CSCL-Agents, as Useful Components to Handle Collaborative Activities within a VLE

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Abstract

Virtual education environments have been increasing their presence and acceptance as a tool to support teaching and learning processes. In this way, there are several educational activities that can be developed through platforms where students’ interaction, either individually or in groups, is an important part of ensuring meaningful learning. Collaborative activities require a track and a special review by the tutor, as coordinating groups are vital to ensure participation and success of students.

This work presents the development of a tool in virtual education based on intelligent agents to support the management of synchronous and asynchronous collaborative activities. Among the activities supported by the multi-agent system is the establishment of working groups depending on the learning style and academic performance of students. Additionally, the management of the collaborative activity development and control of the students’ participation should be considered, looking that fit the subject.

Keywords: CSCL, Collaborative work, Intelligent agents, Synchronous educational activities

1. Introduction

The popularization of the Information and Communication Technologies (ICT) has allowed virtual learning environments to increase their acceptance and application in the teaching-learning from virtual, blended learning or support activities in classroom courses. One of the limitations that were present in the first virtual courses offered was the absence of group activities that allowed enriching the learning process with collaborative and social activities.

These situations of collaboration allow each person to bring his/her knowledge and life experience, creating a space for discussion that leads to an achievement of broader scope than the one produced by the work of a single individual. In the education field, collaborative learning activities allow students to develop a set of skills that enable them to integrate into a new society mediated by digital technologies [1]. Nowadays, the computer-supported collaborative learning (CSCL) has received considerable attention because it provides students with an environment that facilitates the learning process through peer to peer collaboration, in activities such as chat rooms, video conferencing and discussion forums and achieving a joint construction of knowledge through interaction [2], [3].

Virtual learning environments include the possibility of developing both individual and group activities, the latter can be synchronous or asynchronous [4]. Among synchronous activities, there are conversations in chat rooms, video conferencing, discussion forums in real time and, in general, those that encourage communication where the peers have a simultaneous presence, simulating face to face communication [5].

Using these synchronous tools requires the presence of a teacher or tutor to facilitate interaction processes as a learning strategy, being attentive to feedback from students and guiding the discussions. This becomes a constraint, since the moments in which students and teacher could be available at the
same time are limited. This difficulty concerning to arrange a meeting time is a factor that may explain the underutilization of synchronous collaborative tools [6].

Due to the above, one of the constant criticisms of virtual environments is the lack of time periods to ensure the possibility of permanent development of these collaborative activities, while respecting the limitations of time and space of the students. However, the potential that these can generate should not be ignored: the promotion of social relations, feedback resulting in the development of peer to peer or teacher-students discussions and the possibility to contribute from individual knowledge to build knowledge sets by collaborative work [7].

With this proposal, we seek to provide a tool to support the management of synchronous collaborative activities in virtual environments through intelligent agents, which can help coordinate and manage the interaction, acting as facilitators and promoters of discussions available at all times.

The rest of the paper is organized as follows: Section 2 presents basic concepts related to the proposal, while Section 3 reviews some works related to tools to support collaborative activities in virtual learning environments. Section 4 offers a description of the model and its integration in a virtual learning environment. Meanwhile, in Section 5, the tool implementation and initial results are shown. Finally, Section 6 presents the conclusions and future work.

2. Basic Concepts

We continue with a brief introduction to the main concepts related to the implementation of a tool based on intelligent agents, which seeks to support the management of synchronous educational activities in collaborative virtual learning environments.

E-learning

Gros, Kinshuk, & Maina (2016) argue that it is evident that we are experiencing an important and rapid transformation of society that is changing the way we learn and the places where learning occurs. There is need for a fundamental change in the way in which we design and support learning. The complexity of modern society requires specific types of competences to interact within this context; also, the connectivity in today’s society has not only altered the production of knowledge but also the spaces and times where learning takes place.

E-learning can be defined as the learning through technology platforms that allows flexibility in teaching-learning processes, adapting to the skills, needs and availability of each learner while ensuring collaborative learning environments through the use of synchronous and asynchronous communication tools. Likewise, the learning material is provided in online repositories, where course interaction and communication as well as course delivery are technology mediated. E-learning is a computer based educational tool or system that enables learning to take place anywhere and at any time [9], [10], [11].

