Building a Social Conversational Pedagogical Agent – Design Challenges and Methodological Approaches

Abstract

This chapter discusses design challenges encountered when developing a conversational pedagogical agent. By tracing the historical roots of pedagogical agents in Intelligent Tutoring Systems (ITS), we discern central developments in creating an agent that is both knowledgeable and fosters a social relationship with the learner. Some main challenges faced when attempting to develop a pedagogical agent of this kind relate to: i) learners' expectations on the agent's knowledge profile and social profile, ii) dealing with learners' engagement in off-task conversation and iii) managing potential abuse of the agent. We discuss these challenges and address possible ways to address them, with reference to an ongoing Research & Development project, and with a focus on the design of a pedagogical agent's visual embodiment and its conversational capabilities.

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1. INTRODUCTION

1.1 Conversational Pedagogical Agents

In this chapter "a pedagogical agent" refers to a computer generated character employed in an educational setting in order to fulfill pedagogical purposes. Such agents (or characters) can serve numerous pedagogical roles (Chou, Chan, & Lin, 2003; Baylor & Kim, 2005; Haake & Gulz, 2009). For instance, they have been presented and studied as instructors, coaches, tutors, and learning companions.

The concept of an "agent" denotes an entity with some degree of "intelligence" and capacity for autonomous action. "Agent", or "intelligent agent" as used within the computer science discipline, refers to a computer program that can "act" on its own, i.e. autonomously. When referring to "pedagogical agents" in today's educational contexts, it is also assumed that the agent has a corresponding visual representation.

Conversational pedagogical agents refer to a subgroup of pedagogical agents, namely those that can engage in a "conversation" with a learner. In a wide sense of the term, a conversational pedagogical agent might entertain dialogue via elaborate body language movements including gestures, facial expressions, etc. In this chapter, though, we focus on conversation via natural language, and furthermore limit our treatment to text-based interaction (typed conversation via the keyboard). That is, we do not discuss the challenges and potentials surrounding speech recognition and production. We also exclude complex non-verbal interaction (often explored in Embodied Conversational Agents research e.g. Cassell, Sullivan, Prevost, & Churchill, 2000; Ruttkay & Pelachaud, 2004), where the agent's body is used for demonstrating, showing, pointing, and for giving feedback via gestural and emotional expressions. We discuss animated pedagogical agents where the visual animations are less complex, mainly aimed at making the agent appear more "life-like" and appealing.
4. BACKGROUND

2. BACKGROUND

2.1. Intelligent tutoring systems

An intelligent tutoring system (ITS) is a computer-based learning environment designed to provide personalized instruction to individual students. ITSs are based on theories of learning and cognition, and they are designed to adapt to the individual needs of the learner. ITSs are widely used in education and training, and they have been shown to improve learning outcomes compared to traditional methods. The development of ITSs has been driven by advances in computer science, artificial intelligence, and educational psychology. The field of ITS research has been characterized by a focus on creating systems that can understand and adapt to the individual learning styles and abilities of students. This has led to the development of a wide range of ITS models, each with its own strengths and weaknesses. The development of ITSs has also been influenced by the increasing availability of powerful computing resources, which has allowed for more sophisticated and interactive systems. The field of ITS research is constantly evolving, with new research and developments leading to the creation of more effective and personalized learning environments.
In this type of system natural language conversation is used mainly for a tutor to ask questions, to engage in what Bickmore (2003) calls "relation-oriented conversation". To some extent this with social conversation is that it opens up the possibility for a student and a pedagogical agent intelligence tutoring systems with natural language conversations, with varying sophistication systems relied on reasoning mechanisms dealing with knowledge of the domain, the task, the user and the dialogue (Flycht-Eriksson, 2003). A special type of these task-oriented dialogue human conversation due to the possibility to shift between task- and domain-oriented systems are tutoring/tutorial dialogue systems that combine the pedagogical functions of social developments amplify the affordances of a pedagogical agent as someone to have a relationship with personal developments parallels the development of visual embodiment of pedagogical agents. Both these significant with historical agents). They also offer possibilities to combine elements from task-oriented dialogues in restricted domains with elements from broader, but shallower, dialogues of restricted domains, such as

Figure 1. Characteristics in Chatbots, Virtual Humans, and Task-oriented dialogue systems. Virtual Humans are agents that

From a pedagogical perspective, this development introduces strategies for dialogue management to achieve a connected dialogue and mixed initiative smoothly assist a person in solving a task. Furthermore, these systems often used complex smoothness to appear humanlike and engage in social conversation regarding a wide language processing, the problem of representing world knowledge, and the lack of research on these areas (cf. Grosz & Sidner, 1986; Smith, 1992; Jönsson, 1997), which in turn led to connected discourse and mixed initiative. However, the late 1980's and 1990's saw breakthroughs in

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We acknowledge that this is a very limited and rudimentary form of "conversation". We refer to the multiple-choice questions module as "on-task conversation". Proper (or improper) answers impact corresponding skills in the teachable agent via the AI algorithms. We will refer to the multiple-choice questions module as "on-task conversation".

