Concept Mapping: Connecting Educators
Proc. of the Third Int. Conference on Concept Mapping
A. J. Cañas, P. Reiska, M. Åhlberg & J. D. Novak, Eds.
Tallinn, Estonia & Helsinki, Finland 2008

LEARNING WITH CONCEPT MAP: AN ANALYSIS OF A TEACHING EXPERIENCE ON THE TOPIC OF REPTILES WITH 15-YEAR-OLD STUDENTS AT A SECONDARY SCHOOL

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Abstract: Based on the premise that concept map represent an important and relevant tool for the educational process for meaningful learning of scientific concepts, the purpose of this paper is to describe and analyze a specific educational experience involving classes on 'reptiles' for 7th graders (15 years old in average) at a secondary school. Due to the specificity of the educational area and to the various uses concept maps may have, we decided to use the term "map of concepts" to represent a particular type of concept map which is the one that deals only with scientific concepts and the relationship between them. The approach resorted to map of concepts as an aid for teaching the topic. The process consisted of three ninety-minute encounters each with the thirty-eight students of a previously chosen class, in November 2006. With the exception of the introduction of maps of concepts as an instrument for learning the material, the classes used their regular dynamics: an initial free debate, followed by reading of the textbook and a discussion, group activities and, finally, a written evaluation on the newly acquired data. The analysis of the information gathered – maps of concepts developed at the start, during the middle and at the end of the process, answers by the students to the questionnaire about their perceptions regarding the maps – was based on the Meaningful Learning Theory (Ausubel et al, 1978). The results revealed that the students enjoyed elaborating the maps of concepts and saw them as facilitators for learning. Nevertheless, the results also revealed that the short duration of the experience, albeit having contributed to a clear increase of the general vocabulary, was insufficient to stimulate the students into grasping and/or learning the meanings of the central concepts in the topic of reptiles. At the same time, it also failed to establish an overall comprehension of the hierarchical and relational logic of the maps of concepts. As mere suggestions underscoring that the basis for meaningful learning is its process, we recommend greater attention to the process of learning to build map of concepts. Their introduction into the dynamics of formal teaching should occur with themes already familiar to the students, after the teacher negotiates with the class the list of concepts that will make up the map.

1 Introduction

Concepts maps are diagrams that indicate the relationship between concepts (Moreira, 2006) or, according to Novak and Gowin (1984:14), they are explicit open representations of the concepts and propositions someone has on a particular subject. These characteristics, which are coherent with the explanation given by the Meaningful Learning Theory (Ausubel et al, 1978) about the relation between the structure of knowledge and the manner by which someone organizes it in his/her cognitive structure, reveal why these tools had the negotiation of meanings as the dominant perspective in their original conceptualization. It is clear then why these characteristics promoted their immediate acceptance as an important tool for teaching in schools, where evidence shows that their use has always been very successful since the 1970s even though the original use was in research areas (Novak & Gowin, 1984).

More recently, there has also been a productive appropriation of these tools in various contexts for all sorts of purposes (Novak, 1998; Cañas et al, 2004). However, it is predominantly in the educational field that their application in the original conception – focusing on scientific concepts (Novak, 1998; Novak & Gowin, 1984) – occurs. Therefore, it is this original conception that contributes to the successful use of these tools as instructional, learning, curricular planning and evaluation resources. Due to the specificity of the educational area and to the various uses concept maps may have, we have made the option to use the term "map of concepts". We have done so having them represent "bi-dimensional diagrams that try to show hierarchical relations between concepts of a certain body of knowledge and exactly the conceptual structure of this body of knowledge from which they derive" (Moreira, 2006:10). In sum, **we propose the use of "map of concepts"** as a more adequate variation of concept maps **for the educational context, structured primarily by scientific concepts, when the goal is conceptualization**.

Investigations in the educational field have demonstrated that the potential of map of concepts in the optimization of the quality of teaching and learning processes is similar in its various functions, a fact that reveals an existing interdependence. Since they represent relations between scientific concepts, in their diversified use they end up favoring meaning negotiation. That, in itself, is a condition for the learner to grasp the meanings, to establish a consensus about them and finally to learn them (Gowin, 1980). A good part of these investigations have highlighted the didactic and meta-cognitive potential of these tools, and use them as a basis for characterizing the impact of teaching on the acquisition of conceptual knowledge by those that elaborate these maps. For that reason, the analyses tend to give priority to the difference between the initial maps (as evidence of previous knowledge) and the final ones (as evidence of meaningful learning), and not to

the process of learning itself. Therefore, it is not common to find accounts of investigations and/or experiences that have analyzed the learning process in constructing maps of concepts. More specifically, they have not also analyzed the relation between the knowledge represented in these maps of concepts, the evolution of the learning process and the teaching process developed during the experience. It is precisely in this partially unexplored direction that the material we are presenting here goes. The data we are about to describe, considered as a pilot study for an ampler project, focuses on understanding the teaching and the learning processes that come about with the elaboration of map of concepts.

