

USING AGENT-BASED TECHNOLOGIES TO ENHANCE LEARNING IN EDUCATIONAL GAMES¹

Ogar Ofut Tumenayu¹, Olga Shabalina¹, Valeriy Kamaev¹ and Alexander Davtyan²

¹*Volgograd State Technical University, Volgograd, Russia*

²*Moscow Institute of Physics and Technology*

ABSTRACT

Recent research has shown that educational games positively motivate learning. However, there is a little evidence that they can trigger learning to a large extent if the game-play is supported by additional activities. We aim to support educational games development with an Agent-Based Technology (ABT) by using intelligent pedagogical agents that can intervene to offer hints, assistance and suggestions when the learner is lacking knowledge, but does not intervene otherwise, so as not to interrupt game flow. In this paper we describe the possibilities of using pedagogical agents to infer learner's motivation and emotional state as they allow communication and interaction in a digital learning environment. Our approach emphasizes on improving pedagogical agent interactivity: from pedagogical agent techniques to *Tutor and Tutee Agents*' techniques to create a high social and collaborative Digital Educational Game (DEG) environment.

KEYWORDS

Educational games, motivation, emotional state, agent-based technology, tutor agent, tutee agent

1. INTRODUCTION

Recently, one direction of technology enhanced learning that has been attracting increased attention is the study of educational agents, which are human-like virtual characters that play specific educational roles in their interaction with students during learning. With this development we have deemed it necessary to incorporate the agent-based technologies in educational games development in order to improve its' learning goals that they were originally meant for. Agent-based technologies can help students develop a positive relationship with the educational agent, and further enhance their motivation in terms of attention, relevance, and satisfaction.

There are two reasons for embracing agent-based technologies in educational games development. First, the educational agents are regarded as friendly interfaces that can facilitate interaction with students, leading to enhanced motivation and the perception of improved ease and comfort.

Such features can also be applied to benefit student learning so that they can become engaged in the learning environment (Gulz, 2005). Second, a number of advantages have been reported to learning with the support of different types of educational agents on specific aspects, such as exploration (Höök et al., 2000), reflection and articulation (Tholander et al., 1999), communication (Johnson et al., 2000), and negotiation (Bull, 2004). This might be because pedagogical agents can serve as learning companions offering virtual participation in a DEG. By doing so, students are encouraged to interact with the learning agent (Pedagogical Agent) in a social context and experience an enjoyable learning process, which, in turn, results in the aforementioned learning advantages.

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In this paper we further describe the relevance of adopting an agent-based technology in educational game development. First we provide some background on agent-based technologies in learning systems and related technologies in educational games. Next, we would give a brief overview of pedagogical agent intervention and we would discuss the features of improving single pedagogical agent techniques to Tutor and Tutee Agents' techniques, and they implementation in adaptive educational games.

2. AGENT-BASED TECHNOLOGIES IN LEARNING SYSTEMS

When we talk about agent-based technologies in learning system we are referring to educational agents. Educational agents are human-like computer simulated characters that are designed to improve student learning in an individual environment through virtual participants (Chou, Chan, & Lin, 2003). In recent time educational agents have tremendously make valuable remarks in cognitive and affective aspects in digital learning environment. This is because the influence of the educational agents on student learning can be expanded by taking the affective qualities of the virtual character into account in the design (de Vicente & Pain, 2002).

Educational agents are good tools worth considering when designing a learning system. They are tools that exist with external goals, there are easy to use, in order to influence the user's external goal. For example some good educational games are difficult to play, as a result of increased challenges provided to the player. Whereas typical interactive systems like educational agents, system build for human learning should be easy to use. The external goal is for the user to learn how to perform a given task, so the system should make the process of learning how to accomplish that task easy — the process of learning the task, not the task (E. Sklar 2003).

Current developments on Intelligent Tutoring Systems (ITS) also consider 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 (Moussale 1996), where all the agents must be opened to change strategies and believes/knowledge about how to solve problems.