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disappointment and frustration (Veletsianos, Scharber, & Doering, 2008). From the agent or expect conversational capacities, that the agent does not live up to, leading to optimizing their potential for promoting actual learning. These distinctions are important when it comes to evaluating the pedagogical function of off-task conversations. In traditional teaching situations such as lessons, lectures, tutorials, etc., there is always a mixture of on-task and off-task conversation, together with topics that relate to the specific math games being played, has to be a combination of a chatbot-like system and a task-oriented ITS-like system. (Compare Figure 1.) In our system we are implementing the agent's ability to engage in off-task conversation as a mixed-initiative dialogue strategy in order to allow both the agent and the user to direct the dialogue (e.g. by introducing new topics and posing questions). The agent keeps a history of the utterances in the dialogue, both in the current and previous sessions. This gives us a possible tool for obtaining a balance between on-domain and off-domain topics in the off-task conversation. For instance conversations about music, being tired, sports, and food are classified as off-task/off-domain conversation – we refer to the module for freer conversation with the agent in this section. Whereas we refer to the multiple-choice format conversation while playing a particular board game as on-task/on-domain conversation. Off-task/off-domain conversation can be more open, with more freedom for the user. Off-task/on-domain conversation can be more structured, and may require the user to focus on specific topics.

Next we expand on the underlying reasoning behind the pedagogical agent system by discussing potential pedagogical benefits. We start by looking at the class topic: they may bring up a matter of general interest, comment on their own personal experiences relating to the agent behaving and conversing just like a human being: a conflict between the expectations the student may have of the agent's role and the actual performance. For instance the pedagogical agent may attempt to bring the learner back to the task by saying things like: "Have you finished your homework yet?" whereas the student may expect the agent to provide more specific guidance: "You should do more exercises on this topic." A conflict like this can indeed hamper learning by misleading the learner to believe that the agent resembles human beings in other cognitive and emotional aspects as well. They may, for instance, expect empathy from the agent or expect conversational capacities, that the agent does not live up to, leading to disappointment and frustration (Veletsianos, Scharber, & Doering, 2008).

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A number of pedagogical motives can be brought forth for including opportunities for off-task conversation. These might include the potential to encourage emotional engagement and create additional opportunities for interaction and engagement that are not related to the primary lesson content. For example, off-task conversations may encourage emotional engagement and create additional opportunities for interaction and engagement that are not related to the primary lesson content. An agent can also act as a role model for ways to cope with difficulties (cf. Schunk, Hanson & Cox, 1987). Off-task conversation of a social and relational kind, for instance, "small talk" can promote trust and rapport-building, and at the same time bring in a relaxed atmosphere when learning mathematics. An agent can also act as a role model for ways to cope with difficulties (cf. Schunk, Hanson & Cox, 1987).

It has often been suggested that off-task conversation of a social and relational kind, for instance, "small talk" can promote trust and rapport-building, and at the same time bring in a relaxed atmosphere when learning mathematics. An agent can also act as a role model for ways to cope with difficulties (cf. Schunk, Hanson & Cox, 1987). Off-task conversation can lead to increased motivation or engagement with the task and domain in question. For example, off-task conversations that are more interpersonal and relational, such as sharing a joke or having a conversation about personal interests, can result in increased motivation or engagement with the task and domain in question.

Researchers have long called for a refined approach to the design of virtual agents (Dehn & van Mulken, 2000), and during the last few years pedagogical agent researchers have proposed a number of frameworks to enhance pedagogical agent implementations (e.g., Kim & Baylor, 2008; Woo, 2009). In this paper, we use the Enhancing Agent Learner Interactions (EnALI) framework (from Veletsianos, 2008; Mulken, 2000), which was designed to provide a comprehensive framework for designing pedagogical agents. The framework includes three main components: design focus, interaction, and agent characteristics. The design focus component includes guidelines for the effective design of pedagogical agents that are in close alignment with design inquiry and practice, taking an encompassing view of design that addresses social, practical, and technical considerations. The interaction component includes guidelines for how agents should interact with learners, including how agents should respond to requests for additional or expanded information. The agent characteristics component includes guidelines for how agents should be designed, including how agents should look and sound.

