Computers in Education should go beyond task simplification in teaching-learning processes in order to become a strong and effective resource for the construction of knowledge. For computers to fit into a constructivist approach, it is necessary to find a way to develop computer tools in which dialog and comparison with the student's mental and formal models is possible, focusing on the achievement of meaningful learning.

Hypermedia Concept Maps (HCMs), as a way of representing ideas, have a great deal to offer to the development of models for diverse study phenomena and to the adoption of the appropriate pedagogical approach to include computer technology and adapt it to such approach. Here, we propose the use of HCMs to create, together with a specific platform for working with them, an open computing learning environment. New learning development implies, in some cases, a review of the previously acquired knowledge and, in all cases, an integration of newly and previously acquired knowledge. In order to work in this direction, we suggest an environment that supports HCM interconnection and we define the options required to enhance the existing platform.

Introduction

Few activities of man and society have escaped from the impact of computer technology. In education, the attraction of technical features presented by new tools has diminished the attention on how they should be incorporated to learning processes. Technology in itself does not give satisfactory results in education if it is not integrated to an approach in which we wonder about its real power in this field. Computers in Education should go beyond task simplification in teaching-learning processes in order to become a strong and effective tool for the construction of knowledge.

Computer technology should be understood as a means and not as the exclusive purpose of education. For teaching and learning this technology constitutes an additional tool, often appearing to reinforce behavioral and verbalist learning frameworks. To be in agreement with a constructivist approach, it is necessary to find a way to develop computer tools in which dialog and comparison with the student's mental and formal models is possible, not forcing the student to obtain a result but, instead, stimulating his or her knowledge building process and reflection on it. In order to achieve this, it is necessary to focus attention on how these tools are going to be added to the educational process and not only to the contents they are going to introduce.

It is worth remembering what Fenstermacher said about the relationship of ontological dependence existing between the concepts of teaching and learning, and how the central activity of teaching is to facilitate the student to develop learning tasks. That is to say, "to teach is to make learning possible, to provoke dynamics and situations in which the learning process can take place in the students". In this sense, the skill of the teacher in selecting the best tools for the achievement of meaningful learning is very important, [Fen86].

Hypermedia Concept Maps (HCMs), as a way of representing ideas, have a great deal to offer to the development of models for diverse study phenomena and to the adoption of the appropriate pedagogical approach to include computer technology and adapt it to such approach. Neither computer technology in general nor hypermedia in particular can solve completely nor directly the problems posed by knowledge acquisition within the teaching-learning process; success depends exclusively on the way in which it is applied.
Learning Environments
The purpose of incorporating the computer into learning processes is identified with the development of thinking activities, and with the idea that a computer is a support for the student to build his or her knowledge in his or her mental model structuring process.

A learning environment can be defined as an environment formed by a non-homogenous set of elements that are able to create or recreate situations from which students can build knowledge. Although it is an expression that appears linked to Computers in Education, it is used in a wider sense and it can be used even without the use of computer technology. These environments are presented as sites with a great pedagogical value, extremely favorable for learning and metalearning experiences. Regarding computer learning environments, we can distinguish two large groups:

Closed Environments: those that consist of an integrated software and hardware system that does not require any other system outside it except for the students that interact with it.

Open Environments: the computer system forms part of the environment together with other elements and persons, and the role of the teacher clearly stands out.

Within the second group we can include HCM work. In this case, the environment will consist of a computer with the specific platform to develop and read these maps, different kinds of bibliographical material, map authors or readers, and the proper participation of the teacher to assess the map semantically.
HCMs, as a way of representing knowledge, can cover the expectations of the meaningful learning model, and they constitute an important basis for computer technology introduction in new educational processes.

It has been proved that work with HCMs is very valuable for meaningful learning building. Concept selection and its correct hierarchical organization are directly related to the previous knowledge of the map's author and to the structural organization of this with the newly acquired knowledge.

On Hypermedia Concept Maps
HCMs preserve all the educational richness of Novak's CMs enhanced with the benefits of hypermedia technology: easier operational handling, greater richness and versatility for information patterns, and motivationally more attractive, especially for young learners, [Seh96a].

Definition
An HCM is a hypermedia document in which each of its nodes has a collection of no more than seven concepts interrelated by linking words. Each of these nodes is called a view.

