Pedagogical agent design: The impact of agent gender, ethnicity, and instructional role

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The Impact of Agent Gender, Ethnicity, and Instructional Roles

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Abstract: To investigate the role of pedagogical agent gender and ethnicity, 230 students were randomly assigned to one of twelve conditions, where agents differed by ethnicity (African-American, Caucasian), gender (male, female), and roles (expert, motivator, and mentor). Results indicated.

Introduction

The social cognitive perspective in teaching and learning emphasizes the role of social interaction (Lave & Wenger, 2001; J. Piaget, 1962; L. Piaget, 1995; Vygotsky, Cole, John-Steiner, Scribner, & Souberman, 1978). Learning is a social process in nature; learning occurs when learners interact with teachers, peers, and materials provided in the contexts. At the same time, agent technology has been shifting their view of systems “from tools to actors” (Persson, Laaksolahti, & Lonnqvist, 2002) and puts an emphasis on building social relations to learners (e.g., socially intelligent agents). In this sense, intelligence of technology can be accomplished when it encompasses the social aspects of mind and functions in the real life.

The social empathic relations between pedagogical agents and learners could be strengthened when the agents look similar as learners. According to Bandura (1997), attribute similarities between a social model and a learner, such as gender, ethnicity, and competency, often have predictive significance for the learner’s efficacy beliefs and achievements. Similarly, pedagogical agents of the same gender or ethnicity or similar competency as learners’ might be viewed as more affable and could instill strong efficacy beliefs and behavioral intentions to learners. Learners may draw positive judgments about their capabilities when they observe those agents who demonstrate successful performance.

As regard to gender, gender difference in academic interest and cognitive and interaction styles have persisted over time and become more salient in educational computing (Cooper & Weaver, 2003). Boys performed better in non-interactive and low-intrusive hints, whereas girls performed better in highly interactive hints (Arroyo, Beck,
Woolf, Beal, & Schultz, 2000). Also, girls were more sensitive to help messages than boys (Arroyo, Murray, Woolf, & Beal, 2003). Gender difference was clearly manifested in students’ preferences in multimedia interfaces (Passig & Levin, 2000). Boys put the first priority on navigational support and control, whereas girls put the priority to display, such as color and appearance. Baylor and Kim (2003b) found that agents’ gender interacted with learners’ gender on learners’ attitudes toward agents in pedagogical agent-based environments. College students perceived male agents as more instructor-like and preferred to learn from male agents than female agents. Also, Moreno and colleagues (2002) revealed that learners applied gender stereotypes to animated agents, and this stereotypic expectation affected their learning.

Regarding the ethnicity of pedagogical agents, empirical results do not provide consistent results. In both a computer-mediated communication and an agent environment, participants who had similar-ethnicity partners than those who had different-ethnicity partners presented more persuasive and better arguments; elicited more conformity to the partners’ opinions; and perceived their partners as more attractive and trustworthy (Lee & Nass, 1998). In their study, Baylor and Kim (2003b) examined the impact of pedagogical agents’ ethnicity on learners’ perception of the agents. Undergraduate participants who worked with pedagogical agents of the same ethnicity rated the agents as more credible, engaging, and affable than those who worked with agents of different ethnicity. However, Moreno and colleagues (2002) indicated that the ethnicity of pedagogical agents did not influence students’ stereotypic expectations or learning.

Pedagogical agents are often designed to adopt various human metaphors to enhance instructional impact, such as expert, instructor, mentor, learning companion, and so on. In social psychology, social relationships – with parents, teachers, and peers – influence learners’ perceptions and understanding in general (Dunn, 2000). In classrooms, learners are more aware of and develop social empathetic relationships with friends than teachers. In a similar fashion, the instructional roles of the pedagogical agents may influence the perceptions or expectations of and the social bonds with learners. Along this line, Baylor and Kim (2003c) showed that the distinct roles of pedagogical agents as expert, motivator, and mentor significantly influenced learners’ perceptions of agent persona, self-efficacy, and learning.