Collaborative activities

There are several types of collaborative activities. These activities are important during the educational process because the information shared between the partners during the development of the activity may help improve the teaching-learning process. Moreover, it promotes collaborative activities such as interpersonal learning, shared understanding of diagrams, joint problem conceptualizations and common references, among others. There are some cognitive activities that small groups can develop and are relevant in their learning process. In another way, collaborative activities such as text chat or discussion forums can make evident the emerging of group-cognitive accomplishments, and that demonstrates how self-formation of groups and their achievements are accomplished through members of the situated interaction [12], [13].

A synchronous group activity in a virtual educational environment can be developed at the same time and at the same place or simultaneously in different places. Most synchronous collaborative tools enable communication (Marjanovic, 1999), which provides flexibility for their development, providing them with certain asynchronous features, but without losing the advantages of similarity to the traditional class environments, where interaction occurs at the same time and space (Chen et al., 2005).
However, we have identified that synchronous activities have a limitation in terms of the continued availability since, in most cases, it requires the presence of a teacher or tutor to moderate its development in order to work.

Collaborative learning

Collaboration between students’ peers can be seen as the combination of communication, coordination, and cooperation. A collaborative e-learning environment facilitates sharing and accessing e-learning content among users in different systems.

Accomplishments of the competencies and learning objectives can be obtained both in single and group activities. Group activities require the strengthening communicative abilities, reciprocal and symmetrical relationships and problem resolution will on individuals. To achieve that, it is necessary to have clear strategies to create groups with the ability to generate specific competencies. Also, positive interdependence has especial attention between research communities with an interest in finding the goals and the individual responsibility in the activities and attainment the objective [14], [15].

Figure 1 shows the main characteristics of collaborative learning and exhibits the communication as an outstanding factor to advance in group activities. It is possible to relate students with others students or with teachers. Sometimes, the process is coordinate by a facilitator who has the job of selecting the tasks and models to be applied.

Computer-Supported Collaborative Learning (CSCL)

CSCL is one of the most promising research fields to improve teaching and learning with the help of modern information and communication technologies [16]. The inclusion of computer-mediated collaboration in the teaching-learning process has become a field of research that involves issues such as the notion of learning and technology in formal educational environments [17]. In particular, over the past decade, computer-supported collaborative learning (CSCL) has become one of the most influential learning paradigms devoted to improving teaching and learning with the help of modern information and communication technologies [18]. CSCL although very useful, still faces many problems that cannot be ignored [19].
Also, the design of CSCL activities can provide good support for coordination, communication, interaction and negotiation between members of a group. In this context, the computer can be seen as a mechanism to support social interaction and even eventually change the nature and effectiveness of this [20]. The component of interactivity among students in a CSCL environment is essential because, in teamwork, it is vital to have feedback and sharing of resources and information, which can be seen as a chance for students to cooperate and learn from their peer's experiences.

Collaborative learning is more effective if individuals and the groups have to work in well-designed scenarios. Some research had shown that the structure of shared spaces has influence in the type of collaboration and implies that there is an interest to implement shared work spaces that support the design of the activities [21].

**Intelligent Agents and multi-agent systems (MAS)**

Intelligent agents are autonomous entities that have the capability to accomplish tasks in order to achieve their objectives and guided by their beliefs, without human supervision. Agents have characteristics that are desirable, including [22], [23]: Reactivity: An agent perceives and acts, to some degree, on its close environment; it can respond in a timely fashion to changes that occur around it; Proactivity: agents can make activities on their own account; Cooperation and Coordination: they can communicate with other agents through a common language and perform activities together; Autonomy: An agent possesses individual goals, resources and competences; as such, they operate without direct human or other intervention and have some degree of control over their actions and internal state; Deliberation: agents can make decisions through their reasoning processes; Distribution of tasks: each agent defines their limits and identifies the problems that can be solved; Mobility: they can move between computers through the communication network; Adaptation: agents can change their behavior depending on changes in their environment, improving their performance; and Parallelism: they can make activities simultaneously through cloning themselves and working in parallel.

In many situations, intelligent agents coexist and interact with other agents in several different ways. Such a system consisting of a group of agents that can potentially interact with each other is called a multiagent system (MAS), and the corresponding subfield of AI that deals with principles and design of multiagent systems is called distributed AI [24].

**3. Related Work**

This section examines some research work focused on the implementation of CSCL models, highlighting the benefits of creating collaborative educational spaces, although there are some gaps to be filled concerning synchronous and asynchronous collaborative management activities.

[25], [26] proposed the implementation of a chatterbot, seeking to solve the status of limited availability of tutors in virtual education platforms. The chatterbot is called Smart Chat and is a multi-agent system that provides students with a tool where they can ask and solve questions regarding a specific topic or area through the communication with intelligent agents with knowledge and personality. The activity supported by the MAS do not yet contemplate group interaction, as it is designed for the interaction of one student in the chat room, which means several agents at once, but only one student can interact. In Granda, Nuño, Suárez, & Pérez (2013), a synchronous virtual learning tool is designed to offer different types of activities, so that if the number of participants is small, it can highly develop didactic activities; otherwise, if the group is very large, the interactive component is reduced. In addition, the instructor must have the availability to interact with participants by using the system control panel and limiting the use of the platform. A chance to support the tutor in some tasks should be considered, as they can be monitoring the implementation of the activities assigned to the participants.

On the other hand, in Tsuei (2012), a system of synchronous face to face learning aimed at learning math in elementary grades is exposed. The platform has two subsystems: The first one is responsible for providing the tutor with functionalities for managing the activities that will be developed by the
students, as well as assigning a leader and some members of each working group. This assignment may be done manually or automatically and is also responsible for allocating problems in each group, according to the study unit. The second subsystem is responsible for controlling the interaction among members of the working group, thus, allowing students to develop the proposed activities through a game-type computer-mediated learning program in which students learn by solving mathematical problems synchronously on a shared screen. Nevertheless, the tutor has difficulties watching whether each group member is participating in the development of the activity, limiting to possibility to check whether they are learning about the topics proposed as no alert is generated to take appropriate action for that situation.

Dascalu et al. (2015) present a method of personalization for a virtual collaborative learning environment, initially using a recommender agent based on learning styles, which offers two types of recommendation: (1) shortcuts, which consist of materials and learning tools, and (2) suggestions, which are more complex than the former ones. They are also based on the user's learning style and the materials and tools considered important by other users having similar profile. However, this proposal does not include a tool for students to interact with each other providing collaboration and exchange of knowledge among them to facilitate a collective construction of knowledge.

Temdee (2014) proposes the development of a ubiquitous learning environment (ULE), based on the multi-agent architecture, that seeks to promote individual and collaborative learning. The environment developed consists of a ULE server that connects to learning objects (LO) by means of communication tools. Students can access LO through the use of their mobile devices or laptops. LO are developed using multi-agent architecture. Each object is composed of three agents that coordinate internally, as follows: the profile agent, who is responsible for maintaining user profiles and their historical actions in the system; the content agent, who decides what content and LO should be presented to the student and finally the representing agent, who makes the decision of how to present content to students. The proposed model was tested through a case study with two groups of 20 students each. One group studied in ULE without a multi-agent architecture (G1) and the second group studied in a ULE with multi-agent architecture (G2). The results show that the ULE with multi-agent system architecture used in G2 is able to significantly improve some shortcomings in learning compared to the architecture without the multi-agent system.

In Hanna & Richards (2012), the conceptual development of McVille (Multi-Agent Collaborative Virtual Learning Environment) is implemented by using a multi-agent architecture to support a virtual collaborative learning environment; this system is based on the Activities Theory (AT), which is a theoretical framework for the analysis of human practices in a given context. AT offers a number of concepts, which can be used to analyze the activities of collaborative learning and to create a framework for collaboration between students and agents. The authors suggest performing three types of assessments: Skills in drawing conclusions, the social skills that involve interaction with the virtual agent and the social skills that involve the interaction among students. Concerning this work, it does not clearly outline how the monitoring of activities is performed nor how the agents control and moderate the student’s interventions in collaborative activities.

Moreover, the work in Fares & Costaguta (2011) presents a multi-agent model for the supervision of students in a group, recognizing their roles within a team and diagnosing the state of collaboration, taking into account the functions balance of the team as an ideal situation. It proposes corrective actions when the group’s behavior is far from ideal. The authors raise the possibility of implementing the model in a virtual learning environment context. This paper does not particularly meet the type of collaborative activities to be supported, according to the type of communication, whether synchronous or asynchronous.

Finally, Tegos, Demetriadis, & Karakostas (2011) present a web system called MentorChat, supporting collaborative learning using a conversational agent. The function of the intelligent agent is to facilitate and trigger discussion among peers, so the teacher defines a number of key concepts, from which agent interventions are defined and conversation with students is drawn. However, this tool has been designed only for the chat-type activity.

