

Empathetic Virtual Peers Enhanced Learner Interest and Self-Efficacy

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Abstract. This study investigated the effects of empathetic response (responsive vs. non-responsive) and gender (male vs. female) of pedagogical agents as learning companions (PALs) on learner interest, self-efficacy, social judgments of PAL persona, and learning. Fifty-six pre-service teachers were randomly assigned to one of four conditions. The results revealed that students who worked with a PAL who responded with empathy to learners' affect showed significantly higher interest ($p < .05$) and self-efficacy in the tasks ($p < .05$) than students with a non-responsive PAL. Also, students rated the persona of a male PAL more favorably than that of a female PAL ($p < .05$). The findings imply that PAL/learner relationships in computer-based learning might be consistent with human relationships in traditional classrooms.

Keywords. Pedagogical agents, Learning companions, Virtual peers, Motivation

Introduction

Social interaction among participants in learning contexts is seen as the primary source of cognitive and social development of learners [1]. This emphasis on social interaction for learning and cognition might suggest reframing the conventional design of educational software and adopting a new metaphor: computers as interacting partners. Along this line, pedagogical agents can facilitate social interaction in computer-based learning. Pedagogical agents are in general defined as animated life-like characters [2]. Social presence and social interaction may make pedagogical-agent-based environments unique from the conventional courseware. In particular, pedagogical agents as learning companions (PALs) are a specific use of pedagogical agents. PALs as virtual peers may be able to simulate peer interaction in traditional classroom and help learners attain the cognitive and affective gains in human peer-mediated learning.

To build social relations with learners, desirable pedagogical agents should be humanlike and have personas [3]. Similarly, to facilitate social interaction, PALs might need to be perceived as believable virtual peers. To make them believable, a crucial feature may be the PALs' capabilities to demonstrate affect [4].

Affect is an essential part of social cognition, allowing us to function successfully in daily social and intellectual life. It is well documented that affect influences our memory, decision-making, and information processing. In classrooms, the affective states of teachers and peers function as social contexts to influence learners' self-efficacy, motivation, cognitive gains, and behaviors [5, 6]. Also, gender difference manifests in affective expressions, empathetic accuracy, and affective behavior [7]. This affect/gender interaction becomes more salient in peer relationships than in learner/adult relationships. This impact of affective interaction among participants in traditional classroom may be applied to

PAL/learner relations [8]. Given that human/computer interaction is consistent with human-to-human interaction, it is plausible that learners may build empathetic relationship and emotionally interact with PALs in computer-based learning and that the empathetic interactions might be differentiated by PAL gender.

Very few studies have been done in this regard. Although some research on affective computing was conducted in gaming environments [9, 10], it is not clear that the findings from those studies might be generalized to learning environments consistently. Thus, this study was aimed at investigating whether gender and empathetic response of PALs would influence learners' affective and cognitive characteristics similarly to human relationships in conventional classrooms. A controlled experiment was designed to examine the impact of the empathetic response and gender of PALs on learner interest, self-efficacy, social judgments, and learning.

Method

1. Participants

Participants were 56 pre-service teachers enrolled in an introductory educational technology class in a large public university. The intervention was implemented as a mandatory course activity. About 80% of the participants were female; 20% were male. The average age of participants was 20.71 ($SD = 2.92$).

2. Materials

2.1. Instructional Intervention

The learning task was instructional planning, processed in five main stages--Introduction, Case Study, Blueprints, Plan, and Assessment--in each step of which PALs provided learners with context-specific information and suggestions. The stages were indicated by large buttons located at the top of the screens. Introduction briefly explained the learners' task. Case study described a scenario to teach Anna, a sixth grader, the economic concepts of supply and demand. In Blueprints, the participants wrote instructional goals or objectives in a text-box field. As additional information, two links were provided regarding Texas Standards and Benchmarks for supply and demand. In Plan, the participants wrote instructional strategies and activities. In Assessment, the participants described the assessment plans to test Anna's learning.