There are two types of concepts: those owned by the view and those imported to the view. The former constitute the initial concepts of the view and the latter are the image of concepts that belong to another view that are created in order to establish relationships among concepts of different views.

Relationships among concepts of the same view are called internal and relationships among concepts of different views are called external.

In each view, the owned concepts are represented by means of labeled ellipses, imported concepts by labeled rectangles, both with the name of the concept that they represent, and relationships (internal or external) by arcs labeled with linking words.

In order to represent external relationships, a labeled arc is established between the owned and the imported concept. Such relationship appears in both views.

A name and a color identify each of the views. The name corresponds to the most comprehensive owned concept and the color is used in all the ellipses representing owned concepts. Imported concepts keep the color of the view where they were originally defined.
Given a view V1 and a concept C belonging to V1 we can say that C explodes in another view V2 when such concept C develops in V2, i.e. C constitutes the root node of the map developed in V2. In this case we can say that the map represented in view V2 is a submap of the one corresponding to view V1.

The ellipse representing an owned concept exploding in another view is an elliptical button that allows direct access to that view. The rectangle representing an imported concept C is a rectangular button that allows direct access to the view where C is defined as owned.

We can associate to a terminal concept (that is not a button) different features such as graphics, sound, animation, etc. Any concept can be associated to a feature since there will always be a CM view in which said concept is defined as terminal.

Each HCM presents two strata: the strictly speaking HCM and the underlying hypermedia database created from the resources that originated the HCM. Access to it can be achieved during map navigation. Thus, those concepts in an HCM that, due to their richness, can provide new information, can be more deeply explored by means of hypermedia. Both strata can be queried alternatively. HCMs go beyond the educational possibilities of Novak's traditional CMs. This hypermedia bibliography is extremely useful for those interested in reading further about the topic, as well as those assessing it, [Señ96b].

Elements in an HCM Learning Environment
In order to focus the HCM author's attention in the most important and richest aspects from the educational point of view -such as concept selection, hierarchical classification and relationship establishment- and, in order to avoid distractions in building aspects and implementation options that lack any pedagogical value, the platform for HCM work and a methodology for HCM development is introduced into the environment, in addition to bibliographical material on the subject and the corresponding simulation systems for HCM study.

Platform for HCM Development
The design of a specific platform for dealing with HCMs aims at having exclusively those resources necessary for HCM development. Those characteristics can be found in the specific platform for HCM development and reading presented in [Mor96a]. This platform has two work modes, one of them corresponds to the author -map development and modification- and the other corresponds to the reader -map perusal and inspection. Immediate interaction between the two modes is allowed. The author mode presents specific characteristics for HCM development that makes the user completely free from dealing with any aspect that goes beyond the understanding of the topic. It has a graphic interface that offers a tools bar with the different options available for map development and modification and pull-down menus for editing.

HCM Learning Environment Enhancement
New learning development implies, in some cases, a review of previously acquired knowledge, and, in all cases, an integration of newly and previously acquired knowledge. Thus, we propose an environment to develop HCM interconnections. The main reason for this task is given by the need to integrate new knowledge with previously acquired knowledge and the wish to relate different points of view of the same topic.

HCM Interconnection
The interconnection of two HCMs can be carried out from different situations. Let's consider A and B the topics -between these there is some semantic relationship- and HCMA and HCMB the corresponding maps already developed. The idea is to obtain only one HCM from the two existing ones, without having to do all the map again and leaving the corresponding relationships established. This can be done as follows:

i) Establishing a relationship R between a concept C1 of HCMA and a concept C2 of HCMB. From the point of view of learning psychology it is an integrating action that implies a semantic review of the newly learned knowledge in relation to the including knowledge. From the point of view of operation, it is equivalent to the establishment of an external relationship between two concepts of the same HCM, since C1 and C2 are in different views.

ii) Concept C is detected in HCMA and in HCMB. At first, we suppose it is the same concept and that it is represented by the same name; later we shall deal with concepts with synonym and homonym names. Then, there is
a view V1 in HCMA and a view V2 in HCMB where C is represented by a labeled ellipse. We can also see that it is possible for another view with an elliptical button labeled C to exist; but in such case, C explodes in a view that contains it as an ellipse. That is to say, in all cases it is possible to find a view in the map where concept C is represented by an ellipse.

What are the possible solutions to keep the following properties P1 and P2 of the HCM in the map resulting from the interconnection?

