IMPROVING INTERACTIVITY IN E-LEARNING WITH JADE – JAVA AGENT FRAMEWORK FOR DISTANCE LEARNING ENVIRONMENTS

Ricardo Azambuja Silveira [1] and Rosa Maria Vicari [2]

Abstract *— Most traditional computer based learning systems lack to provide adaptive teaching, suitable to each student. Distance Education Systems must support as much as possible the problems caused by the physical distance among teacher and students. This claims for more efficient mechanisms of adaptability and assistance in problem-solving processes. The system must perform some teacher's role as much as possible. Recent advances in Intelligent Teaching Systems have proposed the use of Artificial Intelligence through architectures based on agents' societies. Teaching systems based on Multi-Agent architectures make possible to support the development of more interactive and adaptable systems. The objective of this paper is to discuss the feasibility of implementing Distributed Intelligent Learning Environment – DILE based on the Multi-Agents Architecture approach, aiming at the achievement of human resources qualification through Virtual Training. Besides, we present a proposal of an architecture named JADE - Java Agent Framework for Distance Learning Environments.*

Index Terms — Artificial Intelligence, Distributed Learning Environment, Intelligent Learning Environments.

INTRODUCTION

Computer Science, together with Psychology and Education, has been trying to refine teaching computational tools towards personalized self-learning. Every day, new approaches to the use of Computer and Education are bringing new perspectives to this area. The evolution of Computer and Education became computational teaching environments an excellent choice for Distance Learning, by bringing new vigor to this field of science. Computer Networks and Multimedia fields has provided tools for the development of Tutoring Systems based on client-server architectures. The popularity of the Internet along with the extensive development and use of standard protocols and services make the Internet very attractive for distance learning. There has been a big boom of tools and mechanisms available for implementation and support of Distance Learning.

The traditional Computer Assisted Instruction Systems approach (CAI) lacks to provide an adaptable learning process according to each individual student. The simple use of technological resources without an adequate pedagogical and organizational project results in inadequate educational or virtual training programs (E-learning), within learning environments excessively static and with quite directive teaching techniques. These issues claim for adequate implementation methodologies of these programs and for suitable learning environment projects with adequate pedagogical proposal and proper use of technology.

There is a new look upon Education developed in the last 15/20 years that has been highly influenced by Cognitive Science. The educational system has focused more and more on learning instead of on teaching. The development of learning theories has changed the nature of student's learning and perception. Knowledge is today considered something socially built throughout students' actions, communication and reflections.

The classic approach of education on knowledge transmission has been changing into a model of practical experimentation and interaction that promotes changes in concepts and student's strategy, until he/she reaches proficiency. In this context, teachers perform the role of supporter instead of information provider. Distance Learning, at the present state-of-the-art, when applied in the right way, serves very well this conception of Education.

As we pointed in previous papers [14] [15] [16], the idea of Distance Education, however not new, has showed a great capacity of integrating new technologies successfully. Lately there has been appearing a great deal of mechanisms and tools available for Distance Education support and implementation.

Classic definitions of distance teaching imply that the ideal situation for learning is the traditional one, with teacher and student face-to-face. From this viewpoint, Distance Education would be an "inferior" way of education, always trying to fill the lacks of the traditional model. This conception may be true in many cases, but a growing body of research, exploring other options, has been taking their place, in the light of new educational paradigms, changes in the social dynamics, and technological advance of means of communication and computational systems.

It is important to highlight that Distance Education cannot be seen as a replacement for traditional and presential education. They are two modalities of the same process. Distance Education does not compete with the conventional means, once this is not its objective. If Distance Education presents, as a basic characteristic, the physical and temporal

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[1] Ricardo Azambuja Silveira, Universidade Federal de Pelotas - UFPEL e Universidade Federal do Rio Grande do Sul -UFRGS rsilv@inf.ufrgs.br
[2] Rosa Maria Vicari Universidade Federal do Rio Grande do Sul -UFRGS rosa@inf.ufrgs.br

separation between teaching and learning processes, this does not mean only a specific quality of this modality, but essentially a challenge to overcome, promoting the advance in the use of cooperative processes of teaching in a combined way.

