THE COLLABORATIVE PROCESS OF DECISION-MAKING IN THE COOLED LEARNING ENVIRONMENT

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Abstract: This paper presents decision-making processes and collaboration and coordination mechanisms with the use of an intelligent agent in the CoolED Environment. The CoolED is a collaborative learning environment developed by the LAVI research group at the Federal University of Mato Grosso (UFMT). This system aims to help computer science undergraduate students master the content of Nonlinear Lists, which is a subject of the Data Structuring class, emphasizing insertion, removal and search operations. The group decision-making is made by a leader chosen by the agent and it follows some evaluation criteria stipulated in a leadership model developed on this work. This model allows any user a chance to lead the group at least one work section and respects individual interests on the process of becoming a leader.

1 INTRODUCTION

This paper presents decision-making processes and collaboration and coordination mechanisms with the use of an intelligent agent in the CoolED – Collaborative Learning Environment for the Study of Nonlinear Lists. This environment is one of the results of researches in collaborative environments of the Research Group Laboratory of Interactive Virtual Environments (Laboratório de Ambientes Virtuais Interativos - LAVI) of the Computer Science Institute at the Federal University of Mato Grosso (UFMT).

Decision-making is a very important factor in a collaborative environment, but working collaboratively demands additional effort for coordinating its members. Without coordination, many communication efforts are not put to good use during collaboration. That is to say, in order for the group to satisfactorily act together and make correct and coherent decisions, compromises must be made during conversations among participants. In this context, the agent plays the role of a mediator and contributes to the decision-making process, improving communication among participants and helping develop collaborative learning.

This paper is divided into six sections. Section 2 describes how the decision-making process operates. Section 3 presents a few studies related to the topic. Section 4 presents the CoolED system and shows how it works, describing the decision-making process and the role of the agent in mediating this process. Section 5 presents the conclusions of this study and the next steps for continuing the research. Lastly, Section 6 presents bibliographic references.

2 DECISION-MAKING PROCESS

The decision-making process characterizes a situation that displays a certain degree of uncertainty and a certain level of complexity. When occurring in a group, this process also considers individual knowledge based on each person's values, creeds and experiences. The process is initially based on information exchange between individuals within the group by the resources offered by the environment. From this interaction and group reasoning, a so-called collective knowledge is created, which determines the decision through a sequence of actions that will be executed. At this moment, the decision-making process may be considered pre-finalized because, when discerning the result, a new discussion is generally initiated, creating a certain unbalance within the group and often producing changes in the collective knowledge about a given situation. This experience, in turn, leads the group to acquire new and richer

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experiences, due to the debate generated by the encountered problem.

Figure 1 illustrates a schema of the decision-making process in a group, also called collective decision-making process based on the work authored by Rodriguez et al. (2007), which presents a social software system for the collective decision-making process called Smartocracy.

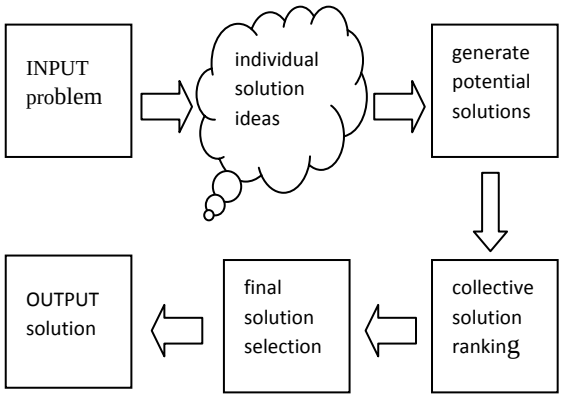

Figure 1: Collective decision-making stages.

According to Moron (1998), the decision-making process is characterized by phases that ensues the so-called decision in an election, for instance, where people generally research, discuss and exchange information. Decision-making can be considered an attempt to resolve a certain problem.

Making a decision means choosing among many well-considered alternatives. Thus a decision must be made as a response to a problem that has many possible solutions and each solution has positive and negative sides (Gomes et al., 2006).

Also, when certain decision involves a high degree of complexity, its resolution simultaneously influences many different objectives. A decision is made considering quantitative and qualitative parameters and their impacts are not easily predictable; they can result on the possibility or necessity of other decision-making processes.

It is also worth noting that not all individuals who participate in a decision-making process necessarily have the power to decide. However, these participants can contend with deciders in order to influence them.

Therefore, the decision theory is neither a descriptive nor explanatory theory, since it does not attempt to describe or explain how and/or why people act a certain way or make certain decisions (Maciel, 2008). Conversely, Gomes, Gomes and Almeida (2006) believe the theory to be at times prescriptive and at other times normative, in the sense that it intends to help people make better decisions according to their basic preferences. The decision theory thus assumes that individuals are capable of expressing their basic preferences and are rational when they face simple decision-making situations.

There are different methods that aid decision-making and the most commonly consensual is voting and leader-based decision-making. The latter is the method used in the CoolED system. This choice is based on an experience that uses a voting tool described in Souza's work (2003) and also on the fact that the proposed environment works with small groups and with non complex problems, demanding some discussion without, however, much time for choosing, for instance, a consensual method. In addition, this choice is also based on the fact that leadership method allows verifying some behavior aspects on students such as diligence and responsibility, among others.

Leader-based decision-making relies on the choice of one member to lead the group and this person will be invested with the power to make a certain decision, though this leader's choice will be influenced by other members. This method requires the establishment of criteria for choosing the leader who will not necessarily remain the whole time with this function. The length a leadership will last depends on the methodology employed – it may have a fixed leader during the whole collaborative process or other members of the group may also play this role. A model of leadership was elaborated and it is described on section 4.3.

After the decision is made, the group must organize itself to assess the efficiency of the adopted solution. This evaluation will serve as a parameter for next decisions. Therefore, we can consider a decision positive when it is democratically accomplished and generates harmony, satisfaction and motivation among participants.

3 RELATED STUDIES

The use of intelligent agents has been widely explored by researchers of this field in order to monitor learner behavior and to facilitate the teaching-learning process in collaborative learning environments, interchanging collaboration and interaction (Wang, 2002).

Souza (2003) developed a collaborative learning environment for problem solving in the field of civil engineering. The presented prototype uses an agent that simulates the behavior of a social constructivist

professor aiming to mediate student interaction. This agent possesses a plan-driven and information-based behavior regarding learners that is dynamically built during the interaction course. The role of the mediator agent is to stimulate and verify the existence of a learning situation, thus it monitors individual and collective participation of the group within the environment and acts according to defined mediation strategies. The agent also assists group members during the decision-making process through voting tool. Despite the existence of this tool, the agent uses its communication strategy to stimulate discussion among members about the decision being made before using the tool.

Goodman et al. (2005) presents the use of an intelligent agent to recognize the dialog between participants and interact with them in a collaborative learning environment. The agent participates in the discussion and interacts with participants when detecting learning problems, for instance, when a participant dominates the debate but does not interact with other participants or when participants do not understand the problem at hand. The agent is also concerned with group interaction during collaborative learning and encourages participation, asking the group questions and stimulating members to think. When a problem is detected, the agent posts a question or comment in order to facilitate learning or improving interaction, serving as assistance or a clue to guide the group in solving the problem. Therefore, the investigation's key concern was determining when and how the intelligent agent should intervene in learning.

After the simulations, improvements were identified in the collaboration process (hence learning process) and showed that the role of the instructor, represented by the agent, should not be lost when the student enrolls in distance learning. Therefore, studies by Goodman et al. (2005) show that the dialogue between participants (students and instructor) provides strong evidence to check whether or not group dynamics in the teaching-learning process is efficient.

Accordingly, Aguilar, Antonio & Imbert (2006) propose an intelligent collaborative virtual environment (ICVE) that incorporates a Pedagogical Virtual Agent (PVA) to assist one or more team members during task execution in situations where the real learning environment is impossible or undesirable due to costs or danger, while acting as an advisor and coordinator in virtual group meetings.

The Pedagogical Virtual Agent (PVA) incorporated into ICVE will take as its bases for the tutorial process, the knowledge of the task, as well as a mechanism for modeling the group based on the interaction process. It may communicate with the apprentices or make them suggestions during the execution of their activities, if necessary. The PVA will offer its help to the team, giving preference to activities that are critical for the task success. The incorporation of a PVA as a team member (leader) with capacity to carry out behaviors similar to those of a human tutor will require integrating with the IVET a cognitive architecture for the virtual agent.

The aim of the study was to develop a strategy for the assisted formulation of small groups in ICVEs called Team Training Strategy (TTS), in order to assist the formulation process. The proposed strategy consists four interdependent phases in which the trained team follows an iterative self-evaluation process for executing a certain task.

4 THE COOLED

The CoolED system is a collaborative learning environment developed by the LAVI research group at the Federal University of Mato Grosso (UFMT). This system aims to help computer science undergraduate students master the content of Nonlinear Lists, which is a subject of the Data Structuring class, emphasizing insertion, removal and search operations.