2.2. PAL Design

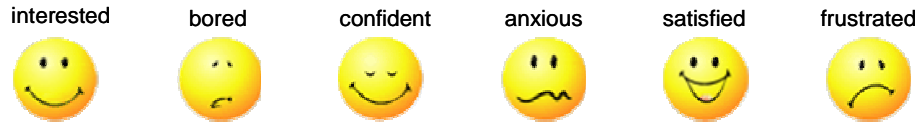
The PALs were developed using Poser 5, a 3D-image/animation-design tool, and Mimic Pro 2, a voice/affect-editing tool. The animation files created in Poser 5 were converted to Macromedia Flash movies for compression and were later integrated into the instructional intervention. The PALs, Chris, (one version male, one female) were designed to look about twenty years old, casually dressed and speaking informally, sometimes using slang. Male and female voices of college students were recorded. The participants estimated the PALs' age as an average of 20.39 ($SD = 7.94$).

2.3. Learners' Expressions of their Emotions

In between the stages, learners expressed their affective states at the moment by clicking an emoticon (i.e., icons expressing emotions). Six emotional states that typically occur in learning situations were derived from classroom emotion/motivation research and Affective Model suggested in Affective Computing Group [11]: interest, boredom, confidence, anxiety, satisfaction, and frustration. A panel of six emoticons appeared when the learners

attempted to move to the next stage. When the learners expressed their affect, the PAL responded to it or not, according to experimental conditions. Figure 1 shows the six emoticons.

Figure 1. Emoticons



3. Independent Variables

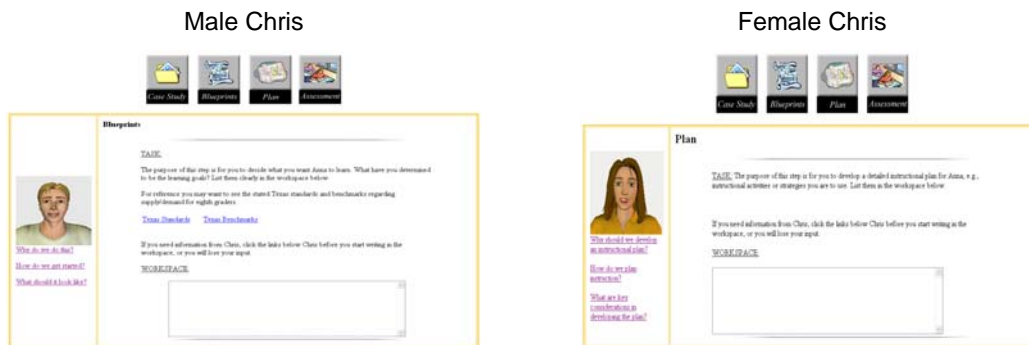
3.1. Empathetic Response

Empathetic response, i.e., whether the PAL responded with empathy to the learners' affect, was categorized as responsive or non-responsive. In the responsive condition, when a learner expressed his/her affect by clicking any of the emoticons, the PAL immediately responded to the learner's affect by verbal expressions. The affective responses were brief and did not affect the overall instruction time. In the Non-responsive condition, the PAL did not respond when the learner expressed affect. The module simply led the learner to the next phase. In both conditions, the amount of information provided by the PAL was identical.

3.2. Gender

Either a male or female PAL, each named Chris, was included depending on experimental conditions. Figure 2 presents the male and female PALs in the intervention.

Figure 2. The male and female PALs



4. Dependent Variables

4.1. Learning

The author was interested in examining the learners' engagement in interactions with the PAL, speculating that if learners were more engaged, they would recall more of the ideas presented by the PAL. Thus, learning was measured by an open-ended posttest question. Students were asked to write all the ideas and information that the PAL had conveyed about instructional planning. The number of legitimate ideas in the students' answers was counted and coded by two instructional designers. Inter-rater reliability was evaluated as Cohen's $Kappa = .94$.

4.2. Interest

Interest referred to learners' disposition toward working with the PALs and toward the task of instructional planning. Based on Anderson and Bourke's guidelines [12], a questionnaire with seven items was scaled from 1 (Strongly disagree) to 5 (Strongly agree): 1) How much are you interested in designing a lesson plan for E-learning? 2) How much are you interested in learning about designing a lesson plan for E-learning? 3) I was interested while doing the task, 4) I was attentive while doing the task, 5) I was absorbed while doing the task, 6) I was interested while working with Chris, and 7) I was attentive while working with Chris. Item reliability was assessed as coefficient $\alpha = .87$. Learner interest was measured before and after the intervention to control for prior interest.

