A pedagogical agent which incorporates a text mining tool to promote collaborative writing

Isis da Costa Pinho[1], Eliseo Reategui[1], Alexandre Moretto Ribeiro[1], Mateus David Finco[2]

[1]PPGIE / PPGEDU, Federal University of Rio Grande do Sul (UFRGS)
Av. Paulo Gama, 110 - prédio 12105 - 90040-060, Porto Alegre, RS - Brazil
isis.letras@yahoo.com.br, eliseoreategui@gmail.com, alexandremorettoribeiro@gmail.com
[2]Faculdade da Serra Gaúcha
Rua os Dezoito do Forte, 2366 - 95020-472, Caxias do Sul, RS - Brazil
mateusfinco@yahoo.com.br

Abstract - *This paper discusses how mediation strategies can be used to design a pedagogical agent integrated to a text mining tool to promote collaborative work in academic reading and writing activities. The agent uses the Artificial Intelligence Markup Language (AIML) to communicate with students, while its text mining features enables it to keep track of what is being produced collaboratively. Mediation strategies based on sociocultural theory are also employed in order to endow the pedagogical agent with the capacity to intervene in students' discussions according to precise goals. A specific architecture is proposed in the paper as a form to integrate these different mechanisms in the pedagogical agent. The proposed solution explores the roles of interaction, mediation and assistance as key elements for structuring the pedagogical agent's participation as a peer guide in collaborative text writing. Keywords: pedagogical agent, text mining, collaborative writing, mediation, distance learning*.

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1. Introduction

The use of technology in education challenges teachers to use the Web 2.0, information and communication technologies, as well as artificial intelligence for engaging learners in intense interaction to promote collaborative and exploratory learning. Moreover, distance education has required the creation of pedagogical tools that provide adaptive assistance to students in an individualized manner to solve problems without the constant teacher supervision. One of these tools is pedagogical agents. In a time where distant teachers face a heavy workload dealing with a large number of students, pedagogical agents can serve as entities to support learning and mediation, minimizing the absence of immediate feedback from the teacher when this cannot be done.

This research aims to examine how mediation strategies may be used to structure the knowledge base of a pedagogical agent in order to support a collaborative writing process. While mediation strategies give the agent some pedagogical knowledge on how to promote discussion and to keep students engaged in their collaborative work, a text mining tool is employed in order to give the agent some domain knowledge about the topic students have to write about.

This paper is organized as follows. The next section presents pedagogical agents and proposes them as a means to mediate collaborative work. Section 3 presents theoretical background on the topics interaction and mediation. Section 4 proposes a specific architecture for pedagogical agents, based on the integration of mediation knowledge, conversational knowledge and domain specific knowledge. Section 5 discusses the pedagogical agent architecture and proposes directions for future work.

2. Pedagogical Agents

André and Rist [1] defined virtual characters as anthropomorphic computerized beings whose main goal is to assist people in performing specific tasks. Based on this definition, we describe pedagogical agents as virtual characters whose main goal is to help students in learning-related activities. They may act as virtual tutors, mentors, experts, virtual partners, providing a more natural interaction with digital educational artifacts. Pedagogical agents may also be classified into goal-driven (tutors, mentors and assistants), and utility-driven agents that perform supplementary tasks related to teaching activities [2]. In any of these cases, pedagogical agents provide an opportunity to improve the communication among students and computers by using paralinguistic cues, such as gestures and facial expressions, which are familiar to human beings. This form of human-computer communication also has the potential to establish emotional and social bonds between pedagogical agents and students, which could consequently facilitate learning [3].

The use of virtual characters as a communication tool in computing systems has spread in a wide range of applications [4]. In the educational area, Shaw & Johnson [5] showed how virtual teachers could guide students in online interactive activities. Rist and Muller [6] demonstrated that the presence of virtual characters in educational material could influence students' perceptions, making them consider topics significantly less difficult and more entertaining. A significant

portion of these investigation results are aligned with the ideas that teaching and learning are highly social activities. Based on this premise, Kim and Baylor [7] showed how virtual characters could be used not as tutors, but as learning companions.