Keegan [8] summarizes the central elements that characterize the concepts of Distance Education: Physical separation between student and teacher, different from Presential Teaching; Influence of the educational institution: planning, systematization, and project, different from individual learning; Use of technical means of communication to put teacher and student in contact each other and to send educational contents; Availability of a two-way communication, where the student benefits from the possibility of dialogue two-way initiatives; Possibility of occasional meetings.

We point a simpler and more encompassing definition, which explores new possibilities [17]: “Distance Education is a system that must provide educational opportunities anytime, anywhere for everybody”.

Spodick, lists five essential points in a successful Distance Education program: Contact between teacher and student, Active learning through student’s answers, Fast feedback to the teacher about the student’s understanding level, Fast feedback to the student about his/her own performance, The student has the opportunity to review and learn through his/her own mistakes.

According to Rosenberg [13], the use of modern technologies and delivering good learning programs is essential but insufficient to guarantee the efficacy of these programs. The increase of human capital of an organization must be based on an E-learning strategy focused on factors that include building a learning culture marshaling true leadership support, and in consonance with the business model.

The projects of E-learning must take into consideration that there are different classes of students: the *non-cooperative*, those who act in a passive way or even try to frustrate the program’s objective; the *cooperative*, who follow orientations, but do not necessarily know where to go; and the *pro-active* students, who know very well their objective, and search for aid to relief the task burden. The teaching methodology employed in each case is different and there must have a clear concern by the technological environment on the profile of the student that will use the system.

In order to reach this goal, cognitive student’s modeling is required, and it must make a clear specification of him or hers. An intelligent teaching environment must build and update the student model according to what the student already knows, what may vary from student to student. This difference must be considered when in the search for efficiency in the development of intelligent teaching environments. Previous experience, student’s performance in the domain, transparency of technical terminology, the student’s objectives and his/her expectations must be also taken into account. That is why the Intelligent Learning Environments, such as JADE, are a class of teaching instruments much more advanced in the pedagogical and organizational point of view.

The state of the art in the Intelligent Tutoring Systems and Intelligent Learning Environments fields points to the use of Agent Society-Based Architectures. The fundamentals of the Multi-Agent systems have demonstrated to be very appropriate to design tutoring systems, since the teaching-learning problem could be handled as a cooperative approach. Using Multi-Agents Systems approach to design Intelligent Tutoring Systems can result in more versatile, faster and at lower costs systems. The introduction of AI techniques and, specifically, the use of Multi-Agents architecture in these environments aim to provide student-modeling mechanisms [9]. We believe that these concepts can be used in the modeling and implementation of Intelligent Distance Learning intelligent platforms.

Pedagogical Agents

One of the major problems of traditional computer based learning systems is how provide adaptive teaching, suitable to each student. A Distance Education system must support as much as possible the problems caused by the physical distance among teacher, student, and classmates. This claims for more efficient mechanisms of adaptability and assistance in problem-solving processes. The system must perform the teacher’s role as much as possible, building a robust student model for each user that would enable: Adapting the syllabus to each user; Helping him/her to navigate over the course activities; Giving support in the task accomplishment, and in exercises and problems to be solved; Providing help resources anytime they are needed.

