Designing Pedagogical Conversational Agents in Virtual Worlds

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Abstract: Pedagogical conversational agents (PCAs) are intelligent dialog systems that can support students as chatbots or voice assistants. However, many users find interactions with PCAs less engaging. One solution to increase learners' engagement is to embed the PCA in a virtual world, e.g., as a humanoid avatar that facilitates collaborative learning. Such a learning setting could be beneficial because virtual worlds positively affect fun and immersion. In this paper, we derive prescriptive design knowledge for PCAs in virtual worlds based on the results of nine expert interviews synthesized with findings from the literature. This design knowledge aims to enable the meaningful design of PCAs in virtual worlds. We contribute to research and practice by demonstrating how PCAs in virtual worlds can be designed to increase students' motivation to learn.

Keywords: Pedagogical Conversational Agent, Virtual World, Education, Design Principle.

1 Introduction and Motivation

Pedagogical conversational agents (PCAs) are intelligent dialog systems that support learners by processing natural language [HM19]. They can teach content, motivate learners, or moderate collaborative learning [Kh22a]. With AI advances, PCAs are getting better at helping learners with individual concerns, as the example of ChatGPT shows. However, users often perceive interactions with PCAs as not motivating, leading to the rejection of PCAs [Be22]. Combining PCAs with game approaches is one way to counteract this issue. This can be done by integrating PCAs as human-like avatars into virtual worlds (VWs) [GG16]. They can, for instance, guide learners through the VW while presenting them with lively challenges [KGR23]. Such VWs have been showing positive effects for years, such as immersion and collaborative learning [DMJ12]. Recent examples such as Roblox or Minecraft show that VWs can be fun for users. They can also be used for serious purposes such as education [HC22]. Hence, by combining both trends, PCAs and VWs, educators could benefit from the positive effects of both [KGR23]. Current literature reviews show that embedding PCAs in VWs is novel and that there does not yet exist prescriptive design knowledge on PCAs in VWs [KGR23, Kh22a]. However,

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this design knowledge helps developers and educators implement PCAs in VWs. We address this research gap using the design science research methodology to derive design knowledge for PCAs. Hence, we address the following **research question (RQ):** *How to design PCAs in VWs to foster students' motivation to learn?* We follow the procedure of [He07] to answer our RQ. We derive design knowledge based on nine expert interviews. We aim to ensure scientific rigor and practical relevance by incorporating this body of expertise. We formulate the design knowledge as design principles (DPs), i.e., abstract requirements for PCAs in VWs [GCS20]. These are complemented by meta-requirements (MRs), design features (DFs), and overarching design guidelines (DGs). In this short paper, we report the results of our first design cycle as a tentative conceptual design.

2 Research Background

PCAs interact with their users either via text (as chatbots) or speech (as virtual assistants) [HM19]. They can take on different roles, which lead to different functionalities [Kh22a]: organizer, tutor, mentor, motivator, and moderator. PCAs, as organizers, support learners in navigating the learning environment. The tutor role focuses on imparting learning content. The mentor role goes beyond merely imparting learning content, so learners are accompanied in the long-term, e.g., through feedback and study tips. The PCA as a motivator serves to promote learners' engagement, e.g., through gamification. The moderator mediates collaborative learning or brainstorming. PCAs can be incorporated into VWs to guide learners in these human-like roles [GG16]. VWs are immersive 3D environments where avatars communicate with each other [DMJ12]. VWs promote immersion and contribute to a social presence experience, and learners thus enjoy learning [ibid.]. In classic game environments, virtual agents were usually implemented by non-player characters (NPCs). While these were not AI-based, PCAs, as an extension of NPCs, enable individualized communication [KGR23]. Moreover, AI allows learners to receive social and empathic support if the PCA acts as a friendly virtual companion [St22]. Some authors already propose design recommendations for PCAs, e.g., for argumentative writing support [WSL20]. However, there is yet no design knowledge for PCAs in VWs.

