adults this is the prevalent concept acquisition mechanism. Ausubelian assimilation is characterized by cognitive interaction between concept meanings to be acquired and the meanings of already acquired concepts. This is a broadly receptive process that is far from being possibly considered a cognitively passive one.

Stephen Toulmin (1972), a well-known science philosopher, considers concepts as the key of the human comprehension. He states that when we want to zoom into the fundamental element of human comprehension, we should ask ourselves (p.27):

> *What are the skills or traditions, activities, procedures or instruments of the intellectual life and of the imagination of Human Beings—in a single word, the concepts—through which one can attain and express human comprehension?*

In sciences, for instance, there are some fundamental concepts that are, so to say, constituents of the sciences in which they are used. As an example, we can say that without the concepts of "rays of light" and "inertia", Geometrical Optics and Dynamics would not exist (p.84). The so called disciplines have much more to do with their own body of concepts than with methods and objectives.

Like Vergnaud, Toulmin emphasizes three aspects, or elements, in the use of scientific concepts: *language; representation techniques*; and *application procedures*. The two first aspects comprise the symbolic aspects of scientific explanation, that is, of what we call "to explain", whereas the third is related to the recognition of situations to which these symbolic activities are applicable (pp.170-171).

Toulmin ascertains that the specific sets of concepts we learn in formal education, or out of it, reflect forms of life and thought, of comprehension and expression that are present in our society. They constitute our conceptual heritage, which in Toulmin's perspective is evolutionary. For him, concepts are micro institutions that evolve both socially and historically.

Jerry Fodor (1998), a psychologist who considers himself totally committed with the representational/computational view of the mind, states that when we choose this perspective, we need a theory of concepts and such a theory must be atomist. That means that concepts are thought atoms, categories applied to the states of things of the world that, in their vast majority, must be learned and shared by many people.

Ernst Mayr (1998), an evolutionary biologist, considers the introduction of new concepts, or the improvement of those already existent, the true key to scientific development, not the scientific discoveries and revolutions.

> *I am absolutely convinced that it is not possible to understand the growth of the biological thought without an understanding of the conceptual structure of biology... Our comprehension of the world is more effectively achieved by concept improvement than by the discovery of new facts, although both of them are not mutually exclusive (op.cit., p.23).*

Many other authors – scientists, philosophers, psychologists, epistemologists, linguists, educators – emphasize the central role played by concepts in the construction of human knowledge, in human development, and in human comprehension. It would be tiresome to describe each of these authors' view on the relevance of concepts.

Surprisingly, however, concepts do not receive the deserved treatment when it comes to teaching, and quite often they are dealt with as no more than definitions. In addition, courses with a conceptual approach are considered easier. Toulmin would state that without concepts those courses could not even exist. In teaching practices, formulae, algorithms, principles, and theories, which would not exist either, get much more attention than concepts from teachers and students.

Going back to our initial question "Why concepts?", we could answer it by saying that they are important " because without them all we call subject matter would practically do not exist", "because in their absence human beings would stop understanding anything", "because without them human cognition would be at risk."

Consequently, concepts should be at the very center of all teaching and learning activities.

Why meaningful learning?

Because meaningful learning stands for learning with meaning, comprehension, retention, and transfer skills. That is, the sort of learning teachers expect as a result from their teaching action.

Nevertheless, pedagogical practice is much different since what predominates is rote learning, which emphasizes the storage of knowledge in a verbatim way, with no interaction with prior knowledge, no grasping of meanings, no retention, and no transfer skills. Students memorize chunks of knowledge that they automatically apply to familiar situations. Teachers present the subject matter and students "study" it, that is, they learn by heart topics of the subject matter on the eve of testing situations in which they reproduce the information they have managed to rotely memorize. They are unable to solve problems that offer minimal differences from the ones worked in class, and, in general, they complain, or argue, that these topics have not been presented in class.

Rote learning is a waste of time in educational terms, although it can be quite handy in training contexts.

On the other hand, rote learning and meaningful learning are ends of the same continuum, and it is feasible to argue that a learner can progressively move from one to the other end of such continuum. However, for this to happen it is necessary to take into account that prior knowledge is the most relevant variable in this move from rote to meaningful learning, and that the use of facilitating strategies such as concept maps together with the mediating action of the teacher are crucial. Meaningful learning (Moreira, 1999, 2000, 2006a) points up that the meaning of new knowledge is constructed through its interaction with specifically relevant prior knowledge. Prior knowledge can be made of propositions, schemes, operational invariants, that is, it can be of different kinds but in all of them there are underlying concepts. Thus, we are back to concepts. We always go back to them since they are, at the same time so important and so much ignored in teaching situations.

In addition to relevant prior knowledge, the other condition for meaningful learning to occur is the predisposition to learn. This means that the learner has to be willing to learn meaningfully, which is only natural since nobody will learn anything if he/she does not want to do so. However, once it starts, meaningful learning generates more predisposition for new meaningful learning. Experienced teachers know that, and they also know that rote learning triggers feelings of aversion towards some disciplines, such as physics, for example.

Following this line of reasoning, we get to Novak's (1977) humanistic idea of meaningful learning as underlying positive and constructive integration of thoughts, feelings and actions. Human beings think, feel, and act integratively, either positively or negatively. Thoughts, feelings, and actions are always integrated. Novak's view is that meaningful learning embodies a positive integration of feeling, thinking, and acting, which leads to human empowerment.

Thus, there are strong arguments in favor of trying to facilitate and give priority to meaningful learning and conceptualization in teaching situations. Let's explore a bit more this idea.

Why collaborative activities

A prerogative for any learning to become meaningful is the occurrence of a cognitive interaction between new and prior knowledge already existent in the learner's cognitive structure. This interaction is non-arbitrary and non-verbatim, that is, it is not any prior knowledge that will allow the learner to assign meaning to the new knowledge, and, furthermore, internalization is not verbatim, but substantive. Since it is an interaction both the new knowledge and what the learner already knows undergo changes: the new knowledge gains meaning and the prior knowledge, which has served as a cognitive anchorage (in subordinate meaningful learning) to new concepts, gets new meanings and becomes cognitively more elaborate, rich and stable .

When a student meaningfully learns that the whale and the bat, for example, are both mammal animals, the meaning derives from an interaction with the prior concept of mammals including animals the students were already familiar with, but what results from this learning is also an improvement and an elaboration of the mammal concept previously learned.

Educational materials in teaching and learning situations should be potentially meaningful. They must have logical meaning for the students who, in turn, should have in their cognitive structure prior knowledge adequate enough to enable them to change the logical meaning embedded in the instructional materials of the curriculum into psychological meaning .

These prior knowledges that are specifically relevant for the meaningful grasping of new knowledges are called subsuming concepts, although they might be more adequately called subsumers since they are not necessarily concepts even though in many instances they are, indeed, concepts.

How does this non-arbitrary and non-verbatim cognitive interaction work in practice? It is at this point that another type of interaction enters the scene: the social, collaborative, and cooperative interaction. Let's see how it works.

Let's take into account Gowin's (1981) triadic model. For him, a teaching-learning episode is marked by the sharing of meanings between teacher and learner regarding knowledges brought about by the instructional materials of the curriculum. This model is sketched in Figure 1.

