Pedagogical Agents as Learning Companions: Building Social Relations with Learners

Yanghee Kim

Department of Instructional Technology, Utah State University,
2830 Old Main Hill, Logan, UT 84322, USA

Abstract. This study examined the potential of pedagogical agents as learning companions (PALs) to build social relations with learners and, consequently, to motivate learning. The study investigated the impact of PAL affect (positive vs. negative vs. neutral), PAL gender (male vs. female), and learner gender (male vs. female) on learners' social judgments, motivation, and learning in a controlled experiment. Participants were 142 college students in a computer-literacy course. Overall, the results indicated the interaction effects of PAL affect, PAL gender, and learner gender on learners' social judgments ($p < .001$). PAL affect impacted learners' social judgments ($p < .001$) and motivation ($p < .05$). PAL gender influenced motivation ($p < .01$) and recall of learning ($p < .05$). Learner gender influenced recall of learning ($p < .01$). The implications of the findings are discussed.

Introduction

Educational theorists and researchers often emphasize the importance of the social context of cognition and its applications to learning and instruction. Learning is a highly social activity. Social interaction among participants in learning is seen as the primary source of intellectual development [1]. This emphasis on social cognition seems to demand reframing the conventional use of educational technology and suggests a new metaphor: computers as pedagogical agents.

"Pedagogical agent" refers in general to life-like autonomous characters. In this study, its anthropomorphic nature is emphasized, the purpose being to render personae to computers. Being human-like, a pedagogical agent might build social relations with learners. In particular, pedagogical agents as learning companions (PALs) simulate peer interaction and are designed to take advantage of the cognitive and affective gains of human peer-mediated learning.

PALs should be considered believable realistic virtual peers for building social relations with learners [2]. At the center of believability is PALs' ability to demonstrate affect [3]. Affect, an integral part of social cognition, allows us to successfully function in daily social and intellectual life [4]. Our feelings may signal our judgements and our daily interaction with others. Thus, the affective capability of PALs might facilitate social interaction with learners.

Furthermore, emotion research has indicated the close association of affect and cognition. Affect and cognition are integrally linked to impact on information processing and retrieval [5]. The affective state of a person influences processing style [6]. That is, positive emotions stimulate heuristic, creative, and top-down processing of information, whereas negative emotions stimulate detail-oriented, systematic, and bottom-up processing of information. Also, gender difference manifested in academic interest and cognitive styles

becomes more salient in such affective experiences as emotional expression, empathic accuracy, and emotional behavior [7].

This paper addresses several questions: Will the gender/affect interaction in real life be applied consistently to human/computer interaction? In particular, will the gender and affect of a PAL influence a learner's affective and cognitive characteristics as in traditional classrooms? Also, will the impact of a PAL's gender and affect varies depending on a learner's gender? Research has shown human/computer interaction to be consistent with human-to-human interaction [8]. Individuals' emotional experiences are attributed to immediate contexts [9], and so it is highly possible that a PAL's affective states might be transferred to a learner and may influence their information processing, motivation to work with the PALs, and social judgments about the PAL. In this regard, very few studies have been done. Thus, the purpose of the study this paper reports on was to examine the effects of PAL affective expression, PAL gender, and learner gender on learners' social judgements, motivation, and learning.

Method

1. Participants

Participants were 142 undergraduates in a computer-literacy course in a university located in the southeast United States. The participants were novices at the learning task, instructional planning.

2. Materials

2.1. Instructional Module
The instructional module was E-Learn, a web-based environment that introduced instructional planning for e-learning classes. The goal of E-Learn was to introduce basic concepts and proceduresof designing e-learn classes. The module consisted of three phases, Introduction, Goals, and Planning. The students' task in the module was to write their ideas for designing an e-learning class to teach freshmen to be more efficient in time management, depending on the information provided by a PAL. When the participants entered E-Learn, Chris (the PAL) appeared and introduced himself/herself as a peer. As students proceeded, Chris provided context-specific information at each learner's request. All the information provided by the PAL was identical across the experimental conditions. Depending on the conditions, the PALs verbally expressed their affective states. These affective comments were very brief and did not significantly impact total instructional time.

2.2. PAL Design
Male and female PALs, both named Chris, were developed using Poser 5, Mimic Pro 2, and Flash and were integrated into the web-based instructional module. To look peer-like, the PALs were designed to appear approximately twenty years old and wore casual shirts. The PALs' comments were scripted. Given that voice was a significant indicator for social presence [10], voices of male and female college students were recorded. The participants in the study estimated the PALs' age as an average of 20.39 ($SD = 7.94$).