Bearing this in mind, we now view the learning process of the meaning of what a map of concepts is, and, consequently, the attention its elaborator dedicates to the selection of the scientific concepts that will integrate the map, besides the (inter)relations he/she has chosen to explicit. We believe these aspects are fundamental for an autonomous management of meaningful learning, even when the learner chooses any other strategy and/or learning resource and/or any other theoretical reference.

The meaningful learning process demands both personal negotiation of the new meanings – when the student compares and negotiates the new piece of information with the ones he has already got –, and interpersonal negotiation, when the student compares and negotiates what he thinks about the topic with the interpretation of his interlocutor. These steps demand attention (not only from the one who teaches, but also from the one who learns) to central concepts of the topic at hand and to the relations established between them. This aspect justifies the potential of the map of concepts as a facilitative resource for meaningful learning. On the other hand, it validates the coinciding steps in the orientations of specialists in the field to construct such maps: the selection and list of eight to ten key concepts, the ordination of the concepts from the more general to the more specific and the establishment of the vertical and horizontal relations between the concepts using lines and words (connectors) that explain these relations (Novak & Gowin, 1984; Moreira, 2006).

From what we have discussed, we will describe the teaching process accomplished. With priority to the concepts present in the constructed maps of concepts, we intend to analyze the nature of the knowledge of the students shown by these tools they elaborated during the three different moments of the intervention. From these data we will discuss the influence of the teaching in the maps of concepts elaborated at the time. Finally, we will present some considerations and suggestions for the use of these maps of concepts as an instructional resource, as well as a tool for the investigation about the teaching process.

2 Teaching about Reptiles with Map of Concepts

2.1 The proposal of the Intervention

One of the authors of this paper, in partnership with a science teacher, developed the activity during regular classes with 7th grade secondary school students in a public school in Garanhuns, in the Brazilian northeastern state of Pernambuco. The class was composed of 38 students, averaging 15 years of age but we have considered as the population for this study only 22 students, for they were the ones that performed all the activities. Besides being in accordance with the school syllabus for the subject, the main objective of the experiment was to favor conceptual meaningful learning (Ausubel et al, 1978) on the topic of 'reptiles'. Starting from this point, there was an introduction of the maps of concepts, until then unknown to this group of students, inserting them in the dynamics of the classes as a learning tool.

The experience was comprised of three one and a half-hour encounters each, during three consecutive weeks. In the first encounter, right after the explanation of what a map of concepts was, the teacher prodded an oral and collective discussion. At that point, the students characterized what reptiles were like without recurring to any text, making up a map of concepts of this group of animals individually and again without any help once the discussion was over. On the second occasion, they worked on the topic during the first half of the class in the usual procedure applied by the teacher and the school: reading from the textbook by the students and a collective discussion on the elements of the text resulting from questions asked either by the teacher and/or by the students themselves. Next, they discussed the topic using posters the students had prepared and comments heard or read in the media. They summed up the topic by developing another map of concepts. During the third and last encounter, they elaborated a final map and had two evaluating activities: one about the content of what had been studied (reptiles) and another about the insertion of the map of concepts as a learning strategy for the school subject. The three maps and the questionnaire for the students' evaluation of the experience, based on their impressions after the implementation of this new element in the dynamics of the classroom activities in a science class represent the data we have collected. We will now go on to present the process and its analysis.

2.2 The elaboration of map of concept as a facilitative strategy for learning during the teaching of the topic 'reptiles': description and analysis of the process

As we have already mentioned, the intervention had the purpose of describing and analyzing how the maps of concepts work to bring out the full potential of their aim: to favor meaningful learning on the topic of reptiles by the students. The application of this learning tool was the only alteration in the daily dynamics of the class, aiming at bringing about individual and/or collective reflection on the concepts and the relation they established among themselves to characterize the topic of study in question. The expectation based on the idea that learning is a process that demands time and negotiation of meanings was that the maps elaborated during three distinct moments – despite being very close in time – could show an evolution in the knowledge of the students during the teaching process.