As the student’s performance is rarely consistent, and it is impossible to preview the entire set of student’s behavior, the Intelligent Tutoring System (ITS) adaptability is limited and the classic ITS models are not robust enough to provide the minimum requirements necessary for an interactive learning environment. According to Mathoff [9], these requirements are:

- *Interactivity*: interaction in learning environments may be considered as a cooperative dialogue between two partners, where some special rules are applied to promote learning;
- *Adaptable instruction:* in an instructional system, there must have an adaptation at any step to the particular needs of the student;
- *Robustness:* the interactive system should fulfill changes of student’s behavior in time, besides mistakes and unexpected actions;
- *Direct monitoring of the learning process:* an Intelligent Learning Environment (ILE) should support the optimization of the student’s learning process;
- *Empirical evaluation:* all stages of the process of interactive learning systems development should be

based on fundamental research on the learning process they support and in a continuous text of each phase of the prototypes development;

- *Parsimony:* the architecture of an interactive learning system must be simple and efficient.

Most recent advances in the field of Intelligent Learning Environments have proposed the use of agents society based architectures. The principles of Multi-Agent systems have showed a very adequate potential in the development of teaching systems, due to the fact that the nature of teaching-learning problems is more easily solved in a cooperative way. For that end, JADE [16], as well as other teaching environments [4], [5], [6], [7], [9], [10], [11], [12], [19], [20], uses this kind of architecture.

In this context an agent is described [2] as a software entity that works in a continuous and autonomous way in a particular environment, generally inhabited by other agents and able to interfere in that environment, in a flexible and intelligent way, not requiring human intervention or guiding. Ideally, an agent that works continuously for long periods of time must be able to learn through experience and, if it inhabits in an environment with other agents it must be able to communicate and cooperate with them, moving from one place to another. An agents' society shares a common world. Each member of this society has different objectives and points of view, often generating some conflicts. These conflicts must be negotiated and solved among agents, and must be committed with a shared plan. This plan is a set of commitments of actions and beliefs in different levels of abstraction [19].

THE JADE PROJECT

The *Java Agent framework for Distance learning Environments* – JADE project [16] proposes an infrastructure of project, development and implementation of Distribute Intelligent Learning Environments – DILE, based on the approach of Multi-Agents architecture towards Distance Education, for multiple domains. In this project we implemented different versions of Eletrotutor prototype. Eletrotutor is a teaching environment for Electrodynamics teaching, and in each version we refined JADE architecture.

The environment we proposed contains a special agent responsible for each teaching strategy developed, that is, for the domain knowledge retrieval over each point to be presented to the student, for the task of proposing exercises and evaluating proposals, examples and extra activities.

JADE architecture encompasses, therefore, a Multi-Agent environment composed of an agent responsible for the system general control (Student's Model), and a Communication Manager and other agents (Pedagogical Agents), which are responsible for tasks related to their teaching tactics, where each agent may have its tasks specified according to its goal. All actions of student's data accessing are taken by the Student's Model, thus when a pedagogical agent is required to update the student's historic, this agent sends to the Student Model data to be updated, as well as any other change in the student's state of teaching (see fig 1).

Communication between agents happens through a definition of a KQML-based message set, implemented through communication resources of JAVA language objects named RMI (Remote Method Invocation), used in the project [1].

The agent's architecture is designed as robust and standardized as possible and that enables reusing codes for different kinds of agents. The tasks performed in teaching are decomposed and performed individually or in groups of agents. How the task will be decomposed is defined by the content of messages exchanged between agents.

