

What Is Age's Affect in Collaborative Learning Environments?

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Abstract. In educational environments, the learners' affective state is the subject of continuous research that seeks to create the most effective learning environment. This state has been shown to have a direct correlation on the learners' motivation and engagement, subsequently affecting their success or failure. This is consistent for both physical and virtual educational settings. In intelligent tutoring systems, embodied pedagogical agents have been used for the many benefits they provide including their affective influence. The agents are designed based on specific criterion including competency, gender, ethnicity or behavioural tendencies, to optimise their effect on a targeted audience. We developed a web-based collaborative learning application that supports simultaneous learner-to-virtual agent and learner-to-learner interactions. We conducted a study that investigated the influence of virtual agents' physical characteristics (attributes), specifically age, on learners' experience and its' influence on learning outcome. The results revealed that the age of virtual agents is an important factor that must be considered in virtual tutor design.

1 Introduction

Bandura's Social Learning Theory states that people learn from one another through observation, imitation and modeling [5]. Research with human social models has shown that people tend to associate with and learn from others who share some cultural, economical, professional, educational or physical similarity. These social models can have a profound influence on people's attitudes, beliefs and behaviours [17]. Further research has demonstrated that people tend to apply human social rules to computer technologies [11,12]. Simulated social modelling is the deliberate attempt to develop virtual agents with similar characteristics as the targeted audience to influence beliefs and attitudes. Aided by the evidence that computer technology can be deployed as social actors [11] and that appearance is an important attribute for social modelling [14,7,8,17], virtual agents are increasingly being deployed as social actors within contextualized virtual environments. Additionally, virtual agents with limited computational ability have the same influence as computationally efficient agents when deployed as social actors [7,8,17,6,24].

We developed a web-based collaborative learning application with four pedagogical agents varied by gender (male, female) and age (younger, older). The

agents were designed to represent peer-like (similar age) and teacher-like (older) tutors of the students from a Introductory to Computer Science course. The students chose an agent and used the application to solved a study guide in preparation for an examination on programming concepts. As the students solved the questions on the study guide, they could engage with either the virtual agent or their class mates in dialogue using real-time synchronous communication. The communication among the students could be a private one-on-one conversation or a public conversation involving a group. The results show that the physical appearance of the agents had a significant influence in the choice of agent, regardless of the competency of the agent. A correlation between students perception of real-life teaching assistants and their virtual choice was observed, corroborating the previous findings that human social models transcend the virtual space. We found that age of the virtual agents affected the male participants more than the female participants as self-reported on a post-experiment questionnaire. The following sections describe related work using virtual agents as social models and the affect they have on their audience, followed by the implementation details of the collaborative learning environment. We then describe the study that was conducted and our results.

2 Related Work

The use of virtual agents as social models is an active area of research especially in intelligent tutoring systems. In MathGirls, Kim found that young female agents were favoured by high school girls and had positive impact on the girls' self-efficacy and attitude [14]. The study also found that girls who chose their agent had a larger effect compared to girls who were randomly assigned an agent for both measures. Similarly, research conducted at Florida State University in the Multiple Intelligent Mentors Instructing Collaboratively (MIMIC) agent-based environment concluded that both the presence of virtual agents as well as specific appearance-related characteristics significantly influenced female students' beliefs and attitudes towards engineering [17,8]. The agent models that were most similar to the students based on age, gender and coolness proved most effective in positively influencing the students stereotypes and self-efficacy. Within the same environment, physio-cultural similarities such as gender [24] and ethnicity [9] between agents and users consistently had a larger influence on users perception.

Dr. Chestr, a virtual game show host, was developed and deployed with a friendly approachable personality to which users were able to identify [1]. Results from that study concluded that Dr. Chestr's personality made him more realistic and improved users' mood and motivation to use the system as a study tool. Ryokai (et al) investigated the role of virtual peers in childrens literacy learning using storytelling. The virtual peer, designed to look like a child, engaged in collaborative storytelling with a user, but was developed with slightly advance narrative ability. The results showed that children who interacted with the virtual peer improved their linguistic capacity, using more advanced speech and expression [19]. Also, Tarturo (et al) used a virtual peer as an intervention for children with social and communication deficits. Their findings suggest that

contingent discourse and improved topic management were more likely to occur with a virtual peer than a human peer [21]. Lok's study showed that a dark skin-tone virtual agent elicited realistic responses and user behaviour consistent with real world skin-tone biases, based on a validated psychological instrument [18]. Medical students empathy towards a dark skin-tone virtual patient was significantly correlated to their measured bias towards African-Americans. Zanbaka found that virtual characters, modelled as cats, with human voices and virtual humans was equally effective at persuading real humans to believe the argument in a message [25]. She also found that humans reacted similarly to the social presence of a virtual human as they do a real human [26].