Lastly, Norman (1994; 1997) expressed some concerns about human-like interface. If interface is anthropomorphized too realistically, people tend to form unrealistic expectations. That is, too realistic human-like appearance and interaction can be deceptive and misleading by implying the promises of functionality that can be never reached. On the other hand, socially intelligent agents are of “no virtual difference” from humans (Vassileva, 1998), and provoke “illusion of life” (Hays-Roth & Doyle, 1998), and thus impress the learners interacting with “living” virtual being (Rizzo, 2000). So we may inquire how realistic agent images should be to establish social relations to learners. Norman argues that people will be more accepting of intelligent interface when their expectation matches with its real functionality. But, what extent of agent realism will match learners’ expectations with agent functionality is an open question.

As seen, the gender, ethnicity, instructional roles, and realism of pedagogical agents seem to play a role to ensure agents to establish social relations with learners and to increase learners’ self-efficacy. Yet, the effects of these factors and their interactive
relationships need empirical validation. Thus, the purpose of the study was to examine the relationships of agent gender, ethnicity, instructional roles, and realism of pedagogical agents on learners’ perception of agent persona and self-efficacy beliefs. The study was conducted in two controlled experiments. Experiment I examined the impact of agent gender, ethnicity, and realism; Experiment II examined the impact of agent gender, ethnicity, and instructional roles.

**Experiment I**

**Agent Development**

**Design**

Four agent images were designed by a graphic artist based on the same basic face, but differing by gender and ethnicity. The animated agents were then developed using a 3D character design tool, Poser 5, and Microsoft Agent Character Builder. Next, the agents were incorporated into the web-based research application, MIMIC (Multiple Intelligent Mentors Instructing Collaboratively) (Baylor, 2002). To control confounding effects, we used consistent parameters and matrices to delineate facial expression, mouth movement, and overall silhouettes across the agents. Also, except for image, the agents were consistent with script, voice, animation, and emotion. For voice, we used computer-generated male and female voices. For animation, blinking and mouth movements were included. Emotion was expressed using the scripts together with facial expression, such as smiling. Figure 1 presents the images of the four agents used in the study.

<table>
<thead>
<tr>
<th>Realistic Caucasian Female (RCF)</th>
<th>Realistic African-American Female (RAF)</th>
<th>Realistic Caucasian Male (RCM)</th>
<th>Realistic African-American Male (RAM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="RCF" /></td>
<td><img src="image2" alt="RAF" /></td>
<td><img src="image3" alt="RCM" /></td>
<td><img src="image4" alt="RAM" /></td>
</tr>
<tr>
<td><img src="image5" alt="RCF" /></td>
<td><img src="image6" alt="RAF" /></td>
<td><img src="image7" alt="RCM" /></td>
<td><img src="image8" alt="RAM" /></td>
</tr>
</tbody>
</table>

**Figure 1:** Images of eight agents

**Validation**
We initially validated that each agent was effectively representing the intended gender and ethnicity with 83 undergraduates in a between-subjects design. The results indicated successful instantiations of the four agents which simulated each intended population respectively. Female agents (M=3.0, SD=1.1) were perceived as significantly more feminine than male agents (M=1.71, SD=.71). Male agents (M=4.02, SD=0.82) were perceived as significantly more masculine than female agents (M=1.57, SD=1.64). Caucasian agents (M=3.1, SD=1.1) were perceived as significantly more Caucasian than African-American agents (M=1.84, SD=1.81). African-American agents (M=4.12, SD=1.16) were perceived as significantly more African-American than Caucasian agents (M=2.451, SD=1.19).

