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Design Guidelines for Animated Pedagogical Agents

Orientações de design para Agentes Pedagógicos Animados

Abstract: The area of animated pedagogical agents is related to the development of applications that aim to improve the human-computer interaction process (by human, we mean students and professors) using software agents represented by characters or human figures. In order to help researchers to project pedagogical agents that can enhance human-agent usability, this paper will discuss basic guidelines for animated pedagogical agents design based on concepts provided by Computer in Education, Artificial Intelligence and Human-Computer Interaction.
Keywords: Animated Pedagogical Agents. Design Guidelines.

Resumo: A área de agentes animados pedagógicos está relacionada ao desenvolvimento de aplicações que visam melhorar o processo de interação humano-computador (por humanos queremos dizer estudantes e professores) utilizando software de agentes representados por caracteres ou figuras humanas. A fim de ajudar os pesquisadores a projetar agentes pedagógicos que possam melhorar a usabilidade do agente humano, este trabalho vai discutir as diretrizes básicas para o design de Agentes Animados Pedagógicos, com base nos conceitos fornecidos pela Informática na Educação, Inteligência Artificial e Interação Humano-Computador.
Palavras-chave: Agentes Pedagógicos Animados. Orientações de design.

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1 Introduction

According to Shaw et al.[1] an animated pedagogical agent can be considered an extension of an intelligent tutoring system. The intention of a tutoring system is to provide learners with an individualized tutor that is implemented with artificial intelligence resources. The addition of an animated pedagogical agent to the interface of intelligent tutoring systems provides elements for embodiment, visibility and personality. These elements open up the possibility for learners to have a personal relationship and emotion connection with the agent which may promote interest in the learning process[2].

1 SHAW, E.; GANESHAN, R.; JOHNSON, W.; MILLAR, D. Building a case for agent-assisted learning as a catalyst for curriculum reform in medical education. In: LAJOIRE, S.; VIVET, M. (Ed.). *Ninth World Conference on Artificial Intelligence in Education, Frontiers in Artificial Intelligence and Applications*. Amsterdam: IOS Press, 1999. P. 509-516.

2 GULZ, A.; HAAKE, M. Design of animated pedagogical agents: A look at their look. *International Journal of Human-Computer Studies*, London, no. 64, p. 322-339, 2006.

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The embodiment, visibility and personality are integrated and constitute the persona effect[3], which means agents producing behaviors that appears to the user as natural and appropriate. The persona effect reveals that the presence of a lifelike animated agent in an interactive learning environment, even one that is not expressive, can have a strong positive effect on student's perception of their learning experience. Several authors are working on educational systems and prototypes with animated agents (such as[4]).

Considering the design aspect of animated pedagogical agents, some authors[5] are working on a set of requirements and qualities that ought to be considered during the design and development phases of an animated pedagogical agents project.

Based on these researches and on concepts provided by Computer in Education (CE) and Human-Computer Interaction (HCI), we will discuss basic guidelines for animated pedagogical agents design, in order to help researchers to project and to develop pedagogical agents that can enhance human-agent usability.

This paper is organized in the following way. Section 2 presents some considerations about animated pedagogical agents. Section 3 presents the background necessary to demonstrate the state of the art in animated pedagogical agent design and serve as a reference to base our proposal guidelines. Section 4 presents our proposed guidelines and section 5 presents the final considerations.

2 Animated Pedagogical Agents

Among the educational systems and prototypes with animated agents cited in the previous section there are two classical samples of pedagogical animated agents: Herman the bug[6] and Adele[7]. Herman is a lifelike agent that guides learners in a microworld, called Design a Plant. The learners can interact with Herman during a learning session. In this interaction, Herman gives advices and explains concepts to the learners.

Adele is an animated pedagogical agent that is represented by a human figure and was developed to work with medicine students. Adele is capable of helping students during problem-solving tasks, presenting contents, monitoring students' activities and performing tests to evaluate the students' comprehension about some subject of study.

Although Herman and Adele are both animated pedagogical agents, they have a different graphical representation. Herman is represented by an animated character and Adele by a human figure. This exemplifies one area of study of animated pedagogical agents: realism versus iconicity. There are diverging claims regarding realistic versus iconic agent with respect to their impact and ability to involve. King and Ohya[8] state that people attribute more intelligence and trust to human-like animated agents, but a (well-designed) non-human character may be more appealing and

3 LESTER, J.; SHAROLYN, C.; KAHLER, S.; BARLOW, T.; STONE, B.; BHOGA, R. The Persona Effect: Affective Impact of Animated Pedagogical Agents. In: PEMBERTON, S. (Ed.). **Human Factors in Computing Systems**. Atlanta: ACM Press, 1997. P. 359-366.

