

The Use of Agents Techniques on Intelligent Tutoring Systems

Lucia Maria Martins Giraffa

Informatics Institute/PUCRS

CPGCC/UFRGS

giraffa@inf.pucrs.br

Av. Ipiranga 6681/16 – Porto Alegre – RS – Brazil – 90610-900

Fax: + 55 51 320-3621

Rosa Maria Viccari

Informatics Institute CPGCC/UFRGS

rosa@inf.ufrgs.br

Abstract

The paper presents some considerations about the impact of agents' and related technologies on educational software research and its application to designing and to implementing Intelligent Tutoring Systems. It also presents an overview about systems for Educational Software that adopted the Pedagogical Agents to better explore the interaction and dynamic changes in teaching-learning environments. The first result with these technologies and the use of multimedia resources to improve the interface design is also discussed.

Keywords: Pedagogical Agents, Intelligent Tutoring Systems, Intelligent Learning Environment, Multi-agent Systems, and Educational Game.

1. Introduction

In recent years, the term agent has been incorporated to the vocabulary of mainstream Computer Science (CS), used to name from simple system process to highly skilled software/hardware resembles, denoting an entity created to perform either a specific task or set of tasks.

Such a wide notion is straighten in Artificial Intelligence (AI), where researchers are interested in a notion that confers to the agent the property of being intelligent. This tendency occurs also in case of Intelligent Tutoring Systems (ITS) and in

Intelligent Learning Environments (ILE) when we can consider agents as Pedagogical Agents.

We can have different types of Pedagogical Agents: Tutor, Mentor, Assistance, MOO¹, Web (agents working on INTERNET applications²), Learner's agents and mixed agents (which can teach and learn). Pedagogical agents have a set of normative teaching goals and plans for achieving these goals (e.g., teaching strategies), and associated resources in the learning environment [8; 38].

Tutoring agents are entities whose ultimate purpose is to communicate with the student in order to efficiently fulfil their respective tutoring function, as part of the pedagogical mission of the system [8; 22]. So, educational applications, in general, are based on Tutor and Mentor agents. Even on WEB applications, where the focus is on distance learning [20; 21; 22; 24; 25; 27; 30].

There is no consensual definition about agents on AI field. Researchers from connected areas (like Education and psychology) interested in have knowledge about it will find the concepts sprayed on very technical reports and papers just into AI meetings or specific magazines. So, the aim of the paper is to give an overview about basic agent's concepts, focussing on Pedagogical Agents and their application to designing and implementing ITS, directed to researches interested in agent's techniques.

This paper is organised as follows: section 2 summarises the different approaches to agents in

¹ MOO are virtual environments on the network where people can meet and communicate [5]

² INTERNET means WWW – World Wide Web or just WEB.

AI and connected areas. Section 3 focus on pedagogical agents. Section 4 discusses the use of animated presentation agents for ITS. Section 5 discusses the use of agents to built ITS in a social approach and what king of educational contributions that can arise using a multi-agent architecture to design and implement educational systems. Section 6 discusses some of the results we obtained, draw some considerations about our experiences and perspectives of using this approach to improve educational software through agent's techniques and multimedia resources.

2. Agents

According to Russel [32], architecture and program compose an agent. By architecture, he means, the hardware components, in general. So, an agent is anything that can be viewed as perceiving its environment through sensor and acting upon that environment through effectors. But, from the software viewpoint, an agent is substantially a program which has a specific plan of action defined in a limited domain and a behaviour pattern which allows it to change at the right moment its own interaction with the world depending on stimuli from the environment [2]. We can say that all software agents are programs, but not all programs are agents.

Wooldridge and Jennings [40] divided the notions of agents in two ways: a weak and a strong approach.

- A weak notion of agent is used to denote a hardware or (more usually) software-based computer system that enjoys the following properties: autonomy, social ability (with some kind of agent-communication language), reactivity, and proactiveness.

- A strong notion means to have the properties identified above and, in addition, conceptualised or implemented some concepts that area more usually applied to humans. For example, notions like knowledge, belief, intention, obligation and so on (mental states). Various other attributes are sometimes discussed in the context of agency: mobility, veracity, benevolence and rationality.

