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Teaching Parasitology with Concept Maps in Laboratory Lessons for Teacher Education Courses

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Abstract This paper presents a teaching strategy developed for lab lessons in a course of Human Parasitology, within the Biological Sciences Teaching Education Course, at the Faculdade de Formação de Professores, Universidade de Pernambuco, FFPG – UPE, located in Garanhuns, Brazil. The proposed strategy was supported by Concept Maps. These are tools whose theoretical foundations lie in Ausubel's Meaningful Learning Theory. The course was taken by a group of 6th semester undergraduate students that were studying to be middle and high-school biological sciences teachers. We have observed that Concept Mapping has favoured the interaction between students, and thus made the lessons about Human Parasitology more interesting. Moreover, the produced Concept Maps showed evidence of progressive differentiation and integrative reconciliation of the proposed concepts. Thus, we argue that Concept Maps are relevant resources for teaching parasitology in lab lessons, enriching the teaching strategies, and thus making them potentially more meaningful for course development in a Teacher Education Course.

Keywords: *parasitology, teaching-learning, teacher training, biological sciences*

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1. Introduction

The occurrence of parasitic diseases is extremely common and thus represents a world-wide health problem. Such diseases are responsible for high death rates ([1,2]). The appearance of diseases caused by enteroparasites (intestinal parasites), such as worms and protozoa, herein called enteroparasitoses [1] is related to poor hygiene-sanitary conditions and is frequent in Brazil ([1,4]) as well as in other countries that present similar hygienic-sanitary conditions. Such conditions are more evident in situations of poverty, social imbalance, lack of basic sanitation and inadequate sanitary education. In order to minimize this situation, formal education, through Parasitology courses, must promote a learning process that engage students in the technical and scientific aspects of parasitic diseases, as well as stimulating philosophical thinking that is responsible for promoting change in social and environmental structures ([2,5]). This means that teaching practices should focus on contextualized, problem-based approaches when discussing health problems caused by parasites.

In the context of learning Parasitology, it is of paramount importance to develop the knowledge of Epidemiology, so that learners can understand the relationships between parasites, hosts and the environment or circumstances in which both occur. However, according to [6], the contexts in which the pedagogical formation of Biological Sciences Teachers occur, with respect to the study of Parasitology, have shown that there is no consensus about their precision and utility for Education and Disease Prevention. Hence its importance in teaching Biological Sciences in teacher formation for Basic Education.

When training teachers, one must emphasize preventative sanitary education, which entails guidance with respect to hygiene, health and environmental care ([7,8]). Concerning Epidemiology notions, these professionals need to: identify the aetiology or cause of the disease; know the natural history and disease prognosis; assess the health of the population and the extension of disease (or death) in the population; and assess prophylactic interventions and existing health programs, so that they can carry out high-quality preventative education.

In this light, it is important that the teacher understands the parasites' transmission mechanisms as well as their biological cycles due to their preference to infest intermediate hosts or various final host species. This biological singularity ensures the maintenance and dispersion of parasites. The parasite's action over the host causes a balance in their relationship, which stems from some basic factors, such as: parasite species; host's age

1 Enteroparasitoses are grave public health problems that still persist in developing countries. The problem concerning intestinal parasitoses in Brazil is graver than it might look, since there is a lack of deep sanitary education policies. The eradication of such parasites requires that socioeconomic conditions are improved, both in basic sanitation as well as in sanitary education, besides changing certain cultural habits ([3], 63).

and nutritional status; sanitary conditions and immune response level of the host.

From an ecological point of view, the relationship between parasite and host is responsible for the life balance of both ([2,5]). The understanding of such mechanism demands visual information that can only be obtained through lab resources [9]. Moreover, lab lessons cannot be replaced by other practices, since they enable students to observe the functional mechanisms that allow organisms to survive, such as the ones studied directly by Parasitology (e.g. of worms such as platelminths and nematelminths) as well as parasite protozoa.

However, despite the fact that the use of available lab resources has been proven efficient for building an understanding of Parasitology, traditionally, teaching practices of this course in Biological Sciences have not used resources for viewing such parasites. Neither have they used other methodologies to foster conceptual, procedural and attitudinal skills about the content, according to what has been recommended by the National Curricular Guidelines ([7,8]). The course was given emphasising only the theoretical aspects introduced to students through a traditional methodology [2]. This has contributed to the students' low learning rates and has motivated our intervention, supported by Concept Maps, integrated to lab resources, with the aim of promoting meaningful learning.