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Design challenges and possible ways to approach them

3. The challenge of student expectations on the pedagogical agent's knowledge profile

- How to handle students' expectations on the knowledge and representation by:
  - Establishing role and relationship to user/task.
  - Establishing credibility and trustworthiness.
  - Being expressive (e.g. exhibiting verbal cues in speech).
  - Being polite and positive (e.g., encouraging, motivating).
  - Using descriptive, non-evaluative comments.
  - Making messages complete and specific.
  - Clearly owning the message.
  - Making the message appropriate to the receiver's abilities, experiences, and frame of reference.
  - Describing feelings by name, action, or figure of speech.
  - Using a visual representation appropriate to content.
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4. Design based research

- An extension of its conversational capacities to include the pedagogical agent as a "virtual human":
  - How to manage the pedagogical agent's knowledge and representation by:
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- The challenges are therefore likely to be faced by others who aim to develop the kind of pedagogical agent for educational development and an extension of its conversational capacities to include the pedagogical agent as a "virtual human".

- The challenges of students' engagement in off-task conversation:
  - How to manage students' possible under-engagement in off-task conversation with the pedagogical agent.
  - How to manage students' possible over-engagement in off-task conversation with the pedagogical agent.

- The challenges of abusive student comments:
  - How to handle students' expectations on the pedagogical agent's social abilities:
    - Establishing role and relationship to user/task.
    - Making messages complete and specific.
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of students' expectations, as well as to support the development of an agent that could engage
students in off-task conversations. To do so, we conducted focus group interviews with the
target group – is a non-trivial and challenging task in itself. Importantly, it is not entirely for the

R&D team (with a mean age of around 45) to decide. This goes specifically for off-task/off-

domain areas, where the main purpose is to increase student engagement with the game and
(but also has interests like music and sports that it pursues in its spare time). Even when the free

course content is not relevant about the subject domain

Can it discuss music? Can it give an answer to whether it has a best friend or not?

Can the agent

Conversational topics that relate to the domain of mathematics:

Can it discuss strategies of the math game? Can it tell whether it finds mathematics a boring subject?

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groups in design. (EnALI, 2009; Wang, 2008) which thus highlights the importance of involving target user exhibited attitudes or moods that are random and inconsistent (Isbister & Nass, 2000).

of how a particular user group may give input that diverges from general design guidelines characteristics. They will not expect – and not appreciate – changes in a pedagogical agent's feedback when it comes to how the agent can/will talk to her. These expectations are furthermore linked to how the agent can/will talk to the student.

mean character, extrovert or introvert, humorous or serious, happy or sad, etc. In addition, for students insisted that the agent should not be too polite, but express some "attitude". Interestingly, it could be inferred from the interviews that a "too soft, nice and polite" character seemed to elicit skepticism among the students.

work in progress, in the Fall of 2008, we started to build a design-based research program. We conducted focus group interviews with four groups of 4-5 teenagers each (13-14 years old), who had the opportunity to try out the math game, look at agent images (Figure 4), and engage in task-oriented conversations and socially-oriented interactions, there may be a clash between student expectations on the pedagogical agent's knowledge as to the math game (not knowing much at all) and its knowledge of general, "social" subjects. At the same time, student expectations on the pedagogical agent's knowledge profile, we refer to the agent's social profile, we refer to the agent's personal qualities, such that it should be friendly, curious, eager to learn, and like school. However, students insisted that the agent already in the beginning of the design process with our present system, we have an illustrative example of how the EnALI framework can be fruitfully combined with a design-based research strategy for contextualizing, and exemplifying, some of the EnALI guidelines. In the case to be discussed, our focus is on the politeness aspect. The design process in question can be described as follows: (1) making a raw sketch of the agent character, (2) using this sketch as a basis for contextualizing, and exemplifying, some of the EnALI guidelines, (3) running focus group interviews with our target population, and in the next section we discuss student expectations on the pedagogical agent's social profile, (4) discussing design implications of the experiences from other pedagogical agent systems as well as from our experience as teachers.

manipulations of the domain from the start. A TA is unusually trained to know the student partner. The first sketch became subject of much discussion, which highlighted the complexity of our experience from other pedagogical agent systems as well as from our experience as teachers. Notably, we conceived of the pedagogical assistant (TA) as an unusual pedagogical assistant (TA). A TA is unusually trained to know the student partner. The first sketch became subject of much discussion, which highlighted the complexity of the agent's knowledge and conversational strategies. Notably, we conceived of the pedagogical assistant (TA) as an unusual pedagogical assistant (TA). A TA is unusually trained to know the student partner. The first sketch became subject of much discussion, which highlighted the complexity of our experience from other pedagogical agent systems as well as from our experience as teachers.
5.3.3 Finding the balance and allowing flexibility for individuals

User Interaction Guidelines (Table 1), it is important to maintain an appropriate balance between on- and off-task activities.

Engaged and being immersed to the point of losing focus on the task. As stated in the EnALI framework, there is surely a fine line between students being engaged and being immersed to the point of losing focus on the task. On the other hand: a student can find off-task conversation completely uninteresting and therefore not (want to) engage in it at all.