3. Independent Variables

3.1. PAL Affective Expression

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.

Affective expression was operationalized by verbal and facial expressions, voices, and head movements. Emotion research indicates that people express and perceive emotions mostly through facial expressions, sounds, and body movements, together with verbal manifestations. According to Keltner and Ekman [11], face is the primary source for expressing distinct emotions nonverbally. The distinctive features of individuals' voices also influence how people decipher emotional messages [12]. Body movements too are clearly differentiated according to positive or negative feelings [13]. In addition, Sinclair and colleagues [14] indicate that the color red is interpreted as "upbeat," and fosters *heuristic* processing aligned with positive affect, whereas the color blue is generally interpreted as more depressing and fosters *systematic* processing aligned with negative affect. So the background colors of the module were adjusted to experimental conditions.

The PALs' affective expression had three levels: positive, negative, and neutral. Psychologists typically classify affect as positive if it involves pleasure (e.g., happiness or satisfaction) and as negative if it includes distress (e.g., frustration or anger) [15]. In the positive-affect condition, the PALs had a happy, smiling face and an engaging posture, with eye gaze and with head nodding. The background tone was red. The participants perceived the positive PALs as significantly more "happy looking" than the negative PALs ($p < .001$). In the negative-affect condition, the PALs had a somber and rather frowning face and an aloof posture, with evasive eye contact and less head nodding. The background tone was blue. The participants perceived the negative PALs as significantly more "sad looking" than the positive PALs ($p < .001$). In the Neutral condition, the PALs did not express affect. The background color had a grey tone. Overall, the adjustment of the emotion parameters in the voice/affect editing tool, Mimic Pro 2, operationalized the degree of positive, negative, and neutral expressions of the PALs.

3.2. PAL Gender

Either a male or female version of Chris was included depending on the experimental conditions. The two PALs were identical in all aspects (e.g., comments and emotional expressions), differing only by image and voice. Figure 1 illustrates the PALs with differing affect and gender.

Figure 1. PALs
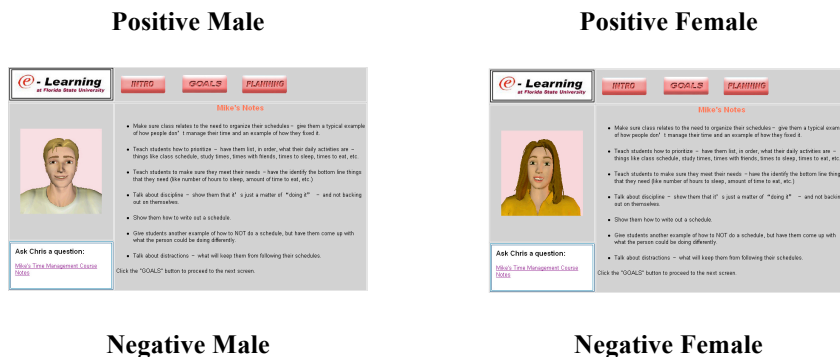
Positive Male   **Positive Female**

Negative Male   **Negative Female**

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.
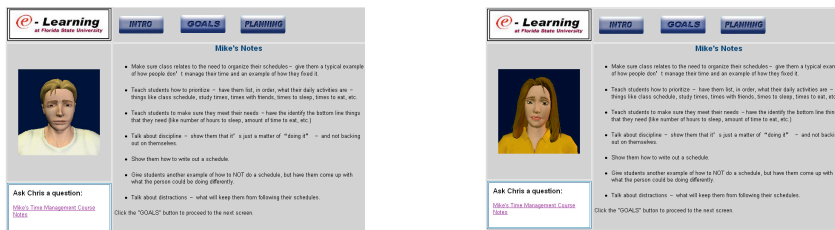
3.3. Learners' Gender

Learners' gender was a within-group factor. Approximately 40% of the participants were males and 60% females.

4. Dependent Variables

4.1. Social Judgments

Social judgments refered to learners' judgments about the attributes of PALs as their learning partners [16]. Learners' social judgments were measured by a questionnaire consisting of three sub-measures: facilitating (4 items), engaging (4 items), and intelligent (3 items). Items were scaled from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Item reliability in each category was evaluated as coefficient α = .91, .81, and .84 respectively.