Thus, taking into consideration the fact that the group of students had no previous knowledge on map of concepts – ignoring both their meaning and the organization of their logic –, the first encounter started by the introduction of these maps. Showing several examples of maps, the teacher explained the guiding principles and the criteria for the building up of such tools. She tried to emphasize the fact that although the maps did not have a rigid format, it is important to respect both the hierarchy and the horizontal relations that the concepts established among themselves in representing a particular body of knowledge. She also pointed out that the maps of concepts are personal, and, due to this aspect, corresponded only to one of the possible interpretations for a certain conceptual structure, which demanded a clear explanation of this particular characteristic.

Next, she outlined on the blackboard an example of a map using the concept 'table'. Having done this and wanting to draw up the students' previous knowledge about the topic she was going to introduce, she proposed a collective discussion on the topic she was about to teach. While they answered orally what they knew about reptiles, the students – most of them participating actively – talked about the ideas that came up, questioning and discussing them. They finally drew up Map of Concept I individually and without consulting any source of information. The information used was taken from their previous knowledge on the subject. The process of elaboration was calm, with few questions and with apparent enthusiasm on the part of the students.

As it can be inferred from Figure 1, this first set of maps of concepts has diversified forms, and, although it is possible to perceive a concern for hierarchy, it is the vertical direction that prevails, despite the fact that the frequently the relation between the general, intermediary and specific concepts is inadequate. Likewise, the concepts placed in the same horizontal position rarely respect that type of relation. Apart from these aspects, what most calls attention in these maps is the diversity in concepts. In average, they have twelve concepts (ideas) which, as a whole, totalize 124 different types. When analyzed these were put together into seven categories: classification, origin (date) and family (ancestors and descendants), vital functions, bodily structure, temperature, habitat and examples.

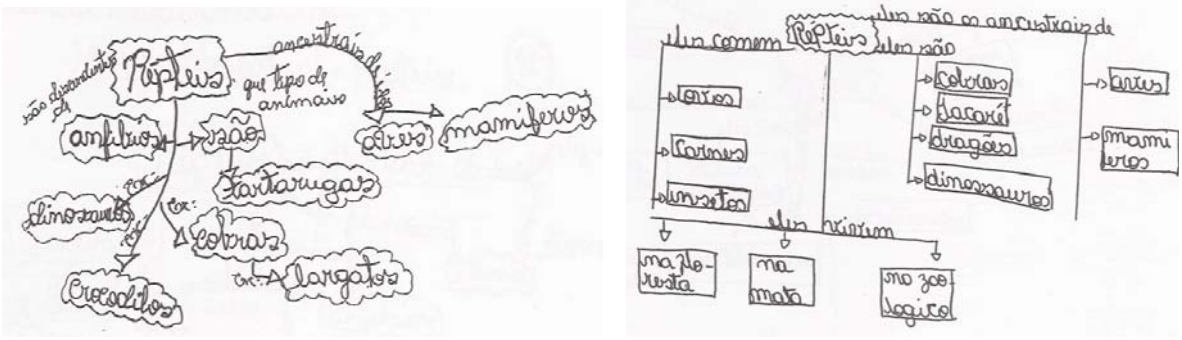

Figure 1. Maps of Concepts I – Students 17 and 5.
[The translation of the concepts and or connectors is: anfíbios= **anphibians**; ancestrais de= **ancestral of**; aves**= birds**; carnes=**meats**; cobras= **snakes**; crocodilos= **crocodiles**; dinossauros= **dinosaurs**; dragões= **dragons**; eles comem= **they eat**; eles são= **they are**; eles vivem= **they live**; ex.= **example**; insetos= **insects**; jacaré= **alligator**; lagartos= **lizards**; mamíferos= **mamals**; na floresta= **in the forest**; na mata= **in the bush**; no zoológico= **in the zoo**; ovos= **eggs**; répteis= **reptiles**; são= **are**; são descendentes de= **they are descending of**; tartarugas= **turtle**]

The most frequently cited aspects were the types of food (nutrition source/nutrition), type of skin and their (external) organs and appendices, and examples. Besides some inadequate relations, "wrong" concepts were limited, having come from three students. Student 1 named "ophidians" as a "class" of reptiles, not an "order"; student 9 stated that reptiles lives "up to 350 thousand years", that they were "the offspring of mammals", and that they fed on their mothers; finally, student 6 used the term "mammal" to exemplify an animal of that group. We can infer from these observations that the class knew about reptiles, knew how to give examples of them,

but resorted to external and behavioral characteristics, especially feeding habits and the type of locomotion, in order to characterize the animals in question.