One major significant about agent-based technologies in a learning system is that it brings about social learning environment which mean collaborative work. Mitsuru said: one of the major educational significance of the collaborative learning is to enhance the participant's motivation to awaken mature reflections on their own understanding and externalize the result of it (Mitsuru 1997). This kind of environment can be created when one or more agents are simulated in the computer: Tutor and Tutee. As a tutor the agent intervene by giving hind, the right solution at the appropriate time etc. And the Tutee Agent provides collaboration support and tries to test the student's self-confidence and his knowledge.

3. ADOPTING AGENT-BASED TECHNOLOGIES IN EDUCATIONAL GAMES

3.1 Pedagogical Agents in Educational Games

Pedagogical agents in educational games facilitate the pedagogical assignment task in a learning session context. The idea of an agent-based approach is to represent the pedagogical knowledges and its use in a tutoring context. The fundamental reason for adopting agent-based technologies in educational games as a tutoring knowledge element is their capabilities of communicating and interacting.

According to Vassileva (Vassileva 1997), an agent must act in a world populated by other agents, because many 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 in a game playing environment.

3.2 Pedagogical Agents' Intervention

In the context of educational games, using pedagogical agent all forms of adaptive intervention provided by Pedagogical agent is summarized as either cognitive or motivational (Ofut and Shabalina 2013b).

Cognitive interventions. Pedagogical agents could possess some cognitive intervention functionalities to strive to enhance cognitive abilities and support the learner based on his/her user model. A number of subtypes of this type of intervention are distinguished below:

- competence activation interventions, when a learner is stuck in a certain task because results led to the assumption that the learner possesses the necessary Skills, the temporary inactive skills could be reactivated. E.g. the agent can hint the learner “we have come across this issue already before”;
- competence acquisition interventions, when the agent concludes that the learner lacks certain skills, the agent could provide the necessary information;
- problem solving support, this intervention consists of providing support in an ongoing problem solving process via hints and indications that bring the learner closer to the solution;
- progress feedback. In this intervention the agent provides the learner with information about learning progress of the game (through NPC or scoring mechanisms). This fosters monitoring and reflection on the learner's own performance;

Motivational Interventions. Pedagogical agents could also possess some motivational interventions striving to enhance and retain the learner's motivation and engagement on a high level. A number of subtypes of this type of intervention are distinguished below:

- praising interventions consists of congratulating the learner after successfully completing a game level, the learner is awarded a certain scores;
- encouraging interventions could be applied in case of failure. To promote further attempts to find the solution, the learner is encouraged to try again by the agent;
- incitation intervention is to foster motivation by announcing pleasing outcomes as rewards;
- affective interventions foster emotional-affective aspects of the game and social interaction with other game characters;
- attention-catchers, if the agent detects a decreasing attention through interpretation of the learner's actions, it could introduce unexpected changes or incidents to increase variability and keep the game interesting.

4. USING PEDAGOGICAL AGENT TO INFER LEARNER'S MOTIVATION AND EMOTIONAL STATE

4.1 Pedagogical Agent as Motivational-Oriented System

Motivating students is a major issue for current ITS (Qu 2005). Modern theories of motivation such as Self Deterministic Theories (Reeve 2004) have shown the positive motivational impact of autonomy-support. Autonomy-support as a way of enhancing motivation is one of the major points of the Self Determination Theory (Reeve 2004) among others. It is on that note that we support the introduction of pedagogical agents in educational games to create motivations by acting as an autonomy-support tool for learning. One of the methods used by agents to provide autonomy is by encouraging the learner to make choices during game play activity. Alternatively, any action which controls or restrains the learner's behaviors has a negative impact on him/her sense of autonomy, which results in lowering his/her motivation to persist in the activity.

“Students with autonomy-supportive teachers compared to student with relatively controlling teachers, show greater mastery motivation, perceived competence and intrinsic motivation, greater conceptual understanding, higher academic performance, and greater persistence in school” (Reeve 2004).