4.2. Motivation

Learner motivation was measured by interest. Getzels [17] defines interest as a "disposition organized through experience which impels an individual to seek out particular objects, activities, understandings, skills, or goals for attention or acquisition." Learner interest in the study refered to learners' disposition toward working with the PAL and toward the task. Anderson and Bourke [18] suggest that the range of interest be best expressed on the scale of "interested-disinterested". Learner interest was measured by a questionnaire consisting of three sub-measures: interest in the task (3 items), interest in the PAL (2 items), and desire to work with the PAL (3 items). Items were scaled from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Item reliability in each category was evaluated as coefficient α = .87, .89, and .91 respectively.

4.3. Learning

The author wished to examine the learners' engagement in the interaction with the PAL and speculated that if learners were more engaged, they would recall more of the ideas presented by the PAL. Recall of information and application of the information were regarded as distinct cognitive functions. Thus, learning was measured by the two sub-categories of recall and application. In the recall question, students were asked to write all the ideas conveyed by the PALs about designing an e-learning class. The number of legitimate ideas in the students' answers was counted and coded by two instructional designers according to a process suggested by Mayer and Gallini [19]. Inter-rater reliability was evaluated with Cohen's Kappa = .94. In the application question, the participants were asked to write a brief e-learning plan according a given scenario. Students' instructional plans were evaluated by two instructional designers given a scoring rubric scaled 1 (Very poor) through 5 (Excellent). The scoring rubric – which has been used multiple times by

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.

Pedagogical Agent Learning Systems Research Laboratory at Florida State University [20] - focused on how specific their plans were in terms of the topic and instructional strategies. Inter-rater reliability was evaluated as Cohen's Kappa = .97.

5. Procedures

The experiment was conducted during a regular session of a computer-literacy course. Participants were randomly assigned to one of the six conditions by PAL affect and gender. The researcher administered the experiment with assistance from the course instructors. The participants first logged on to the web-based E-Learn module by entering demographic information, then performed the task and answered posttest questions. The participants were given as much time as they needed to finish the entire process (approximately 40 minutes, with individual variations).

6. Design and Analysis

The study used a 3 × 2 × 2 factorial design. The variables included PAL affective expression (positive vs. negative vs. neutral), PAL gender (male vs. female), and learner gender (Male vs. Female). For data analyses, three MANOVA's for social judgments, motivation, and learning were first conducted to control for the inflation of family-wise error rates, expected by including multiple dependent measures. Given statistical significance from the overall protected testing, three-way ANOVA's were further conducted for each sub-measure. The significance level for all the analyses was set at $\alpha <$ .05.

Results

1. Social judgments

The overall MANOVA conducted as protected testing indicated an 3-way interaction effect of PAL emotion, PAL gender, and learner gender: Wilks' Lambda = .876, F (6, 240) = 2.97, $p <$ .001, partial η^2 = .07. The MANOVA also indicated the main effect for PAL affective expression: Wilks' Lambda = .76, F (6, 240) = 6.03, $p <$ .001, partial η^2 = .13. To identify the contribution of sub-measures to the overall significance, univariate analyses were further conducted.

For the interaction effect, the univariate results indicated interaction effects on all three sub-measures of facilitating ($p <$ .01), engaging ($p <$ .01) and intelligent ($p <$ .05). When the PALs expressed positive affect, both male and female students rated the male PAL as more facilitating to their learning, more engaging, and more intelligent. However, when the PALs expressed negative affect, male students rated the female PAL as as more facilitating, engaging, and intelligent; whereas female students rated the male PAL as more facilitating, engaging, and intelligent. When the PALs did not express affect (neutral condition), those differences were minimal.

For PAL affective expression, the univariate results revealed significant main effects on "engaging" (F [2, 122] = 12.74, $p <$ .001) and on "intelligent" (F [2, 122] = 12.74, $p <$ .001). Students who worked with the positive PAL rated the PAL as significantly more engaging and intelligent than students with the negative PAL. Also, students who worked with the neutral PAL rated the PAL as significantly more engaging and intelligent than students with the negative PAL.

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.

2. Motivation

The overall MANOVA revealed the significant main effect for PAL affect (Wilks' Lambda = .87, F [6, 250] = 3.03, p < .01, partial η^2 = .07) and the significant main effect for PAL gender (Wilks' Lambda = .92, F [3, 125] = 3.79, p < .05, partial η^2 = .08). For PAL affect, the univariate results indicated the significant main effect on learners' desire to work with the PAL: F (2, 127) = 4.03, p < .05. Students who worked with the positive and neutral PALs desired to keep working with the PALs significantly more than did students who worked with the negative PAL. For PAL gender, the univariate results revealed the main effects on both interest in the PAL (F [1, 127] = 10.04, p < .01) and desire to work with the PAL (F [1, 127] = 9.22, p < .01). Students of both genders who worked with the male PAL showed significantly higher interest in and desire to work with the PAL than did those who worked with the female PAL.