P1: Each concept appears represented as an ellipse only once in the map.

P2: The maximum number of concepts of a view does not exceed from seven.

A first approach could be the following: Both views V1 and V2 are reorganized in one or two views according to the number of concepts that both views have.

For example, if V1 and V2 are the views in Figure 1, both could be replaced by the view in Figure 2.

If, instead, V1 and V2 were like in Figure 3, where the number of concepts gathered between both views largely exceeds the upper limit proposed, they could be replaced by the views in Figure 4, where the original hierarchy among concepts has been taken into account for its organization. We can see that in the first view C is represented by a button.

Figure 1: First approach - first case
Figure 2: Result - first case
Figure 3: First approach - second case
Figure 4: Result – second case
Problems arise with this approach when in HCMA or in HCMB there are views different from V1 and V2 that have an elliptical or rectangular button labeled C. In that case, two views with the same elliptical button exploding in another view will remain in the new map. Interconnection would imply redoing an important part of the map, loosing the pedagogical objective that we have in mind. This situation gets worse when the interconnected maps are in turn the result of previous interconnections, since a cascade effect takes place.

The following is a second approach in which the problem is solved: C is identified in both views by means of an external relation called "equal". In this way, in both views the rectangular button that will allow scrolling from one view to the other will appear, being possible to see C in both contexts, as we can see in Figure 5. The overlapping of the rectangle and the ellipse graphically reinforces the idea of referring to the same concept.

The establishment of an "equal" relationship between concept C of both maps determines a circular behavior in the access to the views from the use of rectangular buttons labeled C.

If HCMA and HCMB are connected and one of them is already the result of an interconnection (for example, HCMB) the following situation may arise: concept C appears in one HCMA view and in two HCMB Views.

We can see that access circularity through rectangular buttons involves the three views after the interconnection, as shown in Figure 6.

Now that we have discussed the advantages of this last approach over the previous one, we consider this is the solution for item ii).

The following special case may come up. In HCMA view V1 has a concept C represented by a labeled ellipse that is a leaf. The same concept C appears as root of view V2 in the HCMB and there it is represented by a labeled ellipse. In this case, the interconnection transforms the C labeled leaf of view V1 in an elliptical button exploding in view V2.

Synonyms: when two maps are interconnected, the same concept may appear represented by different names that are synonyms. In this case, the author may choose between:
- unifying the names and proceed according to ii).
- establishing an external relationship between both, such as "it is a synonym of"

Homonyms: if two different concepts appear represented by the same name, this does not require any special deal for the interconnection, the meaning of each concept will be shown through the concepts and relationships that form part of their respective contexts.
Adding the interconnection option to the existing platform. The current platform allows for HCM construction and reading. It is possible to open two already created maps, for example HCMA and HCMB, leaving all their views available.

**Platform Enhancement**

Interconnection: the choice of this option works on open HCMs. From there, the platform considers all the views of said maps as views of the recently created HCM. Then, the following interactive process begins: the platform asks the author a name for the new map. Once it is entered, if there is some pair of views with the same color associated, the list with the names of said views and a dialog box to allow for the color change in one of them automatically appear, so that different views do not have the same color. Next, the list of concepts represented by labeled ellipses that are present in two or more views of the new map appears on the screen. When selecting each of them, the corresponding views appear and the author, after analyzing them semantically, will decide the effective action to take.

Equal Relationship: the choice of this option will allow for automatic creation of the "equal" external relationship in each of the views, pointing out the equal concepts of the different views indicated and leaving the rectangular buttons with the proper references for a circular visit of the views.

If, instead, V1 and V2 were as in Figure 3, where the number of concepts gathered between both views largely exceeds the upper limit proposed, they could be replaced by the views in Figure 4, where concept hierarchy has been taken into account for organization.

**Conclusions**

The learning environment proposed for HCM work that includes the possibility of interconnecting maps and enhancing the platform with that objective, enlarges the richness of the work with these maps as a valuable and proven resource for the representation of ideas. It expands its potential since it allows to work expressly on the correct relationship between recently learned and previously acquired knowledge or between different approaches of the same topic. It is a proposal for Computers in Education that goes beyond task simplification in teaching-learning processes, and it appears as an effective tool for the construction of knowledge according to a constructivist approach.

**Bibliography**


