Towards a conversational pedagogical agent capable of affecting attitudes and self-efficacy

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Abstract. In this paper we discuss how social conversation with an agent in an educational math game can be used in order to gain pedagogical benefits, for example to increase positive attitudes towards learning math and math self-efficacy. We present the iterative development of the conversational module, architectural considerations, and the type of dialogue phenomenon that support the pedagogical interventions.

Keywords: conversational pedagogical agents, social dialogue, attitudes, self-efficacy, dialogue system architecture.

1 Introduction

We are developing a virtual learning environment that includes an educational math game and a conversational pedagogical agent capable of both task-directed and a more free social conversation. It is based on an existing game, developed by Pareto and Swartz, in which children train basic arithmetic skills (such as transitions between 1s, 10s, and 100s), with particular focus on base ten concepts. It consists of several different board games, with various levels of difficulty, that intertwine game play with learning content through visualisations of arithmetic operations. These are made explicit using a graphical metaphor of colored squares and boxes that can be “packed” or “unpacked”, in numbers of 10. Figure 1 shows an example screen shot of the game.

A crucial part of the game is a pedagogical agent, more specifically a *Teachable Agent,* that builds upon the pedagogy of “learning by teaching”. The agent is thus a peer rather than a tutor and the student’s goal is to “teach” the agent to play the game. This is done by responding appropriately to different multiple-choice questions posed by the agent during game play, which is called the *on-task dialogue*. The questions address the idea of the game, the visual model and strategies for winning.

A novel part of the learning environment is a chat-like written social conversation with the teachable agent, called *off-task dialogue*. This can be further distinguished into *on-domain* conversation, with topics related to school, math, the math game, etc., and *off-domain* conversation, which includes all other topics. The system use the metaphor of regular breaks between lessons in school for switching between on-task

Fig. 1. The virtual learning environment, with the math game and on-task dialogue.

activities (i.e. playing the game and on-task dialogue) and off-task activities (i.e. social conversation).The purpose of the more social conversation is to enrich the game and its motivational qualities for the age group in question and ultimately to enable pedagogical interventions, such as supporting pupils' math self-efficacy and change negative attitudes toward math in general. In this paper we describe the iterative development of the conversational capabilities.

2 The role of social interaction in pedagogical settings

In traditional teaching situations such as lessons, lectures, tutorials, etc., there is practically always a mixture of *on-task* interactions with focus on subject content and tasks of the lesson, and *off-task*/*social* interactions which bear no (apparent) relation to the learning material. There is plenty of evidence that bringing off-task conversation into the educational situation can have a number of positive implications: it allows for cognitive rest, it can increase engagement, it can provide memory cues, it can promote trust and rapport-building with the agent, and it can be used to reframe tasks in a defusing and generally appealing context [1].

Previous studies have also indicated the possibility to use conversations with embodied agents in virtual learning environments for pedagogical interventions, for example to increase self-efficacy and attitudes toward learning tasks. Within the project *MathGirls* [2] it was shown that students who worked with an agent rather than text messages increased their positive math attitudes and their self-efficacy. In the MathGirls system the agent gives help on the learning tasks but also gives motivational messages that consist of praise and encouragements related to the student's performance, as well as persuasive messages that are general positive statements about the benefits of good mathematical ability and careers in this area.

Other studies have shown the possibility of agents to persuade users through dialogue, changing their attitude and motivation. For example, in the area of engineering, Baylor and Plant [3] found that the choice of visual representation of the agent (gender, attractiveness, coolness, age) was important for the effect; best effect had the young, cool agent, i.e. resembling a peer, and the old, uncool, i.e. the stereotypical expert engineer.

We want to further investigate how social interaction can be used for pedagogical interventions, initially to increase students engagement in the learning environment and ultimately to increase the users math self-efficacy and attitudes towards math.

3 System development

The conversational module for the off-task conversations is developed as a rather independent module of the learning environment, but it is based on a character description of the teachable agent that is consistent with the overall role of the agent as a peer in the environment. Rather than designing a complex and knowledge intense dialogue system architecture we aim at reaching our goal through more simple techniques. We have taken a very pragmatic approach, which includes iteratively applied user-centered agile system development methods combining focus group interviews and Wizard-of-Oz role-play with development and evaluation of prototypes, surveys and analysis of natural language interaction logs. For the present project, the intended users are 12-14-year-old pupils, and approximately 50 pupils in this age group have taken part or are still taking active part in the development.