Hence, the goal of this work is to offer conditions for undergraduate teaching students to learn Parasitology meaningfully, considering both the theoretical and practical aspects. The focus of the intervention was the morphology and biology of the main parasites (Platelminths, Nematelminths and Protozoa) emphasizing the relationship between parasite and host [11]. The understanding of the content to be shared and its meaning in different contexts is a basic condition for the teacher to develop the theme in basic schools.

The intervention has shown that teaching with Concept Maps has ensured the differentiation and reconciliation of concepts. It has also emphasized the students understanding about the contents taught and has allowed us to know students' skills related to attitudes and procedures. Thus, we consider that the teaching units, planned in accordance to the aforementioned goals have made learning potentially meaningful to students.

2. Theoretical Background

The intervention carried out by us was based on Ausubel's Meaningful Learning Theory [12] which is supported by Concept Maps, as a teaching instrument. Concept map were developed by Joseph D. Novak and his colleagues in the 1970's. Its original purpose was to analyse clinical interview transcripts that aimed at identifying students' knowledge [13]. Since then, this instrument has been used in various knowledge areas and educational levels. One of its uses lies in making the evaluation of previous knowledge possible. It also enables the observer to diagnose alternative conceptualizations, as well as to identify the mechanisms used to illustrate the hierarchical, conceptual and propositional nature of knowledge [14].

With respect to Biology Education, several authors ([15,16]), , argue for the potential of Concept Maps in the organization of the Curriculum in Biology Courses or in similar courses, proposinge the conceptual restructuring in a microbiology course, after using concept maps with students [17]. The proposal of linking the mapping activities to the course syllabus gives students an extrinsic motivation and active engagement in educational tasks [17].

Moreover, Concept Maps provide a visual tool to illustrate the overlapping of knowledge stemming from the dialog between teacher and learner, as a biological education model, creating something tangible to promote classroom discussions, which, in turn, promote meaningful learning [18]. In this direction, Concept Maps provide a visual means to represent potential relationships between concepts and knowledge organization, which cannot be evidenced through other pedagogical means [19]. The potential of Concept Maps to promote idea discussion, negotiation and reconstruction of biological and pedagogical knowledge were also corroborated in teacher formation courses ([20,21,22,23,24]).

With respect to the teaching and learning of biological themes, such as microbiology, concept map have shown to be efficient in the analysis of scientific themes to project scientific work and in the use in protocols or sections of detailed methods for laboratory work [25]. In the specific case of the discipline of Ecology the potential of Concept Maps in the evolution of the knowledge representation has been tested [26]. The authors considered, after analysing the maps, the capacity of Concept Maps of providing detailed information about the building process in facilitating the identification of the conceptual aspects that evolved during learning. Conceptual maps were also used as a tool for identifying the undergraduate students' attitudes, based on their use in bacteriology lessons [27]. The results corroborate the ability of concept maps to promote thinking organization in the interaction between previous knowledge and new knowledge, as well as to reveal positive students' attitudes with respect to bacteriology, thus enhancing learning skills.

The applicability of concept maps has been shown to be fundamental in the meaningful learning of Biology in Higher Education, especially when there are data related to the quality of learning. When appropriating these empirical data, the teacher may develop pedagogical practices oriented to investigation-oriented learning in each Higher-Education course [28]. In this light, the educational activity with concept maps must foster learners' ability to move through knowledge structures, thus becoming part of a larger learning process, instead of only providing a static record of the student's learning [29]. When students receive the training to become a Biological Sciences teacher in Basic Education, the experience with the elaboration of Concept Maps makes them active agents in their learning process, as it regulates their knowledge, leading to its consolidation, what entails cognitive change that aggregates new meanings to the already existing ones [30].

2 The traditional method prevailed since the 19th century until 1950, focuses on making contact with existing knowledge about a particular subject. In teaching strategy prevails lectures, being the teacher and the textbook the only sources of information. Incentive memorizing settings. In this model, the laboratory experiment only serves to prove the theory [10].

Moreira [31,32] corroborates Novak [14,33] when considering concept maps to be diagrams that depict the relationships between concepts or words we use to represent concepts. In other words, a concept map represent meanings, significant relationships or conceptual hierarchy diagrams. In order to exemplify the meaningful relationship considered by the authors, we explain that "parasite" is a concept. When this is connected to the concept "host", shows the meaning that the map author assigns to this relationship, which may or may not be correct according to what was established by the syllabus. The value assigned to the concepts by the authors is evidenced by the concept disposition in the map, and this, in its turn may represent meaningful learning.