Pedagogical agents are usually designed to present information, to encourage students, to give pedagogical feedback, to guide and help learners [7]. Thus, pedagogical agents can provide a situated social interaction, playing the role of a more expert peer and addressing issues which are relevant to learners' needs. The sense of presence provided by the agents also contributes to fill out the void caused by the lag produced by distance education environments [7].

In order to promote a good interaction with users, pedagogical agents need to be credible, or appear to have life and consistency in their actions. This life-like identity is built from their autonomy, social skills and adaptability features. For that, agents should have a broad and diverse repertoire of behaviors according to likely situations, and they should seek to help students to keep their focus on relevant aspects of the learning material.

By perceiving pedagogical agents as entities which have an identity and life (personae effect), students may get more motivated to participate in activities, feeling they can be assisted at any time when needed [8][9].

Based on social-cognitive principles, Kim and Baylor [7] discuss the instructional potential of pedagogical agents as learning companions to support interaction in pairs. The authors state that, based on the ZPD metaphor, the pedagogical agent can be designed to be in a higher intellectual stage scaffolding learners' performance to advance in their knowledge construction.

Here, our main goal has been to design a pedagogical agent with the capability of mediating the communication between two students in order to get them to work together collaboratively in the best possible way. As our focus has been on tasks related to text writing, the initial goal of the agent is to support students' reading and discussing, helping them keep their focus.

Our agent uses the use the Artificial Intelligence Markup Language (AIML) associated with a text mining tool in order to communicate with students and keep track of what is being produced collaboratively. AIML employs a stimulus-response method by which stimuli (sentences and fragments) are stored and used to search for pre-defined replies [10]. The language has certain features which distinguish it from a simple retrieval of questions and answers from a database. For example, it may keep the context of a speech in order to enable the character to remember a previous statement. It also enables the launching of particular programs when a certain pattern is found. Such a feature is used in our pedagogical agent architecture to get the character to combine a previously compiled AIML knowledge base with a more dynamic representation of specific domain knowledge extracted from texts with the help of the text mining tool.

The use of an AIML knowledge base is founded on the fact that the agent has to be able to talk to students about general topics in order to be more credible and to create a social bond with them. The next section discusses the topic mediation and arguments about the importance of such strategies for a pedagogical agent.

3. Mediation Strategies

The theoretical framework that guided this research comprises the works of Vygotsky, including sociocultural theory applied to language acquisition, mediation strategies and learning processes [11][12][13][14][15]. Collaboration is known to be one of the cornerstones of educational experience. In a computer mediated setting, it may promote the creation of an online learning community through the grouping and the involvement of students. Moreover, collaboration can promote the development of abilities for reasoning in a critical way, and it can produce the co-construction of knowledge and meaning. It may also produce reflection, and trigger transformative learning [16].

According to the Vygotskian sociocultural theory, interaction and collaboration are essential to the co-construction of knowledge, as well as the development of greater control over oneself and one's own learning [13][17][14][18]. Interaction is, thus, an important factor in learning processes. In distance education, it may refer to student-student, student-tutor, student-teacher [15], system-student and student-pedagogical agent contact. However, it is the interactive nature of collaboration, with the establishment of intersubjectivity based on collective goal-directed actions, which best fosters learning. Thus, the engagement of learners in the negotiation of ideas, knowledge and perspectives for the common benefit can lead to opportunities for focusing on the sense and form of language, scaffolding hypotheses and strategy testing, creating and applying learning strategies [19][20][21].

Learning in a virtual environment is the result of the relationships between several factors including: teachers and learners' characteristics, needs, expectations and objectives, amount and type of input received, amount and type of output expected, teaching and learning styles and strategies. Furthermore, the learning process can be seen as a complex system as it is the combination of these multiple factors [22]. Learning remains open to the influence of initial and external conditions, such as feedback, task procedures, and the virtual learning environment in use.

The focus of our work is neither on the student nor on the teacher, but on the interactive flow which structures and keeps virtual communication between people. In this context, learning is socially situated, being the product of the collaboration between learners and their interaction with technology [12][17][14][18]. This process leads to the expansion of a learning zone with the potential to be attained, called Zone of Proximal Development (ZPD). It's in the zone of proximal development that pedagogical intervention and assistance of a more capable partner can produce more effects on learning. This type of assistance is called by Wood et. al. [21] scaffolding, and it consists of an interactive process of

negotiation, in which the expert, based on the learner competence level, chooses the type of assistance required. Little by little, as the learner's competence evolves, the responsibility to complete the tasks has be given to him/her [21][23][24].

This process of assistance is characterized by six functions: (1) recruiting partner's attention to the task, making the partner concerned; (2) reducing the degree of freedom by simplifying or limiting the demands of the task to make it feasible; (3) maintaining the direction by keeping the focus and progress towards their goals; (4) pointing out relevant features through feedback; (5) controlling frustration by decreasing the stress of the novice; (6) and demonstrating the expected procedures to achieve the goals [21].

Therefore, knowledge acquisition can be promoted through a mediation process intentionally organized by the teacher who creates problematic situations that challenge learners to develop self-regulation. Here, these strategies have been implemented in the pedagogical agent who provides assistance to the students in their tasks.

During the social cognitive development of learners, mediation is central to the search for a greater control over one's own behavior. Through interaction, individuals may become skilled with tools; they may get acquainted with signs, meanings and knowledge. Based on this, teachers should consider in their planning and educational intervention not only material resources, but foremost, mediation strategies which are adapted to the students' profile, needs and expectations [25]. A pedagogical agent whose main goal is to assist students in developing collaborative work should also take such factors into account.

4. The Pedagogical Agent Architecture

The main goal of the pedagogical agent proposed in this work is to mediate the interaction between students who are working together in a writing activity. Fig. 1 shows a diagram in which we can see two students interacting in a collaborative work, and interacting as well with the pedagogical agent.

The agent is composed of 3 knowledge bases. One of them stores conversational knowledge, which enables the agent to talk about general topics which may interest students and which may be important for establishing a social bond with them.

The second knowledge base of the agent is composed of knowledge about mediation strategies, guiding the agent on how to intervene on students' discussions as to keep them engaged in the activity and keep their focus on the theme proposed for their assignment.

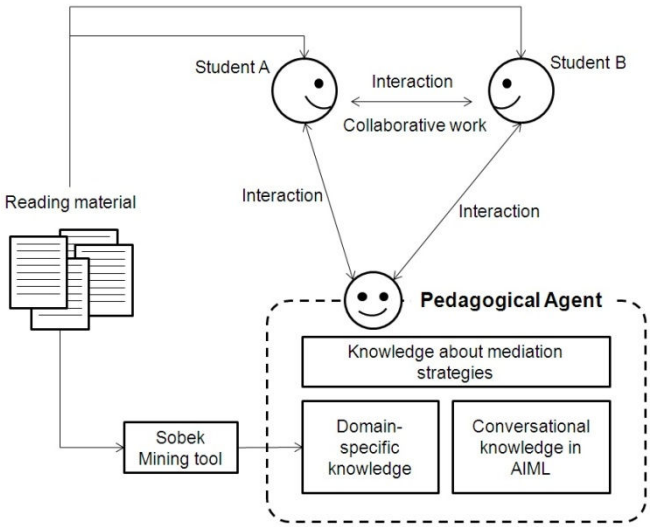

Fig. 1. architecture of the pedagogical agent.

The third knowledge base stores specific knowledge about a topic that is being discussed by the students. A set of texts about the topic feeds a text mining system. This system extracts from the texts relevant terms and relationships among them, representing this knowledge in the form of a graph. Fig. 2 shows a graph extracted from Wikipedia text about data structures1.

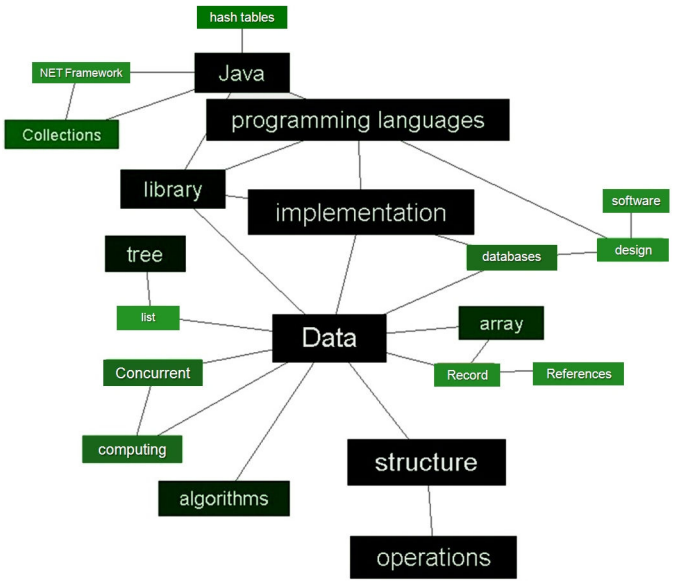

Fig. 2. graph obtained from a text on data structures.

The text mining process developed in this work has been based on Schenker's use of the n-simple distance graph model [26], a graph that has in its nodes words representing the

[1] Text extracted from: http://en.wikipedia.org/wiki/Data_structure, Accessed in March, 2011

concepts found in the text. The edges used to link nodes represent adjacent information, i.e. they represent how the concepts appear together in the text.

The text mining tool presented here has already been used in different educational applications, as in Macedo et al. [27] where the authors showed how the graphs could assist teachers in identifying certain pattern of problems in students' writings. Azevedo et al. [28], on the other hand, proposed a method for identifying the quality of contributions in discussion forums through a computational method employing the graphs extracted from the students' posts. Here, the graphs guide the pedagogical agent on how to arbitrate students' discussions with the main goal of keeping them focused on relevant concepts which have to be considered in their work.

5. Discussion and Final Considerations

The results of this study are intended to contribute to the research on the uses of computers in education, focusing on the impact of pedagogical agents in collaborative writing.

In some terms, our proposal is related to that of Macedo et al. [27], who claim that although the graphs obtained in the text mining process cannot be used to reconstruct an original text, they can provide a good understanding about ideas and key concepts. In Macedo's work, it has also been shown that the graphs elicited from students' writings can show certain features which may help teachers evaluate the quality of the students' work.

Klemann et al. [29] suggest the use of Sobek as a resource for helping students in writing activities. In the proposed methodology, the reflection on what has been read in a text, and the evaluation of the relevance of concepts and their relationships in the graphs can be of great use for organizing ideas and deepening the understanding about a topic being studied. Here, the graphs are not used directly by the students, but they are employed by the pedagogical agent as a source of knowledge for understanding which are the relevant topics which have to be covered in the students' assignment.

Although most of the work in the area has focused on positive aspects of pedagogical agents from a learning perspective, some criticism has also been presented. Gulz, for instance, discusses and questions the types of gain that can be obtained by pedagogical agents [30]. Choi & Clark demonstrated that there was no difference in students' performances when comparing the use of a pedagogical agent with a simple arrow and voice narration [31]. The authors argued that there was no evidence in favor of the pedagogical agents regarding their ability to motivate, interest or tutor the students. Here, however, we are not only concerned with the type of media used to present information to students. We are interested in the actual capacity of the agent to mediate students' interaction through the use of different mechanisms such as an AIML engine, a text mining tool and a mediation knowledge base. In this regard, our position is aligned with that of Veletsianos [32] who argued that Choi & Clark [31] disregarded important aspects of agents' properties in their research.

Regarding the design of the pedagogical agent, it is intended that the agent makes the learning environment more interactive as to provide scaffolding in students' learning process. According to the classification proposed by Giraffa and Viccari [2], our pedagogical agent can be classified as a goal-driven agent, as it is intended to work as an assistant, but it also has features of utility-driven agents, as it is in charge of the specific task of promoting the collaboration between students in writing. It is currently being integrated in a portal in the health area, with the intent to provide medical and nursing students with further support for their writing assignments. A next step in our research will be the integration of domain specific vocabulary in the agent's architecture as a means to associate more semantics to the analyses carried out by the agent.

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