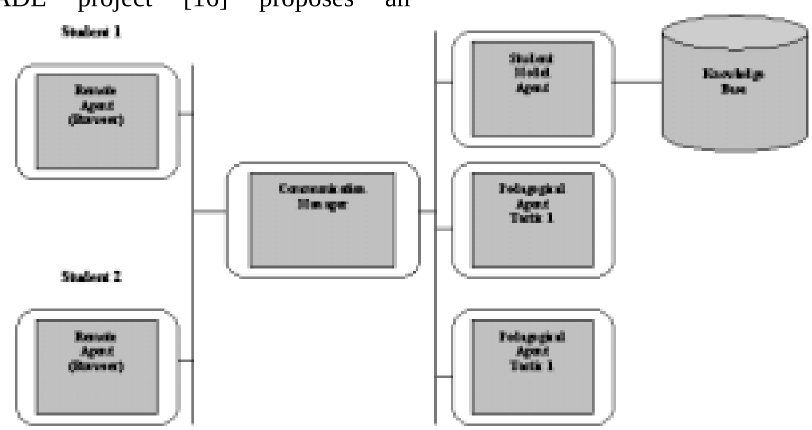

FIGURE 1
SYSTEM ARCHITECTURE

The Architecture of JADE system is composed of a set of agents: (*Pedagogic Agent*) in charge of performing learning activities as examples, exercises, an others. One special agent (*Communication Agent*) performs communication management among the agents. There is an agent (*Student Model Agent*) responsible for student modeling and agents' coordination. The Browser component (*Remote Agent*) performs the student interface and the communication between the student and the system

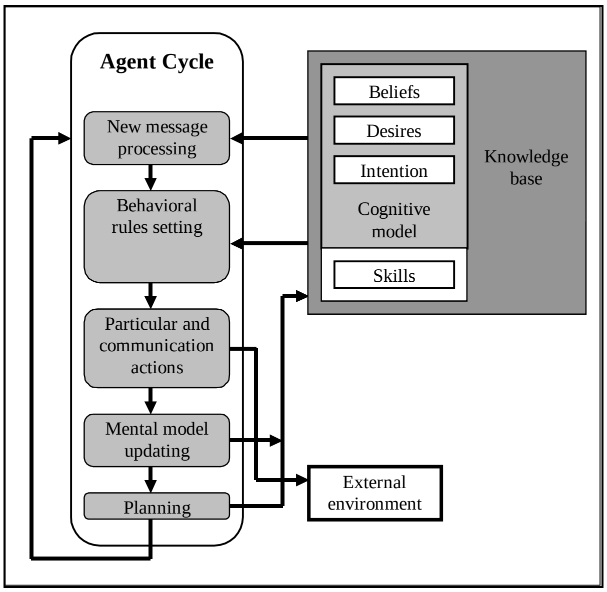

FIGURE2
AGENTS' CYCLE

The cycle of agents' execution, showed in Figure 2, consists of the following steps:

- New messages processing: the task is decomposed;
- Determination of which rules are suitable in the current situation: analysis of task and if necessary delegation of other agent(s) task;
- Execution of actions specified for such rules: task execution;
- Mental state update according to those rules: management of knowledge about the world;
- Planning: module that must develop plans that reach goals specified by agents intentions.

The agents' cycle performs messages sending and receiving and specific task of the agent, according to the knowledge base. As the agent receives a new KQML message it processes the message according to its content, Appling the adequate behavioral rule. According to this rules the message-receiving event can trigger some message sending, mental model updating and some particular specific agent action

The ELETROTUTOR Prototype

The Eletrotutor prototype was implemented as a test bed to evaluate JADE platform. It is an Electrodynamics client-server intelligent learning environment designed according to JADE architecture (available in http://www.inf.ufrgs.br/~rsilv)
Figures 3 and 4 show two snapshots of The Eletrotutor prototype:

