Acquiring Knowledge through PBL within a Computer Collaborative Learning Framework

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Abstract

This work deals with a Collaborative Learning Framework (CLF) assisted by a computer that uses the Problem Based Learning (PBL) model to acquire knowledge within a self-directed approach. This approach requires the development of skills related with motivational and cognitive aspects, as well as a tangible element to assess whether the knowledge has been acquired correctly or not. In this work is proposed a process for acquiring knowledge in two steps. The first step aims to reaffirm the knowledge of a topic previously learned and the second step to acquire new knowledge with the minimal assistance of a guide. During the first step, the students develop the analysis, synthesis and construction of structures skills to extract relevant concepts from the topic to be learned, then, to link them by pairs, and finally to build the structure of a whole network synthetically expressed. This whole network is named Network of Concepts (NC).

The CLF encourages team working and autonomous attitudes and the development of skills for the analysis, synthesis, abstraction and construction of structures to relate concepts. The main motivation is to build a coherent network with the minimal intervention of the guide. A coherent NC is the tangible element that confirms whether the knowledge under study has been acquired. This model was successfully applied both in courses of undergraduate and graduate engineering program, with the participation of 108 students.

1. Introduction

This work deals with a Collaborative Learning Framework assisted by a computer that uses the Problem Based Learning (PBL) approach to acquire knowledge. The task of acquiring new knowledge, within a self-directed approach in collaborative learning environments, requires the development of skills related with motivational and cognitive aspects. In addition, an adequate computer tool to work collaboratively is necessary, as well as a tangible element to assess whether the knowledge has been acquired correctly or not.

Nevertheless, motivational attitudes could be weakly developed or undevolved at all if the process of acquiring new knowledge is carried out without taking care of the progress through which the knowledge will be acquired. That is, the acquisition of knowledge under a self-directed approach without any previous training could bring about risks of giving up this process because low or null motivational attitudes, which are associated with the lack or weakness of cognitive skills necessary in this kind of learning approaches. In order to cope with this problem, we propose in this work a process of acquiring new knowledge that is composed of two steps to be described later in this article.
2. Relevant related works [1]

Self-directed learning has been one of the main objectives in the education domain. Gibbons defined self-directed learning (SDL) as the one where individual takes the initiative and the responsibility for what occurs [2]. For Gibbons some important elements should be taken into account in SDL, which are described as follows: student should control as much of the learning experience as possible; the development of skills; the self-challenge after having been challenged by teachers; self-management of their time, effort and the resources they need to conduct their work; self-motivation and assessment of their own efforts. For Hiemstra [3], self-directed learning should take into account the following relevant aspects: more responsibility of individual learners; self-direction is not necessary carried out in isolation from others; self-directed learners develop skills to transfer learning, in terms of both knowledge and study skill, from one situation to another; teachers in self-directed learning can dialogue with learners, evaluate outcomes and promote critical thinking.

Garrison, as learner, affirmed that more responsibility and control are fundamental in self-directed learning [4]. Teachers in higher education need more responsibility for assisting students to develop self-directed learners, as pointed out by Ryan [5]. Thus, it has been proposed problem-based learning (PBL) as a potential framework to provide this assistance, in such a way that PBL becomes an important part of an adequate educational environment for self-directed learning.

Domains such as pediatrics and nursing have identified PBL as one way to facilitate the development of abilities to become self-directed in learning [6], [7]. Specifically, in pediatrics domain residents exposed to PBL are engaged in significantly higher levels of self-directed learning than their counterparts. The most important component of PBL is known as Ill Structured Problems (ISP’s), which constitutes the key concept used in the work presented in this paper to start the self-directed learning process.

ISP’s are problems as those found in real scenarios [8]. They do not have the problem space well specified, as their main characteristic [9]. On the contrary, in well structured problems, all the necessary information to build the problem space is specified. A person that tries to solve a problem will attempt to understand it, then to describe its objective(s) and propose possible solutions and strategies to solve it [10], [11] [12] [13]. This is known as the problem space, which is built based on a personal interpretation. An ISP can be a problem to encourage the discovery of concepts, in such a way that it can be the root to build the network of concepts necessary to support the problem understanding [14].

During the process of solving ISP’s, the problem statement step represents an important challenge, because the problem understanding is involved. In order to achieve it, the students should dedicate their first efforts to self-learning. In this step, the next activities could take place: to identify the knowledge previously acquired and related with the problem to be solved; to represent these knowledge and relate them, whose goal is to reinforce what has been learned; during the activity of knowledge representation, the students can identify the lacking knowledge; to develop an activity of self-learning to acquire the lacking knowledge. This activity is carried-out collaboratively in this work.

The activities described above are an important part of the model that is proposed in this work. This model of self-learning to acquire new knowledge uses ISP’s within collaborative learning framework.

2.1 Collaborative Learning [15]

The concept of collaborative learning has been treated by several authors [16] [17] [18] [19]. It was defined by Dillendurg as follows: “A situation where two or more persons learn or attempt to learn something together” [20].
In a collaborative learning, the students work together to maximize their own learning [18]; in order to do that, it is necessary to form collaborative learning groups that interacting through shared investigations to build the understanding of each others and their social environment [21].

It has been proven that the interaction between students is bigger and better than the one between a teacher and students [16]. Based on these facts, the collaborative learning is encouraged to take place between students [1] Several tools for working collaboratively have been proposed. The C-CHENE CSCL system was designed to facilitate computer-mediated interaction between human learners. The specific task studied requires students to construct qualitative models for energy storage, transfer and transformation using a specially designed graphical interface [22], [23]. C-CHENE uses two different communication interfaces to examine reflective interactions. A dialogue box allows the exchange of typewriting texts between learners in the first interface. Meanwhile the second one promotes an interaction using interface buttons for specific speech acts.

OSCAR is a framework based on the speech-acts theory that attempts to support students involved in collective activities and tutors in their perception of these activities by structuring textual communication through chats and forums. Woojin Paik et al [24] aim to develop intervention techniques to identify and remove obstacles of online learning groups. A secondary goal is to analyze the conversations of virtual group members using computational linguistics techniques. The final goal is to build an automatic system able to monitor the activities of the online learning group members to alert the instructors when the members encounter barriers.

Other authors are concerned with the study of dialogue patterns, which can help to build systems to assist the interactions student-student or student-teacher in the tasks of collaboration. Ravi and Kim [25] revealed the need of determining patterns of student interactions in online discussions for better information management and assistance. Pilkington [26] pointed out that formal and computational models of dialogue patterns extracted from the interaction of student-tutor and student-student interaction could help to bridge the gap between empirical investigation of interaction and the design of Intelligent Educational Systems (IESs) that interact with students.

3.- The Collaborative Learning Framework Proposed [1]

In this work, the model of self-directed learning is supported by: a collaborative computer tool called FreeStyler, developed by the Coollide group [27] [28]. This tool provides students with a chat and a window to draw geometric basic figures, such as rectangles, circles and arrows; dialogues and draw actions whose purpose is to build a network of concepts that validate the knowledge acquired; and ill structured problems. The construction of a coherent network of concepts is made in several sessions. The network of concepts starts to be built as follows: given a concept represented by a circle node it will be transformed by a dynamic rectangle-node (transition) to get a new concept. The rest of the network is built following the same procedure. The exchanged messages of the dialogues contain collaborative actions to build the network. The network of concepts built in this work has certain similarity with the network of domain concepts built in Adaptive Hypermedia (AH) systems, where such network represents the user's knowledge of the subject [29], [30], [1]. In AH systems, the concepts are related with each other thus forming a kind of semantic network which represents the structure of the subject domain. However, in the present work the links between concepts is given not only by static relations, but also by dynamic relations. For instance, a given concept is transformed into another one by applying actions, operations, mathematical methods, etc. As in Petri nets the transformations take place through special nodes representing transitions, as illustrated in Fig. 1.
Through the chat, students will exchange messages that represent actions aiming to build a network using the geometric figures cited before. The network will represent the knowledge of a topic expressed in a synthetic form. The typical messages could be as follows: Alex, do you have any idea about another concept?? Or, Javier, could we link the concept of objects with the concept of class?? Then, pairs of students will work collaboratively in this learning task. They are situated, physically, in different places in order to avoid the oral communication between them.

The main objective of the first step is to teach students to build structures that relate, coherently, the main concepts belonging to a topic previously learned. At this level, students will analyze which are the main concepts of a topic. In such a way that students will learn to identify the most relevant concepts of a topic. These concepts will be linked by pairs, thus another level of abstraction will be considered. The pairs of concepts will be then linked to build the structure of a whole network synthetically expressed. This network is named Network of Concepts (NC). The way of linking the concepts is by using something similar to a Petri Net as mentioned before. Where concepts are represented by nodes called places and the nodes called transitions will represent the transformation needed to convert one concept into one another. Places nodes are represented by circles and transition nodes by rectangles. For instance, a pair to be formed in the topic of object oriented programming is when the concept of objects is transformed into a class of specific objects through the transition consisting in grouping similar objects, such as described in Figure 1.

Thus, at the end of this step the students reaffirmed the knowledge of a topic previously learned. The role of the mentor or guide is to provide the students with the know-how for building networks of concepts in a coherent way. In addition, the students have developed skills of analysis, synthesis, abstraction and construction of structures to relate concepts. This step served also to motivate the collaborative work using the computer tool. The main motivation is to build a coherent network with the minimal intervention of the guide, which will be achieved at the end of the second step.

The objective of the second step is to acquire new knowledge with the minimal assistance of the guide. The guide just assesses the coherence of the network being built. In the second step, the students are provided with ISP’s that detonate constructors to build the NC.

The process described above result in a feasible way of acquiring knowledge of new topics if students achieve this task in the two steps as mentioned before. Otherwise, it could arrive that students find no motivation and even give up the process of acquiring new knowledge.

This model was successfully proved both in courses of undergraduate engineering program and courses of the graduate program in computer sciences. Three topics were involved: Group Technology (GT), Object Oriented Paradigm (OOP) and Case Based Reasoning (CBR). GT and OOP were used in the step of reaffirming knowledge and CBR for the step of acquiring knowledge. So far, this model has been tested in undergraduate and graduate courses with a participation of a total of 108 students.
4. The Self-Directed Learning Process and Analysis of Results

Figure 2 illustrates the process of self-directed learning proposed in this work. This scheme applies for the second level. As we can see, at the beginning of the process, the teacher provides the students with an ill structured problem (ISP). After carrying out an analysis (block I), the students make a self-identification of constructors and start the construction of the network. The output of block II is a network to be reviewed by the instructor in block III. He proposes tips or suggestions to update the network as output of block III. The students analyze, synthesize, make abstractions and reorganize the structure to update the network in block IV. The process is repeated until the end of the sessions or until the students get a coherent network of concepts.

4.1 Building the Network of Concepts

4.1.1. Reaffirming Knowledge

20 couples participated in this experience. For the case of reaffirming knowledge, the guide has given the topic of OOP by doing emphasis in relevant concepts of this topic, which are described as follows: object, classes, sub-classes, simple and complex inheritance, methods, polymorphism and generalization, among the most important. The guide also shows how to link relevant pair of concepts that represent desirable correct relations between concepts. The network is built dynamically as the messages are being exchanged, because messages contain actions. A guide or mentor assists the students in order to review the coherence of the network. The students could consult the mentor several times per session. Each session took 90 min. Two sessions served to achieve this task of reaffirming knowledge.

Fig. 1 showed the concept of “Objects” to which it has been applied the action of “Grouping” to obtain the concept of “Class”. The corresponding dialogue to obtain the nodes related with Fig. 3 is shown below:


The rest of the dialogue and the process of the construction of the whole network is not showed because lack of space. Fig. 3 shows an example of the whole network of concept obtained by one of the pair of students.
4.1.2. Acquiring Knowledge

24 pairs of students participated in “Case Based Reasoning”. The task of acquiring knowledge was focused on CBR, which is reported below. The information provided by the tutor was limited basic concepts of CBR.

The results after the first session: 8.3% could build the 70% of network; 33.33% of the couples built between 40 y 70% of the whole network; 53.33% of the couples built less than 40% of the network. The results showed that most of the couples needed more time and some assistance from the guide to build an acceptable network.

The results after the second session: 58.33% of the couples got 70% of the whole network; 33.33% of the couples got between 50% and 70% of the whole network; only 8.33% of the couples got 50% of the whole network.

In CBR the couples got better their performance from session 1 to session 2, as follows: 58.33% of the couples got better from 20% to 34%; 33.33% of the couples got better from 10% to 20%; and 8.33% got better lower than 10%.

An average of 70% of the whole network of concepts was built by the couples. The highest percentage of the network was 80%, which was obtained by the 40% of the couples. On the contrary, the lowest percentage of the network construction was 35%, this percentage was achieved by only one couple. However, this problem was caused by technical problems during the second session.

Based on the results obtained, we consider that the environment composed of the computer collaborative tool through dialogues and PBL, in particular ISP’s, helped to encourage the self-directed learning. This kind of environments induces the development of skills such as analysis, synthesis and construction of structures.

An advantage of the FreeStyler tool is that it allows the students to communicate in a natural way. However, it is advisable to determine a set of rules to carry out the communication, otherwise, because there are not restrictions about the way of exchanging messages, students can loose the control without taking care of the main purpose of the conversation. The computer tool could have openers to build the network in order to help students to start the construction of it. These openers could be a list of single and relational concepts relevant to the topic under study. Another important point is to use more than two sessions, which surely improved the percentage of couples achieving a whole coherent network of concepts.
5. Conclusions

In this work we have emphasized on the fact that to encourage the self-learning is necessary to build an adequate learning framework. The learning framework proposed in this work is composed basically of: a collaborative computational tool, through which the students exchange messages to build the network of concepts; ISP’s to challenge the students and detonate their interest for investigating the concepts around the topic being studied.

Two steps have been proposed to carried-out the process of self-learning to acquire knowledge, with the minimal assistance of the guide. We have verified that this process helps to develop and/or improve skills such as analysis, synthesis and the construction of structures which are necessary to improve the results of self-learning. In addition, this learning framework has improved the autonomous and group working attitudes. We have confirmed that the efficiency to build the network of concepts was quite better than that one achieved by students learning under traditional approaches.

A tool such as the one described in this work is adequate for pairs of students working together, more than two students can difficult importantly the use of this tool. The culture and the language are factors that should be taken into account as the exchange of messages take place, that is, the number of messages exchanged depends on cultural factors and should be different in different cultures. The number of useless messages could increase if the students are not concentrated in the objectives to be achieved.

A parallel research made in this context is to discover dialogues patterns and then to build a computational assistant system to aid students when they find obstacles or dead times.

Bibliography


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