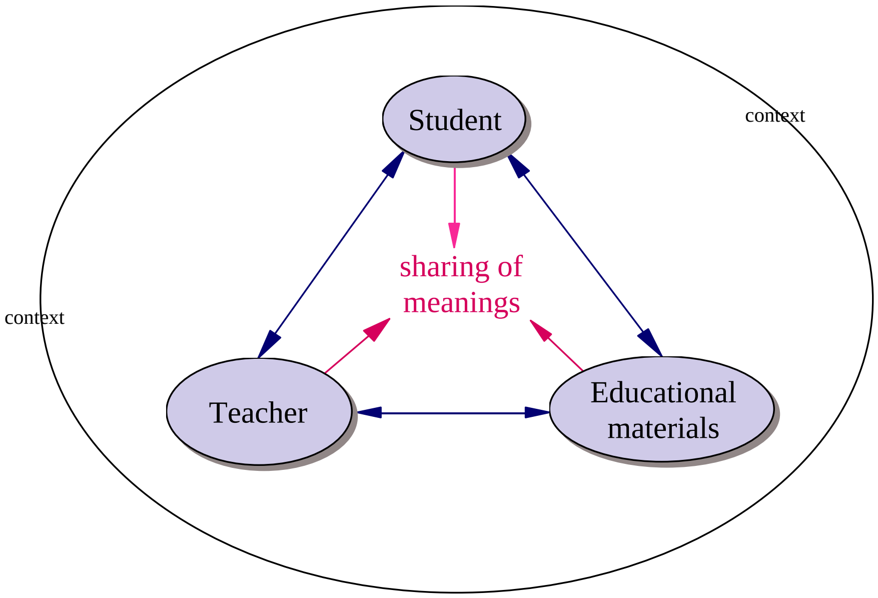

Fig.1 Gowin's triadic model (Gowin, 1981; Moreira, 2006): He perceives a triadic relation among **teacher, educational materials** and **student**. According to him, a teaching and/or learning situation is characterized by the sharing of meanings between teacher and student about the knowledge conveyed by the educational materials of the curriculum.

In this triadic relation there is enough room for dyadic ones as well, such as, for example, student-student and student-teacher provided that they contribute for the achievement of the triadic relation, whose objective is the grasping by the students of meanings that are already contextually accepted and that should have been already mastered by the teacher.

When we refer to the teaching of concepts, it is the teacher's role to offer students situations in which concepts can acquire meanings, and to present learners with the accepted meanings of these concepts within the context of the subject matter.

The student, in turn, should externalize the meanings he/she is grasping. This interactive process, in which the use of language is vital, is called negotiation of meanings and it occurs not just between student and teacher but also among students.

That is, meaningful learning depends on the grasping of meanings that, in turn, depends on personal interactions and collaborative activities. According to Vygotsky's view, we can say that interactions, negotiation of meanings, and collaborative activities must all happen in what he called Zone of Proximal Development.

However, how can we promote collaborative activities that may lead to the grasping of meanings and meaningful learning?

Well, the answer is that this can take place when we leave behind traditional models in which the teacher talks or/and writes and the student takes notes and/or copies what the teacher says, or scribbles, with the sole intention of memorizing mechanically answers and solutions to problems that will probably appear in quizzes or tests.

In meaningful learning, besides prior knowledge and a predisposition to learn, personal interaction is also necessary, and it exists, for instance, in collaborative activities that underlie group accomplishment of learning tasks, such as the drawing of concept maps by small groups of students.

Why concept maps?

Because they constitute a facilitating strategy for meaningful learning and for conceptualization. Nevertheless, it is a mistake to simply associate concept maps to meaningful learning, although they have been proven helpful in facilitating it, when badly used, concept mapping strategies can lead to rote learning, since students can memorize supposedly correct concept maps.

The best argument for the use of concept maps (Novak and Gowin, 1984; Moreira, 1980, 2006a) in the teaching of any field of knowledge seems to be that, as maps of concepts, they focus on concept learning, and concepts constitutes the very basis for knowledge construction and comprehension in any given area of knowledge.

Concept maps should be collaboratively constructed by the students, who should discuss which concepts are to be included in the map and how these concepts should be organized in the map. They also have to negotiate the linking words that will be written on the connecting lines between concepts. It is in the personal interaction that emerges from the collaborative construction of the maps that lays the great potential of concept mapping as a facilitating strategy for meaningful learning and conceptualization. The teacher, of course, should mediate this interaction.

Students start to realize that concepts are relevant elements in the construction of human knowledge and, at the same time, they start conceptualizing – meaningfully constructing key concepts for their own cognitive development – when they draw and re-draw their group concept maps and present them to their peers.