In the absence of research that investigates age, our study focuses on the variability of the physical attributes of virtual agents, specifically age, on the affective state and learner outcomes of both male and female participants in a collaborative learning environment.

3 Implementation

We developed an agent-based collaborative learning system with four virtual tutors varied by age and gender. The agents were designed to represent peer-like (similar age) and teacher-like (older) tutors of our targeted audience, university students. The agents were developed with SitePal[©] virtual host software which comes with several built-in functionalities including text-to-speech, lip synchronization, facial animation, and head movements [20]. They possessed similar, but neutral, personalities and behaviours, and displayed no differentiating emotions or behavioural traits. Figure 1 shows the four agents used in the system.



Fig. 1. Images of the four agents

The tutors were responsive agents that provided immediate informational feedback to the students upon request. Using a Wizard-of-Oz design, the agents' responses were controlled remotely by the actual teaching assistant for the lab session. Queries were made to the virtual agent using text and replies were converted from text to audio in real time. The reply of the virtual agent was also shown to the student in text due to the enclosed nature of the classroom - audio would prove disruptive. The peer-to-peer collaborative functionality of the system was implemented similar to an internet-based chat application. Figure 2 shows the communication path among the various modules of the system.

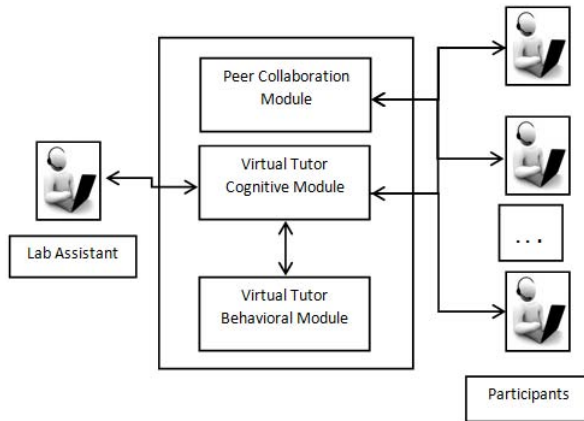


Fig. 2. Architecture

The students could freely navigate forward and backward through the study guide answering each question at their convenience. If they encountered a problem they could seek the assistance of the virtual agent, or alternately, seek the assistance of their peer. Figure 3 shows the user interface of the system with the male teacher selected.

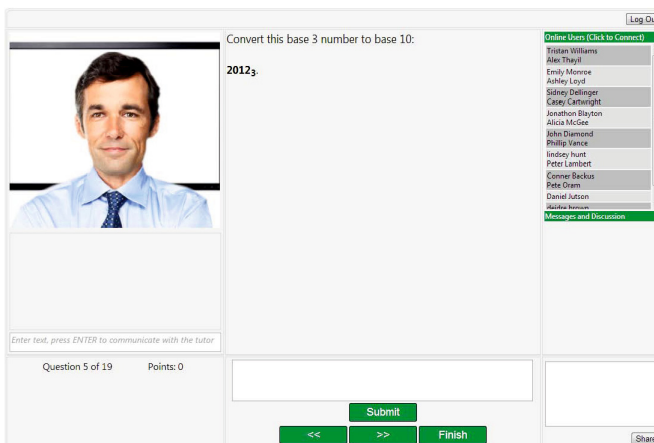


Fig. 3. The user interface of the system

4 Study

The experiment employed a 2 condition repeated measures factorial design. In the control condition (cc), participants were given a study guide to be solved

with the help of their teaching assistant. In the virtual condition (vc), participants were given a study guide to be solved with the help of a virtual tutor and their peers. The study was conducted over the course of two examinations approximately four weeks apart.

4.1 Participants

The participants were 364 (291 males & 73 females) students from a Computer Science class at the University of North Carolina at Charlotte. The study was conducted in a regularly scheduled lab session with the entire lab randomly assigned an experimental condition.