According to the Meaningful Learning Theory, it is possible to learn through the formation of subordinate concepts (subsumers). Those, according to what is described in ([34], p.28) "[…] are previous knowledge relevant to the learning of other knowledge". Subsumers may interact with new concepts, resulting in conceptual evolution [35]. Ausubel et al. explain that a subsumer has a particular structure that allows new information to interact with the learner's cognitive structure. This means that the latter is highly organized and has a conceptual hierarchy that stores the learner's previous experiences. This structure needs to be shown during the learning process, so that one can teach according to what the learner already knows ([12,34]). This supports the use of concept map as a pedagogical instrument that displays the cognitive structure of the student.

In order to infer such evidence, one must use qualitative and quantitative analysis criteria [14]. When qualitatively analysing a Concept Map, it is recommended that the following issues should be assessed [14,36]: number of valid propositions; meaning relationship between two concepts; concept hierarchies; cross-links, links between a given concept and others; and examples that are concepts that exemplify others. Teachers can add other criteria to this analysis, depending on the context of their course. For instance, number of relationships that indicate conceptual, attitudinal or even procedural changes.

During qualitative analysis, one investigates the interaction between the authors and their maps, by using the meanings that they assign to the concepts in question. The meanings assigned may be either denotative or connotative, as articulated during the presentation and discussion of the map built by the students during the activities that were carried out. Ausubel et al. [35] p. 527, show that "denotative meanings are the criterial distinctive attributes evoked by the name of a concept in contrast to the attitudes or emotions that they might elicit…" and "connotative meaning are the attitudinal or affective idiosyncratic [3] reactions elicited by the name of the concept".

With respect to the teaching strategy, in order to foster meaningful learning, we used the recommendation by Moreira [37] who suggests planning Potentially Meaningful Teaching Units that are structured in sequences that involve: to present to students the domain knowledge that they should learn; to defining the specific topic to be discussed, identifying its declarative and procedural aspects; creating or proposing situations, such as discussions, questionnaires, concept maps and others (e.g. lab activities) that stimulate the student to externalize their previous knowledge; proposing problem-situations; taking progressive differentiation into consideration when presenting the knowledge to be taught; revising the most general aspects of the syllabus, promoting integrative reconciliation; revising the most important features of the contents to be taught; ongoing, formative and summative evaluations and presenting progressive learning results. With respect to cross-cutting aspects [4], in all steps the teaching resources and strategies must be varied; one must allow students to propose hypotheses; to give greater importance to individual and collaborative activities [37]. This theoretical background supports many aspects of our planning.

3. Methodology

The intervention took place through a teaching strategy supported by the Meaningful Learning Theory. It was structured in potentially meaningful teaching units belonging to the Parasitology course and involved conceptual, attitudinal and procedural knowledge ([37,38,39]). The following issues were detailed: theme under study, number of lessons, unit goal, specific contents, competencies and skills intended, pedagogical resources, assessment and a description of the activities that were carried out.

The intervention lasted for five months, during which students executed bibliographical research, participated in 21 face to face teaching sessions, which included 16 lessons (with a total of 75 hours). During this period, seminars were held on various themes including Helminths and/or Protozoa, took practical lab lessons to view the morphology of the parasites and produced concept maps about the content. During the whole intervention process, we were able to verify that the interaction between teacher-student-knowledge and between student-student-knowledge is important to help overcome possible learning difficulties ([14,36,40]). We have analysed the interaction relationship based on the meaning sharing and negotiation about the concept maps produced during the intervention. Sharing and negotiation of meaning are evidence that the student has acquired knowledge about the contents taught [40].

Forty-four sixth semester students of the Parasitology course of the Licentiate in Biological Sciences of the Faculdade de Formação de Professores, of the Universidade de Pernambuco - FFPG/UPE de Garanhuns, Brazil took part in the intervention. The planning of the potential teaching units is presented in detail in sections 3 (3.1.1, 3.1.2 and 3.1.3). In order to demonstrate the evolution of knowledge about the Parasitology concepts, we have chosen the building of Concept Maps by the students as the event to be presented in this work. Thus, we have selected 5 maps that present the most concepts related to the contents taught and that have shown clarity about the relationship between parasite and host. The selected maps are also shown in section 5, together with their respective

3 Idiosyncratic – way of seeing, feeling and reacting, particular to each individual [41].

4 Term used by [37] to highlight what must be considered in all sequential aspects (steps) when planning a Potentially Meaningful Learning Unit (PMLU).

interpretations. We remark that the maps were built in the classroom, using paper and pencil, without any computational tools. Consequently, we have used Cmap Tools [42] to transcribe the maps produced by the students.

Each workgroup consisted of 4 students that played similar roles in the groups, selecting concepts, strategically positioning them, discussing conceptual relationships and reaching consensus about the map layout and presenting it. All participated equally in all tasks and consensus were reached with the negotiation and agreement of all members about the inclusion of previously listed concepts, as well as the established conceptual relationships that resulted in the structuring of the map.

