LEARNING WITH MAPS OF CONCEPTS: AN ANALYSIS OF A TEACHING EXPERIENCE ON THE TOPIC "REPTILES" WITH 15-YEAR-OLD STUDENTS AT A SECONDARY SCHOOL[1]

(Aprendendo com mapas conceituais: análise de uma experiência didática sobre o tópico "Répteis" com estudantes de 15 anos de idade de uma escola de Ensino Médio)

Evelyse dos Santos Lemos [evelyse@ioc.fiocruz.br]
Programa de Pós-graduação em Ensino em Biociências e Saúde, Laboratório de Educação em Saúde e Ambiente, Instituto Oswaldo Cruz, Fiocruz – RJ, Brasil.
Conceição Aparecida Soares Mendonça [conceição_mendonça@hotmail.com]
Universidade Federal Rural de Pernambuco, *Campus* Garanhuns – PE, Brasil.

Abstract

Based on the premise that concept maps represent an important and relevant tool for the educational process of the meaningful learning of scientific concepts, this paper aims at describing and analyzing a specific educational experience involving classes about the subject `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/among them. The approach resorted to map of concepts as an aid for teaching the topic. The process consisted of three ninety-minute meetings each with a group of thirty-eight students from 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 of the newly collected data. The analysis of the information gathered – maps of concepts developed at the beginning of the teaching and learning event, in the middle and at the end of the process, students´ answers to the questionnaire about their perceptions regarding the maps – was based on the Meaningful Learning Theory (Ausubel et al, 1978). Findings suggested that the students enjoyed elaborating the maps of concepts and considered them as facilitators of learning. Nevertheless, these findings also indicated that the short duration of the experience, albeit having contributed to a clear increase of the participants´ general vocabulary, was not enough to stimulate the students to grasp and/or learn the meanings of the central concepts involved in the topic "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 a suggestion, which assumes that the basis for meaningful learning is its process, we recommend greater attention to the process of learning how to build map of concepts. Their introduction to the dynamics of formal teaching should occur with topics students are already familiar with, followed by the teacher negotiating with the class the list of concepts that will compose the map.
Keywords: meaningful learning; biology teaching; reptiles; concept maps.

Resumo

Partindo da premissa que os mapas conceituais são recursos de grande relevância para o processo educativo, especialmente o da aprendizagem significativa de conceitos científicos, este trabalho se propõe a descrever e analisar uma experiência educacional que pretendeu ensinar, à alunos da sétima série da educação básica (15 anos, em média), tanto a construção de mapas de

[1] This article is a reviewed and expanded version of a paper presented at the **Third International Conference on Concept Mapping,** in Tallin, Estonia and Helsinki, Finland September 22 to 25, 2008. The original text is available at http://cmc.ihmc.us/cmc2008/cmc2008Program.html, with a link in the Program (Paper B11) and in the volume II, pages 477-484.

conceitos quanto o tema "répteis". Devido à especificidade da área de ensino e os vários usos que os mapas conceituais podem ter, decidimos usar o termo "mapa de conceitos" para representar um tipo específico de mapa conceitual, aquele que lida com conceitos científicos e a relação entre eles. O mapa de conceitos foi utilizado como recurso instructional e o processo consistiu em três encontros de noventa minutos com a turma de 38 alunos, previamente escolhida, em novembro de 2006. As aulas, com exceção da introdução de mapas de conceitos como recurso de aprendizagem, foram desenvolvidas conforme sua dinâmica habitual: debate inicial livre, posterior leitura e discussão do livro texto, atividades em grupo e, ao final, uma avaliação escrita sobre o novo recurso instrucional. A análise dos dados - mapas de conceitos construídos no início, no meio e no final do da intervenção, respostas ao questionário com perguntas sobre as percepções dos alunos sobre os mapas - baseou-se na Teoria da Aprendizagem Significativa (Ausubel et al, 1978). Os resultados evidenciam que os alunos gostaram de elaborar os mapas de conceitos e os perceberam como facilitadores da própria aprendizagem. Entretanto, também indicam que a experiência, curta, apesar da evidente ampliação do vocabulário mais geral, não foi suficiente para a efetiva compreensão da lógica hierárquica e relacional dos mapas de conceitos e tampouco para a aprendizagem significativa dos conceitos centrais do tema "répteis". Como sugestão, ressaltando o caráter processual da aprendizagem significativa, recomendamos maior atenção para o processo de aprendizagem sobre mapa de conceitos e que a sua introdução na dinâmica educativa seja feita com temas já conhecidos e familiares aos estudantes, e com o professor indicando, após negociação com os alunos, que conceitos deverão integrar os mapas.
Palavras-chave: aprendizagem significativa; ensino de Biologia; répteis; mapas conceituais.