In AI literature, some authors point out different desirable properties for agents:

- Agents must act autonomously³ so as to realise a set of actions based completely on built-in

knowledge, i.e., they need to pay no attention to incoming environments information or, according to [33;34], autonomous and "continuous" agents functioning autonomously and continuously in an environment in which processes take place and other agents exist;

- Agents can be temporally, i.e., works just when necessary;

- Agents must be subservient, i.e., must act on behalf of someone else. It is the original sense of the term in AI, where an agent is to perform other's instructions explicitly [33;34];

- Agents are persistent software entities (they work all the time during program execution) dedicated to a specific purpose (so they are distinguished from subroutines) [37];

- They have many functions, but three are essential: perception of dynamic conditions of the environment action to affect these conditions, reasoning to interpret perceptions, solve problems, draw inferences and determine actions [13];

- Agents must have social ability via some kind of agent communication language;

- Agents must have some kind of reactivity;

- Agents must have proactiveness (they are to exhibit goal-directed behaviour by taking the initiative). [40;41];

- Agents must be rational - a rational agent is one that does the right thing. The agent rationality depends on the performance measure that defines degree of success and perception history (the actions that the agent can perform) [32];

- Agents can learn from the environment, by observation, etc.;

- Agents can have mobility to go to different physical places;

- Agents can be flexible and accept other agents interventions;

- Agents can be characters, i.e., have implicit personality based on mental states.

Some times, also, the term High-Level agent is used to distinguish agents from other software and hardware components. This "high-level" is considered present in symbolic representations and/or cognitive-like functions such as planning capabilities, natural language processing abilities and so on [33; 34]. To sum up, agents must have these properties: reactive, autonomous, goal-driven or utility driven, temporally, continuous, communicative, learning, mobile, flexible, character. It will depend on the environment and its connected design. Nevertheless, there is not, in the research community, a consensual definition of.

³ Autonomy is probably the only property that is accepted uniformly by those working in this area, even though the term is not precisely defined. In general, it is taken to mean that the agent's activities do not require constant human guidance and intervention.

The figure 1 shows our graphical scheme to classify agents. This classification was inspired on [7]. More recently appears the notion of **Pedagogical Agents** because many systems for educational purpose have adopted the agents' paradigm in order to better explore interaction and dynamics changing on teaching-learning environment. These Pedagogical Agents incorporate multiple characteristics of Entertainment Agents and some of them are on the board of Artificial Life [9].

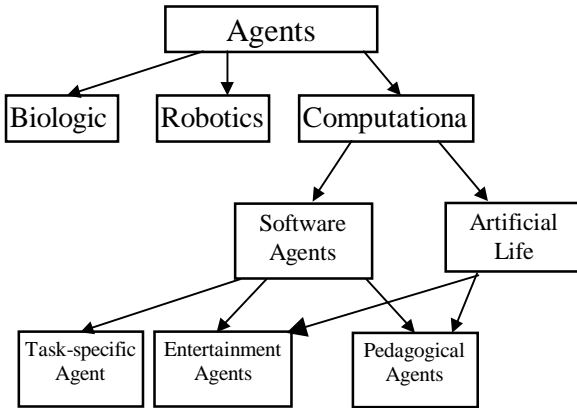


Figure 1: Agents' taxonomy

The following section will make considerations about these special agents on educational applications.

3. Pedagogical Agents

In order to facilitate the assignment of pedagogical tasks in a tutoring session context, the multi-agent-system concept has been adapted to ITS, giving the idea of an agent-based approach to represent the pedagogical knowledge and its use in a tutoring context.

The fundamental reason for introducing agents as tutoring knowledge elements is their capabilities of communication and interaction (agents can adapt and learn during an instructional session). These characteristics are fundamental for agent's survival in an educational environment.

According to Vassileva [39], an agent must act in a world populated by other agents, because many of an agent's goals require the help of another agent. In this way, relationships among agents can be viewed as another kind of resources for achieving goals.

Pedagogical agents may be divided into goal driven (tutor, mentor, assistance) and utility driven (Moo and Web agents). The table 1 shows the characteristics of pedagogical goals' driven agents.

The utility driven agents are used by pedagogical purpose like labour agents, i.e., help students to find things (specific software, files, directories, scheduling group meeting, reminding the deadline of homework, etc.): they execute tasks. The Moo agents have good flexibility and have a textual (same context) approach. The Web-based agents have mobility and operate on different contexts (Textual, hypermedia and virtual reality, for example). In this paradigm the interaction occurs based on co-operative or competitive process in which human and agents communicate and perform activities.

Table 1: Characteristics of pedagogical goals' driven agents

	Tutor	Mentor	Assistant
Knowledge about environment	S	S	M
Domain Expertise	S	S	S
Student Model	S	M	W to Nil
Pedagogical aspects	S	M	W to Nil

Obs.: S: strong, M : medium, W : weak

The goal based agents decide their actions (to achieve the goal) based on information described by desirable situations.

So, pedagogical agents can act as virtual tutors, virtual students, or virtual learning companions that can help students in the learning process. The agent may be a character to which states can be attributed, namely mental states. These mental states are beliefs, desires, intentions, commitments and expectations. Such concepts are similar to the ones' humans possess.

Pedagogical agents have some fundamental properties: autonomously (realise a set of goals), social ability, proactiveness, and persistence. Some of them can be reactive, continuously performing, capable to learn and a character represents most of them.

This classification arises from a detailed analysis made by the authors based on ITS designed with agents approach. This analysis is summarised on Table 2, where agents' properties found in all these systems were joined and compared. The educational purpose of all these environments was analysed in order to identify the three roles played by the goal driven pedagogical agents.

The Table 2 numbers refers to:

1. Persona - ITS to instruct the user how to use a modem [1]
2. ITS society to teach specific subjects [3]
- 3.. ITS - to teach music concepts [4]
4. Assistant - ITS to help students [5]
5. ITS - to teach concepts of radiology in medicine [7]
6. ADELE - Personal tutor for each student on the WEB [19]
7. ITS - to teach Biology for children [18]
8. ITS - to teach some Math concepts [22]
9. ITS - to select student's preferences [24]
10. STEVE - ITS to teach some LAB resources [30]
11. ITS - to teach Math concepts [31]
12. EduAgents - agents that help (teach) students how to solve elementary equation problems [15]
13. Co-operation environment with agents to help student learn about technology [17]
14. Multi-Ecological - ILE to student learn concepts about pollution [9]
15. Eletro-Tutor - ITS to teach some concepts about electricity [35; 36]
16. MCOE-System – ITS to student learn concepts about Ecology and pollution [10; 11]

Table 2: Agents' properties x educational purpose

Educational purpose Agents' Properties	Tutor	Mentor	Assistance
Autonomously	1,2,5,6, 8,10,11 ,13,14, 15,16	3, 7	4, 9
Social ability	1,2,5,6, 810,11, 1213,1 4,15,16	3, 7	4, 9
Proactiveness	1,2,3,4, 56,8,10 , 11,12,1 314,15, 16	3, 7	9
Reactive	1,2,5,6, 78,10,1 4, 16	3	4, 9
Persistent or continuous	1,5,6,8, 10,11,1 2, 13,14,1	3, 7	4, 9

	516		
Temporally	2		
Character	1,7,5,6, 10,12,1 4,15,16		9
Learning	5		
Flexible	5, 10,16		

Obs.: 4 is a MOO system, 5 and 15 are a Web system, 16 is a ITS where interactions between students and the system are performed in a game-like fashion, using multimedia resources. A character, the Ecologist, that represents the Tutor, uses multiple teaching strategies to give advice for the students. It can be a tutor, a mentor or assistance [10; 11].

Some experiments using VR-Virtual Reality are adding some new possibilities to investigate the interaction between student and learning environments [30; 36].

The fact of using characters and/or VR does not imply much difference to classify a pedagogical agent. The difference as arises from the purpose (implicit when we design the agent): it is goal driven or based on utility. Agents like ADELE and STEVE work like tutors in spite of their appearance.

The educational purpose of utility-based agents (MOO and Web) to work likes a tutor. It happens because their strategies focus on teaching students specific skills by using a direct approach, like occur in 4, 5 and 15 presented above.

4. Pedagogical Agents with Animated Presentation

There are several motivations for using an animated presentation agent for teaching/learning propose:

- Add expressive power to a system's presentation skills;
- Help the students to perform procedural tasks by demonstrating them ;
- Serve as a guide through the elements of the scenario (simulations) ;
- Engage students without distracting or distancing them from the learning experience. [12; 13; 14; 29].