4.2 Procedure

There were 24 lab sessions, each consisting of approximately fifteen students and lasting one hour and forty five minutes. For the first examination half of the labs were randomly assigned to the control condition while the other half, by default, assigned to the virtual condition. The assignment of the labs were reversed for the second examination, therefore, each student was exposed to each condition once. In the control condition, the students solved the study guide led by their teaching assistant. This was an open discussion with students assisting each other by sharing knowledge with all queries amenable resolved. Upon completion, the students were asked to complete a post-experiment questionnaire that was an evaluation of the teaching assistant and the study session. In the virtual condition, participants chose one of the virtual tutors and proceeded to solve the study guide with the aid of the virtual tutor and their peers. At the beginning of the session, a member of the research team would give a brief introduction of the system including how to create an account, chose an agent, navigate the through the study guide, and interact with the virtual tutor and other students on the system. The lab sessions used pair programming with two students sharing a computer. Upon completion, the students were asked to complete a post-experiment questionnaire separately.

5 Results

5.1 Choice of Agent

The results revealed a significant difference in female participants' choice of agent, $\chi^2(3, N = 59) = 9.68, p < 0.05$, and male participants' choice of agent, $\chi^2(3, N = 210) = 91.73, p < 0.05$. Both subgroups showed a preference for the younger female agent, approximately 50%, with the other agents choices distributed among the other 50%. Additionally, 10% of the male participants preferred to work with the female teacher compared to 20% for female participants while 30% of male participants preferred the male teacher compared to 20% for the female participants. The percentage of participants who chose the male peer was equal across the subgroups.

5.2 Age and Gender Relationship

For the male participants, a Chi-square test of independence resulted in a significant relationship between their level of age (younger, older) and the age group of the virtual agents, $\chi^2(1, N = 210) = 3.4, p < 0.05$. While the older participants equally chose virtual peers and virtual teachers, the younger participants preferred the virtual peers. There was also a significant relationship between male participants level of age and virtual agents level of gender, $\chi^2(1, N = 210) = 5.23, p < 0.05$. Both older and younger male participants preferred the female agents. There was no significant relationship between female participants level of age and either virtual agents' level of gender or level of age.

5.3 Simulated Social Modelling

An independent samples T-test was done to compare participants who reported that they related better and felt more confident in a younger teaching assistant, and their choice of virtual agent. For the female participants, there was a significant difference in the mean of those that chose a virtual peer ($M = 3.4, SD = 0.6$), and those that chose a virtual teacher ($M = 2.9, SD = 0.5$), $t(57) = -2.1, p < 0.05$. Similarly, for the male participants, there was significant mean difference for those that chose a virtual peer ($M = 3.4, SD = 0.75$), and those that chose a virtual teacher ($M = 3, SD = 0.72$), $t(208) = -2.7, p < 0.05$.

A content analysis of the reason why participants chose their specific agent revealed that 50% chose based on an explicit appearance attribute, including the agent's gender, approachability, friendliness, or age. 43% chose at random and 7% did not specify. Of the participants who preferred the virtual teachers, 25% cited "more knowledge", "more intelligent", "smarter", and "more experience" as their reason. Of this group, 70% were male and 30% female.

5.4 Learning Outcome

A repeated measures T-test showed no difference between the control condition and the virtual condition. A one-way ANOVA showed no significant difference in the virtual condition between agent used.

6 Conclusion

We conducted a study that investigated the influence of virtual agents' physical attributes on learners' affective state and learning outcome in a collaborative learning environment. Four pedagogical agents were deployed as either virtual peer (similar age) or as a virtual teacher (older age) of our target audience, and varied by gender - female peer, male peer, female teacher, male teacher. The students of an Introductory Computer Science course were chosen as our participants. The participants were asked to solve a study guide in preparation for their examination. The results indicated that appearance was a key element

in the participants' choice of a virtual agent, even with limited computational functionality. Overall, participants preferred a young female peer over the other agents. The participants that chose a virtual peer (male or female), reported that they related better and had more confidence in a younger teaching assistant compared to an older teaching assistant. This confirms the theory that humans tend to apply social roles to the agents in a virtual space. Male participants were more affected by the age of the virtual agents. Those who chose a virtual teacher (male or female), ascribed more knowledge or more experience as the reason for their choice. The female participants' choice of agent was consistent with previous research that reported that females are more influenced by female agents who have similar attributes to which they can identify. Additionally, there was almost universal consensus on the virtual agent that was chosen although two participants shared a computer. There were ten participants who did not agree with the virtual agent that was chosen, however the choice of agent did not affect their experience in the environment.

7 Future Work

The virtual agents used in this study were designed to resemble the instructors and teaching assistants of our target audience, therefore they varied by clothes and hair color. This could have biased the choice of agents unfairly. In a future study we plan to eliminate all extraneous variability in appearance and investigate if the results are comparable with the more consistent features and our current results. The age of our audience could have been a factor in the distribution of virtual agent chosen, therefore a study will be conducted on a younger population to investigate if the results are age tolerant.

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