Introduction

Concepts maps are diagrams that indicate the relationship between/among 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 presented in 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 can be 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 their 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 application of these tools to instruction, learning, curricular planning, and to evaluation resources. Due to the specificity of the educational area and to the various uses concept maps may have, we have chosen to use the term “map of concepts”. We have done so by having students 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). Thus, **we propose the use of “map of concepts”** as a more adequate variation for the term concept maps **in the educational context, structured primarily by scientific concepts, since 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 seems to reveal an existing interdependence. Since they represent

relations between scientific concepts, in their diversified use they end up favoring negotiation of meanings. 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). Most 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 the students' 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 the construction of maps of concepts. More specifically, they have failed to analyze the relation between knowledge represented in these maps of concepts, evolution of the learning process and teaching process developed along the experience. It is precisely in this partially unexplored direction that this article goes. Data we are about to describe, which we consider a pilot study for a broader project, focuses on understanding the teaching and learning processes that come about with the development of map of concepts.

Bearing this in mind, we are concerned with the learning process of the meanings embedded in what a map of concepts is, and, consequently, with the relevant role that the attention its maker, or developer, devotes to the selection of the scientific concepts that will integrate the map. Furthermore, we also consider 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, learning resource, and/or theoretical reference.

The meaningful learning process demands both personal negotiation of the new meanings – when the student compares and negotiates the new information with the ones he has already got –, as well as negotiation of the meanings already grasped through interpersonal negotiations and when the student compares and negotiates what he/she thinks about the topic with the interpretation of his/her peer(s). These steps demand the attention (not only of the teacher, but also of the learner) to the central concepts of the topic at hand and to the relations established between/among them. This aspect justifies the potentiality 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 experts in the field related to the construction of such maps: the selection and list of eight to ten key concepts, the organization of the concepts from the most general ones to the most specific, and the establishment of the vertical and horizontal relational axes between/among the concepts by using lines and words (connectors) that explain these relations (Novak & Gowin, 1984; Moreira, 2006).

Based on what we have already discussed, we describe the teaching process. Our prime concern was the concepts presented in the constructed maps of concepts. We have tried to analyze the nature of the students' knowledge shown in the maps they constructed in three different moments of the intervention. Based on these data, we will discuss the influence of teaching on the maps of concepts constructed at the each of these instances. 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 of the teaching process.

Teaching about Reptiles with Map of Concepts

The proposal of the Intervention

One of the authors of this paper, in partnership with a science teacher, developed the activity during the regular classes of 7th graders in a public school in Garanhuns, in the Brazilian northeastern state of Pernambuco. The class comprised 38 students (14 boys and 24 girls), averaging 15 years of age. It is important to state, right from the start, that for analytical reasons we

have considered as the population of this study only 22 students, since they were the ones that participated in all the classes and performed all the activities. Besides being in accordance with the school syllabus for the subject, the main objective of the experiment was to favor meaningful learning (Ausubel et al, 1978) on the topic of 'reptiles'. Starting from this point, there was an introduction to the maps of concepts, which, until then, were unknown to this group of students, introducing them in the dynamics of the classes as a learning tool.

The experience comprised three one and a half-hour meetings each, for three consecutive weeks. In the first meeting, right after the explanation of what a map of concepts was, the teacher motivated an oral and collective discussion. At that point, the students could characterize reptiles without having to resort to any text, and, then, they individually drew a map of concepts for this group of animals without any help once the discussion was over. On the second meeting, they worked on the topic during the first half of the class following the usual procedure used by the teacher and according to the school curriculum: reading from the textbook by the students and a collective discussion on the elements of the text, which derived from questions asked either by the teacher and/or by the students themselves. Next, they discussed the topic using posters the students had prepared according to comments heard or read in the media. They summed up the topic by developing another map of concepts. During the third and last meeting, they developed the third (last) map, and they had two evaluating activities: one about the content of what had been studied (reptiles) and another about the introduction 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 proceed with the process presentation and its analysis.

The development of a 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, this intervention had the purpose of describing and analyzing how the maps of concepts work so as to bring out their full potential: to favor meaningful learning of the topic "reptiles" by the students. The application of this learning tool was the only change in the daily dynamics of the class, aiming at bringing about individual and/or collective reflection on the concepts and the relation students established p between themselves to characterize the topic of study in question. The expectation, which was based on the idea that learning is a process that demands time and negotiation of meanings, was that the maps constructed in three distinct moments – despite their being very close in time – could show an evolution in the students' knowledge along the teaching process.