3.1. Intervention Strategy

This intervention aimed at promoting the meaningful learning of Parasitology concepts through the usage of teaching units planned in their procedural and attitudinal conceptual aspects ([37,38,39]). In the conceptual aspect, we have focused on epidemiology notions: health-disease relationship, agents causing diseases, transmission mechanisms, types of biological cycles, immunodeficiency, opportunistic parasites (nematelminths, platelminths, protozoa), and parasite actions over the host and prophylaxis [11]. With respect to the procedural aspects, we have considered the tasks related to the experimental activity, as well as the building of Concept Maps. In the attitudinal aspect, we have focused on the sharing and meaning negotiation interactions that stemmed from the students' presentations of the concept maps they have built.

In this section, we present and discuss what happened in three face-to-face teaching sessions (lessons) as well as the interpretative analysis of the five concept maps produced by groups of students. The analysis of the concept maps aims at revealing evidence that the students have successfully used the acquired knowledge [36]. Forty-four students participated in these sessions and they were organized in eleven groups (4 students per group). The class took four hours, with the first two dedicated to the theoretical development and map presentation and the other two dedicated to the practical lab lesson. The concept maps were built during the theoretical lesson that took place after the practice session. We remark that all students have had previous experiences with maps, from other courses, such as Zoology and Botanics.

3.1.1. First Face to Face Teaching Encounter

In the first encounter, we introduced the theme by posing the following focus question: "What do you know about Parasitology?". The importance of the focus question has been discussed in detail [43]. According to the authors, a good focus questions can enrich the concept map and this determines the quality of the resulting map. It also defines the context of the problem which the concept map needs to help solve. The focus question influences concept selection and promotes active relationships amongst them ([44,45]) resulting also, in dynamic propositions. Open focus questions, like the one proposed to the students, stimulates the formation of more dynamic propositions by offering more explanation possibilities [46]. By proposing open focus questions, we stimulate students to expose their previous ideas about the Parasitology theme and we estimate their potential with regards to the previous knowledge so that we can teach them accordingy [12].

When analysing their answers, we detected that 97,7% of the students had relevant subsumers for the development of the theme [47]. This result revealed conditions for the progressive meaningful learning of the Parasitology theme based on the previous knowledge of students. To value previous knowledge when one aims at meaningful learning, entails adapting the planned content to the structure of previous knowledge of the student, even though such knowledge can either promote or hinder learning ([14,35]).

After discussing the answers to the question with the students, we proposed that a concept map about the initial question was built by the groups. The Maps were then presented and discussed with the other groups. After that, we pointed out the importance of the concepts of health and disease, emphasizing aspects related to disease causes in humans – within the context of Parasitology. To enrich the debate, we have used texts, group discussions, papers and handouts.

3.1.2. Second Face to Face Teaching Encounter

In the intervals between sessions, which took place once a week, students attended other courses intended for undergraduates in Biology. Due to this interval between sessions, in the second encounter, we reviewed the concepts studied in the previous lesson and introduced new Parasitology concepts, through the use of texts, research, group discussions about many topics, such as basic Parasitology concepts, epidemiology notions, transmission mechanisms and biological cycle types, relationships between parasite and host, immunodeficiency and opportunistic parasites, molecular biology, parasite action over the host and prophylaxis [11].

After reviewing the concepts, which enabled the expansion of discussions about the content, we begun the lesson and experimental activities using the laboratory resources of UPE-FFPG. From the review of the topics covered in the previous class, students exposed and discussed including the matters prescribed in the contents. The activities carried out, e.g. thematic seminars, together with theoretical and experimental lessons were selected and organized, with the aim of stimulating the interaction amongst teacher, student and knowledge [36]. Lab activities have promoted meaning acquisition, negotiation and sharing of tasks [9]. The discussions based on the experiences and observations made via microscope evidenced the processes related to conceptual reconciliation and differentiation, which favoured the consolidation of learning. Consolidation, can be achieved "[…] by means of approval, correction and clarification during the feedback and through the differential practice and revision, over repeated exposition, with the return to the learning material […]" ([12], p. 172). This means that learning is not immediate, but is progressive.

3.1.3. Third Face to Face Teaching Encounter

In the third encounter, we have revised the concepts studied in the previous lesson. Thematic seminars constructed by students during the theoretical and experimental lessons were about the themes discussed in the previous encounter. The next task consisted in asking

the students to get together in workgroups. Each workgroup should choose one of the themes presented in the thematic seminars to build group concept maps. It was up to each group to choose which theme all groups should build their concept maps about. From the maps built and discussed by the groups, we analysed the conceptual evolution of the five workgroups with respect to the theme "action of the parasite over the host". This analysis took into consideration the previous knowledge described in the first encounter as well as the maps built after this description, the thematic seminars and the discussions during the experimental lessons as well as the discussions that took place during the second encounter and the presentation of the maps. When analysing the maps, we considered whether or not there was progressive differentiation and integrative reconciliation of concepts; valid and invalid propositions that might override valid ones; cross relationships and examples.

4. Results and Discussion about the Concept Map Analysis

During the presentation of their map shown in Figure 1, Group 1 expressed the relationship between concepts, forming propositions. For each proposition, the group gave examples that are not expressed in the map. For instance, when talking about the pathogenic action caused by the parasite over the host, they have, besides explaining the action, orally exemplified each action with the name of the parasite. In the centre of the concept map, one finds the main (and more inclusive) concept "host-parasite", which evidences the understanding of the causal relationship between them. This was also the case for the parasitological periods that go from host infection to the period where parasites are hard to be detected. Similarly, they have explained and exemplified clinical periods and the changes a parasite can cause in an organ. From there, we verified that Group 1 was able to progressively differentiate and integrative reconcile content, enlarging the cognitive structure to consolidate new concepts. We have validated the propositions in map 1 as correct according to the content taught. This map contains cross relationships, for instance, when it refers to the most frequent consequences of parasite action over the host, such as oxygenation reduction, as well as when discussing regeneration and healing of cells and harmed tissues, which results in a horizontal relationship. Group 1 has shared their map with the other groups, and there were no questions, only positive endorsement caused by their command of the subject and ease of discussion during their presentation.

Group 2, Figure 2, chose the term "host" as the main concept of their map. The main concept has a cross-relationship with the term "equilibrium", which may exist between host and parasite. They also added examples to the relationship, which indicates progressive differentiation and integrative reconciliation, when they indicate in which parts parasite-caused diseases attack human beings. They have also recorded the structures attacked by diseases as well as the actions suffered by them. Such indication resulted in valid propositions, such as "the parasite transmits diseases"; "diseases attack cells, tissues and organs"; "the host can suffer traumatic and irritating actions [...]" However, when discussing the actions suffered by the host, they only talked about what was already in the conceptual map. During presentation, this group's map was criticized by their colleagues since it did not contain the parasitological and clinical periods in its structures. The group justified this by saying that they preferred to emphasize actions, and were willing to answer questions related to that. This willingness revealed positive attitudes with respect to learning and the understanding of the limitations imposed by the conceptual maps with regards to the number of concepts. These are important variables of the learning process [34,36].