4 JOHNSON, W.L.; RICKEL, J.W.; LESTER, J. Animated Pedagogical Agents: Face-to-Face Interaction in Interactive Learning Environments. **International Journal of Artificial Intelligence in Education**, Amsterdam, no. 11, p. 47-78, 2000.
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5 HAYES-ROTH, B.; MALDONADO, H.; MORAES, M.C. Designing for Diversity: Multi-Cultural Characters for a Multi-Cultural World. In: THE EUROPEAN DIGITAL CONTENT CREATION EVENT - IMAGINA'02, France, 2002. [**Proceedings of ...**] [S.l.: s.n.], 2002. P. 207-225.
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6 LESTER, J.; SHAROLYN, C.; KAHLER, S.; BARLOW, T.; STONE, B.; BHOGA, R., 1997, *op. cit*.

7 SHAW, E.; GANESHAN, R.; JOHNSON, W.; MILLAR, D., 1999, *op. cit*.

8 KING, J.; OHYA, J. The Representation of Agents: Anthropomorphism, Agency and Intelligence. In: BUILGER, R.; GUEST, S.; TAUBER, M.J. (Ed.). **Human Factors in Computing Systems**. Vancouver: ACM Press, 1996. P. 289-290.

entertaining. Isbister et al.[9] choose to represent the agent as a dog to prevent users from assuming and expecting highly intelligent mental capabilities from the agent. Nass et al.[10] argue that the appearance of an animated agent should be as similar as possible to the user group in question. Several empirical evaluations have been made[11] and all researchers conclude that when the agents give the learners an impression of being lifelike and believable, they motivate and instigate the learners to spend more time in the learning task being very helpful, credible and entertaining.

Nowadays, there is a consensus in educational research about the importance of learners' autonomy and the teachers' role in the learning process. Teachers act as advisors, helping learners in their journey to build knowledge. This help should be adapted to the learners' interests, limitations and learning styles. In this sense, computational resources, in general, and animated pedagogical agents, in particular, can expressively contribute. This contribution is evident due to the nature of animated pedagogical agents that according to Lester et al.[12] can deliver sophisticated, real time problem-solving advice with strong visual appeal, increasing students' learning effectiveness with customized feedback.

In order to provide individual support to learners, animated pedagogical agents ought to have several qualities as pointed at[13]:

- Agents' behaviors must exhibit context, continuity and temporality. Agents' advisory behaviors must be contextualized within problem-solving episodes and their physical behavior must be graphically contextualized within the learning environment. To exhibit continuity of action, their behavior must be coherent and agents' explanatory behaviors must take into account temporal resources.
- Agents must appear to care about a learners' progress, encouraging the learners to care more about their own progress.
- Agents must be emotive in order to convey enthusiasm for the subject matter and thereby foster similar levels of enthusiasm in the learner.
- Agents must have an interesting personality because a learner that enjoys interacting with a pedagogical agent may have a more positive perception of the overall learning experience and may consequently opt to spend more time in the learning environment.
- Agents can play two valuable roles: they can serve as instructors for individual learners, and they can substitute for missing team members, allowing learners to practice team tasks when some or all human instructors and teammates are unavailable.
- Agents should be able to answer questions, generate explanations, ask probing questions, and track the learners' skill levels.

9 ISBISTER, K.; NAKANISHI, H.; ISHIDA, T.; NASS, C. Helper Agent: Designing an Assistant for Human-Human Interaction in a Virtual Meeting Space. In: ACM CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS, The Hague, 2000. **The Future is Here**. New York: ACM Press, 2000. P. 57-64.

10 NASS, C.; ISBISTER, K.; LEE, E.-J. Truth is beauty: researching embodied conversational agents. In: CASSELL, J.; PREVOST, S.; SULLIVAN, J.; CHURCHILL, E. (Ed.). **Embodied Conversational Agents**. Cambridge: MIT Press, 2000. P. 374-402.

11 ANDRÉ, E.; RIST, T.; MÜLLER, J. Integrating reactive and scripted behaviours in a life-like presentation agent. In: SYCARA, K.; WOOLDRIDGE, K. (Ed.). **Second International Conference on Autonomous Agents**. New York: ACM Press, 1998. P.261-268.
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12 LESTER, J.; SHAROLYN, C.; KAHLER, S.; BARLOW, T.; STONE, B.; BHOGA, R., 1997, *op. cit.*

13 JOHNSON, W.L.; RICKEL, J.W.; LESTER, J., 2000, *op. c it.*
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- Agents should have the ability to deliver opportunistic instruction, based on the current situation.