4.3. Self-Efficacy

Self-efficacy referred to learners' belief about their competency in the task of instructional design. Based on the guidelines from previous research [13], a questionnaire with five items was scaled from 1 (Strongly disagree) to 5 (Strongly agree): 1) How well can you write a lesson plan? 2) How sure are you that you can design a good lesson plan? 3) I can write a lesson planning on a topic of my subject, 4) I am confident in designing a lesson plan, and 5) I am competent in designing a lesson plan. Item reliability was evaluated as coefficient $\alpha = .95$. Learners' self-efficacy beliefs were measured before and after the intervention to control for prior self-efficacy.

4.4. Social judgments

Social judgments referred to learners' judgments about the attributes of PALs as their learning partners [14]. Learners' social judgments were measured by a questionnaire consisting of three sub-measures: Facilitating learning, Human-like, and Engaging. Facilitating learning included 4 items: 1) Chris led me to think more deeply about the presentation. 2) Chris encouraged me to reflect what I was learning. 3) Chris kept my attention, and 4) Chris presented the material effectively. Item reliability was evaluated as coefficient $\alpha = .91$. Human-like included 3 items: 1) Chris has a personality, 2) Chris' emotion was natural, and 3) Chris was human-like. Item reliability in each category was evaluated as coefficient $\alpha = .73$. Engaging included 4 items: 1) Chris was expressive, 2) Chris was enthusiastic, 3) Chris was motivating, and 4) Chris was friendly. Item reliability was evaluated as coefficient $\alpha = .81$. All items were scaled from 1 (*Strongly disagree*) to 5 (*Strongly agree*).

5. Procedure

The experiment was integrated as a class activity during a regular session. Participants were randomly assigned to one of four conditions by system programming. The participants logged on to the web-based instructional module. First, they entered demographic information. They then answered pretest questions, taking as much time as they needed. After that, they answered posttest questions. The session took approximately one and half hours, with individual variations.

6. Design and Analysis

The study employed a 2×2 factorial design. For learning, two-way ANOVA was conducted. For interest and self-efficacy, MANCOVA was conducted, with pretest interest and self-efficacy as covariates. For social judgments with three sub-measures, MANOVA was conducted. The significant level was set at $\alpha < .05$.

Results

1. Learning

There were no significant main and interaction effects for empathetic response and gender on learning.

2. Interest

The overall MANCOVA revealed a significant main effect for PALs' empathetic response: Wilks' Lambda = .53, $F(5, 20) = 3.54$, $p < .05$, partial $\eta^2 = .47$. Students who worked with the responsive PAL showed significantly higher interest toward the task and the PALs than students who worked with the non-responsive PAL.

3. Self-Efficacy

The overall MANCOVA revealed a significant main effect for PALs' empathetic response: Wilks' Lambda = .71, $F(3, 31) = 4.29$, $p < .01$, partial $\eta^2 = .29$. Students who worked with the responsive PAL showed significantly higher self-efficacy than students who worked with the non-responsive PAL.

4. Social Judgments

The overall MANOVA revealed a significant main effect for PALs' gender: Wilks' Lambda = .85, $F(3, 46) = 3.08$, $p < .05$, partial $\eta^2 = .15$. To identify the contribution of each sub-measure to the overall effects, univariate analyses (ANOVA) were conducted.

The results revealed a significant main effect for PAL gender on "facilitating learning": $F(1, 48) = 3.8$, $p < .05$. Both male and female students who worked with the male PAL ($M = 3.56$, $SD = .64$) perceived the PAL as significantly more facilitating to their learning than students who worked with the female PAL ($M = 3.14$, $SD = .82$). The standardized effect size for this difference was Cohen's $d = 0.57$, which indicated a medium effect according to Cohen's guidelines.

The univariate results revealed a significant main effect for PAL gender on "human-like": $F(1, 48) = 6.95$, $p < .05$. Students who worked with the male PAL ($M = 3.59$, $SD = .52$) perceived the PAL as significantly more human-like than students who worked with the female PAL ($M = 3.14$, $SD = .69$). The standardized effect size for this difference was Cohen's $d = 0.74$, which indicated a medium-large effect.

