Pedagogical Agents in 3D Learning Environments

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INTRODUCTION

A *Pedagogical Agent (PA),* is an intelligent agent who autonomously supports educational procedures, taking place in synchronous interactive learning environments aiming at achieving better learning; educational procedures comprise students' or/and teacher's role's relevancy.

Pedagogical agents or Intelligent Pedagogical Agents (IPAs), albeit they are not a new concept can be considered as an innovative learning technique that aims to support educational procedures, by supporting both students' and teacher's role, in technological enhanced computer mediated learning environments. Four diverse research fields need to be encompassed and combined when implementing an Intelligent Pedagogical Agent for a 3D learning environment: a) Pedagogy and Educational Psychology b) Artificial Intelligence (AI) c) Virtual Reality and Virtual Learning Environments (VLEs) d) Human Computer Interaction (HCI). Figure 1, presents graphically the "pedagogical agents in 3D learning environments" research field as an intersection of the above mentioned axes.

Immersive Learning Environments or *3D Learning Environments* differentiate from the Virtual Learning Environments (VLEs) in their representational richness. Visual metaphors are an essential part of virtual worlds (Konstantinidis et al., 2010). There are many 3D multi-user platforms that can be utilized as learning spaces; the tools and services that these platforms offer, can be categorized with regard to their functionality into communication tools, teacher and student support tools, tools for coordinating the collaborative learning process, shared applications and photorealistic humanoids (Tsiatsos & Konstantinidis, 2007).

In immersive learning environments, users (i.e. students and teachers) have the ability to be represented by 3D avatars as well as to move and act in a realistic manner. Avatars in such environments interact with each other both verbally and non-verbally. A virtual learning environment can distribute knowledge and cognition among various artefacts (such as tools and virtual objects), among students (Perkins, 1992).

BACKGROUND

PAs inherit the main attributes of the intelligent agents. Figure 2, graphically presents the hierarchical analysis of 3D intelligent PAs' structure. As mentioned above, PAs in 3D learning environments, have to fulfil a more sophisticated role that aims to combine issues arising

Figure 1. Intelligent PA in 3D learning environments research field conception

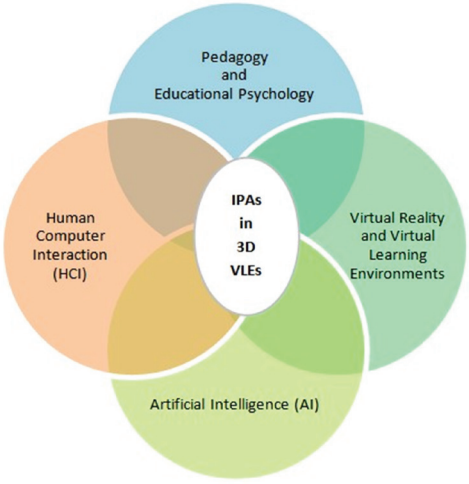

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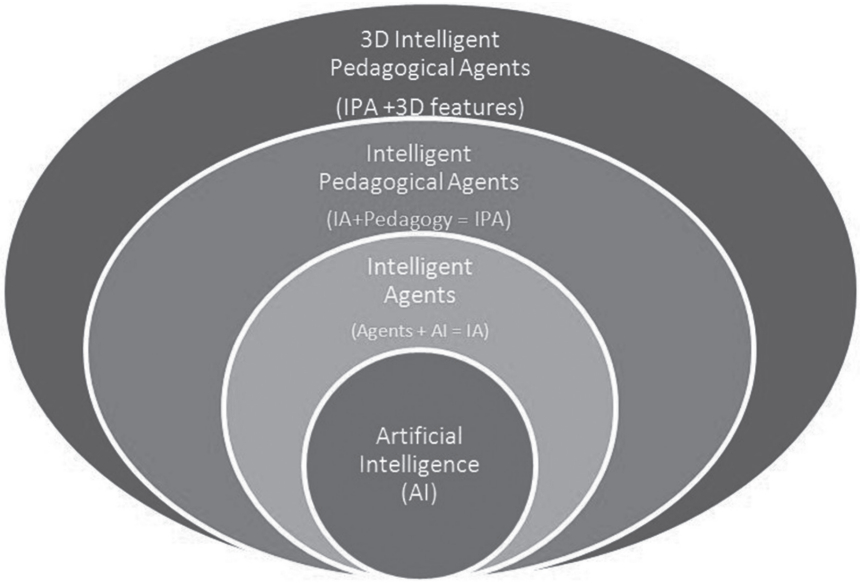
Figure 2. A hierarchical analysis of the 3D intelligent PAs' structure



from different research areas, such as: pedagogy and educational psychology, artificial intelligence, virtual reality, human computer interaction.

Studies so far advocate for PAs' potentiality to deliver higher levels of motivation in learning (Baylor, 2009; Kim et al., 2007; Cheng & Chen, 2012). PAs in 3D immersive environments are usually represented by human-like avatars, also known as embodied PAs. *Embodied agents* are equipped with both verbal and non-verbal communication features, making their design and implementation a very complex process. Thus, researchers aiming to design image effective and realistically behaving embodied PAs for 3D Virtual Learning Environments (VLEs), apart from their pedagogical model, have to take under consideration additional agent's visualization and embodiment choices, such as avatar's attire, gender selection (Hayashi et al., 2013; Gulz & Haake, 2010), non-verbal interaction features and emotional expression capabilities.

Though, research on 3d VLEs but also on PAs have demonstrated many design models per se, there are only few *frameworks* that propose a comprehensive solution for embedding intelligent PAs in 3d learning environments. Kim and Baylor (2008), developed a conceptual framework for an "anthropomorphic change agent" and provided design guidelines to motivate pre-service teachers to integrate technology into their teaching and instruction. The designed agent simulated a mentor while integrating the motivator and companion role. While, the EnALI - "Enhancing Agent-Learner Interaction framework" by Veletsianos et. al. (2009), provides "practical guidelines for the effective design of pedagogical agents," focusing on three main design principles: a) user interaction, b) message and c) agent characteristics. Furthermore, another solution approach, offers guidelines for the design of a pedagogical agent acting in a 3D collaborative educational game focusing on following expected outcomes: a) reinforce competition, b) encourage involvement, c) trigger interaction between players, d) reward players, e) remind aim and rules of the game, e) provide help and awareness during the game and f) motivate students (Terzidou & Tsiatsos, 2014).

PEDAGOGICAL AGENTS IN 3D LEARNING ENVIRONMENTS

PAs tend to become essential part in computer based learning and especially in 3D learning environments. PAs in 3D learning environments, also referred as *Pedagogical Virtual Agents (PVAs),* are situated in learning environments that are designed based on virtual reality technology (Aguilar et al., 2006). Pedagogical Virtual Agents have characteristics that allow to increase the