3. Learning

Learning was measured by two open-ended questions asking recall and application of information. The overall MANOVA revealed the significant main effect for PAL gender (Wilks' Lambda = .83, F [2, 59] = 5.99, p < .01, partial η^2 = .17) and the significant main effect for student gender (Wilks' Lambda = .89, F [2, 59] = 3.78, p < .05, partial η^2 = .11). For PAL gender, the univariate results indicated a significant main effect on recall: F (1, 60) = 6.14, p < .05. Students of both genders who worked with the male PAL achieved significantly higher recall scores than did those who worked with the female PAL. For student gender, the univariate results revealed the main effects on recall: F (1, 60) = 7.36, p < .01. Female students achieved significantly higher recall scores than did male students. Regarding application, there was no significant difference across the groups.

Discussion

The study examined the potential of PAL to build social relations with learners by implementing PAL affect and gender. To do so, the impact of PAL affect, PAL gender, and learner gender was investigated in terms of learners' social judgments, interest, and learning. Overall, the study revealed the interaction effects of PAL affect, PAL gender, and learner gender on learners' social judgments, to reflect human-to-human relations. PAL affect and gender influenced learner interest in working with PALs. The gender of PAL and learner had influence on recall of learning.

The study was grounded in human emotion research revealing the close interaction between gender and emotion in human relationship. Similarly, the results revealed that affect and gender were significant indicators for learners' social judgments in the PAL-based environment. Also, the PAL's positive affect had an positive impact on learners' social judgments and motivation. Specifically, students who worked with the PAL that expressed positive affect rated the PAL as significantly more engaging and more intelligent and more desirable to work with than did students who worked with the negative PAL. These results were consistent with classroom research indicating that students in classrooms placed value on having teachers who showed positive affect [21] and that teachers' expressions of negative emotions were less favorable and associated with learners' negative affect [22].

Regarding PAL gender, students who worked with the male PAL showed higher interest in and desire to work with the PAL. This positive motivation might lead them to

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.

engage in and recall the PAL's comments more than those who worked with the female PAL. This superior impact of the male PAL to the female counterpart is analogous to the previous study indicating learners' high motivation toward and favorable perceptions of male pedagogical agents over female agents [23]. This tendency implies that stereotypic expectations of males and females in human relationships [24] might be infused to PAL/learner relationships. In the future, it will be worthwhile to examine ways to reduce stereotypic bias associated with gender by manipulating PAL gender along with other characteristics of learners and PALs in various learning contexts .

Regarding learner gender, female students showed higher recall scores than did male students, perhaps because the female students tended to show positive attitudes toward the PALs in general, indicated by their higher ratings on most of the items. This trend was also observed in previous studies [23, 25]. This positive attitudes of female students might lead them to engage more fully in the task and, consequently, acquire and recall more information.

In the current study, however, there were some limitations. First, learners' social judgments were not differentiated across the PAL who expressed positive affect and the PAL who did not express affect. Perhaps because the individual PALs' emotional expressions did not vary--all happy, all sad, or all neutral--some students might not have been aware of PAL affect while working in the instructional module unless the affect was clearly negative. This speculation sounds persuasive, since the awareness of feelings mediates the effect of feelings on social judgments [16]. Second, the study was done by one-time implementation. Building social relations with learners may require sustained interactions in a longer term. Also, the study was focused on an "outer" quality of the PALs and may serve as a preliminary step for the investigation of PALs performing intelligently. Future research might overcome the limitations of the current study.

References

[1]   V. John-Steiner and H. Mahn, "Sociocultural contexts for teaching and learning," in *Handbook of psychology: Educational psychology*, vol. 7, A. Reynolds, M. William, and G. E. Miller, Eds. New York: John Wiley and Sons, 2003, pp. 125-151.

[2]   K. Dautenhahn, A. H. Bond, L. Canamero, and B. Edmonds, "Socially intelligent agents: Creating relationships with computers and robots." Norwell, MA: Kluwer Academic Publishers, 2002.

[3]   J. Bates, "The nature of characters in interactive worlds and the Oz project," School of Computer Science, Carnegie Mellon University, Pittsburgh, PA CMU-CS-92-200, 1992.