According to Elliot [6], using robust artificial personalities in tutoring agents allows us to study the implementation constraints, effectiveness, and appealingness of social interaction between tutoring agents and students.

The agents are capable of expressing these emotions through a variety of theoretical paths resulting in various multimedia manifestations.

Emotions arise naturally in many human social situations as a by-product of goal-driven and principled (or unprincipled) behaviour, simple preferences, and relationships with other agents. Through the use of social and emotionally intelligent reasoning components it may be possible for automated tutoring systems to make use of a subset of these techniques formally associated only with human teachers.

Giving different personality types to a tutoring agent provide some additional tools with which work toward a number of goals. It allows us, for example, to present the same material in different ways. An example is the Multi-Ecological system [9], which has animated agents with specific personalities (implicit into the modelling) to improve the interaction between student and system.

5. ITS built in a social approach using agents

Wang and Chang, [40] say that the social learning systems are emerging learning environments that allow multiple students and agents to work at the same computer or across connected machines under different protocols of learning activities.

Recent developments on ITS consider, also, a co-operative approach between the learner and the system. Many research groups created environment-using simulation where the teaching-learning process is simulated by a set of agents in order to have interaction among them and allow us to observe the dynamics changes that occur during the interaction process. One example is presented by Moussalle [23], where all the agents must be opened to change strategies and believes/knowledge about how to solve problems. Another example is the simulation created by Frasson [7] where two agents are simulated in the computer: a tutor and a troublemaker. This second agent is a particular companion who has a specific behaviour: it deliberately misleads the solution to systematically test the student's self-confidence and his knowledge. The learner debates the solution with the troublemaker in a process controlled by a tutor. Should there be an impasse the tutor can intervene by giving a hint, the correct solution, etc.

According with Oliveira and Viccari [28], if teaching is considered a problem-solving activity, then the principal contribution of Distributed Artificial Intelligence - DAI - is the possibility of improving the problem-solving performance of the system. Such an improvement is possible if the task

can be divided in sub-tasks with some degree of locality and parallelism. In fact, there are many works presented in the literature showing that such a division is possible. That is called the **distributed** perspective to implement DAI-based learning environments. Usually, the architectures developed with this approach are variations on the traditional, functional, architecture for ITS (domain model, student model, and teaching model), where one or more specialised agents implement each function. Since each agent has a well-defined function, its role within the system does not change - in other words, the system's organisation is fixed. These characteristics are often found in Distributed Problem Solving systems. Combining the contributions from the different agents generates the overall teaching plan. Control is distributed with respect to the generation of the plan, not to its execution; i.e., there is one central communication channel. Therefore, from the student's viewpoint, the system is an "individual," although internally it is a society.

A teaching/learning environment may be regarded in a social way, i.e., a society made of various autonomous agents (human and/or artificial). Some of them playing the role of tutors and other the role of learners (with the possibility of role exchange), and all involved in building a common corpus of knowledge about some particular domain. Each agent may or may not be subdivided in internal agents (subagents, local agents): if it is the case, we can talk about an **external** society and an **internal** society.

Such a view raises a number of theoretical and practical issues, and shifts the discussion towards topics like co-operative learning, the application of Vygotsky and Piaget's theories, and others. One important point is that the behaviour of each agent affects the behaviour of the society as a whole, and vice-versa. A quick learner and/or a person with learning disabilities may have some influence in the rhythm of the other learners. Such a differentiated behaviour may lead to situations demanding, for example, the interference of another agent (a tutor or another learner). The need of mechanisms to detect and deal with this kind of situations will impact the architecture and behaviour of the agents and of the external society.

Again, according to [28], it is important to notice that the two perspectives depicted here are not mutually exclusive. As we can see in the examples, the social perspective regards the computational systems as embedded in an external society, composed of multiple human/artificial agents. The distributed perspective is concerned with the internal organisation of the system. While

the later focuses on engineering aspects, the former brings up to mind the questions of which educational principles we should apply, and in what kind of real environment our systems are to be applied.

For many authors like Mitsuru and Cook [21; 4], social environments mean collaborative work. Mitsuru said: one of the major educational significance of the collaborative learning is to enhance the participants' motivation to awaken mature reflections on their own understanding and externalise the result of it; Cook said that collaborative learning is not always effective.

