

The Effects of Peer-Like and Expert-Like Pedagogical Agents on Learners' Agent Perceptions, Task-Related Attitudes, and Learning Achievement

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ABSTRACT

The present study examined the impact of peer-like and expert-like agent stereotypes, as operationalized by agent's image and voice, on learners' agent perceptions, task-related attitudes, and learning achievement. 56 university freshmen (23 males and 33 females) interacted with either the peer-like agent (female college student) or the expert-like agent (female college lecturer) in computer-based multimedia lesson on C-Programming. Consistent with similarity-attraction hypothesis, expert hypothesis, and interference hypothesis, it was found that: (1) learners assigned higher ratings on lesson enjoyment with peer-like agent than with expert-like agent, (2) female learners assigned higher trust to the lesson presented by expert-like agent than to the lesson presented by peer-like agent, (3) female learners reported less anxiety in learning task with expert-like agent than with peer-like agent, and (4) learners who were more attracted to virtual agent were more likely to score lower in learning achievement. Additionally, results from this study suggest that gender bias affects learner's perception on virtual agent. Implications are discussed in terms of how stereotypes of expert-like and peer-like agent can be effectively utilized in e-learning environment.

Keywords

Pedagogical agent, Stereotype, Expert-like agent, Peer-like agent, Gender

Introduction

Pedagogical agents are virtual characters embedded in multimedia learning environment that simulate human instructional roles (Johnson et al., 2000). In today's multimedia technology, virtual agents are incorporated in several e-learning systems such as AutoTutor (McCauley et al., 1998), Herman the Bug (Barlow et al., 1997), and Steve (Rickel & Johnson, 2000). Advocates of pedagogical agent cited the benefits of the *persona effect* (Barlow et al., 1997), which posit that the social cues exhibited by pedagogical agents can increase learner's motivation (Barlow et al., 1997), cognitive engagement (Johnson et al., 2000; Mayer, Sobko, & Mayer, 2003), self-efficacy (Atkinson, 2002) and transfer achievement (Moreno et al., 2001) in learning tasks.

The persona effect is somewhat related to the idea of media equals real life in human-computer interaction. That is, people will tend to apply the same social rules of human to human communication to computer agents (Reeves & Nass, 1996). For example, it was shown that college students' perceptions on virtual agents were "knowledgeable, nice and friendly," which reflected the learners' social expectations of human instructors (Kim, 2007). Furthermore, users tend to perceive computer agents to be more appealing and intelligent when computer agents matched their personalities (Nass et al., 1995).

The activation of social expectations is triggered by the visual and voice characteristics of a virtual agent (Haake & Gulz, 2008; Kim et al., 2003; Veletsianos, 2010). Specifically, agent features such as voice inflection, hairstyle, clothing, ethnicity, and gender form the basis of first impressions on agent usefulness, credibility, and intelligence. A number of researchers have highlighted the importance of agent design (Moreno et al., 2001; Haake & Gulz, 2008). In a review done by Heidig & Clarebout (2011), it was concluded that the choice of agent design reflects the social perceptions such as competency and appeal, which in turn promote or hinder learning.

However, it seems that the importance of agent design has not been acknowledged accordingly in a number of studies. Veletsianos (2010) argued that researchers are failing to regard the effects of agent design on learner's stereotypic beliefs, which in turn, affect learning performance and task-related attitudes. In his study, the researcher cited some examples in which virtual agents were designed without considering the impact of visual stereotypes. For

example, sorcerers have been employed to teach economics (Craig et al., 2002) and cartoon-like characters have been depicted as physics experts (Mayer, Dow, & Mayer, 2003).

One possible reason as to why agent design is often neglected in research is that much of the research on virtual agents is technologically driven; hence, the cognitive and psychology aspects are often disregarded. In addition, the choice of agent design is not an easy task (Haake & Gulz, 2008). The researchers cited an example of a virtual character that was designed for a legal information system in Italy (de Rosis et al., 2004). The virtual agent was originally modeled upon a very attractive young female assistant, since the developers anticipated that the typical user would be a male lawyer. However, after realizing that the lawyer's (female) secretary was the one who most frequently used the system, they became aware that the appearance and behavior of the character distracted these users. Therefore, the designers remodeled a new virtual agent with more professional communication style and more classical attire. From the cited example, it was apparent the choice of agent design is contextual to the subject domain and the target user.

Stereotypes of expert-like and peer-like virtual agents in multimedia learning

The objective of this research is to investigate the effects of expert-like and peer-like agent stereotypes on learning outcome and behaviors. