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Pedagogical Agents as Social Models to Influence Learner Attitudes

Yanghee Kim, Utah State University
Amy L. Baylor, Florida State University

Abstract. In this paper we propose the role of pedagogical agents as social models. We first framed our arguments in social cognitive perspectives and supported them with findings from several experimental studies we have conducted. In the studies, we found that learners perceived their agents socially and that the agents' social presence influenced the learner's cognitive and affective characteristics. Two on-going projects highlighting the agents' role as social models for enhancing females' motivation and attitudes toward math and engineering are briefly described.

We have consistently found that a particularly effective use of a pedagogical agent is as a "social model" to enhance learners' motivation and attitudes. Given that such affective characteristics enable the learner to face challenges, to engage, and to persist in learning, implementing pedagogical agents for this purpose is of great value. In that an individual's learning and cognitive development are inevitably rooted in the social context where the individual has been placed, his/her positive or negative attitudes towards the learning task may also be mediated by simulated social relations and social interactions. Social modeling research illustrates how the presence and role of others (in this case, that of an anthropomorphic pedagogical agent) can influence one's self-efficacy beliefs and social and intellectual functioning. Social modeling refers to psychological and behavioral changes that result from observing others in social contexts. Through vicarious experience and/or social interaction, learners acquire resources or expertise mediated through the social models.

For example, a pedagogical agent serving as a 'mastery model' may demonstrate positive attitudes towards the task and/or the desired levels of performance so that a learner can learn vicariously. Or an agent may work along with a learner as a companion (see Cassell & colleagues, and Goldman & colleagues, this issue) and even figuratively learn from the learner (see Schwartz & colleagues, this issue), serving as a 'coping model.' We first inquired into the design constituents of a pedagogical agent that would produce successful modeling effects. Relying on Bandura's (1997) concept of *attribute similarity* – that having similar personal characteristics of learner and social model is desirable, we (Kim & Baylor, in press) proposed seven design constituents important for a pedagogical agent serving as an effective social model: 1) agent competency, 2) interaction type, 3) affect, 4) gender, 5) ethnicity, 6) multiplicity, and 7) feedback. We have conducted several experimental studies examining the impact of varying permutations of the constituents on learners' perceptions, social judgments, and motivation.

Agent Competency and Interaction Type

We experimentally examined whether the levels of competency and interaction type of a pedagogical agent designed as a simulated peer would influence learners' self-efficacy beliefs in the task and their attitudes towards the agent and their learning as measured by recall and application (Kim *et al.*, 2006). Agent competency (high vs. low) was examined, in that the competency of a human social model often influences learners' self-efficacy and achievements (Schunk *et al.*, 1987). Also, the agent interaction types (proactive vs. responsive) were examined, given that the exercise of control over one's environment helps determine one's self-efficacy beliefs (Bandura, 1997). Participants, who were novices in the domain, wrote instructional plans to teach 6th graders the economic concepts of 'supply' and 'demand'. In the module, a simulated peer named Mike constantly stayed on the screen and served as a collaborating partner, providing information or suggestions to help learners perform the task. Because Mike was the only information source, the learners relied on Mike's comments to progress in the task. Figure 1 shows an example screen with Mike.

Figure 1. The agent Mike in the intervention.

The study showed that students who worked with high-competence Mike achieved higher scores in applying what they had learned and showed more positive attitudes towards the agent. This result was in line with instructional design guidelines, in that the information provided by high-competence Mike seemed to support their learning, which might subsequently enable the students to perceive him as being more helpful and more facilitating than low-competence Mike. Interestingly, students who worked with low-competence Mike reported significantly enhanced self-efficacy beliefs in the learning tasks. The novice learners in instructional design might evaluate their own abilities as relatively high and feel more confident in instructional planning when working with low-competence Mike. This phenomenon of increased self-efficacy after observing weak performances had been found in human social modeling research as well as other related pedagogical agent research (see Baylor, this issue). Also, the learners who worked with proactive Mike demonstrated higher recall of learning than did those with responsive Mike. This mirrors previous studies indicating that providing learner control is not always advantageous given learners' lack of meta-cognitive awareness of their learning needs.