As we have already mentioned, during the second class there was a discussion on the topic resorting to several strategies: shared reading of the textbook used by the school (Cruz, 2005), posters, discussion about pieces of news in the press, radio and TV and the individual construction of a second map of concepts. The class showed enthusiasm about and commitment to all the activities. The posters, elaborated from magazine clippings brought in by the students themselves and put up on the walls of the classroom, were then the focus of the discussion. For the construction of Map of Concepts II, as it had happened in the prior encounter, the students were free to decide about what concepts to use. During the elaboration of the map of concepts, the students recurred to teachers for guidance not only about the hierarchical organization of what they were putting together, but also about the words that they were trying to use as connectors. When the discussion centered on the bits of news the head teacher had brought to class, the students made comments about some programs they had seen on TV on the subject or about experiences of their daily lives in comparison to the textbook. They said they considered "the material in the textbook was too brief", adding that they had learned more by the elaboration of the map of concepts than by the reading from the textbook.

The analysis of these maps of concepts followed the same pattern applied previously, checking the nature of the hierarchical relations, the list of the concepts and their organization into categories. The result shows little difference between the maps that inaugurated the process and this second ones. Hierarchies were still poorly contemplated and the diversity of concepts/ideas, despite smaller, maintained the emphasis on examples and external characteristics and behavior.

Among the 102 concepts cited, 31 were new and not much representative of the central and specific characteristics of reptiles, and the distribution into categories was similar as the ones cited before. Of this total only "eggs with shell" and "poikilotherm" characterized correctly reptiles despite not being exclusive characteristics of that animal group. The new concepts/ideas were: "is born", "grows", "reproduces" and "dies" (S9, S22); "280 millions years ago" (S5); "350 million years ago" (S14); "the turtle was born first" (S14); "similar to birds" (S4); "testicles" and "deferential duct" (S2); "eggs with shells" for "protection" and for "nutritional reserve" (S4); "don't drink milk" (S7); "jaw", "rectum" (S2, S16); "lung" (S2); "urethra" (S2); "vertebral spinal column" (S5, S6); "caudal vertebrae" (S16); "poikilotherm" and "cold blooded animals", "impermeable skin" (S26); "shell"(S10); "bone carapace cast into the spinal column" (S14); "rib" (S6, S16); "locomotive limbs" (S4); "swamp" (S8); "water as habitat" (S5, S7, S11, S17); and "cat, dog and rabbit" as examples (S9). Except for some inadequate relations, the examples just mentioned were the only mistakes present in the Map of Concepts II chart.

In the third and last class, the students developed individually the final map and took part in two evaluation activities. The first, concerning the contents of the topic (reptiles) under study, is not analyzed in this paper. The other was about the insertion of map of concepts as a learning strategy in that particular school subject (science). Despite their certain degree of agitation, the students were able to carry out the activities in a calm and cooperative atmosphere. Among the concepts used in these maps, only seven-out-of 87 were new in relation to the ones found in the two preceding moments. They are: "toothless" (S4, S14, S20); "ear" (S10); "neck" (S14, S15); "habitat on land" (S4); "endotherm", "amphibian" and "mammal", the three being wrong. The Maps of Concepts III, elaborated at the final phase of the intervention, show us that still at that final moment there wasn't an improvement in the level of attention on concepts/ideas that effectively differentiates reptiles from the other vertebrates. On the other hand, there wasn't neither an increase in the use of hierarchical relations what evidence that, although the concepts present in the maps were part of the conceptual structure, the topic 'reptile' was incorrectly perceived or perceived loosely and in fragments.