Thus, considering the fact that this group of students had no previous knowledge of map of concepts – they neither knew what maps of concepts meant nor what their underlying organization was –, the first meeting started with the introduction of these tools. The teacher showed several examples of maps and explained the guiding principles and the criteria for building such tools. She tried to emphasize the fact that although the maps did not have a predetermined format, it was important to comply with both the hierarchy and the horizontal relations concepts established among/between themselves when representing a particular body of knowledge. She also pointed out that the maps of concepts were personal, and, for this reason, they corresponded to one among the various possible interpretations for a given conceptual structure, which in itself demanded a clearer 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. Then, they drew up a 'Map of Concepts I', individually and without resorting to any other source of information. The information they used came from their prior knowledge of the subject. The drawing process was calm, with just a few questions and the students' visible enthusiasm.

As it can be inferred from Figure 1, this first set of maps of concepts has a variety of formats, and, although it is possible to perceive a concern for hierarchy, though it is the vertical direction that prevails, despite the fact that often relations between/among the most general, intermediary, and specific concepts are inadequate. Likewise, concepts placed in the same horizontal axis rarely have to do with that type of relation. Apart from these aspects, what calls most of our attention in these 22 maps is the diversity of concepts presented. In average, they include twelve concepts (ideas), which, as a whole, adds up to 124 different types (Chart 1). When analyzed, these were organized into seven categories: classification, origin (date) and family (ancestors and descendants), vital functions, bodily structure, temperature, habitat and examples.

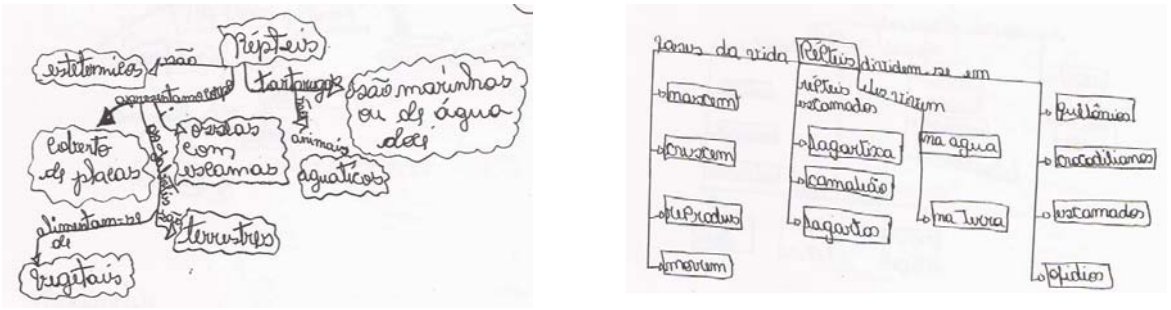

Figure 1. Maps of Concepts I – Students 17 and 5.
[The translation of the concepts and connectors is: anfíbios= **amphibians**; ancestrais de= **ancestral of**; aves**= birds**; carnes=**meats**; cobras= **snakes**; crocodilos= **crocodiles**; dinossauros= **dinosaurs**; dragões= **dragons**; eles comem=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

Chart 1 shows these categories including their main subcategories, the total number of different concepts mentioned in the maps (conc), and the number of students that have mentioned these concepts (freq) in the Map of Concepts I, II and III. 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, as they derived from three students. Student number 1 named "ophidians" as a "class" of reptiles, not an "order"; student 9 stated that reptiles live "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 a reptile animal. We can infer from these observations that the group of students knew about reptiles, as they could give examples of them, but resorted to external and behavioral characteristics, especially feeding habits and the type of locomotion to characterize the animals in question.

As we have already mentioned, in the second meeting there was a discussion on the chosen topic using various strategies: shared reading of the textbook used in 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 students showed enthusiasm and commitment to all the activities. The

posters, made from magazine clippings brought in by the students and placed on the classroom walls then became the focus of the planned discussion. In the construction of 'Map of Concepts II', as it had happened in the prior meeting, the students were free to decide what concepts they would use. During the development of the map of concepts, students came to the teachers for guidance, not only about the hierarchical organization of what they were constructing, but also about the words/phrases that they were trying to use as connectors. When the discussion centered in the bits of news the head teacher had brought to class, the students commented on some programs about the subject they had seen on TV, or about their daily life experiences in comparison to the textbook. They said they considered "too brief the material in the textbook", adding that they had learned more with the development of the map of concepts than by the reading from the textbook.