Agent Affect

Through an experimental study, we examined whether an agent's empathic responses (responsive vs. non-responsive) to a learners' affective states would influence the learners' self-efficacy beliefs and interest (Kim, 2004). Participants included 56 pre-service teachers enrolled in an introductory educational-technology class. The learning task was instructional planning, processed in four main stages (Case study, Blueprints, Planning, and Assessment), in which the agent Chris served as an information provider. In between the stages, learners were asked to express their affective states at the moment by clicking an emoticon (i.e., icons expressing emotions). A panel of six emoticons appeared when the learners initiated a move to the next stage (see Figure 2). When the learners expressed their affect, the agent responded to it or not, according to experimental conditions.

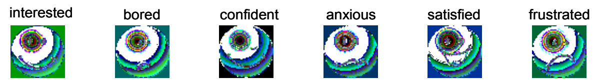


Figure 2. The emoticons.

Results indicated that students who worked with the responsive Chris showed significantly higher self-efficacy and higher interest in the task and in working with Chris than did students who worked with the non-responsive Chris.

Agent Ethnicity

In this study, we examined the effect of agent race (Caucasian vs. African-American) on college students' perceptions of agent persona (A. L. Baylor & Kim, 2003). Participants were 139 pre-service teachers enrolled in an introductory educational technology class in two large southeast universities. 59.7% of the participants were Caucasian and 40.3% were African-American. The learning task was instructional design, and the learning environment was similar to those of the previous studies described above. Four versions of agents were developed from one prototype agent face, as shown in Figure 3.

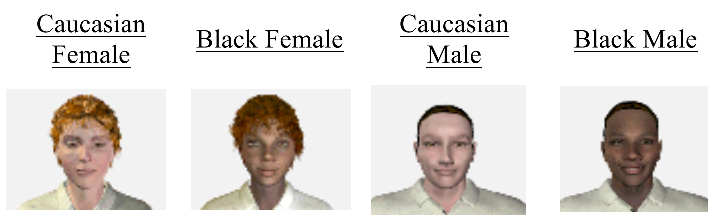


Figure 3. Agents differing by ethnicity and gender.

Results indicated an interaction between agent race and student race, in that students who worked with agents of their own ethnicity perceived the agents as more credible, more engaging, and more affable than did students who worked with agents of different ethnicity. This tendency appeared more strongly among African-American students than among Caucasian students. Also, both male and female African-American students reacted more positively to the agents, perceiving the agents as more affable, than did the male and female Caucasian students.

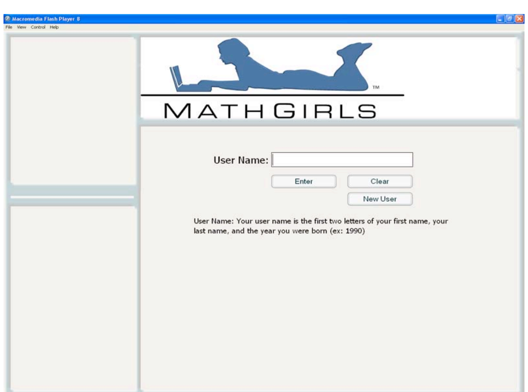
To summarize, a consistent theme of the reviewed studies is that a pedagogical agent is not just multimedia or a combination of texts, images, and animations. The agents in those studies were not intelligent; rather, they were very limited in their functionality and naturalness. Nonetheless, the agents influenced learners' motivations. The learners perceived the agents as if they were social entities, thus supporting the potential of pedagogical agents as social models in computing environments. Given the implications of the reviewed studies, we are now designing pedagogical agents to serve as role models to enhance females' attitudes towards STEM (science, technology, engineering, and math) in two separate projects.

MathGirls: Virtual Peers Help Improve Girls' Self-Efficacy in Learning Math (Supported by National Science Foundation, HRD-051503)

MathGirl is a web-based environment developed by the first author (Kim), where girls in high schools are able to practice algebra problem-solving anywhere in classrooms and at home. Many girls tend to hold beliefs that interfere with their learning of STEM and limit their pursuit of careers in those fields. The girls' negative beliefs seem attributable mainly to the social and cultural influences of family, friends, and teachers, which include low expectations for girls in STEM, less attention and intellectual encouragement to girls than boys in STEM classes, expectations that girls will be polite rather than active in class, and lack of role models. Studies indicate that girls' performances are often equal to or even better than those of boys in math and science during early school years. Through less-than-favorable educational experiences in traditional classrooms, girls are frequently imbued with gender-related stereotypes and may develop negative beliefs about their potential to learn STEM. To overcome these stereotypical negative beliefs, these girls need to be exposed to social environments that will encourage them to build constructive views of their competency and self-efficacy in STEM. Ultimately this is a societal issue, involving parents, teachers, and friends. However, with MathGirls, it is possible immediately to create virtual friends or teachers to help girls build positive attitudes toward STEM. MathGirls is engineered with pedagogical agents that serve as peer models, persuade the girls to be confident in learning math, and encourage the girls to build positive attitudes toward STEM.