Considering the qualities previously presented we can observe that animated pedagogical agents assume an important communicative and intrinsically social role in learning. When assuming an interesting personality and evoking empathy, agents introduce an affective component that can improve and make easier the learning process.

3 Design Principles of Animated Pedagogical Agents

In this section we are going to make an overview of some aspects related to the design principles of animated pedagogical agents. As previously presented, animated pedagogical agents are very important as interaction elements incorporated in learning environments. A well-designed interaction brings several advantages for learning, such as motivation to spend more time in the environment and increase of learning effectiveness through suitable and contextualized feedback to learners.

As interaction is a fundamental aspect and, in the case of educational environments, is intrinsically related to pedagogical questions and the behavior of animated pedagogical agents, next sections present concepts of interaction design, pedagogical software design and requirements for designing animated pedagogical agents. These concepts are going to be used as basis for the ideas presented in the next section.

3.1 Interaction Design

By interaction design, Preece et al.[14] mean "[. . .] designing interactive products to support people in their everyday and working lives [. . .]". Traditional HCI authors[15] present some principles to help in the design of interactive products (or interactive systems). These principles are broadly used by the academy and by the HCI professionals as basis for their research and work. For instance, we can see the Nielsen heuristics[16]:

1. **Visibility of system status.** The system should always keep users informed about what is going on.
2. **Match between system and the real world.** The system should speak the users' language and follow real-world conventions.
3. **User control and freedom.** The system must have support to undo and redo actions.
4. **Consistency and standards.** It is necessary to follow platform or environment conventions.
5. **Error prevention.** Careful design to prevent problems occurrence.
6. **Recognition rather than recall.** It is necessary to minimize the user's cognitive load by making objects, actions, and options visible.
7. **Flexibility and efficiency of use.** The system should allow users to tailor frequent actions.
8. **Aesthetic and minimalist design.** Dialogs should not contain information which is irrelevant or rarely needed.
9. **Help users recognize, diagnose and recover from errors.** An error message should be expressed in plain language, precisely indicate the problem, and constructively suggest a solution.
10. **Help and documentation.** It is necessary to provide help and documentation. It should be easy to search, focused on the user's tasks, list concrete steps, and not be too large.

3.2 Some Issues about Pedagogical Software Design

Squires and Preece[17] present a synopsis of the

14 PREECE, J.; ROGERS, Y.; SHARP, H. **Interaction design**: beyond human-computer interaction. New York: John Wiley & Sons, 2002.

15 HIX, D.; HARTSON, H.R. **Developing User Interfaces**: ensuring usability through product and process. New York: John Wiley & Sons, 1993.
NIELSEN, J. Heuristic evaluation. In: _____.; MACK, R.L. (Ed.). **Usability Inspection Methods**. New York: John Wiley & Sons, 1994. P. 25-62 SHNEIDERMAN, B. **Designing the User Interface**: strategies for effective human-computer interaction. 3rd ed. Menlo Park, CA: Addison-Wesley, Reading, 1998.

16 NIELSEN, J., 1994, *op. cit*.

17 SHNEIDERMAN, B., 1998, *op. cit*.

socio-constructivist view of learning to identify salient learning issues that should feature in educational software design and evaluation. They claim that taking a socio-constructivist approach leads to a consideration of the interaction between usability and learning. They propose a set of five socio-constructivist concepts which represent issues to be considered when designing pedagogical software:

1. **Credibility.** For learners to feel that an environment offers credible opportunities for learning they need to be able to explore the behavior of the systems, environments or artifacts.
2. **Complexity**. Learners may need help in coping with complexity.
3. **Ownership**. Learners need to be encouraged to take responsibility for learning.
4. **Collaboration**. Peer group discussion and work are prominent in helping students to learn.
5. **Curriculum**. Necessity for a match with the curriculum.

3.3 Design Requirements for Animated Pedagogical Agents

Isbister and Doyle[18] pointed out that the research in embodied agents is a discipline and not yet a science, because we do not have formal theories to explain our discipline. The researches done until now are very important and necessary in order to explore the contributions of different areas involved in the development of embodied agents, such as artificial intelligence, emotions, interface design, sociology, psychology and animation. However, to continue to mature as a discipline, it is necessary to develop criteria to design embodied agent and consequently animated pedagogical agents.

There is a set of requirements and qualities that ought to be considered during the design and development in order to produce believability in animated agents[19].

As animated pedagogical agents are animated agents introduced in educational software[20], the requirements described by those authors could also be applied to animated pedagogical agents. Besides these requirements, Stone and Lester[21], Lester et al.[22] and Johnson et al.[23] present some characteristics that animated pedagogical agents should have.

Making a list with all requirements and characteristics presented by the aforementioned authors, we have the following requirements that ought to be considered for an animated pedagogical agent design to produce believability: personality, to make an agent unique; emotions, in accordance to their personality-specific ways; self motivation, being proactive, starting and stopping their own actions; change, growing and changing their emotions, motivations and social relationships over time, consistent with their personality; social relationships:, the behaviors and interactions of a relationship should be described in detail; expressions in accordance with their personality, feelings and situations; illusion of life.

In order to reach these requirements Hayes-Roth et al.[24] and Hayes-Roth et al.[25] propose some qualities that an animated agent should have. These qualities indicate that animated agents should seem: individual, conversational, empathic, social, intelligent, variable and coherent. Details above these qualities can be seen at[26].

18 ISBISTER, K.; DOYLE, P. The Blind Men and the Elephant Revisited: Evaluating Interdisciplinary ECA Research. In: RUTTKAY, Z.; PELACHAUD, C. (Ed.). **From Brows to Trust**: Evaluating Embodied Conversational Agents. Norwell, MA: Kluwer Academic Publ., 2004. P. 3-26.

19 HAYES-ROTH, B.; BROWNSTON, L.; SINCOFF, E. **Directed Improvisation by Computer Characters**. Palo Alto, CA: Stanford University, Knowledge Systems Laboratory, 1995. (Tech. Rep. No. KSL-95-04)
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20 LESTER, J.; SHAROLYN, C.; KAHLER, S.; BARLOW, T.; STONE, B.; BHOGA, R., 1997, *op. cit*.

21 STONE, B.; LESTER, J., 1996, *op. cit*.

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25 HAYES-ROTH, B.; MALDONADO, H.; MORAES, M.C., 2002, *op. cit*.

26 [[Referência removida para não permitir a autoria.]]

4 Designing Animated Pedagogical Agents

Considering that this research intends to support agents' designers and that they don't, necessarily, have specific knowledge about the human-computer interaction area, the proposal aims to build specific guidelines for animated pedagogical agents. It is important to notice that these guidelines are developed considering as basis all the background presented in section 2 and 3.

Table 1. Proposed Guidelines

Visibility of system status
To provide feedback, when requested by the learner, indicating activity status, such as list of all steps already done, total time predicted for an activity and remaining time for an activity.
To present animations for idle state, indicating when agents aren't executing any specific functionality.
To make clear the rules which guide the learner interaction during a learning process.
Match between system and the real world
To represent agents using characters or human figures (with physical appearance, age, weight and gender).
To have personality considering likes, dislikes and particular behaviors.
To have an emotional model that influences their behavior. This model should be dynamic, affecting what is said, how it is said, and the reactions of the agent in light of the learner's utterances.
To work with different kinds of language meaningful words (spoken or written) and agents visual aspects. Agents should speak in a way that the intended audience understands, using local language instead of a foreign language.
To specialize language in order to relate it to a specific role that an agent will execute. Agents should demonstrate role-appropriate knowledge and expertise.
To shape animated agents appearance considering two aspects: to represent a specific local culture and to be used by a group of users from a specific local culture.
To project gestures which are in accordance with specific cultural and educational conventions and norms. The gestures presented by the agent cannot compete with the content that the agent is trying to explain or advise.
To promote correct expectations about agents intelligence.
To have many variations of their most frequent role-specific exchanges.
To present contents which are in accordance with the learner's curriculum and grade level.
To establish an empathic relationship with learners.
To inspire confidence, aiming to have the learner trust the agents' recommendations.
User control and freedom
To assure that learners have control of their computational systems. Learners should feel comfortable and safe about the agent's automatic actions.
To enable learners to direct, instruct and control agents, when requested by the user, to execute a specific task.
To allow learners to undo agents´ actions when these actions leave the learners in an inconsistent state.
To have generic commands such as stop and start agents' execution.
To provide the learner with the control of his/her learning process. The agent cannot control the learning. The agent must be a mediator in the learning process.