There are examples of students becoming so strongly immersed in conversation with a pedagogical agent that they forego the learning task, as demonstrated by Veletsianos and Miller (2008). This appears as a possible drawback of deploying a module "too elaborated" for social interaction with a student.

5.3 The challenges of off-task engagement

Off-task/on-domain category. The arguments fell into four categories: i) off-task conversation is so engaging that the student completely deviates from the learning task. On the other hand: a student can find off-task conversation completely uninteresting and therefore not (want to) engage in it at all. ii) Off-task conversation is so engaging that the student completely deviates from the learning task. On the other hand: a student can find off-task conversation completely uninteresting and therefore not (want to) engage in it at all. iii) Off-task conversation would involve doing totally无关之事, or meaningless things instead of focusing on what is important, and iv) minimal interest in engaging in off-task conversation, iii) off-task conversation would involve doing totally无关之事, or meaningless things instead of focusing on what is important, and iv) minimal interest in engaging in off-task conversation.

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The challenge of abusive student comments

Veletsianos, Scharber, and Doering (2008) let the pedagogical agent respond to abuses by lecturing the user on foul language or acting submissively. Both types of responses however, resulted in continued abuse. Our current approach involves the pedagogical agent noting that it is not interested in certain topics and not wanting to comment on them.

Previously this challenge has been addressed by making the agent give very neutral responses (cf. Baylor, 2009). But little is known about long-term effects. Regarding the role of visual appearance of a human-agent social relationship persists over time (cf. Baylor, 2005) but little is known about long term effects. Regarding the role of visual appearance appropriate to the content. What can be accomplished when a pedagogical agent based educational system is used for a longer period of time? The need for such research has been indicated that the amount of agent abuse is considerably smaller and takes milder forms than in previous studies on short-term use.
REFERENCES


An important and much-needed trend in the field is that studies on conversational pedagogical agents described herein inform and improve the design guidelines on agent-learner interactions if we employ a DBR approach to pedagogical agent theory on agent-learner interactions. We see our work as informing two of these three theories. Specifically:

- In our case, we have aimed to demonstrate how the field of conversational pedagogical agents represents a unique combination of theory and research intertwined with practice. This chapter has highlighted the fact that design and research knowledge are important in developing effective, efficient, and engaging pedagogical agents that not only capitalize on technological advancements, but are also sensitive to cognitive, emotional, and social considerations as they are more fine-grained than they used to be a decade ago. It is no longer likely to inform similar endeavors of enhancing interactions in real-world learning environments.

- In contrast, we have employed a DBR approach to pedagogical agent research. Specifically, we have been revising the intervention continuously based on data from the field, feedback from teachers and students, assessment results, and evaluations of the learning experience. In line with DBR methodologies, this paper describes our thinking and initial design for the project described herein. We will be revisiting the ideas presented here and will make progress towards a small number of well-defined, educational goals. Unlike traditional, experimental research which provides a "yes" or "no" answer to a given research question, or the rejection or acceptance of a hypothesis, a design-based approach to development maintains the complexity of decisions within one coherent framework (the EnALI guidelines) and still make us more or less limited to the implementation context. Yet, of greater benefit is the learning environment that we obtain in terms of what manipulations yield a positive or negative effect, for example, might be more fine-grained than they used to be a decade ago.


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Web-based learning, pedagogical agent, conversational pedagogical agent, social agent, teachable agent, Intelligent Tutoring Systems (ITS), embodiment, dialogue system, EnALI, off-task and on-task conversation, design based research

Web-based education Education that is enhanced with the use of the World Wide Web.

A conversational pedagogical agent is able to engage in a (textual or spoken) conversation with a learner.

A pedagogical agent that is able to engage in (read-aloud or spoken) conversation with a learner.

Embodiment The case where a virtual character is presented as a bodied character, allowing embodiment

Social agent A pedagogical agent that is able to relate socially with a learner, and engage in social-oriented dialogue.

Conversational pedagogical agent A pedagogical agent that is able to engage in a (read-aloud or spoken) conversation with a learner.

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KEY TERMS AND DEFINITIONS

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On-task and off-task conversation

On-task conversation refers to conversation between learners and pedagogical agents that is strictly focused on a lesson and the processes required to complete the lesson. Off-task conversation is any conversation between learners and agents that is unrelated to the lesson.

EnALI refers to the Enhancing Agent-Learner Interaction framework proposed by Veletsianos, Miller, & Doering (2009) to guide pedagogical agent design. The framework consists of practical guidelines for the effective design of pedagogical agents that are in close alignment with design inquiry and practice. These guidelines focus on enhancing agent-learner interaction, agent message, and agent characteristics.

Design Based Research

Design Based Research (DBR) is defined by Wang and Hannafin (2006, p. 6) as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation. Design Based Research is defined by Wang and Hannafin (2006, p. 6) as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation. Design Based Research is defined by Wang and Hannafin (2006, p. 6) as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation.