

An Adaptive Multi-Agent Environment

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INTRODUCTION

This article aims to develop a new environment of collaborative learning, by taking into account the criteria of construction of knowledge by the apprentices and the adaptative management of that knowledge by artificial agents. The multi-agent technology has been chosen due to the possibility of having artificial agents with internal decision processes to help students in the construction of their own projects and enabling learning objects available in accordance with the cognitive characteristics of the students and of their group. In this multi-agent system, exchanges of messages between the agents can occur so that they can perform their tasks in the best possible way.

BACKGROUND

In CSCL (computer-supported collaborative learning) environments, collaborative learning happens mainly when groups of students have as a common objective the resolution of a certain problem (Santos, 2003). In this article, environments of collaborative learning including TelEduc (Rocha, 2002), AulaNet (Lucena & Fuks, 2000), AME-A (Pereira, D'Amico & Geyer, 1998), AdaptWeb (Freitas et al., 2002), and WebSaber (Santos, 2003) were studied, and it was observed that the criteria related to the adaptation in presenting the didactic material for the students, along with the possibility of the learners to act as authors in the construction of these didactic materials, are characteristics that have not been found in these analyzed educational environments.

According to Bannan-Ritland, Dabbagh, and Murphy (2000), most of the systems of learning objects that use didactic basis are made up of the behaviorist or cognitive kind, where the apprentices continue to be receivers of information that will be

contained in the software. These researchers assert that educational environments, using learning objects through a constructivist approach, have not yet been developed.

The same authors mention that the environments of learning objects that use objectivist theories allow the users only to receive instrumental content, when it is finished, and do not give the apprentices any options so to create educational material (Bannan-Ritland et al., 2000). Therefore, those environments restrict the possibility of the apprentices to be an author or co-author on the development of the objects, making active participation of the apprentices impossible.

The reconstruction of digital resources, such as text and video/audio components, allows the users to adapt, rebuild, or reconfigure those media in their own representation of meaning, while it does not happen when the apprentice receives an instructional content developed by the teacher (Wiley, 2000).

The adaptation of the media or of the learning objects is related to the way of showing these objects on the interface of the system. Thus, we will use the concept of personalized learning, which consists of using the software technology to make the learning objects available, according to the profiles of the apprentices.

THE ENVIRONMENT PROPOSED

This educational environment is formed of two sides: the pedagogical side and the technological one. The pedagogical side consists of the use of two learning theories: the Genetic Epistemology of Jean Piaget (1975) will be used to construct the students' model (profile) to make the adaptation of the interface possible, and the socio-cultural theory of Vygotsky (1998) will be used for the construction of the group's

model (profile) according to the relationship of the students for the construction of their learning objects. The technological side that was already mentioned above is constituted by the multi-agent technology.

This educational environment uses the socio-constructivist approach analyzed by Dillenbourg, Baker, Blaye, and O'Malley (1994) which focuses on the individual in a social interaction context and is based on the two learning theories mentioned above.

The learning process will include constructed educational projects, which will be developed by groups of students working face-to-face and at a distance. The students will be able to construct their own didactic material through learning objects that will be available in the environment. Wiley (2000) defines a learning object as any entity, digital or non-digital, that can be used, reused, or referenced during technology-supported learning.

This educational environment uses a playful locale where the learners construct their knowledge and discover the solutions for their problems with the construction of toys and the use of games. In the playful locale, the learners have the help of the teachers, who instead of imposing the information will assist them so that they can discover how to solve the tasks that will appear in implementing the learning process.

In the considered environment, the students will use the available learning objects to construct their stages in order to reach the objectives sought, and will also have the help of the facilitator and artificial agents. So, the learning objects will function as toys or games that stimulate the imagination of the students and will enable them in accordance with their level of cognitive development. These objects will be developed by the students in groups or alone.

This educational environment is formed by human agents who are the students and the facilitator, and by three types of artificial agents: Accompanying Agent, Student's Profile Agent, and Group's Profile Agent.

These virtual agents are based on probabilities and utilities, and the process of decision is made through the use of Bayesians Nets, defined by Jensen and Lauritzen (1999) as a set of variables and lines directed between the variables. Each variable has a set of finite states and a probabilist value whose result depends on the parents' variables; this dependence is called conditional probability.

The base of knowledge of these agents—based on uncertainty that will be used in this research—uses Bayesians Nets to calculate the probabilities of the relevant variables to one determined situation and uses Decision Nets to calculate the utility of these variables.

The Student's Profile Agent is responsible for the cognitive characteristics of the students based on Piaget's theory of the learner's development stages. They can be in the following levels: novice, intermediary, experienced. The base of knowledge of this virtual agent will store the variables that correspond to the cognitive characteristics of the students and when this agent were requested to inform which the best profile to insert student is, it will have to cover the Bayesian Net to search for this result.

The Group's Profile Agent is responsible for the interaction of the learners of a group and for the interaction of the groups between themselves. The base of knowledge of this agent will have variables that will be defined based on the theory of Vygotsky, where mediation between the individuals and zone of proximal development is used.

The function of the Accompanying Agent is to assist the learners in implementing the learning process that will occur in the development of the educational projects. The base of knowledge of this agent will contain learning objects already constructed by other learners.

The architecture of this educational environment can be seen in Figure 1; the interactions that occur between the human and virtual agents in this system are numbered and correspond with the following actions:

- **[1]:** The student requests the help of the Accompanying Agent, and he answers to this requirement.
- **[2] and [3]:** The Accompanying Agent requests the learning objects that will be available in the interface of the environment.
- **[4.1] and [4.2]:** The facilitator has access to the data bases of learning objects for possible updates that it needs to make.
- **[5]:** Interactions between learners or groups of students and the facilitator can be performed.
- **[6.1] and [6.2]:** The Accompanying Agent and the Facilitator request results about the

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