Concept Maps: Making Learning Meaningful
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# THE USE OF CONCEPT MAPS, MEANINGFUL AND TELECOLLABORATIVE LEARNING IN UNDERGRADUATE SCIENCE COURSES

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Abstract. The scenario of science education in Brazil denotes fragility when subjected to international evaluation criteria. It is presented a pedagogical action taken at a Brazilian university, encompassing changes in a discipline of computer science conducted under a traditionalist approach to undergraduate science courses. Consequently it is proposed a new discipline, Applied Informatics for Science Education, which seeks to articulate: the pedagogical use of Information and Communication Technologies, telecollaborative and ausubelian meaningful learning and the use of concept maps and virtual learning environment (VLE) to promote a view of pedagogical change in students and teachers. The learning content is a sub-theme of physics, called the launch of projectiles. It is discussed some concepts and teaching approaches used in the new discipline, involving the development of the meaningful learning process and cycles of "learning spirals". It is described possibilities for promoting student´s articulations in order to facilitate reflective, creative and critical learning and evaluate the use of Discussion Forums in a virtual learning environment. Concept maps and telecollaborative reports prepared by students are presented and discussed in order to characterize the proposal of teaching and learning and to illustrate the pedagogical contributions of the discipline.

## 1 Introduction

In the first decade of this century, Brazil has occupied the last places in the scenario of international assessments of educational science and mathematics that are conducted by PISA, Program for International Student Assessment, (Ribeiro et al., 2008). To improve the process of construction of new knowledge by the students, the teacher should propose new pedagogical strategies to minimize factors as learning difficulties and the aversion to the scientific world, which may be reflected in the professional, social and personal life.

## 2 Contributions to Learning, Science and Curriculum

Thinking about solutions to solve this educational problem, an alternative proposal is to promote the use of Information and Communication Technology (ICT) integrated with the curriculum and as a tool to help the development of telecollaborative and ausubelian meaningful learning (Moreira, 2006; Cañas & Novak, 2008).

As a case study, Brazilian teachers of the Department of Computer Science of Federal University of Ceará, UFC found that the discipline Introduction to Computer had a profile that strongly reflected the reality of computing from the 60s and 70s of last century. Thus this discipline was not appropriate to the reality of the knowledge society, the web 2.0 and the development of telecollaborative learning.

To improve the curriculum a new discipline called Applied Informatics for Science Education (AISE) was created and offered in 2007 according the following goals: (a) to promote a view of pedagogical change of the undergraduate students. (b) to introduce students to the culture of using VLE as a pedagogical tool to help and promote the development of telecollaborative learning (Valente & Bustamante, 2009) and ausubelian meaningful learning and (c) to develop a methodology for constructing new knowledge using concept maps.

### *2.1 The Pedagogical Use of ICT and Telecollaborative Construction of the Concept*

Litto and Formiga (2009) emphasize that at the international field it is not possible to identify and predict trends and changes in any area of knowledge, especially in Distance Education. In the field of strategic changes to reduce educational inequalities, the role of ICT will be important in the aspects related to processes of formation of future societies. In the field of science education the emphasis should be the need to investigate the use of ICT integrated

to the curriculum in order to support the implementation of educational telecollaborative practices in the laboratories of scientific experimentation (Ribeiro et al., 2008). The development of new educational practice proposals should emphasize student's collaboration in classroom. This is important because the steps toward the deconstruction and reconstruction related to the development of the learning process require the actor's participation and socialization, constituting a new path that can help to develop their view of pedagogical changes.

The theory proposed by Ausubel, Novak and Hanesian (1978) is noteworthy among the learning theories used in science and math education. Part of the success of the marriage between this theory and the exact sciences is due to the fact that the structure of scientific knowledge is very hierarchical. The education process should encourage students to develop learning using prior knowledge existing in their cognitive structure. Establishing relations between what is already known and new content facilitates the understanding of the subject. The Concept Map proposed by Novak (Canãs & Novak, 2008) represents an excellent tool to facilitate the development of the telecollaborative learning process. It induces the learner to navigate between the boxes of personalized concepts, which makes the learner to think, question and mature the construction of his own concepts, reinforcing the principles of constructivist theories. With the continuous evolution of educational computing, Novak's ideas were adapted: innumerous educational software were created to promote education through the use of concept maps, as the CmapTools, which is very used in science or mathematics courses.

## 3 Experiencing the Meaningful and Telecollaborative Learning in the Discipline Applied Informatics for Science Education

In general aspects, the objective of the AISE discipline is to prepare students to be able to use ICT in a pedagogical context, helping the development of learning processes and the development of the research. The aim is to create a learning environment based upon the learning spiral principles (Valente & Bustamante, 2009) to prepare professionals to be critical and creative, to be able to think and to work cooperatively in groups, and to continually seek to improve and to debug ideas and actions. When the AISE discipline was offered in the second semester of 2007, it had the effective participation of 12 students. It was observed that most of the students reported did not have previous contact with the cooperative approach, Ausubel theory, concept maps or VLE. To promote the process of cooperative construction of knowledge, teachers and students of the AISE discipline worked using the pedagogical tools of the TelEduc[1] VLE. Teachers used TelEduc´s email to mediate the exchange of messages between participants. The Teleduc pedagogical tool Agenda shared to learners the plan for each session. Support material was used to make available to students a didactic material, involving learning content about the launch of projectiles in the form of text, audio, Figures and animations. At the TelEduc pedagogical tool Forum it was happened the development of asynchronous and tellecolaborative discussions related to the learning theme. Finally at the TelEduc pedagogical tool Portfolio the students could store the material produced during the course.

The thematic[2] forums were a fundamental space to promote critical and cooperative discussion. The strategies used by students during development of the thematic discussion forums were favored by the development of telecollaborative and successive learning spirals cycles according: action-reflection-debugging and new-action. Such strategies have enabled teachers to monitor the development of the process of meaningful learning, where students were more socially participative, critical and cooperative. The progressive development of the learning process was observed by the development of sequential concept maps of 4, 8 and 12 boxes. These tasks were worked in three TelEduc thematic forums that were created. The first one directed the student's discussion to promote the construction of a concept map of 4 boxes; the second, for the concept map of 8 boxes and the third forum for the concept map of 12 boxes. The reason for these forums was to promote among students a process of discussion and cooperative construction of knowledge, encouraging the use of programmatic principles of Ausubelian meaningful learning.

After the development of the personal concept maps, the students made them available in their individual portfolios. The Figures 1 and 2 illustrate a set of 3 concept maps, developed by a student and posted in his portfolio

[1] The TelEduc VLE provides an environment for the creation, participation and administration of courses on the Web. It was designed targeting the process of teacher training and is based in the training context. It has features that differentiate it from other environments for distance education: it is pedagogical easy and flexible to use it.

[2] It was created 10 thematic discussion forums during the development of the discipline, addressing aspects of Ausubel´s theory, concept maps and pedagogical aspects related to the discipline.

TelEduc. At a further presential and collaborative pedagogic section in the classroom, the students analyzed together their concept maps posted in TelEduc and questioned some theoretical concepts used: they concluded that some concepts presented in their maps were wrong and so it was necessary to improved them. These pedagogical actions of conducting the students to deconstruct and reconstruct concepts, certainly leads to the use of ausubelian programmatic principles for reach the development of meaningful learning: progressive differentiation, integrative reconciliation, sequential organization and consolidation of knowledge.

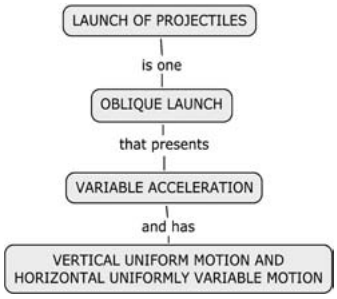


**Figure 1.** Structure of the Concept Map of 4 boxes sequentially constructed by a student of the AISE discipline, made available in his TelEduc VLE individual portfolio and further discussed at the class.