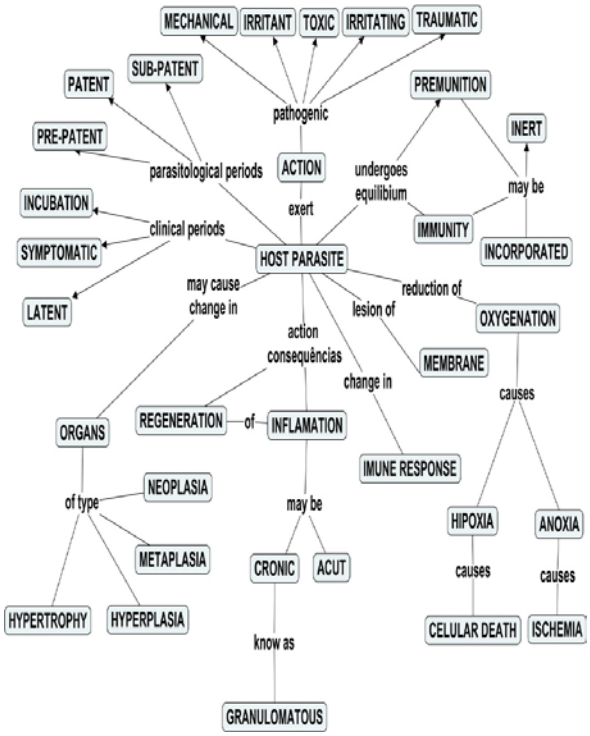

Figure 1. Concept Map Built by Group 1

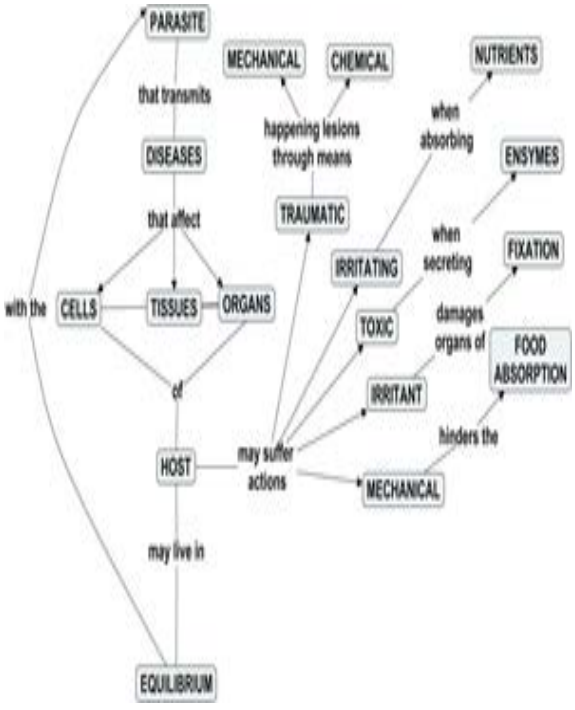

Figure 2. Concept Map Built by Group 2

When Group 3 was presenting their map Figure 3, made the following comment "Teacher, we had to use concepts from other topics in our map, such as Parasite Dispersion. Thus you will find concepts that are not in the other maps". They were referring to the concept "imbalance", discussed and studied in the first encounter, such as *Parasitoses Dispersion.* This comment served as an example for the other groups to notice the themes defined for their map were related to themes discussed in previous lessons. This demonstrated that the group did not restrict themselves to the theme indicated in the map. They started their presentation with the general concept "*host-parasite"* and explained the concepts below the main concepts. It was only afterwards that they proceeded to explain the causes of the pathogenic action caused by the parasite. For each case, they gave examples and discussed the consequences of the harmful agent for human beings. The propositions indicate adequate, valid relationships in the context of the course. When sharing the meanings they assigned to the conceptual relationship, Group 3 showed evidence of progressive differentiation and of integrative reconciliation, processes that characterise meaningful learning [12]. The map structure shows few cross-links in the map. Cross-links are identified when significant segments of the map are connected to other significant segments [48]. Such connections indicate reasoning, creative ability and theme understanding [48]. However, during their explanation, Group 3 established several cross-relationships, relating, for example, "cellular" alterations to the nutritional status of the host; the concepts "causative agent", "worm" and organism infected by parasite and the sanitary conditions involved in prophylactic measures. The precision, clarity and objectivity of their presentation showed their domain of the relationships in the map, thus preventing any criticisms from the other groups.

Figure 3. Concept Map Built by Group 3

Group 4 started the presentation of their map (Figure 4) by discussing the general (and most inclusive) concept "parasites". They moved next to the "pathological action" caused by parasites. They explained each action, giving examples and putting the names of each agent causing each action in the map. They then moved on to explain the occurrence periods of infections caused by parasites, giving oral examples of each of them. Finally, they presented the damage that parasites cause, specifying the body parts where such damage occurs. The propositions built are compliant with the contents taught, and thus were considered to be correct. This entails progressive differentiation and integrative reconciliation, during acquisition, negotiation and sharing of meaning, which widen the cognitive spaces for the consolidation process. The occurrence of some non-cross relationships, but that counted with valid interaction between the concept "parasite" and the causes and places where they happen, demonstrates the group's ability to differentiate these concepts. Some examples were recorded in the map and others were cited during the group's presentation.

Figure 4. Concept Map Built by Group 4

The map built by group 5 is shown in Figure 5. When presenting their map, the group only remarked on the concepts that defined its structure, and did not emphasize verbal explanations or examples. The most general concept used by the group was "parasitism". There were many questions about explanations relating to pathological causes, parasitological and clinical periods as well as to the consequences of parasitism. The concepts presented hierarchically correspond to the contents discussed during lessons, and the propositions result from valid interactions and depict the knowledge acquired by the group. However, there were no conceptual links

evidencing cross-links. The explanations provided by the group showed their ability to provide examples, that is, to add events or complementary concepts to the map with the aim of widening the understanding of the theme. The conceptual interactions established by the group indicate progressive differentiation and integrative reconciliation, which result from building knowledge that was acquired in a meaningful fashion.

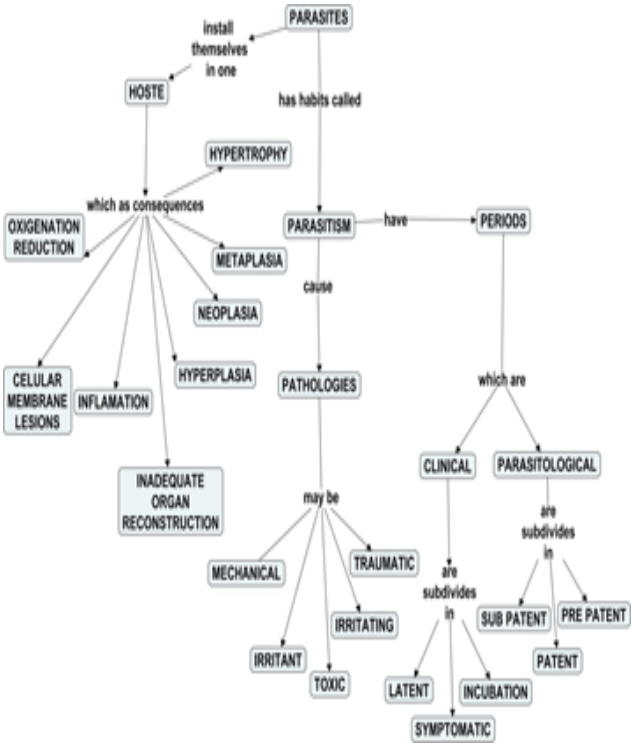

Figure 5. Concept Map Built by Group 5

4.1. Synthesis of the Observations Resulting from the Analysis about the Concept Maps

Group 1: Has broadened the information contained in the map; established relations between the concepts and formulated valid propositions; they have exemplified the pathogenic action of the parasite over the host; named the parasite from its action; recognised the most inclusive concept "parasite-host"; established the causal relationship between parasite and host; included the parasitological periods in the process; explained and exemplified the clinical period; recognized the effects of the parasite actions in the host's organs and established cross-relationships when mentioned the more frequent consequences of the parasites actions over the host. We have seen in the group evidence of their ability to progressively differentiate and to integratively reconciliate the concepts from the contents taught, as well as the broadening of space for the consolidation of new Parasitology concepts in the cognitive structure of students.

Group 2: Has resorted only to the information contained in the map; accepted the limitations with regards to the number of concepts to be included; recognized the concept "host" as the most inclusive and related it to the actions suffered by the host when infected by parasites; established the maintenance relationship between host and parasites based on examples; registered the human morphological structures affected by the parasites and the actions suffered by them that cause disease; established different valid propositions; justified the criticism as to the absence of concepts related to the parasitological and clinical periods. This group has also shown the evidence of progressive differentiation and integrative reconciliation of parasitology concepts, as well as the manifestation of attitudes favourable to new learning.

Group 3: Has incorporated concepts previously studied and put them in the map; argued in favour of the inclusion of other concepts related to the theme; used the more inclusive concept "parasite-host" to establish relationships between it and the pathogenic actions caused by the parasite; exemplified the actions and demonstrated the consequences of the agent that are harmful to the human being; built valid propositions in the context of Parasitology; shared meanings assigned to conceptual relationships; used verbal arguments to establish cross-relationships not visible in the map; demonstrated with clarity and objectivity the relationships established in the map. Similarly to the previous groups, we have observed progressive differentiation and integrative reconciliation, together with the ability to retrieve and integrate concepts that originate from other contexts.

Group 4: Has added examples to the map; recognized "parasites" as the inclusive concept, subordinate to "pathological action"; explained and exemplified and nominated every action originating from the causing agent; emphasized the periods of parasite infections and the body parts affected; built propositions aligned with the theme; established valid relationships, albeit not crossed with the parasite their living modes. This shows progressive differentiation in the process of integrative reconciliation, derived from capturing, negotiating and sharing of meanings about Parasitology, thus promoting in this group the advancement of knowledge structures that can lead to consolidation.

Group 5: Only accessed the concepts that gave rise to the map; exemplified the listed concepts; recognized "parasitism" as the most inclusive concept; defined hierarchies according to the theme; built interactions that resulted in valid propositions, albeit without evidences of cross-relationships. The observations of this group are similar to the previous one, with respect to the evident realization of progressive differentiation in processes of integrative reconciliation of Parasitology concepts, with advancement of the knowledge structures and consolidation possibilities.

Besides representing the previous knowledge about the theme that may serve as *"anchors"* for new knowledge, [12], the conceptual maps built by the student groups have shown positive attitudes with respect to the Parasitology lessons, similarly to what was witnessed in Bacteriology lessons [27]. The results also reinforce the ability of concept maps to promote meaningful learning while evidencing a series of learning competencies and skills that subsidize lab practices.

4.2. The Contributions of Concept Maps to the Teaching-Learning Process in the Classroom

The dynamics of the intervention made Concept Maps the pedagogical resource most indicated for Parasitology

Teaching in the education of Biosciences Teachers. The fact that the results of their building and presentation are not related to quantitative assessment or any other classification form stimulated students' participation ([21,24]). In such conditions, its pedagogical potential was built by students when sharing their achievements with their peers, making them more efficient in identifying the connections between concepts, as well as in manifesting competencies and skills. Moreover, it has proven to be an excellent agent of social interaction and of language stimulation when promoting an environment that is favourable to the dialogue between teacher and student, a condition that facilitates meaningful learning [18].