These impressions are confirmed when we compare, the frequency of the concepts in the three maps. There is no expressive difference in the number of concepts/ideas in each category, nor in the frequency of their use by the 22 students. The gradual decrease in the number of concepts in the second instance, which we could initially interpret as a positive impact, did not reveal any closer attention to the more general and central concepts on the theme. On the other hand, the number of concepts grouped in the categories indicates that those students were frequently recurring to different concepts (words/labels) to express one same idea or meaning. Thinking about these results, w**hat can we say about the learning process of the students and about the influence of the map of concepts on that process?**

Meaningful learning is a process in which new information relates substantively and in a non-arbitrary fashion to a relevant aspect of our cognitive structure (Ausubel et al, 1978). The more stable and consolidated

these structures are, the greater the possibility of using this knowledge the person will have, especially in novel and therefore unfamiliar situations. In this perspective, to evaluate meaningful learning requires close attention to the type of use the person makes of his/her own knowledge in distinct situations under conditions that are unfamiliar to him/her. In the current study, the elaboration of map of concepts was in itself an unknown situation for the students. The topic – reptiles – was not completely new to the students, although barely known from that educational perspective. Thus, one of the possible evidences that there has effectively been some learning from maps of concepts – still considering the students as a whole – should be the perception of a tendency to focus on the central concepts of the topic and of some improvement of the hierarchical relations between them. We have already mentioned that we did not observe this tendency in the construction of the maps with the students we were working with.

Summing up what we have so far presented, we have a teaching process that intended to favour meaningful learning on the topic of reptiles with the aid of maps of concepts, together with an assessment of these maps built by the students – which was loose and fragmented at first, but which did not evolve much as the teaching process progressed. Finally, there is our interest to get to know and understand the type of influence the insertion of map of concepts exerted in this process. In other words, the partial results impose upon us questions that precede our main goal. These questions, on the one hand, explicit that both the insertion and the analysis of an instructional strategy need a theoretical base to back them up. It is not our aim here to qualify the teaching process as having been good or bad. Nor do we intend to affirm whether the influence of the use of map of concepts was either positive or negative. Our purpose is to understand what happened. The Theory of Meaningful Learning, which guided us to propose the use of map of concepts in the first place, offers us important elements for our reflection. These will be the core aspects of what we will now discuss.

3 How did the Insertion of Map of Concepts in the Teaching Process influence the students' learning on Reptiles?

The choice of applying the principles of the Meaningful Learning Theory (Ausubel et al, 1978) implies that the teacher should necessarily build up potentially meaningful material and that the students should have the intention of using the tools available in this type of learning process. Hence, it is fundamental for us to assess if these two conditions have been simultaneously present in order to understand the nature of the acquired knowledge expressed in the maps by those students, analyzing above all their choice of concepts for the construction of the referred maps.

In relation to the students, from the description of the teaching activities we learn that they showed "favorable disposition to learn meaningfully", and, furthermore, that they interacted friendly with other students and with the teachers, reacting positively towards the topic they were supposed to study. Aside from their active participation in the activities that were familiar to them, they were equally receptive to deal with two new objects: the map of concepts as a new learning tool, and 'reptiles' as a new topic. Even faced with these two unfamiliar elements, they were committed to the process.

The evaluation by the 22 students themselves about the insertion of the concept maps confirms these impressions. The first of the four questions asked for the students' opinion about the potentiality of the concept maps as facilitative tools for learning. Eighteen students were explicit in answering positively to the issue saying they liked the experience. Eleven emphasized that they had learned more due to the specific influence of this tool. The second question asked about the difficulties that they may have had when building the maps. Only three students affirmed they had none. For the rest, the difficulties referred to the choice of words (4 students), to the structure of the map in its organization, format and relations (8), to the need of further explanation (4) and to the general difficulties with the first map (3) or because "did not know what to do" (1).

The third question was about the advantages and disadvantages about the use of those tools in the year they were studying. The answers remained personal, and ten students pointed out that there were advantages. Five students stated they had liked it and two approved the aspect of conferring grades (scores). One mentioned about the possibility of making the maps, but also of talking about their contents. As to the disadvantages, two students stated that they "had not liked it". Three affirmed that they had difficulty in making the maps, while another one mentioned his/her difficulty in finding the correct words. Finally, when they were asked to say "what they thought about an eventual utilization of map of concepts in other school subjects", fifteen defended the appropriation of these tools in other classes, seven related the advantage to its facilitating learning. In smaller proportions, there were comments about "teaching in a different way", which made classes "more interesting ('cool')". Besides, grading was included as disadvantage by three students.

Summing up, there was no evidence that the students had no interest to think with and about what they were learning. Therefore, lack of interest cannot explain the fact that their level of knowledge at the end of the experiment was very close to the one they had in the very beginning (after a diagnosis of this aspect), when the intervention had started. There was neither lack of interest in negotiating and grasping new meanings, nor in relating them substantively – and not at all arbitrarily – to the previous knowledge they had on the subject. Being fully aware of that, we now turn to reflect if the second condition was met: **was the teaching materials in fact potentially meaningful to this group of students?**

According to Ausubel and to others who shared his views (Ausubel et al, 1978), the teaching material is potentially meaningful when it is possible to relate it to some relevant aspect already present in the cognitive structure of the learner. Thus, reproducing his premise, we affirm that, in order to promote meaningful learning, it is necessary to have a diagnosis of what the students already know, and from there teach them accordingly. In turn, teaching accordingly requires, as we have mentioned, the analysis not only of the structure of the knowledge that there is to teach, but also of what the students already know about the topic. Based on the difference between both, we find what there is to teach, and plan the teaching process.

The study of reptiles (in Latin = crawl, creep) at this level of teaching involves, in broad terms, situating it as a group (Class) of **Living Beings** in the **Animal Kingdom** (multi-cellular heterophics), **Filo Chordate** and **Sub-filo Vertebrata** that, in the evolutional scale, primarily present evident adaptations to life on land: **impermeability of the skin** (carapaces, scales and corneal plaques); **hard shell eggs**, offering protection against dehydration and allowing nutritional storage, not only for the **oviparous** but also for the **ovoviparous.** Apart from these specific aspects, the conquest of land environment was also promoted by lungs with more internal folds (**lung respiration**); hearts with three (partially divided ventricles) or four cavities divided ventricles, but still **incomplete circulation;** complete digestive system; **sexual reproduction** with **internal fecundation; developed sense organs;** with (two pairs of) extremities or with these extremities either reduced or absent, among others. Despite these adaptations, reptiles remained ectoterms, which makes them dependent on external sources of heat, limiting their occupation of spaces. They are sub-divided into **Orders**, the most representative of which are the crocodilians, the scaled and the chelonians. The main criteria for the differentiation of these groups are the types of skin coverage and the locomotive appendices.

After we have defined what the students should learn, it is necessary to make a diagnosis of what they already know about the topic. In order to do so, our attention should focus on the concepts they already know, on the relations they establish between them and to the meaning that this set represents to the learners. In other words, it is important to verify how close or how distant the student's knowledge is from what one desires to teach. The evaluation of their previous knowledge by means of maps made it evident that, by means of the concepts that were mentioned, the students knew the characteristics of the reptiles, although the relations were inadequate. Furthermore, they could not group them – mentally – in an organized totality that would allow them to become aware of the interdependence between anatomy, physiology, external characteristics and behavior. **Therefore, what was important to teach the students?**

In this case, according to the diagnosis on their knowledge, in order for the teaching material to be potentially meaningful it should give priority to the integrative reconciliation (Ausubel et al, 1978) of the concepts and ideas already known by the students. This requirement indicates that the strategies chosen for the development of the teaching process were correct, since all of them made personal and interpersonal negotiation of meanings possible. The map of concepts structural organization corresponds to the manner we organize knowledge in our mind (cognitive structure). They can promote the establishment of substantive and non-arbitrary relations (meaningful learning), as well as the diagnosis – despite only being an approximation – of the elaborator's steps "in his structuring, establishing hierarchies, differentiations, relations, discriminations and integration of concepts of a determined unit, topic or subject area" (Moreira, 2006:19).

Such characteristics of the maps of concepts allow for not only the initial evaluations, the final one, but also the evolution of the students' knowledge along the teaching experience. This last focus is the one which agrees with the goal of this study, for it is the quality of the difference of the concepts and their respective relations that will allow us to consider the insertion of this tool as having optimized the teaching of the topic 'reptiles'. Hence, if the comparative analysis of the maps of concepts developed reveals that the concepts found in Map III were qualitatively better than those in Map I, we can accept this result as evidence that the teaching process was potentially meaningful, which reveals that it promoted the grasping of meanings.

In order to find this answer, we have to evaluate whether the concepts used only in Maps III and both in Maps II and III – and which are absent from Map I – correspond to the central and general aspects of the theme. Equally, if the concepts found only in Maps I correspond to the non-specific characteristics of reptiles, we will have one more indicator of the success of the event. On the other hand, if the "major" concepts are found in the three maps, we would have to assume that the influence of the teaching on the knowledge of the students was incipient, and that it did not alter much their knowledge. Let us then see what the maps tell us.

Map of Concepts III totalized 87 different concepts/ideas, seven of which were new to the precedent concepts. Thirteen coincided with the ones that were found in Map II and 67 were the same as the ones found in Map I. With exception of the idea "terrestrial" (pertaining to the land), none of the 7 new concepts listed in the preceding was relevant for the topic. Apart from that, three of them (endoterm, amphibious and mammal) were wrong. The thirteen concepts/ideas exclusive to Maps II and III, whose origin could be related to the teaching developed during the experience are: "280 million years ago"(1); **egg with shell** - protection (1); jaw (2); rectum (1); tail vertebrae (1); **impermeable skin** (1); rib (2); locomotive limbs (1); water (3); is born (5); grows (5); reproduces (5); dies (5). In this set, egg with shell, impermeable skin and locomotive limbs are fundamental in the characterization of reptiles, integrating the categories well cited by the students. Among the 67 concepts found in Maps I and III, the most frequent are: reptiles (20), turtles (15), snakes (12), lizard (10), crocodilians, scaled, alligator (8) ophidians, chelonians and tail (7), **internal fecundation, carnivorous, carapaces**, eyes, crocodile, turtles (of another specific kind) (6), **ectotherm** and **scales** (5) and others mentioned from one (the most frequently among them) to four times. The concepts common to Maps of Concepts I, II and III are the ones that are closest to the characterization of reptiles, despite their having maintained the profile of the one described earlier. They are: vertebrate (1), reptiles (20), crocodilians (2), with scales (2), chelonians (2), oviparous (1), eggs directly on the ground (1), mouth (2), feed themselves (1), breathe (1), nostrils (2), skin (1), eyes (3), tail (1), snake (5), crocodile (2), dinosaurs (1), turtles (of the Brazilian variety "jabuti") (2), alligator (5), turtles (5).

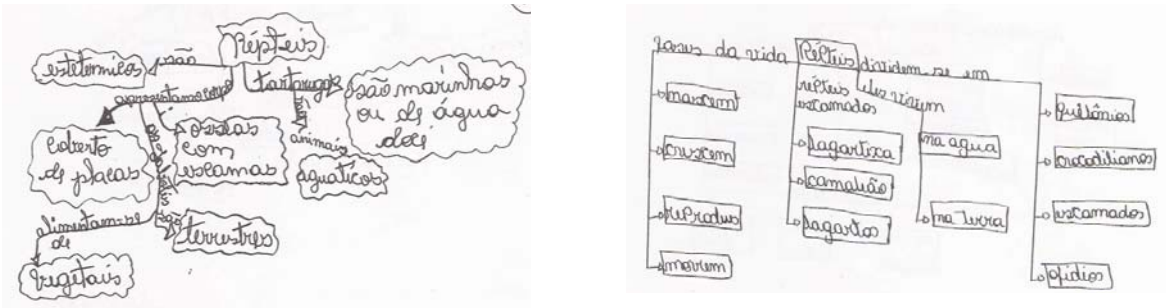

Figure 2. Maps of Concepts III – Students 17 and 5

[The translation of the concepts and or connectors is: alimentam-se de= **they feed themselves of**; apresentam o corpo= **their body have**; camaleão= **chameleon**; com escamas= **with scales**; crescem= **they grow**; coberto de placas= **covered of plates**; crocodilianos= **crocodilians**; eles vivem= **they live**; escamados= **with scale**; exotérmico= **cold blooded animals**; fases da vida= **fases of life**; lagartos= **lizards**; lagartixa= **small harmless lizard**; morrem= **they die**; nascem= **they are born**; na água= **in the water**; na terra= **on land**; ofídios= **ophidians**; os jabutis são= **a Brazilian variety of turtle**; ósseas= **boned skin**; quelônios= **chelonians**; répteis= **reptiles**; são= **are**; são marinhas ou de água doce= **they are marine or of candy water**; reproduzem= **they reproduce**; são animais aquáticos= **they are aquatic animal**; terrestre= **habitat on land**; vegetais= **vegetables**; tartarugas= **turtle**].

In short, as anticipated, although the more important concepts for the characterization of reptiles appear in the set of all the elaborated maps, only a small number of students mention them. The nature of these concepts centered on the examples and external characteristics and behavior is very similar to the one we diagnosed in the first encounter. Just to illustrate the hierarchies we present in Figure 2 the maps of concepts draw by the same students whose maps of concepts we presented as example in Figure 1.

Therefore, even without having analyzed in full detail the hierarchies established by the students among these concepts on the maps, the analysis authorizes us to say that the students kept on using various concepts to express similar meanings because they did not grasp and did not share the meanings that were "taught" to them. For this reason, in case they choose to learn, they make the option for doing it in a mechanical form. Before qualifying the insertion of the maps of concepts in this process we should take into consideration the fact that we based our reflections on the premise that Maps of Concepts I represent what **the students previously knew** before the beginning of the process. It so happens that, as we have described, the students drew up these maps after a collective oral discussion. As there were no notes on the principal ideas of this debate, we cannot ignore that the diversity of concepts diagnosed afterwards – coincidentally very similar to the contents of the textbook – can be a consequence of this interactive activity and/or even of any previous consultation of the material in the

textbook. It is very likely that this decision has covered up the positive impact of the teaching and the maps of concepts during the experience.

According to the students, the influence was positive because the tool helped them to learn in a pleasant form, despite the difficulties they came up against in choosing the "words" and in establishing "relations". The process of evaluation of the maps tells us that the number of concepts utilized had an expressive decrease (from 124 to 87). Aside from these aspects and considering that the integrative reconciliation – here understood as this group of students' main demand – has not been perceived in this analysis, it is important to make a point at this stage of our study. It amounts to the fact that the maps of concepts elaborated by the students were the elements that enabled us to analyze in fuller detail the nature of the knowledge this group had represented mentally. In the daily routine where the teacher had been teaching, and the students had been learning, it would have been more difficult to identify the specific demands of this group.

4 Final Coments

In this investigation, as the report on the experience attests, the plan for the intervention gave priority to the presentation of the map of concepts, dedicating little attention to the conceptual structure of the topic. The latter aspect was what should have been at stake. This does not mean that there was a lack of commitment by the teacher to the organization of the teaching process. On the contrary, the revision of the process allows us to perceive that the concern with the insertion of the map of concepts in the process, in addition to the teachers' experience in this level and with this class in particular, diverted their attention from the relation content-learning-teaching-context-evaluation, as deemed appropriate, to the teaching strategies. According to them, it was a difficult group of students to work with. Getting them involved in the process demanded dynamic studying strategies (explaining the diversification in the activities that went on despite the little time allotted to their development) and some form of gratification. In this kind of context – which reproduces the predominant practice in most Brazilian schools – the textbook was the guide for what they should present to the students. Nevertheless, it is true that the contents of newspapers or magazine clippings brought in by the teacher and the students' previous knowledge on the topic had some influence in the process.

Finally, among the various considerations that the study allows us to make, we would like to emphasize that the use of map of concepts is not a trivial task. For this reason, we suggest that their introduction into the dynamics of a class take place with themes from the school curriculum the students already know or are familiar with, stressing that it is also fundamental that, with negotiating with the students the central concepts of the topic, the teacher indicate the concepts that must integrate the first maps. In other words, gradual familiarization of the tool 'map of concepts' is at the basis of an autonomous success of its use. This is what we will continue trying to do …

5 Acknowledgements

The authors would like to thank Aleksandra Marcelino da Silva for the opportunity of developing this research. Accepting the challenge of applying new teaching techniques to her students, as a teacher at the José Brasileiro Vila Nova Municipal School in Garanhuns, in the Brazilian state of Pernambuco, she contributed not only to the possibility of new learning and teaching experiences, but also with her reflections on that process.

References

Ausubel, D.P., Novak, J.D. and Hanesian, H. (1978). *Educational psychology.* New York: Holt, Rinehart and Winston.

Cañas, A., Novak, J.D., González, F.M. (2004). *Concept Maps: Theory, Methodology, Technology*. Proc. of the First International Conference on Concept Mapping. Eds Pamplona, Spain: Universidad Pública de Navarra. http://cmc.ihmc.us/CMC2004Programa.html access in 20/03/2008.

Cruz, D. (2005). Ciências e Educação Ambiental (Science and Environmental Education). São Paulo: Ática.

Moreira, M.A. (2006). Mapas Conceituais e Aprendizagem Significativa. Porto Alegre

Novak, J. D. (1998). Learning, creating, and using knowledge: Concept Maps as Facilitative Tools in Schools and Corporations. Mahweh, NJ: Lawrence Erlbaum Associates.

Novak, J. D., & Gowin, D. B. (1984). Learning How to Learn. New York: Cambridge University Press.