CONCEPTS					CONCEPT MAPS					
					I		II		III	
categories	Subcategories and examples				conc	freq	conc	freq	conc	freq
Classification	Living being	Vital cycle				0		0		3
	Animal – vertebrate – endoskeleton					3		5		2
	Classes: crocodilian – scaled – chelonian					7		0		6
Origin and kinship	time					2		3		1
	Ancestry and family					2		2		0
Vital functions	Repro duction	Sexual – internal fertilization				7		4		7
		Oviparous – ovoviviparous – viviparous				6		2		1
	Nutrition	digestive	SYSTMS	complete		7		4		7
				organs		6		2		1
				Nutrition Source nutritious		2		0		0
		respiratory		pulmonary		12		9		8
		Circulatory		Heart - cavities		17		6		11
		excretory		Organ		3		3		1
	Control	Nervous System		Brain – nervous tube – furcated tongue		3		1		2
		endocrinal		endocrinal		1		1		1
Bodily structure	Skin	Corneal plates – scales – thick dry skin				15		9		19
	Organs and appendices	Eyes – mouth – tail – paws/legs				13		9		15
temperature	Ectotherm – cold blood - poikilotherm					0		6		2
examples	snakes - alligators - crocodiles – turtles - dragon - lizards					15		13		31
habitat	Land – water – run – swim - crawl					9		11		15
TOTAL OF GENERAL CONCEPTS LISTED					124		102		87	
TOTAL OF NEW GENERAL CONCEPTS IN EACH PHASE					**124**		**31**		**7**	

CHART 1: Categories and subcategories in which the concepts found in Maps of Concepts I, II and III were grouped and their respective frequency. [CONC means the total number of the different concepts placed in the maps of concepts and FREQ the number of students that mentioned these concepts].

The analysis of these maps of concepts followed the same pattern previously applied, that is, checking the nature of the hierarchical relations, the list of the concepts, and their organization into categories. The result showed little difference between the students' initial maps and the second ones (Chart 1). Hierarchies were still poorly considered and the diversity of concepts/ideas, though smaller, maintained the emphasis on examples and external characteristics and behavior of reptiles.

Among the 102 concepts mentioned by the students, 31 were new and not much representative of the central and specific characteristics of reptiles, and the distribution into categories was similar to those that had been mentioned before. Of this total, only "eggs with shell"

and "poikilotherm" characterized correctly reptiles regardless of not being exclusive characteristics of that animal group. The new concepts/ideas were: "is born", "grows", "reproduces" and "dies" (Students 9 and 22); "280 million years ago" (Student 5); "350 million years ago" (Student 14); "the turtle was born first" (Student 14); "similar to birds" (Student 4); "testicles" and "deferential duct" (Student 2); "eggs with shells" for "protection" and for "nutritional reserve" (Student 4); "don't drink milk" (Student 7); "jaw", "rectum" (Students 2 and 16); "lung" (Student 2); "urethra" (Student 2); "vertebral spinal column" (Students 5 and 6); "caudal vertebrae" (Student 16); "poikilotherm" and "cold blooded animals", "impermeable skin" (Student 26); "shell"(Student 10); "bone carapace cast into the spinal column" (Student 14); "rib" (Students 6 and 16); "locomotive limbs" (Student 4); "swamp" (Student 8); "water as habitat" (Students 5, 7, 11 and 17); and "cat, dog and rabbit" as examples (Student 9). Except for some inadequate relations, the aforementioned examples were the only mistakes presented in the 'Map of Concepts II' chart.

In the third and last class, the students individually developed their last map and they participated 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 adding the map of concepts as a learning strategy in that particular school subject (science). Despite their certain degree of anxiety, 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 were: "toothless" (Students 4, 14 and 20); "ear" (Student 10); "neck" (Students 14 and 15); "habitat on land" (Student 4); "endotherm", "amphibian" and "mammal", the three of them considered wrong. The Maps of Concepts III developed at the final stage of this intervention, may show us that even at the last moment there did not seem to show an improvement in the level of attention to the concepts/ideas that effectively differentiate reptiles from the other vertebrates. On the other hand, there wasn't an increase in the use of hierarchical relations, which could evidence that, although the concepts presented in the maps integrated the conceptual structure of the topic 'reptile', it seemed to have been either incorrectly or loosely or fragmentally perceived by the students.