From the literature reviewed, it is concluded that there are several drawbacks identified for designing collaborative learning environments. Intelligent agents generally are a good choice when it comes to facing the problems of permanent availability in synchronous activities in virtual educational environments, which is the case we want to develop in this study.
The proposal described below is seen as a promising strategy for the implementation of several educational activities in CSCL systems.

4. Model

The process of learning through peer collaboration, such as chat rooms, videoconferences and discussion forums allows for a joint construction of knowledge through interaction. This strategy requires the presence of a teacher or tutor to facilitate interaction processes, be attentive to feedback from students and guide discussions. But this becomes a limitation, since the times when students and teacher may be available at the same time are limited and is a factor that may explain the underutilization of synchronous collaboration tools.

The fundamental contribution of our work is attacks this limitation through of a tool in virtual education based on intelligent agents to support the management of synchronous collaborative activities and the establishment of working groups depending on the learning style and academic performance of students.

The model proposed in this paper aims to support activities associated with the realization of collaborative educational tasks in virtual learning environments. On one hand, the interactions of the participants are focused on the objectives proposed for the selected activity. On the other hand, these interactions generate discussions around a topic established. Discussions consist of both questions from the students and concepts presented by the system. In addition, the proposed design assists the teacher’s role because the student’s responses are evaluated according to the given topic. In addition, the model design attempts to maintain the interest and motivation of the students in collaborative tasks, crucial to enrich teaching and learning processes. Figure 2 presents the outline of the model proposed.

The tool built supports synchronous activities, but it also applies to asynchronous activities within virtual platforms. It was implemented from the perspective of a MAS, knowing that agents can take different roles - being this a big advantage - as well as the ability they have to be autonomous, allowing learning activities to be performed at different times without the presence of a real tutor.

Then, the behavior and role that the agents exhibit within the system will be explained.
Moderator Agent: it is responsible for verifying that students are involved in the proposed activity so that, in addition to being connected, they are providing relevant contributions. Additionally, in the case of activities having different moments, it coordinates times and interventions for the students and set their attention at key points of the activity, thus preventing their dispersion.

This agent is also responsible for verifying that the replies sent by students are related to a series of keywords previously defined by the teacher in charge of the course in which the activity occurs. Taking into account these keywords, it is determined how related the given answer is to the topic. The intervention is graded as well in order to know the quality of it.

In addition to the above, this agent must keep each student’s interactions with the platform, so that it has the chronological order of participations and, whenever a user belonging to a group enters, the system can easily retrieve messages written by their peers to improve the quality of cooperation.

Task selector Agent: this agent is responsible for selecting which type of activity must be developed, depending on group size or other factors defined by the teacher, such as learning styles and the student’s academic performance. Similarly, this agent considers the homogeneity or heterogeneity criteria of the group that the teacher wants to apply according to the nature of the learning activity.

Interface Agent: it is responsible for introducing students to the activities to be developed by the group and supports the interaction between students and the moderator agent. It is also responsible for giving students access to the tool through the user login. Once logged in, this agent requests the moderator agent the previous interaction of the group in the activity in development, so that it can offer previous participations.

With this model, it is expected that the multi-agent system can assist teachers to coordinate synchronous activities; moreover, it also has the ability to support asynchronous activities within virtual educational platforms, as it can retrieve the history of messages sent by other students, allowing a view of all information, even when peers are offline.

The selection of groups where the teacher can choose a criterion for the formation of the same and the system does that automatically are part of the coordination activities supported by the system. The system also allows students to interact through the platform in order to carry out the activity through a chat interface where the speeches of each student in each group are published. In this way, each group has interface interaction.

Finally, the tool allows users to track activity, as it saves interventions of each student within an activity, verifies that the intervention is about the previous subject, grades it to help ensure its relevance and make it easier for the teacher to give a score on the development of it.

5. Implementation And Initial Results

In our case study, simulations were performed in a discussion forum activity. This kind of collaborative activity is normally asynchronous; however, some modifications were performed in its working, such as the activity expiration time. Changes in the activity are aimed to force students to enter during established time slots. In addition, these changes make the forum to be carried out by students in real time. Therefore, these improvements modify the forum behavior, from asynchronous activity to synchronous activity, which is the problem identified across the literature reviewed.