Pedagogical agent in educational games with increasing teaching autonomy support results in an enhancement of Learners' engagement in a learning task.

4.2 Pedagogical Agent as an Emotional-Oriented System

Emotion is an important aspect of human intelligence that should be considered while designing pedagogical agents in educational games, because it plays a very important role in the human teaching and learning process. According to Scherer (Scherer 2000), emotion is the relatively brief episode on synchronized responses for most or all organic systems for the evaluation of an external or internal event as being of major significance.

Pedagogical agents with emotional intelligence possess abilities such as: recognizing the current emotional state of the learner and addressing it, provide intelligent interactive learning environment, and can also create a more personalized and friendly environment for learning.

In our work (Ofut and Shabalina 2013b) we have strongly argued that the inclusion of emotional features in pedagogical agents is with high importance for improving the level of interaction in man machine communication system.

5. IMPROVING PEDAGOGICAL AGENT INTERACTIVITY: FROM PEDAGOGICAL AGENT TECHNIQUES TO TUTOR AND TUTEE AGENTS' TECHNIQUES

We have decided to improve pedagogical agent interactivity techniques by introducing two types of pedagogical agents: Tutor and Tutee Agents to create a high social and collaborative atmosphere in a DEG environment.

The Tutor Agent (TrA) primary function is to interact directly with a learner and explicitly guide him/her through the domain. These pedagogical agents are applicable in teaching components and user interfaces. They encourage the learner by providing feedback within the learning environment.

The Tutee Agent (TeA) is an agent that serves as a peer-mediated learning agent. This type of agent is positioned in the user interface to act as interactive partners in a learning process. One of the major objectives of this agent is to provide collaboration with each other in a game play environment.

We are of the opinion that the absence of learner's companion agent and lack of social interaction in the games give rooms for low motivation and poor emotions. That is why we have decided to diversify the functionality of a Pedagogical agent by introducing a Sub-agent (TeA) as a learner's companion (Ofut and Shabalina 2013a).

6. IMPLEMENTATION OF AGENT-BASED TECHNOLOGY IN ADAPTIVE EDUCATIONAL GAME

In this session we discuss the implementation process of Tutor and Tutee agents in an Adaptive Educational Game. The Goal of the Game is to make the learning of programming as simple as possible by not just using a pedagogical agent as an instructor, but also by introducing a learner's companion agent to serve as a peer to the learner to improve interactivity.

Responsibilities/characteristics of TrA

1. Introducing the learning task at the beginning of the a game level
2. Providing coaching instructions to learner by communicating verbally and none verbally.
3. Providing assistance to learner when the learner is slow to act or repeatedly unable to get a task right.
4. The TrA would motivate the learner by appraisal, when he/she is doing well.
5. The TrA would express emotions when the learner fails a particular task by calling the learner by name and encouraging him/her to try again.
6. TrA provides progress feedback intervention to the learner with information about learning progress of the game (through NPC or scoring mechanisms). This fosters monitoring and reflection on the learner's own performance.