These impressions can be confirmed when we compare, using Chart 1, the frequency of concepts in the three maps. There is no significant 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 linked to the theme. On the other hand, the number of concepts grouped in the categories may indicate that those students often resorted to different concepts (words/labels) to express the same idea or meaning. Taking into consideration these findings, w**hat can we say about the students' learning process and about the influence of the map of concepts on that specific process?**

Meaningful learning is a process through which new information relates substantively and in a non-arbitrary way 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 applying the knowledge the person already has to unfamiliar situations. In this perspective, evaluating meaningful learning requires close attention to the type of use the person makes of his/her own knowledge in distinct situations that are unfamiliar to him/her. In the current study, the development of maps of concepts was, in itself, an unknown situation for the students. The topic – reptiles – was not completely new to them, although barely known from the educational perspective proposed in this intervention. Thus, one of the possible evidences that some learning through the use of maps of concepts has occurred – still considering the students as a whole – should be the perception of a tendency to focus on the key concepts of the topic, as well as some improvement in the presentation of hierarchical relations between/among them. We mentioned before that we had not observed in the students we were working with this trend in their construction of the maps.

Summing up, what has been presented so far, we have a teaching process that aimed at favoring meaningful learning of the topic "reptiles" with the introduction of maps of concepts, together with an assessment of these maps built by the students – which were loose and fragmented at first and 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 use of map of concepts has had in this process. In other words, the partial results have triggered questions that even precede our main goal. These questions explicit that both the use and the analysis of an instructional strategy need a theoretical base to support them. It is not our goal here to qualify the teaching process as good or bad. Nor we intend to state that the influence of the use of map of concepts has been positive or negative. Our purpose is to understand what has happened. The Theory of Meaningful Learning, which motivated us to propose the use of map of concepts in the first place, offers us relevant elements to our reflection. These will be the core aspects of what we will now discuss.

How did the Implementation of Map of Concepts in the Teaching Process influence the students' learning about Reptiles?

The choice of applying the principles of the Meaningful Learning Theory (Ausubel et al, 1978) implies that the teacher should necessarily use potentially meaningful materials and that the students should have the intention of learning, using the tools made available to them for this type of learning process. Hence, it is fundamental for us to verify whether or not these two conditions have been simultaneously present so as to understand the nature of the acquired knowledge expressed in the students' maps, analyzing, as our prime concern, their choice of concepts to integrate the construction of their maps.

In relation to the students, from the description of the teaching activities, we learn that they have shown "a favorable disposition to learn meaningfully", and, furthermore, that they have had a friendly interaction with their peers and teachers, reacting favorably towards the topic they have been supposed to study. Aside from their active participation in the activities, which were familiar to them, they have been equally receptive not only to learning the technique involved in the construction of the maps, but also to the new topic. During the experience, we could observe that the students have had 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 seemed committed to the process.

The evaluation performed by the 22 students themselves about the implementation of maps of concepts confirms these expectations, although we cannot forget the possibility of a certain degree of bias in their responses that aimed at pleasing the teachers. The first of the four questions asked the students' opinion about the potentiality of maps of concepts as facilitative tools for learning. Eighteen students were explicit in answering affirmatively to the issue saying they had enjoyed the experience (they thought it was important or that it was 'cool'). Eleven emphasized that they had learned more due to the specific influence of this tool. Only one referred to his own interest in applying this tool to other school subjects and/or to other school years, while two did not answer it. The second question asked about the difficulties that they might have had when building the maps. Only three students affirmed they had had none. The remaining students credited their difficulties to the choice of words (4 students), to the structure of the map in its organization, format and relations (8 students), to the need of further explanation (4 students) and to the general difficulties with the first map (3 students), or because "did not know what to do" (1 student).

The third question was about the advantages and disadvantages of the use of those tools in that specific school year. The answers were strictly personal, and ten students pointed out that there were some advantages. Five students stated they had liked it, and two approved the aspect of

conferring grades (scores). One student commented about having had not only the possibility of making the maps, but also of talking about them. 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 mentioned his/her difficulty in finding the correct words. Finally, when they were asked to say "what they thought about the possibility of using the map of concepts in other school subjects", only four were against it, while two did not answer. Regarding the fifteen reasons for defending the application of these tools in other classes, seven pointed out as an advantage their possibility of facilitating learning. In smaller proportions, there were comments about "teaching in a different way", making classes "more interesting ('cool')". Besides, three students considered grading as a disadvantage in the use of these tools.