For initial testing of the MAS, the forum discussion activity was implemented in real time. Figure 3 shows the flow performed within this activity regarding the participation of teachers, students and agents.

A set of simulations were performed to determine the correct formation of the groups according to the implemented criteria. For learning styles, it was considered VARK model proposed by Fleming & Baume (2006). It is intended to form heterogeneous groups, that is, in the case of learning styles, a group formed by students displaying different learning styles.

For instance, one group may be formed by students with the following learning styles: auditory, visual, kinesthetic and reader. On the academic performance, the objective is to have also heterogeneity in the grade averages of the students in each group because it is possible that, having students with good performance integrated with students who have presented greater difficulty in the process together may cause that the former can strengthen and provide feedback to the learning process of the latter.
The algorithm used for the formation of groups distributes students randomly, but respecting the criteria defined by the teacher from the beginning.

The teacher has the freedom to decide if the distribution is homogeneous or heterogeneous, this can help to make several simulations with different distribution and he can see which of these simulations throws best results with regard to increasing in performance academic of students.

In addition to the above, through the use of agents, teachers can perform several experiments in a short time, moreover, the help of agents reduces the teacher’s workload, especially at the moment of assessment, because the platform performs analysis of the messages and verify their relevance to the theme, helping the teachers in their assessment task.

The main system interface is presented as follows: Figure 4 shows a fragment of the simulated interactions in Web. For these tests, the database and interactions are conducted in the Spanish language. The theme shown within the interface is part of the course named Databases I, which is taught in higher education associated with Informatics and Computer Science Studies.

The tool initially displays a link to an educational resource related to the issue, defined beforehand by the teacher. This resource allows an introduction to the subject and generates in students motivation and initial concerns. Once visualized this resource, the agent asks a general or main question and the participants start to contribute around this.

Each time a predefined number of interventions are completed, the moderator poses new questions to avoid students dispersion. Additionally, each time one of the students do an intervention, the moderator agent reviews the list of keywords of the activity to verify that the intervention fits the theme; otherwise, a message is sent to rectify and focus the discussion again.

Once the moderator agent has completed the secondary questions of the learning activity, and taking into account the total time defined by the teacher for this activity, a closing procedure is done with a final thought on the subject, which has been stored in the learning tasks database by the teacher. In the initial simulations, we found that the formation of groups is satisfactory and that the moderator agent is attempting to make the necessary interventions in the development of the forum. A more complex strategy should be considered for analyzing the messages of the students so that the fact that coordination is being done by an agent rather than a human tutor cannot be noticed by users.
For the experiment, several students were selected and the VARK test, which classifies the learning style, was applied. His academic record was previously known.

Group selection algorithms were applied and group work themes were determined. Intelligent agents were provided with knowledge and behavior commensurate with the situation.

The group of students accessed the system and participated in guided synchronous activities. Subsequently the participants were asked about the other partners in the activity, informing them that at least one was an intelligent agent. In addition to the surprise the answers allow to deduce that in general they perceiving that the intelligent agents were human actors (80%).

The environmental assessment was positive (87%) and they believe that it could be applied in other types of courses and feel accompanied in the process of strengthening some knowledge (90%).

6. Conclusions

It can be concluded that the designed tool can help teachers to perform monitoring of synchronous collaborative activities since the system can record the intervention of each student as well as verify its relevance to the topic addressed.

In addition, we can assert that the MAS approach is relevant for monitoring synchronous activities in which many students participate because several agents are able to analyze each student-platform interaction and evaluate the quality of this interaction based on the criteria established by the teacher.

As future work, a test execution with other real groups of students and some criteria to measure usability of the tool and acceptance by students and teachers will be designed.

The possibility of implementing more complex strategies for the formation of groups, including strategies associated with genetic algorithms or trading algorithms are also considered. In addition, to give the possibility to the teacher to add new criteria for group selection.

Also, include a field where the teacher or the agents may have a private communication with each student, this in order to motivate participations in accordance with the proposed theme or other issues, without diverting the forum central topic.
7. Acknowledgments
The research presented in this paper is part of the project funded by COLCIENCIAS entitled "RAIM: Implementación de un framework apoyado en tecnologías móviles y de realidad aumentada para entornos educativos ubicuos, adaptativos, accesibles e interactivos para todos" of the Universidad Nacional de Colombia, with code 1119-569-34172.

8. References