Following the National/State Standards, the content was developed in collaboration with participating math teachers. The content consists of five lessons in which students practice problem-solving after learning the content from teachers in traditional settings. Lessons in MathGirls take one class period each, dealing in turn with Using real numbers (Lesson 1), Combining like terms (Lesson 2), Factoring (Lesson 3), Algebraic expressions and linear equations (Lesson 4) and Graphing linear equations (Lesson 5). Each lesson is divided into four or five sub-topics. Figure 4 presents example screens of MathGirls.

Log-in



Problem practice

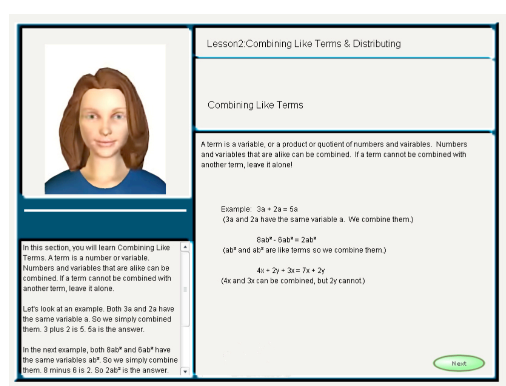


Figure 4. Screen excerpts of MathGirls.

Currently, MathGirls includes four agents (see Figure 5) for students to choose among. Based on literature, the functions of the agents were defined according to four sources of self-efficacy (Bandura, 1997) and three qualities of interactive process (Burgoon et al., 2000). For the girls' mastery experience, the agent will proactively provide information and knowledge intermittently while the girls progress from problem to problem. So when the girls are engaged in practice problems, they will be dependent on the agents' informational support. Girls will observe the agents confidently presenting information and solutions and may vicariously improve self-efficacy. The agents will provide social persuasion to cheer up a girl at the moment of failure in solving problems. For instance, when the learner makes a mistake, the agent may comment "Everyone makes mistakes sometimes. Just keep working on it and you'll get through it!" Also, in between sections, the agent offers positive messages about doing math well -- e.g., "Hey, a recent study showed that jobs that involve math pay much more than jobs that don't. So developing math skills is an investment in our future. Umm…another advantage of mastering math and science is the respect that people will have for us and that we'll have for ourselves. So… let's keep it up, okay?" The demeanors and talking styles of the agents were developed based upon observations of teachers and girls of similar ages in classrooms and literature on social psychology and communication.

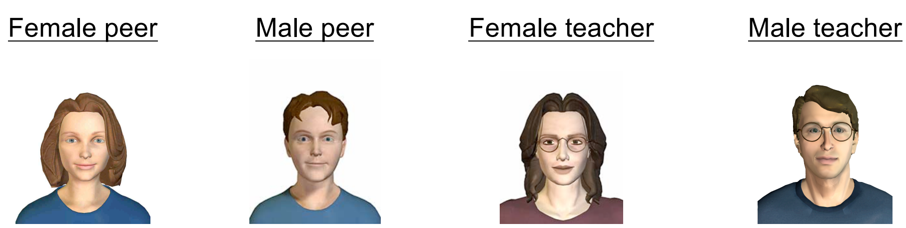


Figure 5. Agents differing by age and gender.

The initial implementations have been done with about 100 students, both male and female, from two high schools. Although, we are still analyzing data, the initial findings on student choice indicate that the majority of the students chose female agents as their learning partners: 45% of the students chose the female peer agent, 32.5% chose the female teacher agent, 20% chose the male peer agent, and 2.5% student chose the male teacher agent (χ^2 = 15.8, p<.01). This indicates that the students are seemingly expecting a type of social relationship with the agent. More information of this project can be obtained via http://www.create.usu.edu.