[4]   R. Adolphs and A. R. Damasio, "The interaction of affect and cognition: A neurobiological perspective," in *Feeling and Thinking: The Role of Affect in Social Cogniton*, J. P. Forgas, Ed.: Cambridge University Press, 2000.

[5]   G. H. Bower and J. P. Forgas, "Mood and social memory," in *Handbook of Affect and Social Cognition*, J. P. Forgas, Ed. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2001.

[6]   N. Schwarz, "Situated cognition and the wisdom in feelings," in *The wisdom in feelings*, L. F. Barrett and P. Salovey, Eds. New York: The Guilford Press, 2002, pp. 145-166.

[7]   L. Brody, *Gender, emotion, and the family*. Messachusetts: Harvard University Press, 1999.

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.

[8]   B. Reeves and C. Nass, *The Media Equation: How people treat computers, television, and new media like real people and places*. Cambridge: Cambridge University Press, 1996.

[9]   C. Saarni, "Emotion communication and relationship context," *International Journal of Behavioral Development*, vol. 25, pp. 354-356, 2001.

[10]   R. E. Mayer, K. Sobko, and P. Mautone, "Social cues in multimedia learning: role of speaker's voice," *Journal of Educational Psychology*, vol. 95, pp. 419-425, 2003.

[11]   D. Keltner and P. Ekman, "Facial expression of emotion," in *Handbook of Emotions*, M. Lewis and J. M. Haviland-Jones, Eds. New York: The Guilford Press, 2000, pp. 236-249.

[12]   J. Bachorowski and M. J. Owren, "Vocal acoustics in emotional intelligence," in *The wisdom in feelings*, L. F. Barrett and P. Salovey, Eds. New York: The Guilford Press, 2002, pp. 11-36.

[13]   M. Chen and J. A. Bargh, "Consequences of automatic evaluations: Immediate behavioral predispositions to approach or avoid the stimulus," *Personality and Social Psychology Bulletin*, vol. 25, pp. 215-224, 1999.

[14]   R. C. Sinclair, A. S. Soldat, and M. M. Mark, "Affective cues and processing strategy: Color coded forms influence performance," *Teaching of Psychology*, vol. 25, pp. 130-132, 1998.

[15]   V. Ottati, N. Terkildsen, and C. Hubbard, "Happy faces elicit heuristic processing in a televised impression formation task: A cognitive tuning account," *Personality and Social Psychology Bulletin*, vol. 23, pp. 1144-1156, 1997.

[16]   G. L. Clore, "Affective influences on social information processing," in *Handbook of Affect and Social Cognition*, J. P. Forgas, Ed. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2001.

[17]   J. W. Getzels, "The problem of interests: A reconsideration," *Supplementary Education Monographs*, vol. 66, pp. 97-106, 1966.

[18]   L. W. Anderson and S. F. Bourke, "Assessing affective characteristics in the schools," 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates, 2000.

[19]   R. E. Mayer and J. K. Gallini, "When is an illustration worth ten thousand words?" *Journal of Educational Psychology*, vol. 82, pp. 715-726., 1990.

[20]   Y. Kim and A. L. Baylor, "Pedagogical agents as learning companions: The role of competency and type of interaction," *Educational Technology Research & Development*, in press.

[21]   C. A. Wong and S. M. Dornbusch, "Adolescent engagement in school and problem behaviors: The role of perceived teacher caring," presented at Annual Meeting of the American Educational Research Association, New Orleans, LA, 2000.

[22]   R. Lewis, "Classroom discipline and student responsibility: The students' view," *Teacher Education*, vol. 17, pp. 307-319, 2001.

[23]   A. L. Baylor and Y. Kim, "Pedagogical agent design: The impact of agent realism, gender, ethnicity, and instructional role," presented at Intelligent Tutoring Systems, Maceió, Alagoas, Brazil, 2004.

[24]   L. L. Carli, "Gender and social influence," *Journal of Social Issues*, vol. 57, pp. 725-741, 2001.

[25]   Y. Kim, "Learners' expectations on the desirable characteristics of learning companions," presented at the Annual Conference of American Educational Research Association, San Diego, CA, 2004.

Acknowledgements

Kim, Y. (2005). Pedagogical agents as learning companions: Building social relations with learners. In C. K. Looi, G. McCalla, B. Bredeweg & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 362-369). Amsterdam, The Netherlands: IOS Press.