Obviously, meaningful learning does not depend solely on concept mapping. It can occur – and it does happen – without concept maps. The point we are trying to make here is that concept learning is fundamental for the learner's cognitive development and that concept mapping can help a lot in this process.

Examples of concept maps

Figure 2 presents a concept map drawn by the author of this paper involving the content of an introductory college course of electromagnetism. In this map its key concepts and propositions (laws, in this case) can be seen. When the mapping of concepts is done, the teacher can be more confident about what concepts and propositions (made of concepts) should be emphasized in the course. It becomes also clear that, according to the principle of progressive differentiation, the field concept (central to the map) should be the starting point of the course together with all the basic electromagnetic phenomena instead of presenting them in a subsequential manner.

Figure 3 shows an example of a concept map for the content of electricity constructed by an engineering student taking a conventional course of electromagnetism, which begins with electricity, then gets to magnetism, and ends up with electromagnetic phenomena while trying to integrate these contents.

This map has a written explanation in which the student externalizes his difficulty in placing in the map the concept of *electric potential*. In addition, he also externalizes a conceptual misunderstanding (in an insulator the electric current does not pass because there is no electric field inside it) which could be not perceived by the teacher in other learning situations.

Finally, Figure 4 displays a concept map on Piaget's theory drawn by a group of graduate students taking a course on learning theories. This is the second or third version of a collaborative task: students draw the map in small groups and then they present it to the large group that offers them critical reviews as well as comments and suggestions. The students at this point are free to do the map again, modifying it according to the feedback received from the large group, and then they hand it to the teacher for a qualitative evaluation of the level conceptualization it suggests. The teacher, in turn, makes comments on the map and hands it back to the students that can redo it once more. It is an activity involving recursive evaluation.

These three examples were presented here to emphasize the potentiality of concept maps as instruments for conceptual analysis of a given content of study, for externalization of meanings, and for creating opportunities for the negotiation of meanings.

Concluding remarks

We live in a world of concepts. Without them we are unable to understand our world, and without conceptualization we cannot develop cognitively. However, in teaching at schools, concepts are most underestimated and even ignored.

It is true that nowadays concept maps are quite used in teaching and learning situations, however, in spite of this, concepts do not receive the attention they deserve. Most of the concept maps we see today are not really maps of concepts; they are conceptual diagrams for storage and/or disclosure of information.

We have attempted here to rescue concept maps as an instructional resource to deal with concepts, that is, for the facilitation of the meaningful learning of concepts. This facilitation can be greatly improved when concept maps are collaboratively constructed. When a concept map is collectively drawn, it implies that its concepts have been negotiated in terms of what concepts should be in the map, how they will be hierarchically positioned, what kind of linkages among concepts will be privileged and what sort of connecting words or sentences will be used to explicit the linkages among them in the map. This negotiation in which language is totally implicated is crucial for meaningful learning.