So, the analysis of dialogue data has the purpose to then uncover a correlation between a teacher's goals, intentions, and interventions for creative reflection and the student's attempts at creative reflection.

However, we must make a distinction between **collaborative** and **co-operative** learning. For us, a co-operative learning means that two or more students have the same task and they divided the task in sub-tasks and each one do something, but the others cannot make changes on others work. Then, the final solution is a patchwork of the individual solutions. Each student has the same task and the final solution is something made by everybody. Each student can suggest his/her own solution and the group discuss about it. The final solution arises from the group interactive work. Both situations adopt the social perspective.

6. Final Considerations

As Khuwaja [16] remarked, even though Intelligent Tutoring Systems have been implemented with relative success they are not practical enough to be used in the real world. This situation can change if we introduce new methodologies with multiple domains, which will allow us to apply them at schools as well as in training schemes in companies.

Our research group have been running some experimental evaluations, using traditional ITS (as a tool for explanatory class) and multi-agent ITS (co-operative work using local network and WEB). These experiments are made in order to find the advantages and restrictions of using new approaches to build better ITS.

The figure 2 shows the results presented by our research group [36], between a traditional ITS (Eletrotutor I) and the WEB version (Eletrotutor II), using as a tool in a computer class, and the explanatory class conducted by a human tutor. The Eletrotutor first version, using Artificial Intelligence Techniques, controls the minimal

amount of examples and exercises made by the student, monitoring his performance and making learning more efficient. As we can see through the analysis of the results, in which tutorial class afforded as good grades as the explanatory class, with no significant difference between the two group students' grades. In the second version, Eletrotutor II, such control does not occur, since no student modeling and no learning strategy adjustment have been implemented.

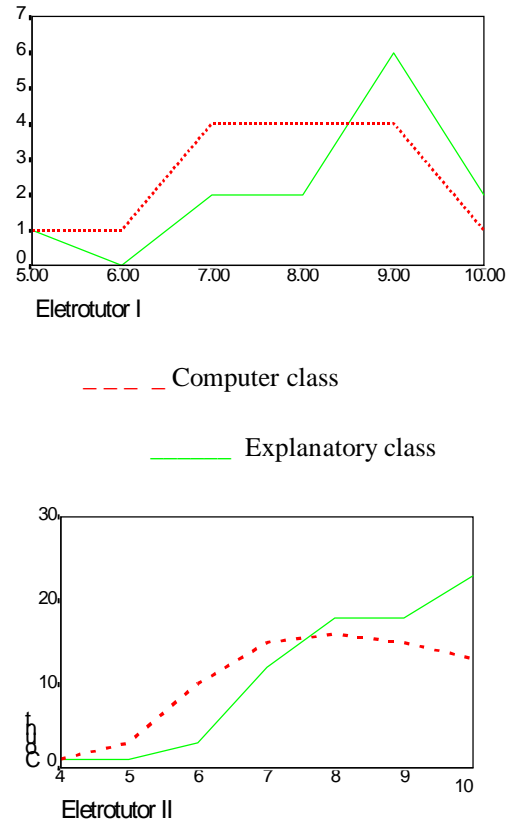


Figure 2: Evaluation results between ITS

The results suggest that the simple paradigm change to a client-server architecture and the use of a graphical interface are not sufficient to obtain results at least similar to those of the explanatory class, in which the teacher is present. The use of multimedia resources did not guarantee more efficiency for leaning process. However, the restrictions of these systems can be overcome when we attempt to integrate the notion of co-operation to the teaching-learning process using multi-agents focus. These techniques and methods allow us to work in a co-operative way taking into account external human agents and internal agents modelled in the machine (computer).

The work of Moussalle et alii [23] presents some encourage results concerning about student modelling improvements using agents approach, and Giraffa et alii [9; 10; 11] presents an

environment with multi-agent hybrid architecture and an interface with multimedia resources. The interface design was made based on heuristic evaluation. This is the most popular of the usability inspection methods [26]. Heuristic evaluation is done as a systematic inspection of a user interface design for usability. The goal of heuristic evaluation is to find the usability problems in the design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognised usability principles (the "heuristics").

So the potential use of these combining resources (agents and multimedia) in an educational environment allows us to investigate aspects of the environment dynamics and the user's behaviour that were not possible through conventional techniques.