Summing up, there was no evidence that the students had not shown any interest in thinking about what they were learning. Therefore, lack of interest cannot explain the fact that their level of knowledge at the end of the experiment seemed to be very close to the one they had shown at 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 prior knowledge they had about the subject. Being fully aware of that, we now turn to reflect if we have met the second condition: **were the teaching materials in fact potentially meaningful to this group of students?**

According to Ausubel, and to others who share 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 learner' s cognitive structure. Thus, rephrasing Ausubel's premise, we state that 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 to be taught, but also of what the students already know about the topic. Based on the difference between both, we knew what there was to teach, how the teaching process should be and how long it should last. However, when and planning the teaching process, must consider the difference between the subject/topic to be taught and what the students already know about it.

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** (with cell organization, which needs that need food to obtain raw material, that is, the necessary energy for the vital cycle: to be born, grow, reproduce, develop and die) in the **Animal Kingdom** (multi-cellular heterotrophic), **Phylum Chordata** and **Subphylum Vertebrata (**notochord and spinal column), which, in the evolutional scale, primarily present evident adaptations to life on land. The "adaptation innovations" that permitted the conquest of this new space were the: **impermeability of the skin** (carapaces, scales and corneal plaques); and the development of **hard shell eggs**, a characteristic that by, offering protection against dehydration and allowing nutritional storage, granted the possibility of a greater reproductive success with direct development (without metamorphosis), not only for the **oviparous** (depositing the eggs on land after fecundation), but also for the **ovoviparous** (depositing the eggs in the environment when the young, already developed inside them, are close to eclosion).

Apart from these specific aspects, the conquest of the land environment was also promoted by the improvement of characteristics already present in other groups: lungs with more internal folds (**lung respiration**); hearts with three (partially divided ventricles) or four cavities divided into ventricles, but still allowing for the communication between the blood rich in oxygen and the one rich in carbon dioxide (**incomplete circulation);** complete digestive system (mouth and cloacae); **sexual reproduction** (male and female gametes) with **internal fecundation; developed sense organs;** with (two pairs of) extremities (adapted for running, crawling, climbing, rowing) or with these extremities either reduced or absent, among others. Despite these adaptations, reptiles

remained ectotherms (incapable of keeping their body temperature constant), which makes them dependent on external sources of heat, limiting their occupation of spaces. They are sub-divided into **Orders**, the most representative of them 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 diagnose what they already know about the topic. In order to do so, our attention should focus on the concepts they already know and, on the relations they establish between/among them. At this point, attention should turn to the meaning that this set represents to the learners. In other words, when we take as a parameter the nature of knowledge about this specific subject, it is important to verify how close, or how distant, the student's knowledge is from what one wants to teach. The evaluation of their previous knowledge by means of their maps seemed to evince that, through the concepts the students had chosen, they apparently 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 of their prior knowledge, for the teaching material to be potentially meaningful it should give priority to the process of integrative reconciliation (Ausubel et al, 1978) of the concepts and ideas students already know. This requirement indicates that the strategies chosen for the development of the teaching process have been adequate, since all of them have aimed at favoring personal and interpersonal negotiation of meanings. The map of concepts' structural organization corresponds to the manner we organize knowledge in our mind (cognitive structure). These maps can promote the establishment of substantive and non-arbitrary relations (meaningful learning), as well as the diagnosis – despite the fact that it offers only 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 may allow not only for the initial evaluations (aiming at the diagnosis of the previous knowledge), the final one (aiming at the assessment of the learning and the teaching processes), but also for assessing the evolution of the students' knowledge along the teaching experience. This last focus 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 implementation of this tool as an optimizer of the teaching of the topic 'reptiles'. Hence, if the comparative analysis of the constructed maps of concepts reveals that the concepts found in 'Map III' has been qualitatively better than those in 'Map I', we can accept this result as an evidence that the teaching process has been potentially meaningful, which seems to evince that it has 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 – whereas are absent in Map I – correspond to the central and general aspects of the theme. Equally, if the concepts presented only in 'Map 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 appear in the three maps, we will have to presume that the influence of teaching on the students' knowledge has been just inceptive and that, besides, it has not altered their knowledge substantially. Let us then see what the three maps can tell us.

'Map of Concepts III' summed up 87 different concepts/ideas, seven of which were new in comparison to the precedent concepts. Thirteen coincided with the ones that were found in Map II while 67 were the same as the ones found in Map I. With the exception of the idea "terrestrial"

(pertaining to the land), none of the 7 new concepts listed in the students' last map was relevant for the topic. Apart from that, three of them (endotherm, amphibious and mammal) were inadequate to characterize reptiles. The thirteen concepts/ideas exclusive to Maps II and III, whose origin can 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 mentioned by the students (chart 1). 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 concepts mentioned from one (the most frequently among them) to four times.

The concepts common to all maps – that is, to Maps of Concepts I, II and III –, are the ones that are closest to the characterization of reptiles. 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), tortoise (of the Brazilian variety "jabuti") (2), alligator (5), turtles (5).

In short, as anticipated, although the most important concepts for the characterization of reptiles appear in the set of all the students' maps, only a few of them have mentioned these concepts. The nature of these concepts centers on the examples, external characteristics, and behavior. It is very similar to the one we have diagnosed in the first meetings. Just to illustrate the hierarchies, we present in Figure 2 two examples of maps of concepts drawn by the same students whose maps of concepts we have shown in Figure 1.

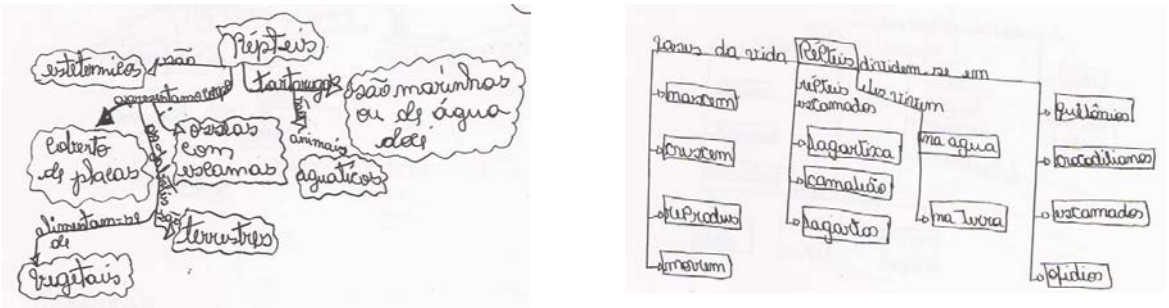

Figure 2. Maps of Concepts III – Students 17 and 5

[The translation of the concepts and connectors is: alimentam-se de= **they feed on**; apresentam o corpo= **their body has**; camaleão= **chameleon**; com escamas= **with scales**; crescem= **they grow**; coberto de placas= **covered with plates**; crocodilianos= **crocodilians**; eles vivem= **they live**; escamados= **with scale, scaly**; exotérmico= **cold blooded animals**; fases da vida= **life stages/phases**; 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= tortoise are **a Brazilian variety of turtle**; ósseas= **boned skin**; quelônios= **chelonians**; répteis= **reptiles**; são= **are**; são marinhas ou de água doce= **they are marine or freshwater or white-water**; reproduzem= **they reproduce**; são animais aquáticos= **they are aquatic animals**; terrestre=terrestrial; vegetais= **vegetables**; tartarugas= **turtles**].

Therefore, even without having analyzed in full detail the hierarchies established by the students among these concepts in their maps, the analysis authorizes us to say that the students have kept on using various concepts to express similar meanings because they have not grasped and have not shared the meanings being "taught" to them. For this reason, in case they are willing to learn, they make the option of doing it in a mechanical form. **How can we qualify the implementation of the maps of concepts in this process**?

Before evaluating the implementation of the maps of concepts in this teaching process, we should consider the fact that we based our reflections on the premise that 'Maps of Concepts I' represent what **the students have already known** before the beginning of the process. It so happens that, as we have described, the students draw these maps after a collective oral discussion. As there have been no notes on the main ideas of this discussion, we cannot ignore that the diversity of concepts we have diagnosed afterwards – coincidentally they present great similarity to the contents of the textbook – might be a consequence of this interactive activity and/or even of any prior contact with the textbook material. It is very likely that this methodological decision – consider Map of Concept I as the prior knowledge of the students - might offer evidences the positive impact of the teaching and the maps of concepts during the experience.

According to the students, the influence of maps of concepts seemed encouraging because the tool may have helped them to learn about reptiles in a pleasant way, despite the difficulties they have had in choosing the linking "words" and in establishing "relations". The process of evaluation of the maps shows us that the number of concepts used has had 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 might be important to make a point at this stage of our study, which has to do with the fact that the maps of concepts developed by the students have been the elements to enable us to analyze in greater detail the nature of knowledge this group has mentally represented. In the daily routine of the teacher teaching, and the students learning, it might have been more difficult to identify the specific demands of this group.