Method

Dependent Measure and Analysis

The six dependent variables included agent persona, agent personality, affability, satisfaction, self-regulation, and learning. Agent persona was measured by Agent Persona Instrument (Baylor & Ryu, 2003a), which includes 4 sub-measures: Facilitating learning (10 items), Credible (5 items), Human-like (5 items), and Engaging (5 items). Agent personality were measured according to the Big Five Personality Traits (McCrae & John, 1992), including Open to new things, Conscientious, Extraverted, Agreeable, and Neurotic. Agent affability was measured by three items (nice, attractive, and personally warm). Satisfaction was measured by a question asking how much the students were satisfied with their performance. For self-regulation, the students rated their reflective and self-monitoring behaviors on two items. The scale of the measures and sub-measures ranged on a Likert scale from 1 (Strongly disagree) to 5 (Strongly agree). Learning was measured by open-ended recall and transfer posttests.

The study used a three-factorial design: 2 (agent gender) × 2 (agent ethnicity) × 2 (agent realism). MANOVA was conducted to analyze each sub-measure of agent persona and agent personality, affability, satisfaction, and self-regulation, and learning respectively. Alpha was set as .05.

Participant

Participants included 312 pre-service teachers enrolled in an introductory educational technology class in two large southeast universities in the United States. Approximately 30% of the participants were male and 70% were female; 53% of the participants were Caucasian, 33% were African-American, and 14% were others. The average age of the participants was 20.54 (SD=2.63).

Procedure

The experiment was conducted during a regular session of an introductory educational technology course. The participants were randomly assigned to one of the eight agent conditions. They logged on the web site loading MIMIC (Multiple Intelligent Mentors Instructing Collaboratively), which was designed to help the students develop instructional planning. The participants were given as much time as they needed to finish each phase of the tasks. The entire session took about an hour with individual variations.
Results

Experiment II

Agent Development

Twelve agents differing by gender, ethnicity, and roles were designed using a 3D character design tool, Poser 5 and Mimic Pro 2. For gender, male and female agents were designed. For Ethnicity, Caucasian and African-American agents were designed. For roles, expert, motivator, and mentor agents are defined first and development. Each agent had a viable persona to represent the intended population.

To operationalize the twelve agents, we focused on both the media features as well as functionality. In terms of media features, researchers argue for the importance of agent image, animation, affect, and voice in impacting perceived agent persona. Image is a key factor in affecting the learners’ perception of the computer-based agent as credible (Baylor & Ryu, 2003b) and motivating (Baylor & Kim, 2003a; Baylor, Shen, & Huang, 2003; Kim, Baylor, & Reed, 2003). Animation includes body movements such as hand gestures, facial expression, and head nods, which can convey information and draw students’ attention (Cassell, 1998; Johnson, Rickel, & Lester, 2000; McNeill, 1992; Roth, 2001). Affect, or emotion, is also an integral part of human intellectual and cognitive functioning (Kort, Reilly, & Picard, 2001; Picard, 1997) and thus was deemed as critical for facilitating the social relationship with learners and affecting their emotional development (Saarni, 2001). Finally, voice is a powerful indicator of social presence (Nass & Steuer, 1993), so the human voices were recorded to match the voices with the gender, ethnicity, and roles of each agent and with their behaviors, attitudes, and language.

The agent-student dialogue was pre-defined to control for agent functionality across students. The agent scripts were developed according to research on human experts, motivators, and mentors, and reflected the given perspective in the content domain of instructional planning for e-learning (the focus for this study). Lastly, the agents were incorporated into the web-based research application, E-Learning. Figure 1 shows the images of the twelve agents.

<table>
<thead>
<tr>
<th>Experts</th>
<th>Motivators</th>
<th>Mentors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian Female (ExCF)</td>
<td>African-American Female (ExAF)</td>
<td>Caucasian Female (ExCF)</td>
</tr>
<tr>
<td>Caucasian Male (ExCM)</td>
<td>African-American Male</td>
<td>Caucasian Male (MoCM)</td>
</tr>
</tbody>
</table>

![Image of agents](image-url)
Role Operationalization

Given that people tend to apply the same social rules and expectations from human-human interaction to computer-human interaction (Reeves & Nass, 1996), we referred to research on human instructors for implications for the agent role design.