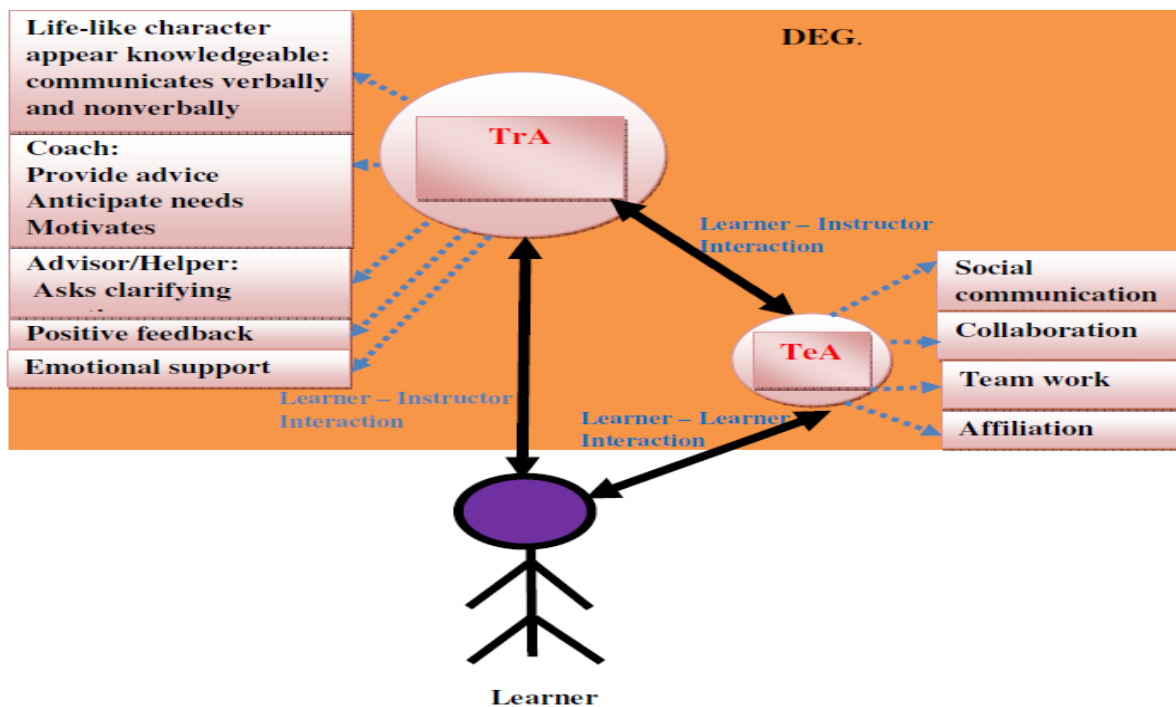


Figure 1. DEG interactivity with Tutor and Tutee Agents

Responsibilities/ characteristics of TeA

1. TeA provides problem solving support in an ongoing problem solving process via hints and indications that bring the learner closer to the solution.
2. TeA Provides solution to a task which the learner could not complete within a reasonable number of actions/time. These ensure the game flow continuity.
3. If the learner is presented with an unclear or ambiguous task the TeA can be contacted for clarity.
4. The TeA can attempt to provoke the learner's reflections about his/her own abilities, thinking process and confidence
5. The TeA can also congratulate his co-learner in the case of success to motivate him/her
6. The TeA could encourage the learner in case of failure. To promote further attempt to find solution.

The Game's Interface: The Java Pyramid Game is a one player game and the task of the player is to demolish the pyramid completely at every game level.



Figure 2. Java Pyramid game interface showing Tutor and Tutee Agents interactive approaches.

In the first instance the player is welcomed by the Tutor Agent and required to enter his/her name. This would enable both the Tutor and Tutee Agents to refer to the player by his/her name.

The Tutor Agent can now call the player by his/her name and introduce the Tutee Agent to the player.

The interactivity level of the game at all level is high as both the TrA and TeA communicate with the learner based on his/her action during game play. The interaction is modeled in such a way that the emotion and motivation is boosted at every point of intervention by both agents. The social interaction between the agent and learner is either in verbal (Voice) or non verbal (dialog box) form.

The TeA knowledge is modeled to have a better understanding of every task in all the game level in order to mentor the learner as well as provide collaboration support. The TrA interacts directly by coaching the learner throughout the game play.

7. CONCLUSION AND FUTURE WORKS

This paper presents the relevance of Pedagogical agent's technology as an approach in enhancing the interactive learning in a game based environment. We have compromised a lot in the pedagogical agent strategies and we stick to two, which are agent collaboration strategy and learner's companion/peer agent. Both the collaboration strategy and learner's companion are being influenced by the Tutee Agent (TeA) in the game environment. The idea is that we are taking advantage of the social interactions between the learner and the TeA to improve the game interactivity. Currently we are designing a game prototype to demonstrate the effectiveness of our approach.

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