The results revealed a significant main effect for PAL gender on "engaging", $F(1, 48) = 4.11$, $p < .05$. Students who worked with the male PAL ($M = 3.79$, $SD = .52$) perceived the PAL as significantly more engaging than students who worked with the female PAL ($M = 3.51$, $SD = .43$). The standardized effect size for this difference was Cohen's $d = 0.59$, which indicated a medium effect. There was no significant effect for affective response on agent persona.

Discussion

This study examined whether the empathetic response and the gender of a PAL influenced learners' affect and cognition. The results supported the positive impact of the PAL's

affective response on both interest and self-efficacy. Students were more interested in the task and the PALs and showed higher self-efficacy beliefs in the task when the PAL was empathetic to their affect than they did when the PAL was not empathetic. These results were parallel with the findings of human emotion research in classrooms. When students understood that their teachers cared about them, the students' motivation and self-concept were improved [15]. In the same fashion, when the PALs expressed care about the learners' affective states by verbally responding with empathy, the learners' interest and self-efficacy were enhanced. These affective gains from affective response were demonstrated in a gaming environment as well. Klein and colleagues [10] reported that users in a computer game stayed longer in the game when they received affective support by the computer. This positive impact of affective response may provide an implication for the design of PAL affect for learner motivation. To be effective, PAL affect should be tied to the learner's affect when possible. Rather than being simply a "happy" talking head, a PAL should respond to or deal with the learner's affect and flexibly adapt its affect to the learner's in order to motivate the learner.

However, the presence of PAL affective response did not influence learning. There was no statistically significant difference on learner recall between responsive and non-responsive PALs. This result confirms the current knowledge of affective pedagogical agents research, which has supported the impact of agents on motivation but not on learning [16, 17]. It should be further investigated why enhanced motivation fail to bring enhanced learning. The one-time implementation might be a reason. Many affective computing studies are typically conducted on a short-term basis, unlike the classroom-based research that indicated a significant impact of affective interaction on both learners' affective and cognitive outcomes. Social relations seems to be built over time; fostering virtual relations may require even more time. Long-term research may expand our understanding. Also, learning in the current study was measured simply by recall. However, the benefits of social empathetic interaction might be better exercised in learning transfer [18] or higher-order learning, such as reflective thinking and making a solid argument.

At any rates, the inconsistent impact of PAL affect on motivation and learning might suggest judicious implementation of agent emotions. Typically, in instructional settings, there are different goals and emphases, which might focus more or less on cognitive skill acquisitions or on affective gains. Given the findings of the current and previous studies, PAL affect can be effectively utilized in the context emphasizing motivational and attitudinal changes, but not necessarily in the context where knowledge and skill acquisition is the sole issue.

Regarding PALs' gender, the results support the positive impact of a male PAL on learners' social judgments of PAL persona. Both male and female students perceived the persona of the male PAL more favorably than that of the female PAL. This result indicated that PAL/learner relations might reflect the stereotypic expectations in the real world. Men are generally more influential than women [19], perceived to possess a higher level of expert and legitimate power [20]. In a similar fashion, the male PAL was perceived as more facilitating to learning, more human-like, and more engaging than the female PAL even though they provided identical informational and emotional support. Future research should examine how to overcome this infusion of real-world stereotypic expectations to computing environments.

Lastly, there were some limitations in the study. The measures of interest and self-efficacy relied solely on self-report. Brody [7] argued that affective experience is a feeling state known only to the individual; thus, the best way to really measure experience might

be to ask people to think about their feeling states. However, Brody also pointed out that people may not want to articulate socially unacceptable feelings to others. In order to gather more accurate information on learners' affective states, we may employ multiple methods to complement this study, including advanced technology to sense learners' emotional states [21]. Second, Given that voice is a significant indicator of social presence [22, 23], the PAL's interactions with learners were all scripted in order to include human voices, thus not allowing adaptive response. Further elaborated studies including PAL intelligence in emotional interactions are invited. Lastly, the study was conducted through one-time implementation. It is open to question whether the impact of PALs on interest and self-efficacy would sustain in the long term as well. Future research may be complement the limitations of the current study to confirm the findings.

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