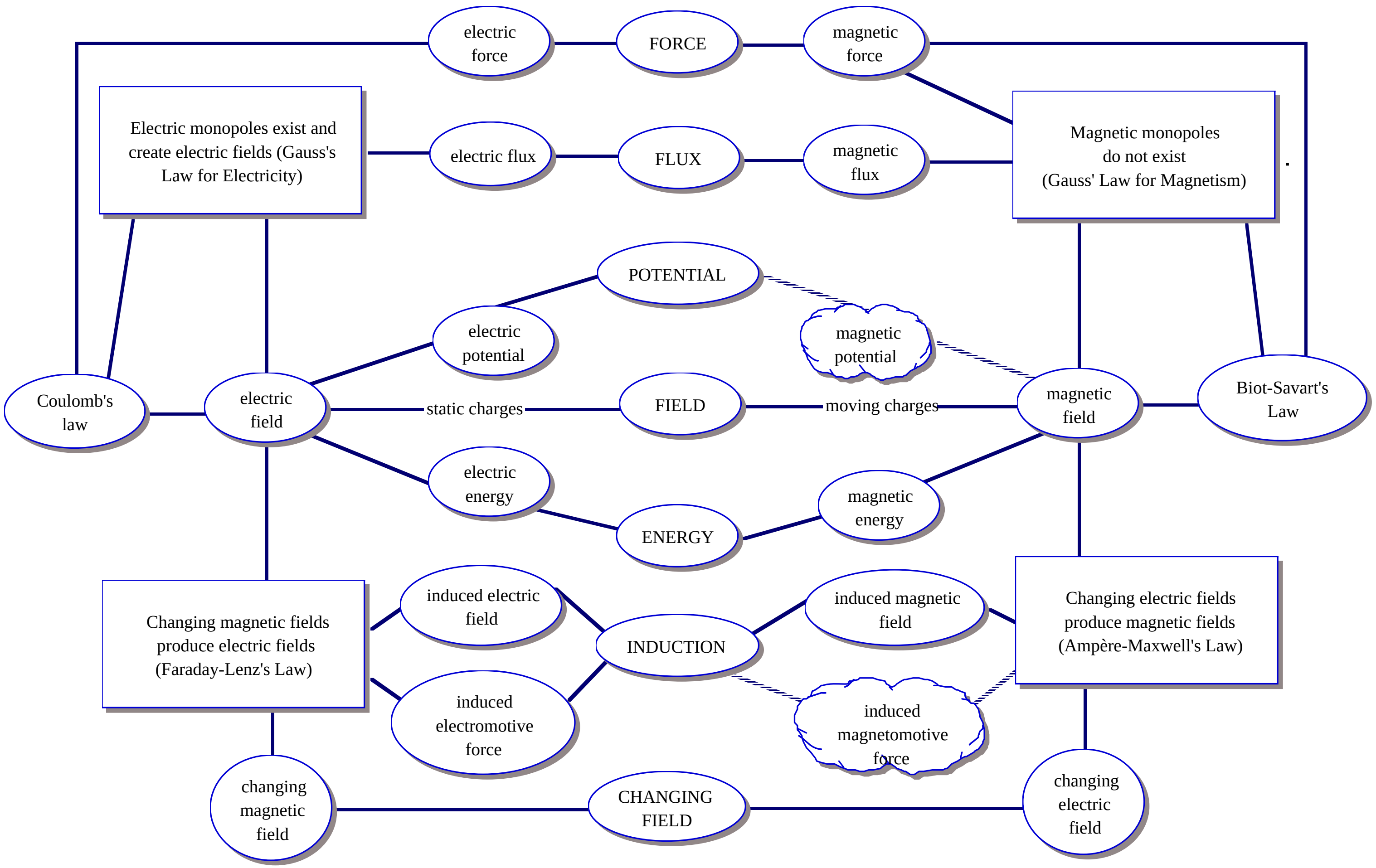

Figure 2. A concept map for electromagnetism from a curricular perspective (Moreira, 1983). In this map, the concepts inside "clouds" and linked by dashed lines to the other concepts are not relevant for this content, and they were placed in this map just to keep the symmetry between concepts of electricity and of magnetism. The central concept is *field* which might be electric and/or magnetic depending on whether the charges are moving or not. Other key concepts are in the middle vertical axis whereas the corresponding concepts in electricity are in the left and those from magnetism are in the right side of the map. The linking words would be "may be" in almost all cases. In this area of physics there are *four key propositions* (Maxwell's Laws or Maxwell's Equations) which appear in rectangles.