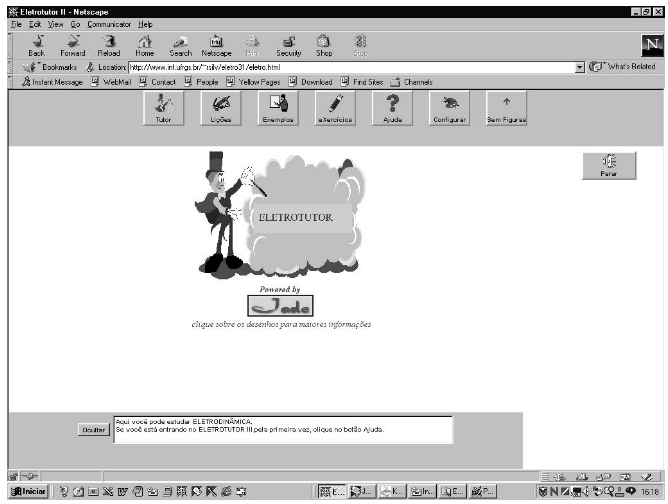

FIGURE 3
ELETROTUTOR'S SNAPSHOT1

Eletrotutor's snapshot 1 shows the main screen. The first button (*Tutor*) changes from the autonomous mode to the tutorial mode. The second (*Lições*) invokes the lessons menu. The third (*Exercícios*) invokes the exercises menu. The fourth (*Exemplos*) invokes the examples menu. The fifth (*Ajuda*) call the help system. The sixth (*Configurar*) seventh (*Sem* figures) and eighth (*parar*) change several interface configuration

Eletrotutor's snapshot 2 shows an exercise. The system presents as many exercises as the student want by clicking (*Novo Exercício*) button. This changes the instance of this kind of exercise. By clicking the buttons (*Tela1*, *Tela2*, *Tela3*) the student invokes different kinds of exercises for this lesson

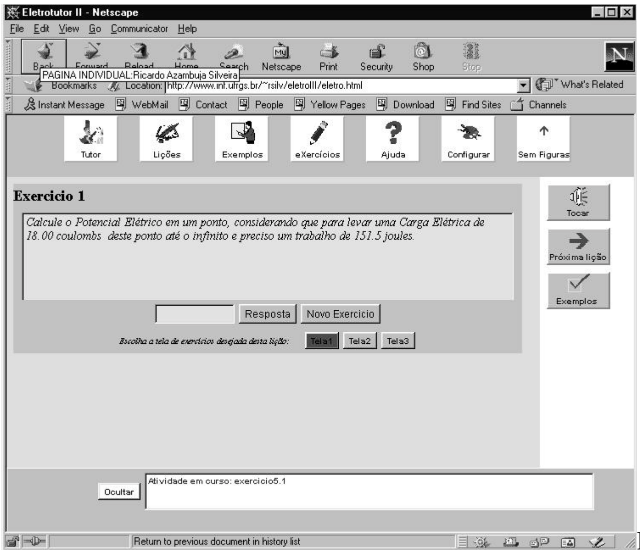

FIGURE 4
ELETROTUTOR'S SNAPSHOT2

The environment may be used in two different ways: Tutorial, and Autonomous modes. In the Autonomous mode, the student has total control over the study session, and may perform any lesson, check any example or make any exercise in the sequence he/she chooses. In the Tutorial mode, the system undertakes the session control, defining the sequence of lessons, examples, and exercises. For that end, the tutor makes use of a student's cognitive diagnostic, taken through the record of every action the student takes. Thus, teaching strategies observe the student's historic before taking the next actions. Teaching strategies are the sequence of contents, examples and exercises that will be proposed to the student.

THE SYSTEM EVALUATION

In order to have some partial evaluation of the teaching tactics used in this environment, we perform an experimental investigation comparing the performance of two groups of students in high school classes [14] [15]. The first group attended a special course using the Eletrotutor in non-tutorial mode. The second group attended a classic expositive class. The same test measured the knowledge acquired after the session class. Figure 5 shows the obtained results. The findings show that both groups have similar performance.

The evaluation of Eletrotutor system compares the performance of an Experimental Group of students (*ELETRO2*) with a Control Group (*EXPO2*) in the same test. The Y-axis represents the number of students and the X-axis represents the score obtained in the test. The first group (dark *line*) had a little bit lower performance than the second group (*gray line*). But Parametric Statistic test shows that this difference is not significant. This experiment used Eletrotutor in the non-tutorial mode.

This evaluation shows that the experimental group has a performance similar to the control group. This shows the potential of the tools and teaching tactics implemented. Further work will evaluate the tutorial mode to verify how much the pedagogical agents can improve learning.