Agent as Expert. The design of the Expert was based on research that shows that the development of expertise in humans requires years of deliberate practice in a domain (Ericsson, Krampe, & Tesch-Romer, 1993), and experts exhibit mastery or extensive knowledge and perform better than the average within a domain (Ericsson, 1996; Gonzales, Burdenski, Stough, & Palmer, 2001). Also, experts will be confident and stable in performance and not swayed emotionally by instant internal or external stimulation. Based on this, we operationalized the expert agent through the image of a professor in forties. His animation was limited to deictic gestures, and he spoke in a formal and professional manner, with authoritative speech. Being emotionally detached from the learners, his function was to provide accurate information in a succinct way (see sample script in Table 2).

Agent as Motivator. The design of the Motivator was based on social modeling research dealing with learners’ efficacy beliefs, a critical component of learner motivation. According to Bandura (1997), attribute similarity between the learner and social model significantly affects the learners’ self-efficacy belief. In other words, learning and motivation are enhanced when learners observed a social model of the same age (Schunk, 1989). Further, verbal encouragement in support of the learner performing a task facilitates learners’ self-efficacy beliefs. Thus, we operationalized a motivator agent with a peer-like image of a casually-dressed student in his twenties, considering that our target population was college students. Given that expressive gestures of pedagogical agents may have a strong motivating effects (Johnson et al., 2000), the agent gestures were expressive and highly-animated. He spoke enthusiastically and energetically, while sometimes using colloquial expressions, e.g., ‘What’s your gut feeling?’ He was not presented as particularly knowledgeable but as an eager participant who suggested his own ideas, verbally encouraged the learner to sustain at the tasks, and, by asking questions, stimulated the learners to reflect on their thinking (see sample script in Table 2). He expressed emotion that commonly occurs in learning, such as frustration, confusion, and enjoyment (Kort et al., 2001).

Agent as Mentor. An ideal human mentor does not simply give out information; rather, provides guidance for the learner to bridge the gap between the current and
desired skill levels (Driscoll, 2000). Thus, a mentor should not be an authoritarian figure, but rather a guide or coach with advanced experience and knowledge that can work collaboratively with the learners to achieve goals. Thus, the agent as mentor should demonstrate competence to the learner while simultaneously developing a social relationship to motivate the learner (Baylor, 2000). Consequently, the design of the Mentor included an image that was less formal than the Expert, yet older than the peer-like Motivator. The Mentor’s gestures were designed to be identical to the Motivator, incorporating both deictic and emotional expressions. His voice was friendly and approachable, yet more professional and confident than the Motivator. We operationalized the Mentor’s functionality to incorporate the characteristics of both the Expert and Motivator, (i.e., to provide information and motivation); thus, his script was a concatenation of the content of the Expert and Motivator scripts.

Validation
We initially validated that each agent was effectively representing the intended gender, ethnicity, and roles with 174 undergraduates in a between-subjects design. The results indicated successful instantiations of the twelve agents which simulated each intended population respectively.

Method

Dependent Measure and Analysis

Participant
Participants included 229 undergraduates enrolled in a computer literacy course in a large southeast university in the United States. Approximately 39% of the participants were male and 61% were female; 70% of the participants were Caucasian, 10% were African-American, and 20% were others. Approximately 39% of the participants were male and 61% were female. The average age of the participants was 19.39 (SD=1.64).

Procedure
The experiment was conducted during a regular session of a computer literacy class. The participants were randomly assigned to one of the twelve agent conditions. They logged on the web site loading E-Learning, which was designed to help the students develop instructional planning for an e-learning course. The participants were given as much time as they needed to finish each phase of the tasks. The entire session took about an hour with individual variations.

Results

Discussion

References


