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Distance learning, problem based learning and dynamic knowledge networks

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Abstract

This paper is an attempt to develop a distance learning model grounded upon a strict integration of problem based learning (PBL), dynamic knowledge networks (DKN) and web tools, such as hypermedia documents, synchronous and asynchronous communication facilities, etc. The main objective is to develop a theory of distance learning based upon the idea that learning is a highly dynamic cognitive process aimed at connecting different concepts in a network of mutually supporting concepts. Moreover, this process is supposed to be the result of a social interaction that has to be facilitated by the web. The model was tested by creating a virtual classroom of medical and nursing students and activating a learning session on the concept of knowledge representation in health sciences. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

Web based learning still lacks a general accepted theory underlying its use. For example, the so called exploratory learning [1,2], which is supposed to activate a sort of incidental learning [3], often leads to some globetrotting with the risk of being lost in the cyberspace. The classical long distance 'courses' are usually based upon the mere presentation of the didactic materials with an interaction which is usually limited to the answer to some quizzes. Web conferences and net meetings are not integrated in a comprehensive model of teaching and learning.

In order to develop such a model, it was assumed that one of the main obstacles to meaningful learning is the discipline oriented approach of most of the educational curricula and courses. This is the fundamental reason why many authors claim that problem

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based learning (PBL) is the most useful way for engaging the students in a learning process based upon real-life-like situations in which knowledge from different disciplines is to be integrated. [4–7]. This is particularly relevant in teaching knowledge domains, such as medicine or health sciences, where the connections between what is learned and its application to real practice should be the focus of the education process.

However, even if PBL is actually adopted in several contexts and knowledge domains, it still lacks a sound theory of learning, in particular a theory of what knowledge is and how it is acquired and retained in the long term.

On the other hand, cognitive maps [8,9]were conceived as a tool for gathering information about the structure of the knowledge of individuals, and is based upon the idea that knowledge can be understood as a net of concepts connected by means of links. Cognitive maps were also suggested as mind tools for developing and communicating knowledge [10].

In dynamic knowledge networks (DKN), the learning process is understood as the process of setting up a network of concepts, i.e. as a net where each node is a concept and links are didactic actions. Each node can be in turn another DKN [11,12]. Moreover, the learning process is conceived as the result of a social interaction in which several actors are involved, i.e. students, tutors, experts, etc. Therefore, DKN allows for an interactive process in which knowledge is progressively updated by adding or subtracting nodes and links from an initial, maybe empty, network.

However, both DKN and PBL are highly demanding in terms of interactions among the actors of the learning process, and several meetings are necessary in order to complete one single learning session. In this respect, web based teaching seems to be a suitable tool in order to avoid frequent transfers of students from distant sites to a central site. Moreover, the typical web tools such as synchronous and asynchronous communication, hypermedia documents and so on, seem to be, in principle, good candidates to introduce new dimensions in DKN and PBL.

This paper describes an attempt to formulate an interactive web based model for distance learning grounded on a strict integration of DKN and PBL.

The model was tested at the Laboratory of Computational Medicine of the Faculty of Medicine at the University of Naples in teaching the concept of knowledge representation in the health sciences.

2. Methodology

A ‘virtual’ classroom composed of ten students and the tutor is created. The communications are based upon a mix of e-mail, web conferencing, access to HTML pages, personal contacts, and group meetings. The main idea is to involve the students in a set of different types of instructional occasions which can be activated several times during the learning process.

The learning process evolves in different phases.

(1) A web site is created.

(2) According to his didactic objectives, the tutor posts a first presentation of the problem on the site. The usual format is a HTML document where each page displays a didactic toolbar on the left side, i.e. a set of icons linked to didactic interactions, i.e.

1. e-mail to the tutor,
2. e-mail to the students of the virtual classroom,
3. e-mail to experts,
4. URL to other web sites,

5. URL to libraries (i.e. Medline) and search engines,
6. download files,
7. quizzes and questions,
8. activation of a netmeeting session,
9. access to a list, maybe active links, of bibliographic references.

Depending on the stage of the learning process and on the specific problem at hand, only a subset of the didactic actions may be enabled and can be activated by the students.

(3) A netmeeting session is activated in which the students are given, as usual in PBL, the objective of constructing, with the supervision of the tutor, the list of items that, in their opinion, characterise the problem. In this phase, the tutor acts mainly as an observer, and his interventions are essentially aimed at focusing upon pertinent items and discharging the irrelevant ones in order to keep the discussion within the boundaries defined by his didactic objectives.

(4) The tentative list of items is then displayed by the tutor on a common whiteboard and iteratively adjusted according to the evolution of the developing discussion.

Each intervention is recorded and marked for a differed analysis according to the following classes:

criticizing
providing alternative explanations or hypotheses
convincing another peer
comparing different hypotheses
reviewing
referencing

(5) At the end of the netmeeting session, the students are grouped according to their main interests and assigned the task of gathering more information. Another netmeeting is programmed. Each student can browse the HTML document and, by clicking one of the icons displayed on the HTML page, can consult other sources of information, e.g. experts or data bases, exchange ideas with other students of the same or different group by e-mail, etc. The results of this information gathering process are sent via e-mail to the tutor, who analyses the materials, posts them on the web site, and informs by e-mail the whole virtual classroom. The process restarts from step 2 until a shared final list of items is formulated.

(6) Once the shared list of items is built up, the tutor assigns to the students the task of organizing the information items into a hierachical structure of related topics (HSRT), i.e. a type of book index with chapters, paragraphs, etc. The HSRT is communicated to the tutor by e-mail and posted on the web site so that all the students can access it.

(7) Another netmeeting sequence starts which terminates with a final HSRT.

(8) Now, the students are grouped according to their main interests and the task of producing an electronic paper concerning one of the chapters of the HSRT is assigned to each group. The tutor interacts separately by e-mail and/or by netmeetings with each group and suggests further readings, interesting web sites, names of experts to be consulted, main modifications of the paper, etc.

(9) The tutor engages a separate non virtual personal meeting with each group aimed at transforming each electronic paper into a hypertext, and also assigns students the task of building a cognitive map of the structure of the hypertext.

(10) The whole set of hypertexts is transmitted to the tutor who uploads it along with a HTML page containing the list of hot keys corresponding to each of them. As a result, the students can browse through one or more of the hypertexts produced by other groups.

(11) Now, after another group discussion, the students are asked to build a cognitive map of the relationships between the hypertexts and to transform it into a DKN.

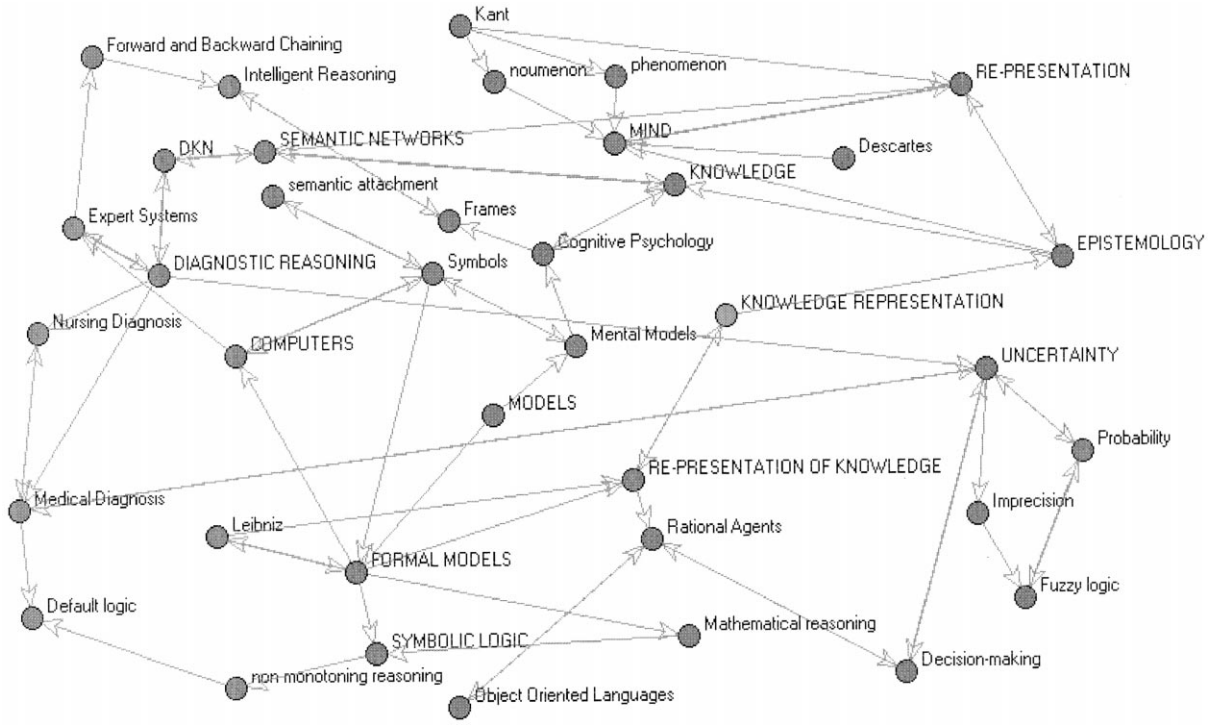

Fig. 1. Final DKN of a learning session on the concept of knowledge representation.