Consistency and standards
To have a consistent backstory, referring to any self-recognized individual experience and history that had a direct influence on the animated agent's personality. Also it could contain some information about agents´ previous learning environments, lessons and contents, when appropriate and applicable.
To be a unique and singular creature, directed by an identity and persistent manners.
To show coherence in all aspects of conversation, gestures, facial expression and body language coordinated with the focus of attention of the current situation.
To present concepts and terminologies that are consistent during all the learning process and which are consistent with the learning theories and contents studied by the learners in the environment.
Error prevention
To prevent actions by learners to compromise agents' functioning.
Recognition rather than recall
To make clear the available agents´ options.
To make easy for a leaner to restore his/her learning backup. For instance, advices and tips, which the agent has already provided.
Flexibility and efficiency of use
To be capable of executing the same content (semantic or syntactic) of different manners graphically or through textual description, depending on the agent's emotional state.
To have frequency in the pace of the turn-taking conversation and the frequency with which questions can be exchanged. The interruptions of an animated pedagogical agent cannot compromise the learning process.
To ensure that the role is adequate to the animated agents qualities such as personality, emotional dynamics and social relationships.
To deliver explanations and advices in alternative forms considering the knowledge level and the learning style of a learner.
To have the ability to deliver opportunistic instruction based on the current situation.
To provide an easy way for learners to manipulate the agent. The complexity of the learner-agent interaction should be in the studied content and not in the agents' manipulation.
To provide ways for a learner to adapt to the kind of interaction (contents, lessons, tests) with the agents considering the learners evolution during a learning process.
To have more than one learning strategy to use with learners.
To provide for the teacher the possibility to configure the learning strategies.
To provide in some way the development of learners' reflection about their cognitive skills.
Aesthetic and minimalist design
To present relevant information to the learner. The information should be clear and task focused.
To have a variety of dialogs for the most frequent role-independent exchanges, for example: greeting, farewell and thank you.
The visual and verbal communication should be in accordance with the agent's personality. The agent personality must be in accordance with the personalities related to human tutors.
To represent an ethnical similarity to the audience. If a learner group is ethnically mixed multiple agents should be provided with correspondingly different ethnicities from which the user can choose one agent to interact with.
The agent appearance should cause a good "first impression".
The agent should be appealing. The learner has to like the agent.
The use of hair, cosmetics and costume should be culturally sensitive.
The backstory of the agent has to be consistent with its visual style (shape, color and movement).

The appearance and personality of the agent must not distract the learner's focus on learning.
The agent must to appear to care about a learner's progress in order to encourage the leaner.
The agent may convey enthusiasm for the subject matter and thereby foster similar levels of enthusiasm in the learner.
Help users recognize, diagnose and recover from errors
To provide feedback in case of failure.
To make possible for learners to refine their concepts, learning from those errors. The agent must treat errors in a constructivist manner.
Help and documentation
To provide help and documentation about the use of agents.
To provide a portfolio with basic information about agents in order to facilitate interaction.
To provide help about the lessons and contents to be studied. This help could be explanations, tips, advices, tasks and problems to be solved.

5 Final Considerations

The design and development of animated pedagogical agents is a complex and interdisciplinary work involving disciplines ranging from artificial intelligence to arts. The diversity of aspects to be considered adds to the difficulty of having clear criteria for design and evaluation. An important question to be taken into account by researchers who desire to contribute to clear these criteria is to indicate where their contributions lie. The taxonomy proposed by Isbister and Doyle[27] proposes four areas that lead to predominant evaluation strategies: believability, sociability, task and application domains and agency and computational issues. Our contributions lie in three of these four areas: believability, sociability and task and application domains. In this paper we propose a set of basic guidelines to be used during the design of animated pedagogical agents.

In order to build our proposals, we use as basis the background knowledge presented in section 2. We start introducing the concept of animated pedagogical agents. We discuss the design principles of animated pedagogical agents, approaching questions such as interaction design, pedagogical issues in software design and requirements for animated pedagogical agents design.

To verify the suitability of the guidelines proposed, we are doing some tests. Among the guidelines presented in section 4, there are some that could be applied to animated agents in general. We start the testing with these ones. So, these guidelines have already been evaluated and analyzed for the domain of conversational animated characters, or, chatterbots, and the results can be found in[28]. We choose to start the testing for the chatterbots domain due to the great availability of conversational agents on the Web. Now we start cooperation with researchers that are implementing animated pedagogical agents.

Through this work we intend to contribute with design guidelines that go in the direction of a more mature discipline, with formal metrics for design of animated pedagogical agents. We do not claim that our guidelines and method are complete and closed. On the contrary, we hope to induce some debate and provoke improvements and extensions.

27 ISBISTER, K.; DOYLE, P., 2004, *op. cit*.

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