4.1 Functions

The CoolED system includes two types of users – student and professor – who are identified by login. The professor's first task is to make a pre-registration of students containing only essential data. At this point the professor can either create work groups with two or three students or let the system randomly perform this operation. The professor's main activities in CoolED are: including new exercises in the environment, since CoolED already has some available exercises; inserting didactic texts to download; recording appointments in a planner; creating topics for discussion in the forum; and visualizing and/or printing reports of student activity in the environment.

The agent that welcomes the student receives this student's first access in CoolED and provides a brief description of the operation and aims of the environment. The agent then asks the student to finalize his/her registration through the option profile, which is made available in the environment.

The main menu shows the options concerning the domain (binary trees, AVL trees, and B trees), didactic material for download, and an option to activate the Help system and the following submenus include concepts, tree operation simulations and proposed exercises about insertion, removal and search operations.

CoolED also presents chats to allow student group discussion; a forum, which acts as a repository of topics of interest for discussion, where students and professors may participate; an agenda or planner, where the professor posts deadlines for activities and meetings; and an animated agent that acts as a mediator in the collaborative process, stimulating participation of all group members, observing the development of activities, and assisting the decision-making process as well.

4.2 The Agent

The agent is responsible for the student-environment communication interface. It acts as mediator, intervening when the student, for instance, experiences difficulties in using a CoolED tool or in conducting exercises and also when choosing the group leader. The term mediator was constructed from the concept of mediated relation described by Vygotsky and is based on the behavioral analysis of a teacher in a classroom who follows a social constructivist approach.

In the developed prototype the agent's figure is represented by Peedy, an animated agent developed by Microsoft that is available free of charge. Peedy possesses a few movement functions, appearance and text balloons. The remaining functionalities are being developed by LAVI.

The following functions pertain to the agent:

- Warning – shown to the students every time new information is included by the professor in the Planner, when material is available for download, and when interest topics are inserted in the Forum;
- Assistance – provided whenever the agent notices that a student faces difficulties in solving the exercise, when there is lack of communication between group members or when communication is unilateral;
- Correction – at the end of an exercise, the agent compares the group answer to the exercise solution;
- Decision-making – for a solution of each exercise, the agent uses the leadership model for determining which student will lead the group.

4.3 CoolED's Decision-making Process

In solving exercises collaboratively, group decision-making is conducted by a leader, who is selected by the agent, considering evaluation criteria described in the leadership model. The student chosen as a leader is the only one who conducts insertion, removal and search operations in trees, and the role of the remaining students is to participate in the solution of the exercise, expressing their opinions through the chat room.

In the model of leadership each student has a leadership reputation grade that corresponds to the probability of being chosen to be leader and a variable that indicates how many times the student has already been a leader. The system initially bestows grade 5 to each student, hence all students are equally likely to become leaders. As students lead the exercises, their grades vary from 0 to 10, where 0 means least likely to be chosen and 10 means most likely to be chosen. Grades start at 5 because, after each leadership, a student can have his or her grade increased or decreased depending on his or her performance. Whenever there is someone in the group who has not yet been leader, this person will always be chosen. The number of times a student has been a leader will also be taken into consideration, and priority is given to those who were leaders the least often. In case of a tie between the grade and number of times two people were leaders, both will have the same chances of being chosen, and the agent will randomly select one of them.

At the end of each collaborative student-led exercise, the group will answer an evaluation survey that aims to analyze leadership performance, and thus serve as a positive or negative weight for the leadership grade. CoolED possesses two types of surveys, one for group members lacking leadership functions and another for leader self-evaluation. The self-evaluation questions induce leaders to reflect on their performance in this role and their interest in repeating the experience. The other survey makes the remaining participants of this work session to analyze the leader's role and investigate whether they wish to work with this leader again. The result after compilation is presented by the agent to the leader.

4.4 Implementation

The CooIED system is in a final stage of development taking as a basis the Document of Requisites Specification, the Entity-Relation