Intelligent software agent technology has been suggested as a promising approach to extend intelligent tutoring systems in such way that the need for social context for learning can be fulfilled.

7. References

1. Andre, E.; Muller, J.; Rist, T. Life-Like Presentations Agents: A New perspective for Computer Based Technical Documentation. AI-ED97: Eighth World Conference on Artificial Intelligence in Education - Workshop V: Pedagogical Agents, 8., 1997. **Proceedings...** Kobe: Japan, 1997.
2. Colazzo, L.; Silvestri, L. The pragmatics of the Tutor: A proposal of modelling. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
3. Costa,E.B.; Perkusich,A. A Multi-Agent Interactive Learning Environment Model.AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
4. Cook,J. An Empirically Based mentoring Agent for Supporting Music Composition Learning. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
5. Dillenbourg, P; Jermann, P.; Schneider, D.; Traum, D.; Buii, C. The Design of MOO Agents: Implications from an Empirical CSCW Study.AI-ED97: Eighth World Conference on Artificial Intelligence in Education - Workshop V: Pedagogical Agents, 8., 1997. **Proceedings...** Kobe: Japan, 1997.
6. Elliott, C. Affective Reasoner Personality Models for Automated Tutoring Systems. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
7. Franklin,S.; Graesser,A. **Is it an Agent, or just a Program?:** a taxonomy for Autonomous Agents. (<http://www.msci.memphis.edu/~franklin/AgentProg.html>)
8. Frasson,C.; Mengelle,T.; Aimeur,E. Using Pedagogical Agents in a Multi-Strategic Intelligent Tutoring System. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
9. Giraffa, L.M.M.; Nunes, M. A.; Viccari, R.M. Multi-Ecological: an Intelligent Learning Environment using Multi-Agent architecture. MASTA'97: Multi-Agent System: Theory and Applications. **Proceedings...** Coimbra: DE-Universidade de Coimbra, 1997.
10. Giraffa, L.M.M; Viccari, R.M.; Self,J. Improving tutoring activities using a Multi-Agents system Architecture. Twenty-ninth SIGCSE Technical Symposium on Computer Science Education, 29,1998. **Proceedings...** Atlanta: Georgia, February 25-March 2,1998.
- 11.Giraffa, L.M.M; Viccari, R.M.; Self. J. Multi-Agent based pedagogical games. ITS'98- Fourth International Conference on Intelligent Tutoring Systems. **Proceedings...** New York: Springer Verlag, 1998.
12. Hayes-Roth,. et alii. **Directed Improvisation.** Stanford: CA,1994. (Technical Report KSL-94-61)
13. Hayes-Roth,B. et alii. Directed Improvisation with animated puppets. CHI'95: Conference on Human-Computer Interaction, 1., 1995.**Proceedings...** Denver: 1995.
14. Hayes-Roth,B.; Van Gent,R.; Huber,D. Acting in Character. In: **Creating Personalities for Synthetic Actors:** towards autonomous personality agents. Trappl,R.; Petta,P. (Eds.). Berlin: Springer Verlag, 1997.
15. Hietala, P.; Niemirepo,T. Collaboration with Software Agents: What if the Learning Companion Agent Make Errors? AI-ED97: Eighth World Conference on Artificial Intelligence in Education - Workshop V: Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
16. Khuwaja.R.; Desmarais,M.;Cheng,R. Intelligent Guide: Combining User Knowledge Assessment with pedagogical Guidance. International Conference on Intelligent Tutoring Systems - ITS'96, 3., 1996. **Proceedings ...** Berlin: Springer-Verlag Verlag: 1996.
17. Leroux ,P. Co-operation between a Pedagogical Assistant, a Group of Learners and a Teacher. In: Euro AI-Ed - European Conference on Artificial Intelligence in Education,1996. Brna,P et alii (Eds.). **Proceedings...**Lisboa: Colobri,1996.
18. Lester, J. et alii. Mixed Initiative Problem Solving with Animated Pedagogical Agents. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
19. Lewis, W J.; Shaw,E. Using Agents to Overcome Deficiencies in Web-Based Courseware. AI-ED97: Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.
20. Miyahara and Okamoto. Collaborative Filters Towards Distributed Work/Learning Environment. AI-ED97 : Eighth World Conference on Artificial

Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

21. Mitsuru,I. Et alii. Opportunistic Group Formation. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

22. Morin, J.F.; Lelouche,R. Tutoring Knowledge Modelling as Pedagogical Agents in an ITS. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

23. Moussale, N.M.; Viccari,R.M.; Correa,M. Intelligent Tutoring Systems Modelled Through the Mental States. In: Lectures Notes on Artificial Intelligence - SBIA'96. Borges,D. and Kaestner,C.(Eds.). Berlin: Springer Verlag, 1996.