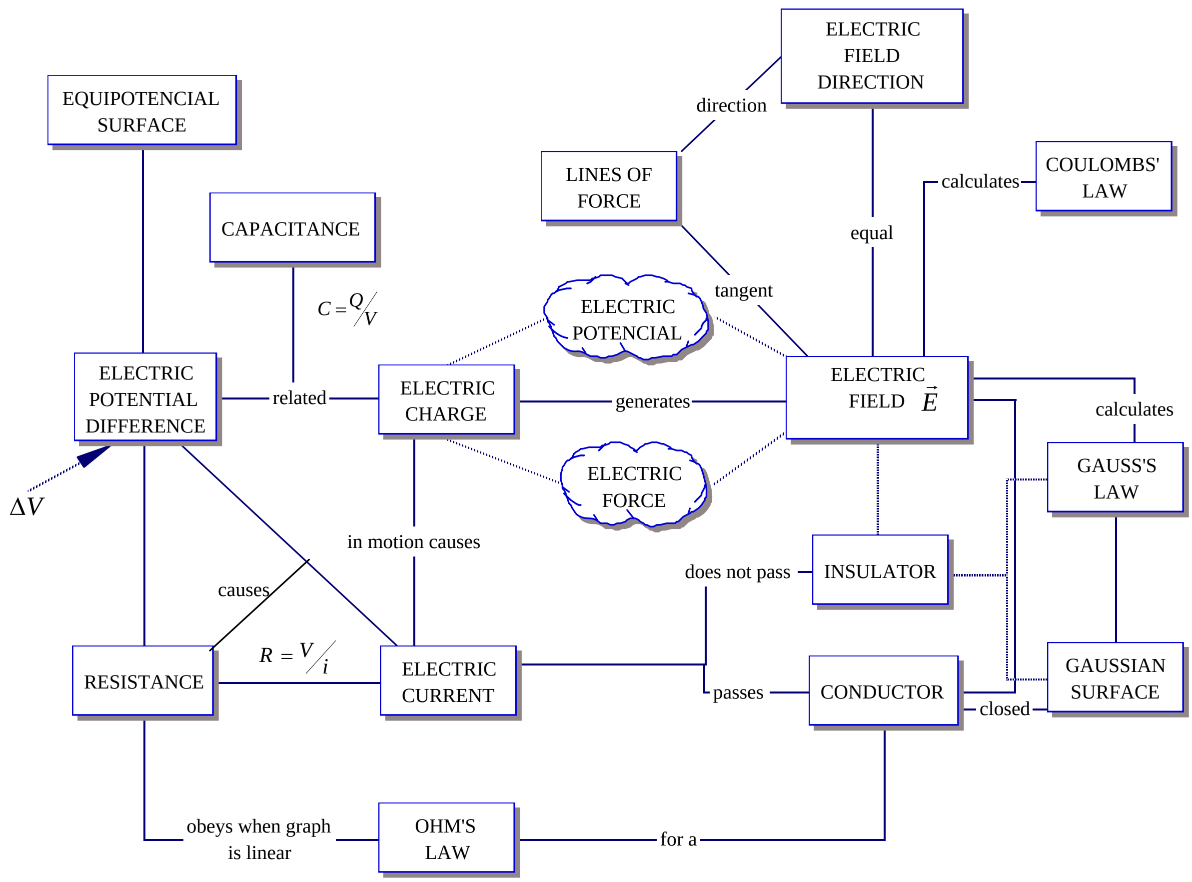

Figure 3 - Concept map drawn by student # 1 after the tenth unit of study. Dashed lines where added to the map during the oral explanation and discussion with colleagues and teacher.

Student’s explanation

“I put electric charge at the center of the map because it is the foundation of electromagnetism. After that I tried to separate everything in order to see better and I also tried to relevate everything that was important.”

“Electric force would get in the map through the relationship with potential since potential is related with work and in order to do work a force is needed.” (The student was, in fact, talking about the electric potential difference.)

“I don’t know where the concept of electric potential would be placed in the map.”

“The field of an insulator cannot be calculated through Gauss’s law. In an insulator the current does not pass, there is no field inside it.”

“The less important concepts would be equipotential surface, direction of $\vec{E}$, Ohm’s law; in general, those at the periphery of the map, including the laws because they are used just to calculate the field, are not important as concepts.”