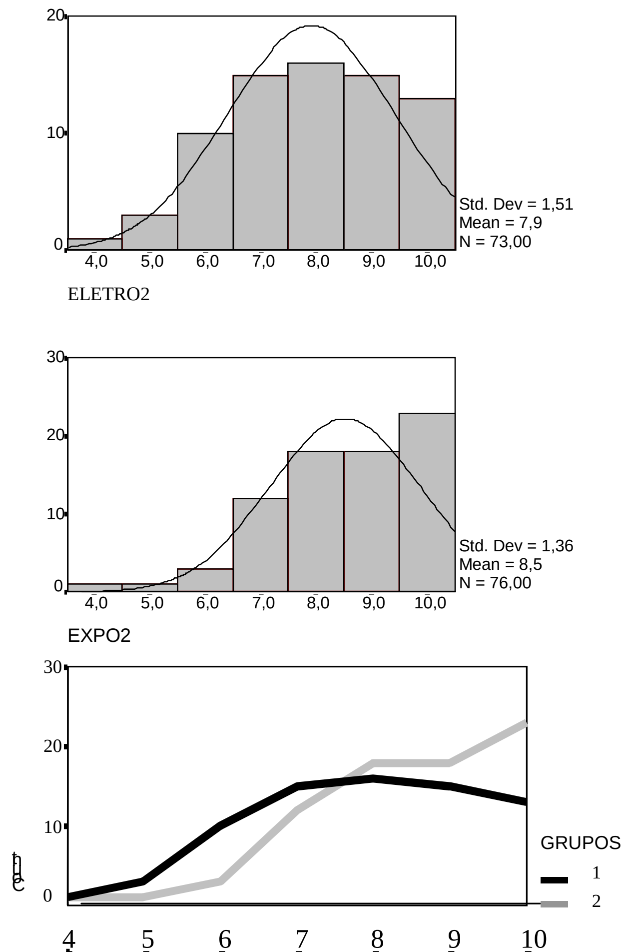

FIGURE. 5
EVALUATION OF ELETROTUTOR

CONCLUSIONS

Distance Education systems based on the Internet does not have any time or space constraint. Students can interact with the system anytime, anywhere. The available tools enable the communication between students and teachers very easily and allow quick feedback. Students and teachers can share information. Excellent teaching strategies may be taken through the available resources over the web, all over the world. Nowadays, it is possible to have access and display broad and advanced knowledge, not available until then. Students can decide what, how and when to learn, favoring teaching methodologies focused on the student and with an explorative and constructivist basis. .

However, there are not only advantages in the www-based teaching. Some important aspects should be considered: Most of Distance Education systems based on the web are not intelligent or adaptable. Students usually get lost when they need to navigate choosing paths among the labyrinths of links displayed in HTML pages. Web pages by themselves are not a teaching system. It is very hard for the student alone to get material that is of his/her interest, amid the great deal of material available. .

Research have turned towards three great directions: the use of adaptive www pages that use some method to verify the pages content and adapt them to the student's actions; the use of www systems based on ITS, which use the traditional architecture of Intelligent Tutors and use a www interface, including sometimes collaborative learning mechanisms; and architectures that use intelligent agents, as in the case of the architecture proposed in the present work.

However, all these issues have in common a strong dependence on a sharp and robust student modeling. Through the student model it is possible to provide customized teaching tactics, which reflect the knowledge level of each student, his/her learning abilities and objectives. The Student Model registers the student's mistakes in a way that the system can provide teaching strategies adequate for content review. Thus, the more precise this model is the better and higher is the system adaptability.

In this work we intend to bring some important contributions, refining the efficacy of learning environments, aggregating concepts of different areas to establish a methodology for the implementation of Distance Education projects, and stressing the use of cooperative solving problem paradigm using Multi-agent architecture.

Further work will integrate the JADE implementation of pedagogical agents with commercial or well-known academic learning environments or frameworks [3]. This integration takes advantage of the pedagogical and administrative resources of these environments and improves their adaptability using cognitive modeling and solving problem strategies of JADE framework.

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