3.1 Technical platform(s)

As a starting point for the implementation AIML, *Artifical Intelligence Markup Language,* was chosen as the technical platform. AIML is widely used to construct chatbots, both commercially and for other purposes such as education. AIML works on the surface level of utterances, and map user utterances, interpreted through patterns, to system responses, represented as templates. The patterns can consist of alphanumeric characters and place holders for one or many unknown word, and in a similar way the patterns are predefined with slots that can be filled by values of variables. AIML allows for some very simple dialogue management techniques, through the tags that, which refers to the systems last utterance, and topic, which can span multiple exchanges. A mixed initiative strategy where both user and agent can pose questions, and follow-up questions can be handled by AIML. For the first version of the conversational module only AIML was used. However, the shallow processing of utterances and the lack of long-term record of the dialogue history, that can be used to achieve a more natural dialogue, was a limitation. In the second version of the system we therefore extend AIML with a dialogue history, user model and dialogue manager, described below.

3.2 The 1st version of the system

The primary focus of the first version of the system developed through iteration 1 to 3 was to bootstrap topics and linguistic expressions used by the target group. In this version of the system the main goal of the off-task conversation is to increase engagement and allow for some breaks in the on-task activities. In the conversation the agent focuses on getting to know the pupil by posing and answering questions about their personal interests, family and friends, school etc. There is a very rudimentary user model with 15 topics that are linked to questions and the possibility to store users' answers related to these topics. The pupil can either introduce the topics and the agent can ask a follow up question, or the agent can initiate a new topic, for example, when it fails to interpret a pupil's utterance. Most of these topics are related to off-domain topics but some introduces topics that are on-domain such as school, math and the math game, which provides opportunities for the type of general persuasive positive statements used in MathGirls. These are interspersed in the off-task conversation and can come as a result of a direct question from the pupil, eg. *What do you think about math*, or as a statement from the agent as in the example given in figure 2.The example shows the agents abilities to discuss various topics and also how the system handles statements it can not understand. The agent does not understand *me too!* Nor the pupil's clarification *it is fun to get stars* and instead begins a new topic.

Kim:	what type of music do you listen to?
Pupil:	I like almost everything, Michael Jackson is good
Kim:	ok
Pupil:	what about you?
Kim:	sort of everything but dance band music hehe
Pupil:	do you like Michael Jackson, or not?
Kim:	mm, I like his music
Pupil:	mm
Kim:	Do you play computer games?
Pupil:	mm, a lot
Kim:	aha
Pupil:	wbu?
Kim:	mm, computer games are fun
Pupil:	which games do you usually play
Kim:	Sims and Age of Empires
Pupil:	okey
Kim:	What do you think about the math game?
Pupil:	it is funny, but difficult in the beginning
Kim:	I think the game is funny, too
Pupil:	okki
Kim:	I think it is fun to get stars
Pupil:	me too!
Kim:	how do you mean?
Pupil:	it is fun to get stars
Kim:	Hmm, let's talk about something else
Pupil:	Okey
Kim:	Maths is fun, but sometimes I don't get it, what do you think about maths?
Pupil:	don't like maths, it is so boring
Kim:	Why don't you like maths?

Fig. 2. A dialogue between pupil and agent that starts out with off-domain topics and turns to on-domain conversation regarding the math game and maths.

The flow of the dialogue, as exemplified by the ability to introduce new topics and pose general follow-up questions, is implemented using various variables, called predicates, in AIML and also relies on heavy use of the AIML that and topic tags. These can also support implementation of a strategy for handling failed interpretations or to follow up on a topic. However, to provide a more coherent and focused dialogue with the possibility to balance on-domain and off-domain conversation and more deliberate strategies for pedagogical interventions a more sophisticated model for dialogue management is needed.

3.3 The current version of the system

In the second version of the system that we are currently working on, AIML is still used as the backbone, but a more elaborate representation of the context is represented in a dialogue history, which keeps track of utterances, topics, who has the initiative, the type of the utterances, and the current and previous goal of the conversation. The second version also includes a more elaborate user model with hierarchical topics, which allows pupils to discuss more than one aspect of a topic and also facilitates a more natural change of topic.

The new architecture is inspired by our previous work on dialogue system architectures [4] and is shown in Figure 3. It comprises two process modules, the Dialogue Manager and AIML, two dynamic information structures, Dialogue history and User model, and a static set of dialogue rules. The dialogue rules are used to govern the flow of the dialogue, more specifically on how to use information in the dialogue history or user model to contextually interpret utterances and/or decide what action to take next. The systems' response is still taken from the set of AIML templates and the interpretation of the pupils' utterances, after being updated with information from the dynamic information sources, is done using AIML patterns.

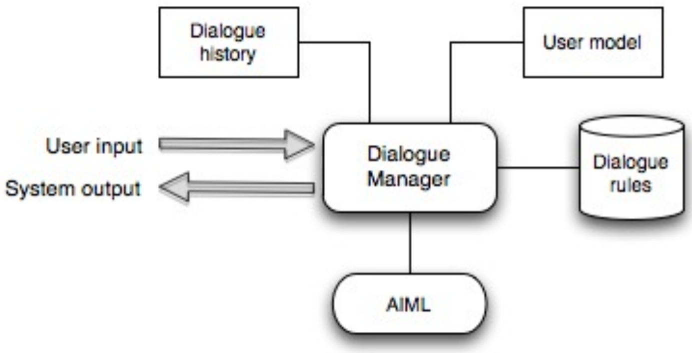

Fig. 3. The new architecture for the conversation incorporates a Dialogue Manager, Dialogue history and User model, and a static set of dialogue rules, besides AIML.

Input from the user is sent to AIML for initial interpretation and a tentative response is suggested. The input and suggested output is inspected by the Dialogue Manager given the dialogue rules, the Dialogue History and User Model. For example, if interpretation has failed, a dialogue rule is triggered which tries to contextually interpret the user input given previous turns in the dialogue history. It is then sent to the AIML module for reinterpretation and a new suggestion for a response. The dialogue rules can also trigger if the dialogue does not progress and, for instance change topic Dialogue rules can also be used to steer the dialogue on a level above the current utterances and topics, setting overall goals such as aiming for social dialogue, persuasive dialogue, and feed-back on game-play. These in turn affect other rules that can be triggered in a cascading fashion.

Further iterations will also utilise information from the learning task, i.e. the game, about how well the user has performed, how the agents knowledge has changed, etc to be able to give more specific feed-back on the pupils performance and further affect self-efficacy. Typical utterances from the agent could be (remember that the pupil teaches the agent to do maths): *It had not been easy to learn this without your help,* or *Great fun! Shall we play again. But you must help me,* or *I never thought that maths could be this fun, thanks to you.* It is important to be honest and not give positive feedback unless the pupil achieved something, e.g. *Today it was really tricky, I am sure it will be better next time* if the agent has not learned anything new during a session. We will also include mini-narratives such as: *The other day in school when we had math, the teacher was explaining on the whiteboard but made a mistake and could not get the right answer. I saw the mistake and could tell him the correct solution, which was neat.*

4 Future work

We are extending the conversational capabilities of a pedagogical agent in a educational game to go beyond task-oriented interaction and onto more social conversation, since we believe this can be a means to positively influence the learning experience and in the long run to affect attitudes and self-efficacy. We plan on testing the effects of the off-task conversation by contrasting two versions of the learning system, one with and one without the off-task conversation. Further development of the system with continued close cooperation with target user groups will take place in parallel, with focus on the content and expression of on-domain conversations regarding math and the attitudes toward math, as well as the requirements of the dialogue manager to perform pedagogical interventions.

5 References

1. Gulz, A., Silvervarg, A. & Sjöden, B. (2010). Design for off-task interaction – Rethinking pedagogy in technology enhanced learning *Proceedings of the The 10th IEEE International Conference on Advanced Learning Technologies*
2. Kim, Y., Wei, Q., Xu, B., Ko, Y., & Ilieva, V. (2007). MathGirls: Increasing Girls' Positive Attitudes and Self-Efficacy through Pedagogical Agents. In *Proceeding of the 2007 conference on Artificial Intelligence in Education,* pp 119-126. Los Angeles, CA
3. Baylor, A, & Plant, E.: (2005) Pedagogical agents as social models for engineering: The influence of agent appearance on female choice. In: *Proceedings of the 12th International Conference on Artificial Intelligence in Education,* pp 65-72. Amsterdam, The Netherlands
4. Flycht-Eriksson, A. & Jönsson, A. (2000). Dialogue and Domain Knowledge Management in Dialogue Systems, *1st SIGdial Workshop on Discourse and Dialogue*, Hong Kong, 7-8 October 2000