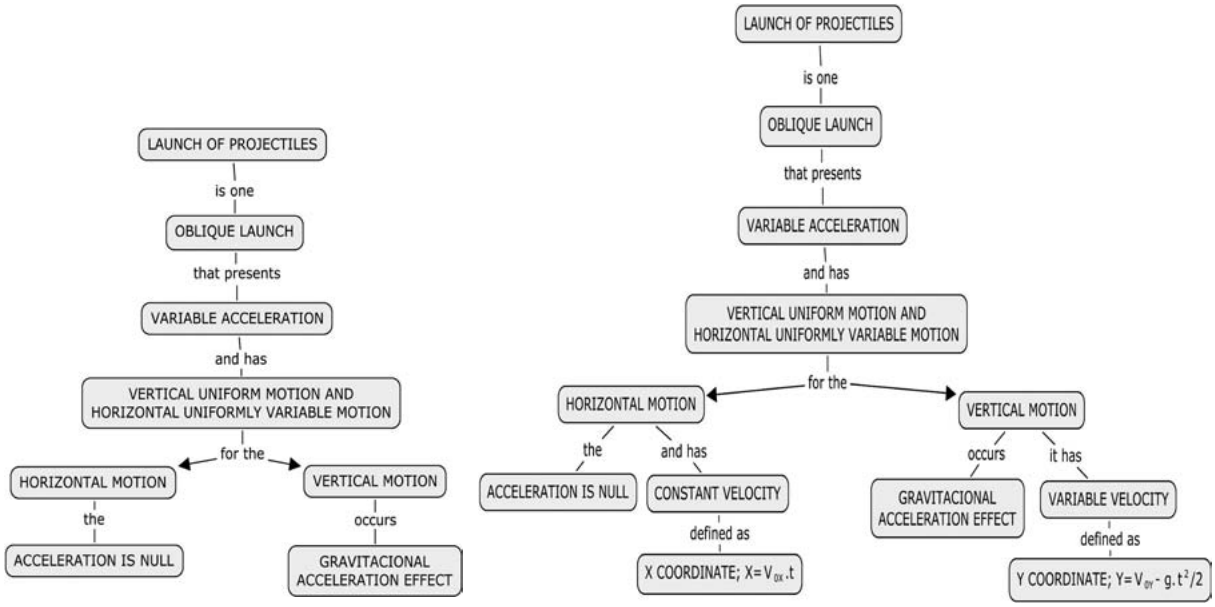


**Figure 2.** Structure of Concept Maps of 8 and 12 boxes sequentially constructed by a student of the AISE discipline, made available in his TelEduc VLE individual portfolio and further discussed at the class.

As a way of continuing maturation of the concepts and theories studied, it was suggested to the students to promote face-to-face as well as online cooperative discussions, focusing the task of (re)constructing theirs concept maps on the theme of science related to the launching of projectiles. During these discussion, for instance, in order to a student build his concept map of 8 boxes, it is previously necessary he analysis his concept map of 4 boxes, as well as to go deeper in the analysis of the physics concepts to mature and improve his task of map construction, as illustrated in the following message, posted by a student at a thematic forum entitled "Problems, Comments and Suggestions": I think that the initial difficulty to finding the way how to construct concept maps is the same for 4 or 12 boxes but after getting the way, other maps are produced without major difficulties, because the difficulty is to begin the task. So I believe that there isn't some difference by which way to start. The bigger problem is to do the first. But as a suggestion I think we should start by a smaller number of boxes because it is easier to compose later a larger map.

Observing Figure 1 from the meaningful learning perspective, to reach the development of the concept map of 4 boxes, the student initially deals with the theme of launching projectiles beginning from a very general way and interacting with his colleagues presentially or at TelEduc classroom. After finished the construction of the map of 4

boxes, to conceive the construction of a concept maps with a larger number of boxes, the student collaboratively needs to reassess and expand his concepts, taking as reference his previous concept map of 4 boxes. So he needs to specify/deep/expand/elaborate knowledge from a previous construction, in order to elaborate the concept maps of 8 and 12 boxes, as illustrated in Figure 2. So these actions expressed the combined use of the development of meaningful learning and the pursuit of development of collaborative learning spiral cycles.

Concerning the aspects of course evaluation, all the 12 students were approved. The evaluation emphasized qualitative aspects as the development of meaningful and telecollaborative learning process and the view of pedagogical change. About the aspects of how the students learn new physics knowledge: 44% of the class have total domain, 41% have reasonably domain and 14% do not have a sufficient domain. About some other general aspects as how students learn theory of meaningful learning, concept maps and methodological aspects: 4% of the class have total domain, 49% have reasonably domain, 38% do not have a sufficient domain and 8.0% never heard of it. Finally it was observed that after the students finished the AISE course, they matured a new pedagogical approach for the pedagogical use of ICT articulated to the development of telecollaborative and meaningful learning.

## 4 Final Considerations

The teaching experience developed in the classroom shows the importance of promote a broad curriculum reform of undergraduate programs, encouraging the integration of ICT and the meaningful learning among students pedagogical activities, and the exercise of telecollaborative reflection and learning. The use of systematic and progressive development of concept maps, with increasing number of boxes during the course of AISE discipline, favored the telecollaborative maturation and understanding of concepts related to the physics subject launch of projectiles.

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