

# Agents for Collaborative Learning in Virtual Worlds

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**Abstract.** Virtual worlds provide educators with rich environments to explore the application of advanced learning theories in collaborative learning which is hard to achieve in traditional classroom based settings. However, the process of converting these theories into useful scaffoldings in such unique environments is highly challenging. In this paper, we explore the use of intelligent software agents to infuse advanced learning theories into the interactions among the learners as well as the learning environment. We propose a collaborative teachable agent which incorporates learning-by-teaching-others theory into a virtual learning environment (VLE) we have developed. We aim to set up conditions conducive for collaborative learning in VLEs using this agent. The effects of the proposed agent on the learning experience of the students have been verified in a field study in one of the high schools in Singapore.

**Keywords:** intelligent software agents, teachable agents, virtual learning environment, collaborative learning.

## 1 Introduction

Recent advances in computer graphics technologies enabled virtual worlds to achieve levels of immersion not seen before through a heightened sense of presence and the suspension of disbelief. High quality, low bandwidth graphics rendering makes accommodating massive numbers of users in a virtual world possible. These two key developments have catapulted online virtual worlds to a high level of fame especially among the “Net Generation” [4]. The virtual worlds, which offer users a connected computer simulated environment where people can interact via their avatars, provide educators with a powerful medium to experiment with new ideas in collaborative learning that can reach out to a large audience [1]. The use of software agents to incorporate learning activities into virtual learning environments (VLEs) has been advocated by pioneer researchers [2], [3].

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Augmenting VLEs with software agents has the potential to open up vast opportunities not only for providing infrastructural support for collaborative learning (e.g. communications, learning task management and personalization, etc.), but also for engaging the students in a deeper cognitive level to facilitate the construction of useful scaffoldings through the application of the learning-by-teaching-others theory during the collaborative learning process. In this paper, we explore how collaborative teachable agents (TAs) can be designed to assist knowledge creation within a group of learners.

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## 2 Related Work

Learning by teaching others is a well known educational theory [5]. When in a position to prepare to instruct others instead of just learning for one's own knowledge gain, the students often take on a higher sense of responsibility. This motivates them to organize the knowledge they have acquired in anticipation of the needs from their pupils. In the field of teachable agent research, the most popular one so far is the agent Betty [6]. It is an agent using a cognitive map (CM) to represent its knowledge. By doing so, Betty is able to understand and infer the causal relationships among various concepts. Nevertheless, due to the limitation of CM being able to denote only the causality but not the degree of causality between any two concepts, the level of sophistication of the concepts that users can teach Betty is limited. Moreover, the Betty family of teachable agents has not made provision for collaborative learning situations.

## 3 The Collaborative Teachable Agent

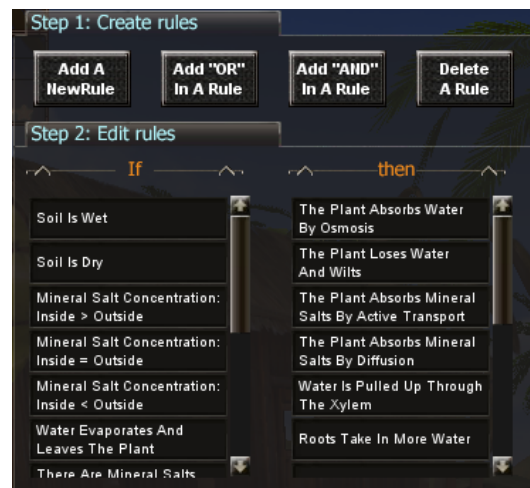


Fig. 1. The Rule Creator Interface for the TA

The collaborative TA is designed to support the learning-by-teaching-others theory in small groups of collaborating learners. The main objective is to infuse intelligent behaviors into the TA. We incorporated inquiry based learning and collaborative learning in the TA based on fuzzy reasoning in an agent controlled avatar – “Little Banana Tree” – in CS. It enables the students to reflect upon what they have learnt in the VLE and to counter check the coherence of their knowledge. After the learning tasks are completed, the students can use the rule creator interface as shown in Fig 1 to collaboratively incorporate knowledge to the TA in the form of rules (i.e. if...then...else... clauses). The learners are free to decide the level of details of the rules to facilitate the checking process for any rule conflict. Once new rules are entered, the TA checks them against the existing rules on the related concepts in the rule database for potential conflicts. If a conflict is found, the TA will generate alerts of conflicting rules to the group of collaborating students to prompt them to resolve the conflict. Through this mechanism, discussions and consensus building among the group members will be stimulated and they will become aware of their potential misunderstandings thereby, improve their knowledge on the subject topic.

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The TA constantly monitors the learning activities the students are engaged in. When it recognizes a known concept has been involved in the current activity, it synthesizes an enquiry for the students to answer. The enquiry is produced making an inference with the recognized concept. For example, “does more sunshine lead to higher temperature?” An error bias is added into the TA’s configuration which can introduce a degree of random error into the inference result to make the inference result incorrect. This may prompt the learners to think about the problem from a different angle and correct the TA’s mistake. Through this interaction, the students could reflect deeper on the relationship of the various knowledge points they have learnt and possibly form a more in-depth understanding of the various concepts.

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#### 4 Field Study

A prototype VLE – the Chronicles of Singapura – equipped with the collaborative TA has been deployed in a secondary school in Singapore for science class topics. A total of 68 secondary two (i.e. Grade 8 in the U.S. system) students participated in the study. The students were divided into two groups according to their respective classes. Students formed into sub-groups of either 3 or 4 to collaboratively explore the VLE as a team. While learning concepts related to the transportation of materials in plants through osmosis, diffusion and active transport mechanisms as well as the process of photosynthesis.

A survey has been conducted to evaluate the students’ learning experience with the TA. Some of the comments in the questionnaire from the students include: “*I could do things like fly, float and walk on water, I also could shrink and teleport. This is not life-like, and it is fun, as it receives a lot of imagination*”; “*I found the process of progressing up the xylem and answering questions rather innovative and enjoyable. We actually had to rise up the xylem, which demanded a lot on scientific information, we recalled from Uncle Ben's teaching*”; “*Working together with my teammates to achieve much more, for instance, we would split ourselves into smaller groups, one*

*concentrating on creating food while the other two collect and transport it*". The overall rating for the learning experience was 5/7.

The TA offers the students a satisfactory learning experience. The novel learning activities that allow students to participate in experiences that are not possible in the real world have elicited positive interest in the VLE from the students. The TA is perceived as helpful by the groups of collaborating students.

## 5 Conclusions and Future Work

In this paper, we have explored the opportunity to assist learning scaffolding construction in collaborative learning with learning activities revolving around TAs. We have conducted a preliminary study of the prototype system in a secondary school in Singapore. The preliminary assessment on user acceptance and feedback on the effectiveness of the TA is encouraging. Additional field studies will be conducted in our future work to verify the effectiveness of the proposed TA more formally.

Nevertheless, there are still many research issues worth exploring for the novel use of agents to assist collaborative learning. In a socially complex learning environment such as a VLE, the emotions derived from the interactions with other people or autonomous entities, such as agents, is an important factor that can affect the learning experience and learning outcome of a student [7]. Therefore, it may be beneficial for agents in collaborative learning situations in such environments ~~to be~~ equipped with affective capabilities. These include incorporating emotional response to students' actions, inferring students' emotional states at runtime and eliciting desired emotional states from students by means of simulated emotions or verbal or visual stimuli. These issues will be further investigated in our subsequent studies.

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