Pedagogical Agents as Social Models for Influencing Stereotypes toward Engineering (Supported by National Science Foundation, HRD-0429647)
Over the last two years, the second author (Baylor) has investigated the role of pedagogical agent appearance as an influence on young women's (middle school and undergraduates) stereotypic attitudes toward engineering as a potential career. With respect to appearance Baylor and colleagues (A. L. Baylor & Plant, 2005; A. L. Baylor *et al.*, 2006) have manipulated four social model features (attractiveness, "coolness" [operationalized by dress and hairstyle], gender, and age) to investigate their influence, holding message constant. When given a choice of 16 validated agents to represent

permutations of these four features (see Figure 6), as expected undergraduate women were significantly more likely to choose a female, attractive, young, and cool agent as "most like themselves" and as the agent they "most wanted to be like." However, they tended to select "male, older, uncool" agents as most like engineers (confirming the stereotype of an engineer), and, surprisingly, tended to choose to "learn about engineering" from agents that were male and attractive, but uncool.

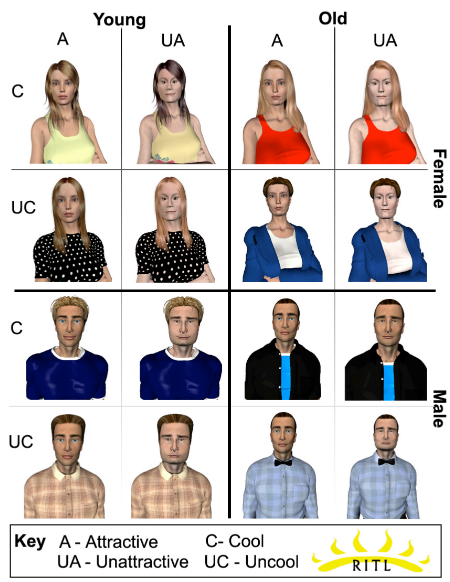


Figure 6. Agents differing by attractiveness, gender, age, and "coolness"

After receiving a 15-minute persuasive message from the chosen agent (see Figure 7), students' attitudes and motivation were positively impacted as compared to a control group.

Figure 7. Sample screen shot

Given that the attractive agents were more influential in this choice study, a large-scale experimental study was conducted with the eight attractive agents. Results revealed that participants reported more positive stereotypes of engineers after interacting with a female agent, perhaps because it challenged their existing beliefs of a typical engineer. In contrast, participants interacting with a male agent reported that engineering was more useful and engaging. An interaction of "coolness" and age indicated that agents who were young and "cool" (i.e., peer-like; similar to participants) and agents who were old and "uncool" (stereotypical engineers) were both most effective in enhancing self-efficacy toward engineering; thus, for self-efficacy, it appears that either the perception of similarity or expertise increased the effectiveness of the agent. With middle school females and males, results indicated that all responded significantly more positively to the female agent. Specifically, participants who received the message from the female agent compared to no agent reported more positive current and future efficacy regarding mathematics and rated science and mathematics as having greater utility. They were also more interested in pursuing a career in the sciences compared to students who had no agent. In addition, the participants with a female agent performed better on the mathematics problems than did participants in the control group. This suggests that for younger students, females may be more powerful role/social models overall, perhaps due to both parental influences and the fact that most K12 teachers are female. Currently, results are being evaluated as to the role of race (with Black participants), message (stereotypical versus self-efficacy focus). More information of this project can be obtained via http://ritl.fsu.edu .

Conclusion

We ground the instructional application of pedagogical agents in social/cognitive perspectives, finding that to be a useful framework to describe the effectiveness of pedagogical agents as social models. Ample research indicates that learners perceive and interact socially with pedagogical agents even when their functionality and adaptability are limited. Unlike traditional computer-based learning that may be limited to learners' cognitive changes, an anthropomorphic pedagogical agent can socially interact with a learner to enhance motivation and engage the learner in learning tasks, much as human teachers and peers. In this sense, pedagogical agents may extend the horizon of conventional computer-based learning and could be defined as *social-cognitive tools*. Pedagogical agents serve to build social relations, model new beliefs and attitudes, and share empathy, thus enabling learners to demonstrate more skillful performances and positive attitudes.

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