Final Comments

We started this paper by stating that the most basic characteristic of a map of concepts is its instrumentality as a tool of great importance for the educational process. This applicability derives from the fact that, structured by scientific terms, they favor the negotiation of meanings, when used as a tool for teaching, learning, *curriculum* planning, curricular activities, and evaluation. Therefore, as a learning tool, their use in our study has stood as our main priority. Nevertheless, considering how subjective these tools can be , the same maps also served as an instrument for evaluating the learning and teaching processes. On the other hand, the result of this evaluation is promoting the development of important notes for a future intervention plan, as well as for the use of maps of concepts as instructional tools.

The findings show that the students liked constructing the map of concepts and considered them facilitators of the learning process. Nevertheless, they could also show that this short-term experience with maps of concepts was not enough to promote the grasping and/or learning of the meaning of the central concepts of the topic 'reptiles'. The students, resorted to different concepts to express the same idea, which may evince their low level of comprehension in relation to the hierarchical and relational rationality of the map of concepts. These facts, nevertheless, may stress the potentiality of map of concepts in the learning and teaching process. Furthermore, what seems mostly important is that the use of this tool becomes meaningless without its underlying theory.

In this particular investigation, as the report on the experience shows, the plan for the intervention has priorized the presentation of the map of concepts, devoting less attention to the conceptual structure of the topic. The introduction of maps of concepts as learning and teaching tool was our main concern and what should be at stake. This does not mean that there has been 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 implementation of the map of concepts in the process, in addition to the teachers' experience in this level and with this class in

particular, redirected their attention from the relation content-learning-teaching-context-evaluation, as deemed appropriate, to the teaching strategies. According to them, this group of students was very difficult to work with, and, besides, getting them involved in the process demanded : (i) the use of dynamic studying strategies (which might explain the diversification of activities that occurred despite the scarcity of time that had been allotted to their development): and (ii) the presence of some form of compensation. In this kind of context – which reproduced predominant practices in most Brazilian schools – the textbook was the guide for what they should teach and present to the students. Nevertheless, it is true that the contents of newspapers and magazine clippings brought in by the teacher together with the teacher's interest in getting to know what the students already knew on the topic had influenced the process.

Consequently, instead of focusing on the central and general ideas of the topic, classes were guided by the students' comments and by the sequence found in the textbook (Cruz, 2005). In fact, in relation to the evolutional sequence, which theoretically favors the differentiation of already known ideas by the students (mammals) to less familiar ones (birds, reptiles, amphibians, fish), the opposite kind of differentiation has happened. In fact, the text presents very superficially the main characteristics of animal groups, without stressing the comparison among them, as the organization of the textbook suggests. Hence, it seems important to point out the interdependence between the conception of meaningful learning proposed by the Meaningful Learning Theory and the actual application to maps of concepts and to other educative resources.

If one has a conception of meaningful learning that corresponds to that of the Theory of Meaningful Learning, it may be easier for this person to learn how to develop a map of concepts and to learn about the field of knowledge in question. On the other hand, the more distant from meaningful learning the concept of learning is, the more difficult it is to learn how to favor its occurrence and to apply the newly constructed knowledge on a given subject to a different, or even similar, learning situation. Summing up, if the person wants to work with the meaningful learning process, he/she will have to look for the central ideas and their relations, and will probably learn map making techniques more easily, even though there will always be difficulties inherent to the appropriation of a new field of knowledge.

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 its introduction into the dynamics of a class should occur with the use of themes, from the school curriculum, that the students already know or are familiar with, stressing that it is also fundamental that, when negotiating with the students the meanings of central concepts of the topic, the teachers list the concepts that integrate the first maps. In other words, a gradual familiarization with the tool 'map of concepts' is at the very basis of an autonomous success of its use. This is what we will continue trying to do.

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 northeastern 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 Int. Conference on Concept Mapping. Eds Pamplona, Spain. 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.

Lemos, E., Moreira, M.A., Mendonça, C. (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. In: Cañas, A.J., Reiska, P., Åhlberg, M. & Novak, J.D. (Eds.), *Concept Mapping: Conecting Educators. Proceedings of the Third International Conference on Concept Mapping*, (Vol. II, pp 477-484). Tallinn, Estonia & Helsink, Finland: Tallinn University.

Moreira, M.A. (2010). Mapas Conceituais e Aprendizagem Significativa. São Paulo: Centauro Editora.

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.