24. Murray,W.R. Knowledge-based Guidance in the CAETI Centre Associate. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

25. Nakabayashi ET alii. Architecture of an Intelligent Tutoring System on the WWW. AI-ED97: Eighth World Conference on Artificial Intelligence in, 8., 1997. **Proceedings...** Kobe: Japan, 1997.

26.Nielsen,J.**HeuristicEvaluation.** (<http://www.useit.com/papers/heuristic>),1995.

27. Ogata and Yano. Knowledge Awareness Filtering toward Efficient Collaborative Learning. AI-ED97: Eighth World Conference on Artificial Intelligence in Education -, 8., 1997. **Proceedings...** Kobe: Japan, 1997.

28. Oliveira,F.M.; Viccari,R.M. Are ..or social systems? In: Euro AI-Ed - European Conference on Artificial Intelligence in Education,1996. Brna,P et alii (Eds.). **Proceedings...**Lisboa: Colobri,1996.

Proceedings... Valparaiso: CLEI, 1997

29. Petta, P.; Trappl, R. Why to Create Personalities for Synthetic Actors. In: **Creating Personalities for Synthetic Actors:** towards autonomous personality agents. Trappl,R.; Petta,P. (Eds.). Berlin: Springer Verlag, 1997.

30. Rickel,J.; Johnson, W.L. Intelligent Tutoring in Virtual Reality: A Preliminary report. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

31. Ritter,S. Communication, Co-operation and Competition Among Multiple Tutor Agents. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

32. Russel, S.; Norvig,P. **Artificial Intelligence: A modern Approach.** New Jersey:Prentice Hall,1996.

33. Shoham,Y. **Agent-oriented programming.** Stanford: CSD-Stanford University, 1990. (Technical Report STAN-CS-1335-90)

34. Shoham,Y. Agent-oriented programming. **Artificial Intelligence**, 60,1,1993.

35. Silveira,R.A.; Viccari,R.M.. Projeto Eletrotutor: Desenvolvimento e Avaliação de Ambientes Inteligentes de Ensino-Aprendizagem. CLEI-PANEL'97:XXIII Conferencia Latinoamericana de Informática, 23, 1997.

36. Silveira,R.A.; Viccari,R.M.. Distance Learning: From The Intelligent Tutor Paradigm To A Multiagents Architecture Lectures Notes on Artificial Intelligence - SBIA'98. Oliveira,F.(Ed.). Berlin: Springer Verlag, 1998. (submitted paper)

37. Smith,D.C.; Cypher,A.; Spohrer,J. KindSim: Programming Agents Without a Programming Language. **Communication of the ACM**, 37,7,1994.

38. Thalmann,D.; Noser,H.; Huang,Z. Autonomous Virtual Actors Based on Virtual Sensors. In: **Creating Personalities for Synthetic Actors:** towards autonomous personality agents. Trappl,R.; Petta,P. (Eds.). Berlin: Springer Verlag, 1997.

39. Vassileva,J. Goal-Based Pedagogical Agents. AI-ED97 : Eighth World Conference on Artificial Intelligence in Education - Workshop V : Pedagogical Agents, 8.,1997. **Proceedings...** Kobe: Japan, 1997.

40. Wang,W.C.; Chan,T.M. Experience of Designing an Agent-Oriented Programming Language for Developing Social Learning Systems. AI-ED'97:World Conference on Artificial Intelligence in Education, 8.,1997. **Proceedings...**Tokyo: IOS Press,1997.

41. Wooldridge,M.;Jennings,N.R. **Intelligent Agents: Theory and Practice.**London: QM&Wc, 1995 (<http://www.doc.mmu.ac.uk/STAFF/mike/ker95.ps>)