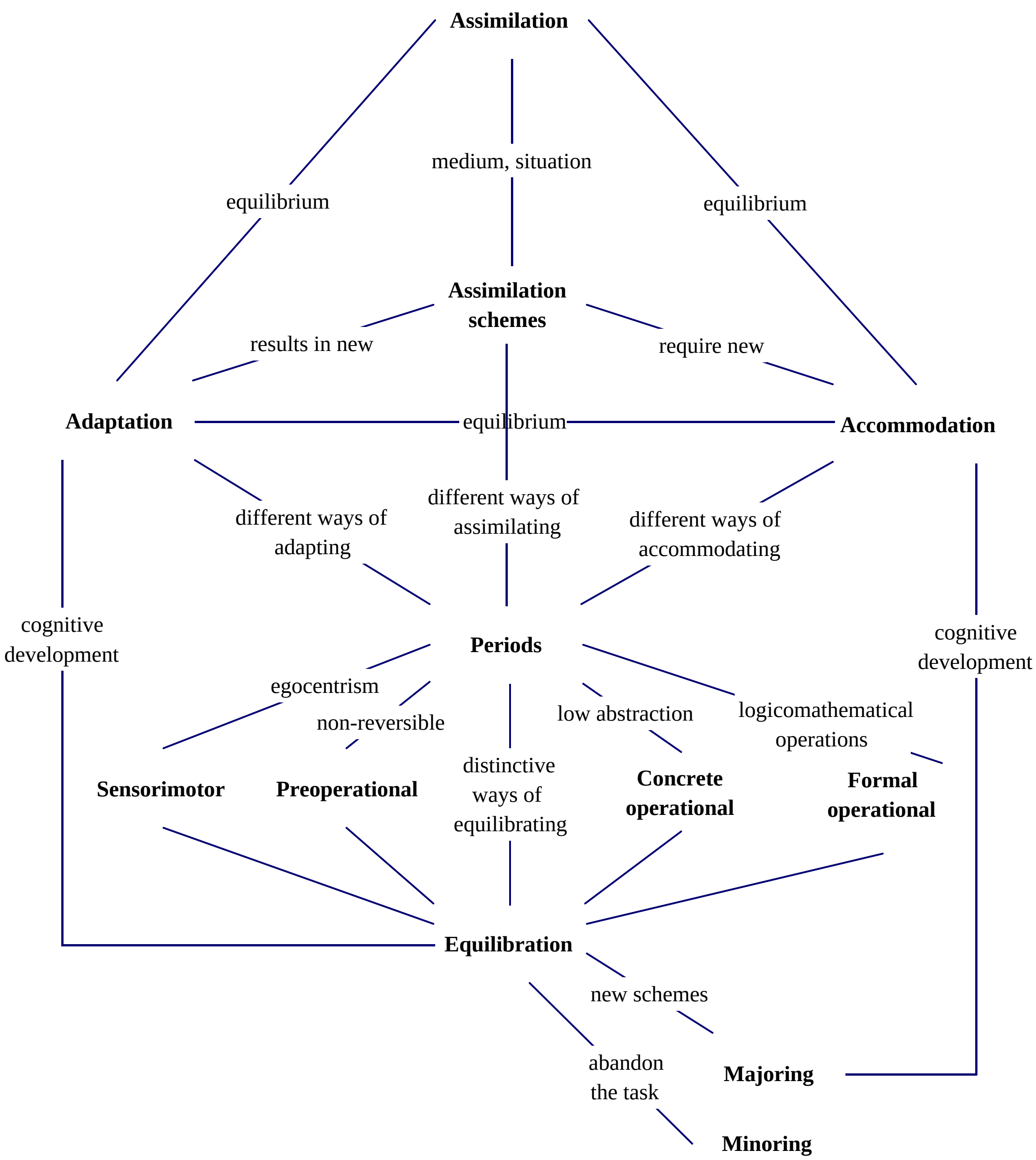

Figure 4. A concept map for Piaget's theory of cognitive development drawn collaboratively by a group of graduate students.

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