Thus, concept maps have acquired sense by allowing students to bring something of their own thinking and to demonstrate their effort to show their comprehension, while they worked to differentiate to show their difficulties and potentials of learning Parasitology. Thus, it enabled students to evidence their attitudes regarding to feeling the meaning, positive or negative feelings stemming from their errors and hits [14]. This represented a positive aspect in the negotiation of conceptual meaning related to the contents as well as to the structuring of the map. The immersion of the student in this task has caused cognitive conflicts that were superior to what was expected.

The majority of cognitive conflicts, generated by the challenges imposed by the elaboration and presentation of the concept map in the classroom, has deliberately shown the conceptual weaknesses or potentials of attitudes or students procedures regarding the contents. They have also evidenced the efforts towards a greater and better compromise of the group with respect to learning. This means that the concept maps present a set of efficient conditions fundamental for exercising criticism and creation from who analyses it (the teacher) and from who learns (the student). Thus, teaching with conceptual maps, focused with the negotiation of meanings, has challenged the students to take a stand with regards to the problems faced by their realization. This was advantageous for the learning process, since it stimulated the students' participation, broadening their predisposition for learning ([12,35]).

In this perspective, the weaknesses or potentialities evidenced by the representation of the student's reasoning process over the concept map, have stemmed from the teaching centred on the meaning of negotiations that challenged them to present new problems and demanded a new stand towards its realization, making their building and presentation a means for externalizing denotative and connotative meanings. When used in such fashion in the classroom, concept maps may broaden, the ability of students to move between knowledge structures, making it a part of a broader dynamic learning process [29]. One must take into account that the building of concept maps presented some challenges, namely: the selection of concepts from the focus question; the spatial organization and the fidelity to the proposed theme. In order to face such challenges, students or their groups started to retrieve and reorganize their previous knowledge and tried to establish a reasoning trend that was coherent with the proposal elaborated in their map to share the assigned meanings.

Finally, the emphasis assigned to the interpretation of the representations of the students groups when structuring and presenting their maps and that were obtained during the intervention, need to be credited by the teacher in the classroom, as evidences that admit, deny or reformulate the theoretical hypotheses, built during the declaration of the students' thoughts through their verbalization and behaviours emerging from the intervention ([14,34]). Thus, we emphasize the importance of broadening the investigations about the qualitative assessment of Concept Maps, so as to stimulate teachers to use this teaching resource in their classroom routine, and from it, to obtain data derived from interpretations founded on different possibilities. It is a matter of considering the various facets related to the learning process, that arise from the thinking feeling and action that populate the students' cognitive nature in the face of Concept Maps.

5. Final Remarks

From our point of view, we have achieved our goal, since the implementation of the teaching strategy provided conditions for the students of graduation in Biological Sciences to learn Parasitology contents meaningfully as evidenced in the final course evaluation. Teaching with the support of Concept Maps favoured the differentiation and reconciliation of concepts, although the analysis of the built map, absent from his presentation, has not highlight developments in scientific concepts. However, on the whole, preparation / presentation of the statement by the groups evidenced that the scientific concepts of the theme, have been expanded, differentiated, reconciled and shared within the dynamics of the classroom.

Moreover, the dynamics of elaboration and integration between lab resources and concept map allowed us to identify more easily procedural skills related to observing, recording, building schemes and explaining the learned conceptual concepts. Attitudes regarding the importance of acquired knowledge, from the point of view students, as well from the future teachers, students of primary school and the society in general, were evidenced by the groups during discussions about the parasite-host. This was also the case with the respect and consideration of different opinions and criticism about their maps and presentations, for example: "The study with the maps for me it was something new, a learning facilitator. I really enjoyed the technologies used and how the maps I am using this method in my work and it's working [...] the maps help thinking to be organized in a logical sequence that makes real learning, thus avoiding the act of memorizing" (Student 1), and "Concept maps in my view come to offer better methods for new learning, both in the health area with in various segments presented in other disciplines, with a better understanding of the subject matter [...] in case the diseases transmitted by contaminated water and food should review the basic education part from childhood to adulthood of people to at least reduce the large incidences of diseases" (Student 2).

In this light, we argue that teaching strategies, organised in teaching units, can promote potentially meaningful teaching. The use of concept maps within the dynamics of lab lessons stimulated the interaction between

students, made knowledge more complete, adding relevance to previous knowledge through the offering of new information, thus adding value to the teaching-learning process of Parasitology.

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