(12) The DKN is posted on the web site in order to enable other students to download it.

3. Results

In Fig. 1, the first tentative DKN concerning the concept of knowledge representation in the health sciences developed in a virtual classroom composed of medical and nursing students is shown. The triggering HTML document can be found at the URL http://www.unina.it/medicina/lmc/K_r/index.htm.

4. Discussion

From a general point of view, less is still known about how and why students retain what they learn and how they update their knowledge when confronted with new knowledge domains. From the telematic point of view, the question arises of whether it is possible—and if so, how—to use the web based facilities in order to develop models of learning and teaching aimed at stimulating meaningful learning.

In this respect, the traditional PBL format engages learners in an active, collaborative, student-centred learning process in order to develop the problem-solving and problem finding skills needed to meet the challenges due to an increasingly complex environment. It is also oriented to develop an integrated knowledge structured around real world problems, i.e. problems the learner will face in his future work.

The model suggested in this paper is based upon the idea that learning is a cognitive process aimed at connecting, consistently with previous knowledge, new facts and ob-

servations into a cohesive whole of mutually supporting evidences and concepts, and that PBL is in fact the process of setting up a DKN.

Therefore, learning is conceived as a particular kind of diagnostic reasoning [13], i.e. the cognitive process of structuring an ill structured problem by gathering further observations and connecting them according to a reasonable model or theory. The construction of the network is in turn conceived as the result of a social interaction among the actors of the learning process.

In fact, it is supposed that the subjects are initially confronted with an incomplete set of partially interconnected observations, and that their objective is to complete the whole picture. The situation is similar to a puzzle scenario, where there is uncertainty about where to place a given puzzle piece. In this respect, the triggering problem of the PBL format acts as a source of expectations which in turn guide the 'problem structuring' process.

In this process, the web is used as:

1. a repository of multimedia documents that can be accessed by the students of the virtual classroom;
2. an asynchronous way for student–student, student–tutor, student–experts communications;
3. a source of valuable structured information;
4. a synchronous communication channel with the capability of recording and marking the sequence of interventions.

Therefore, the model provides several active-learning contexts which can be recalled several times during the learning session, depending on the didactic needs. Moreover, since the final goal is the development of a DKN, i.e. a network that can be used for teaching students other than those involved in the virtual classroom, the model also instantiates a learning-by-teaching process.

In this process, a crucial role is played by analysis of the records of the past netmeetings. In fact, each intervention is recorded and marked according to its category so that the students and the tutor are enabled to re-examine the whole learning process and to single out, for example, the most difficult, the most important concepts, the most 'exciting' discoveries made by the classroom, etc. This possibility is a unique facility provided by netmeeting programs, and is one of the main reasons why, in our experiments, written chats were the preferred methods of synchronous communication. Another reason probably lies on the fact that written communication implies a more elaborated form of reasoning with respect to verbal or visual communication which is faster and more difficult to analyse.

Moreover, the students learn that there is not just one 'correct' way to connect facts and to look at the problem. For example, a genetic disease can be seen in very different ways depending on the context in which the learning process occurs. Therefore, depending on the interests of the students and of the tutor, some aspects related, e.g. to genetics, DNA sequencing, chemical laboratory tests would be emphasized, whilst in other contexts the aspects related to community medicine, to the management of the psychological or social problems would be the focus of the learning process.

In Fig. 1, the result of an application of the model to the concept of 'knowledge representation' is shown. This is an experiment in progress aimed at involving medical and nursing students in reasoning about their own knowledge, connecting the concept of model building, i.e. the core of scientific research, with the underlying philosophical and epistemological issues, understanding the role of computers in setting up artificial reasoners, analysing the strict relationships between

medical and nursing diagnosis, and so on. Even if it is incomplete at the moment, from Fig. 1, one can perceive the richness of the structure of concepts that can be developed in few weeks.

In summary, the suggested model not only preserves the liveliness of human interactions that usually characterise the PBL and DKN sessions, it also enriches it with the unique opportunities provided by the different web based communication modalities and tools. These are embedded in the conception of PBL as the construction of a DKN, which is in turn an attempt to model knowledge as the dynamical process of formulating a network of networks of networks…of concepts which enables the subjects to capture some aspects of a complex reality and to act accordingly. In our opinion, this idea ensures a sound theoretical ground to web based teaching and learning.

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