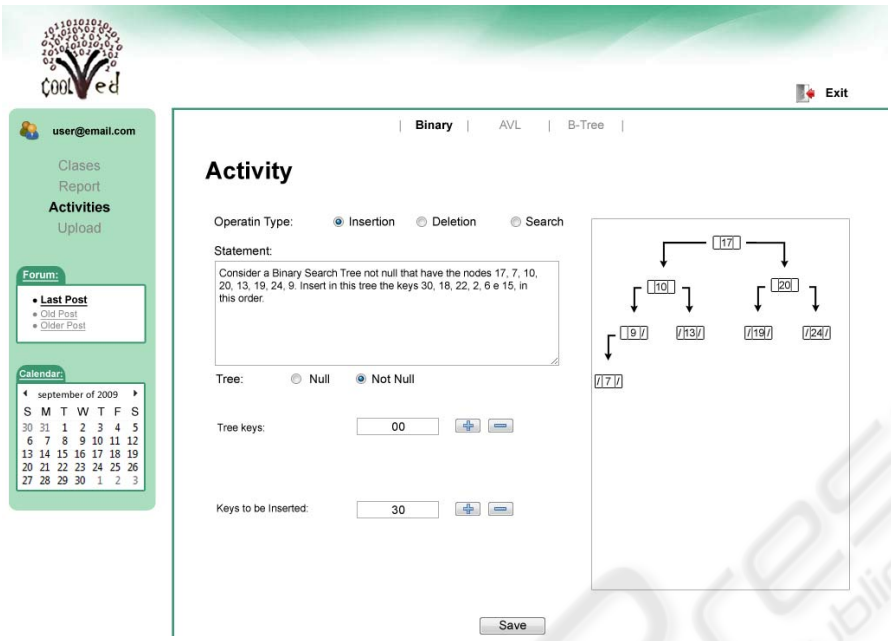

Figure 2: Interface of the instructor's module.

Diagram, and the Interface Project. The CoolED interface project was elaborated according to methodology proposed by Pressman (2006) to create interface projects for web. Different criteria of usability were adopted during the whole project and a session of inspection was implemented using heuristic evaluation.

After defining MySQL as management language, the data basis was created, as well its tables and its relations. In addition, some tests were taken in order to verify their integrity. For its implementation Java was the language selected and this choice was made for its particularities, for non additional costs for the project, and for been known for the development team. After studies, the following frameworks were defined: JSF (with facelets, richfaces, and Ajax4Java – A4J), Hibernate JPA, and JavaMail. Proper implementation started with the process of building the classes which are related to the data basis entities and its maps using Hibemate JPA specifications. After that, insertions of random data were made on the data basis and a few tests were taken as well.

In accordance to the CoolED Specification Document, the implementation of the system followed MVC architecture and the layer model was subdivided on business and persistence. On the persistence layer several interfaces (Java) were defined to be implemented. A number of tests were taken in order to verify the mapping made by classes and the XLM file, the Hibermate framework behavior inside the application, and also the Java code necessary for access operations on data basis.

The layer of vision is on a process of development based on images available for the interface project team, where mapped actions and attributes have been used on the pages. The Controller has been developed as an intermediate stratus among layers of vision, persistence and business. It is responsible for providing required information and registering it, applying some validation rules.

After dividing responsibilities between creations of data basis, its application and the classes that support that structure, the construction of the pages of web application was started attending to the student´s and the instructor´s modules. The construction of the pages and the application of the tests have been finalized and soon the integration between web application and the agent will be done, concluding the construction of the first version of the CoolED System.

To illustrate how the CoolED works, figure 2 presents an interface for the instructor's module of insertion of the binary tree activity. On the screen the instructor determines what type of activity: insertion, removing or search. In this example, the teacher has chosen a sort of tree (null or not null), and typed some keys and the complete statement of the activity as well. After finishing (save key) the activity it is storage on the CoolED system data basis and ready for use at the student module.

5 CONCLUSIONS AND FUTURES STUDIES

Investigation of related studies still leads us to believe in the need for an environment that considers collaborative learning, where the professor can be present during the whole work session represented by the mediator agent and where the professor's role is not limited to analyzing the end result of collaborative activity. Every issue involving communication, activity coordination, and above all decision-making processes is related to the opportunities that the environment bestows, favoring constant dialogue between group members and especially interest in teamwork. Leadership is a crucial issue in this work since it is not fixed and continuous in all work sessions and is thus able to permeate all group members. Besides, there is an attempt to respect individual interest in leading the group by means of an evaluation conducted according to previously established criteria in the leadership model.

As regards the investigative aspects of this study, the next step is to conduct an empirical study with a data structuring class of students enrolled in the undergraduate department of Computer Science and Information Systems at UFMT, thus analyzing the agent's performance as a mediator of student interaction and especially in the decision-making context.

In this experiment the researchers intent to observe the CoolED support during the learning process of non linear lists (trees), the decision making process behavior of the students, and also the efficiency of the developed leadership model. The study is not restricted to the environment, as we also intend to use the interviewing method with users in order to conduct a more accurate analysis.

In this final stage of the development of the system, the methodology for this empirical study and interview is on the process of elaboration. It is expected that in middle of March those activities will be done and thus the experiment will be concluded in April of 2010.

It is worth noting that one of the members of the research group LAVI is a professor who teaches data structuring classes. She is the responsible for elaborating the whole contend related to the domain of the system: texts, examples, simulations, and tests on trees.

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