3 Study Design and Results

We conducted semi-structured interviews with nine experts from different research streams (psychology, computer science, information systems) and industry practitioners. All experts had prior experience with designing PCAs or VWs. The interview guide consisted of questions about design recommendations and desired features for PCAs in VWs. The interviews lasted between 42 to 64 minutes. We transcribed and analyzed all interviews based on a pre-defined coding guide in two coding cycles. The coding guide followed our interview guide and included categories on the benefits of PCAs in VWs and learners' challenges to be solved, the design of PCAs and VWs, the design of the PCA roles in the VW, and mentioned kernel theories. Following [Mö20], we synthesized the results with supporting literature and formulated MRs for PCAs in VWs. We then combined MRs that relate to each other into DPs and illustrated these DPs with example DFs [Mö20]. In formulating the DPs, we followed a unified scheme according to [GCS20]. We structured the DPs according to the PCA roles (see Chapter 2) so that each DP corresponds to a particular PCA role. We choose this approach because, according to social agency theory, different roles of human-like agents lead to varying expectations of users and functions to realize [Be22, MSM03]. Since the experts also mentioned aspects that apply to all roles, we furthermore formulated role-independent design guidelines (DGs). Figure 1 outlines the DGs and DPs, which we will explain in detail in the following. Our **digital appendix** contains a mapping diagram of all MRs, DPs, DFs, and DGs and information about the interviewees: https://doi.org/10.6084/m9.figshare.23538363.v1.

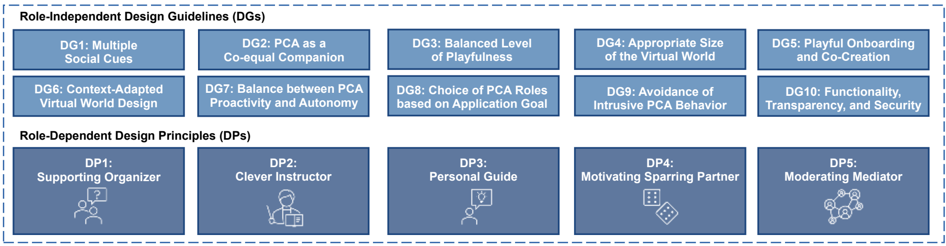

Fig. 1: Overview of Design Guidelines and Design Principles for PCAs in Virtual Worlds

Role-independent design guidelines: The experts emphasized that the PCA should have human-like “social cues” to exude social presence [Fe19] (DG1). E.g., the PCA can have a human-like name and a personality, greet learners, use emojis, and tell jokes to appear natural [Fe19, St22]. The experts addressed that the PCA should act as a co-equal companion to ensure learners' trust [St22] (DG2). However, the learning environment must have a balanced level of playfulness and an appropriate size so that learners do not get distracted (e.g., no open world) (DG3, DG4). Upon initial entry into the VW, learners should be welcomed and onboarded by the PCA. The experts emphasized that learners should set up the world with their classmates and lecturers in the first sessions to meet students’ needs (co-creation) (DG5). The joint design of the VW might contribute to a sense of team cohesion. However, the design of the VW should fit the context, e.g., not be too fictional or playful (like a space world) but also not entirely true to reality (DG6). E.g., students could learn in a classroom with open windows and nature to simulate a relaxed learning atmosphere. If possible, the room's virtual objects should be included (e.g., to simulate processes). The PCA should act proactively but also leave freedom of decision. Hence, according to self-determination theory, learners can act autonomously, which is crucial for their motivation [RD00, St22]. E.g., they could choose between learning tasks and select the desired PCA role [Kh22b] (DG7). In addition, we suggest that practitioners base the choice of design elements and roles of the PCA on the application goal. Thus, we recommend deciding which DPs should be implemented (DG8). We suggest considering that it is also possible that a PCA in a VW takes on multiple roles [GG16]. However, role changes should be clearly communicated so that the PCA meets the learners' expectations. The experts emphasized that the PCA should not be intrusive (DP9) so that users perceive it as trustworthy. E.g., it should not constantly follow learners or get too close. The proximity can vary, depending on the use case. If the PCA acts as a mentor (see DP2), it could stand next to the learner, and as a moderator, it could be in a central location. For learners to accept this technology, basic prerequisites such as technical functionality or transparency on data security must be considered [Kh22b, St22] (DG10).

Role-dependent design principles: The first **DP1 (Supporting Organizer)** concerns the PCA as an organizer. The experts suggested the PCA explain the controls and navigation when learners first enter the VW so that they can find their way around and do not have technical hurdles (MR1). In doing so, the PCA should proactively explain the functions so that users have clear expectations [Kh22b, St22] (MR2). The PCA should be able to answer questions about the VW and relieve instructors if, e.g., users have technical problems logging into the VW (MR3). This onboarding by the PCA should be skippable if learners are already experienced (MR4). **DP2 (Clever Instructor)** focuses on the delivery of learning content. The PCA should explain content naturally and use VW objects for illustration (MR5). The PCA should support the human teacher and enable learners to ask questions anonymously, e.g., if they have not understood something and do not dare to ask them publicly. If the learners have difficulties in understanding, the PCA should explain the learning content step by step using "scaffolding (an established teaching technique) [Kh22b, VC78, WSL22] (MR6). In addition, the PCA should present the learners with tasks in which they test their knowledge [Be22, Kh2] (MR7). The interviewees recommended using troubleshooting tasks, e.g., identifying errors. To promote learners' understanding, they should be encouraged to explain circumstances on their own in dialog with the PCA to promote interactive learning [WSL22] (MR8). In addition, to be perceived in its role, the PCA should be positioned centrally to be visible to all (MR9). **DP3 (Personal Guide)** relates to the PCA going beyond the tutor role and becoming a mentor by accompanying students in the long term, for instance, by promoting the "how to learn" instead of only teaching content [Kh22b]. During the onboarding, the PCA should inquire about the current learning status and students' current challenges, e.g., using practice tests to identify knowledge gaps to support learners individually (MR10). Within the VW, the PCA should initiate the completion of learning tasks to let students gain practical experiences [Kh22b] (MR11). In addition, the PCA can provide hints to facilitate the completion of tasks (MR12). These hints could be adapted to the learning pace and, if desired, be anonymous to provide individual support and not expose learners. To ensure learning success, it is crucial that learners receive feedback, so the PCA should be able to point out errors and incomplete answers or recommend further learning content and paths [GG16, Kh22b, WSL20] (MR13). Moreover, the PCA might proactively initiate breaks to help students learn focused [Kh22b] (MR14). E.g., the PCA could use a "pomodoro timer" or allow learners to explore the VW while listening to relaxing music during breaks. To achieve long-term learning success, students should not only absorb the knowledge once but are also proactively reminded to repeat and apply it in practice tasks (MR15). **DP4 (Motivational Sparring Partner)** aims to promote learners' engagement.

Thus, the PCA should congratulate users for successes [GG16, Kh22b] (MR16). The PCA can also use methods from design thinking (e.g., warm-ups) to lighten the mood, make it clear to learners why group learning is important, and reward all participants for collaborative learning (MR17). In addition, the PCA can present learners with playful challenges, e.g., asking them to run a maze or solve quizzes [Be22, GG16] (MR18). Moreover, the PCA can reward learners to appreciate their performance, visualize their progress, and motivate them intrinsically and extrinsically [Be22, Kh22b, RD00] (MR19). Points can be awarded for completing individual units, and learners can receive achievements for longer-term successes [Be22]. The PCA could give these achievements to learners, keeping them in a "virtual display case." The further development of the world and the avatar was also particularly desired, e.g., possibilities to unlock additional features/furniture or to buy new avatar items. Rewards should be given both for fun activities in the VW and topic-related activities. Additionally, respondents recommended giving learners opportunities to compare themselves if actively desired (e.g., by who asked the most questions to the PCA) (MR20). **DP5 (Moderating Meditator)** refers to collaborative learning. The PCA should help to match learners with each other (Kh22b) (MR21). The PCA could, for instance, match learners with peers at a similar skill level and that are online in the VW simultaneously. Thereby, it is useful to form diverse teams, so teammates complement each other (MR22). For data protection reasons, they should be asked whether they would like to connect with others [St22] and the PCA should initiate the matching as a mediator (MR23). To do this, the PCA can, e.g., guide learners through the room to others or beam them to another location. To support collaborative learning, the PCA should contribute ideas when learners are stuck and suggest collaborative and creative methods (e.g., ABC method) (MR24). The experts recommended encouraging (introverted) learners to contribute knowledge, e.g., by the PCA sending a hint to learners to contribute more to the group (MR25). To do so, the PCA might analyze the group dynamics and emotions of the participants, e.g., who contributed how much (MR26).

4 Conclusion and Outlook

PCAs can be integrated into VWs to make learning immersive and motivating. We have derived design knowledge to assist researchers and practitioners in creating such learning scenarios. We are implementing these abstract conceptual considerations into a virtual design thinking training in the VW Unity that includes two PCAs to support learners, one using the chatbot service Rasa and one interfacing with ChatGPT. The Rasa-based PCA is to take over simple tasks like welcoming the learners to the VW and introducing them to the design thinking method. The ChatGPT-based PCA will take on more complex tasks, such as moderating the training, and generating creative ideas. We plan to evaluate our approach's effectiveness using focus group interviews with our target group.

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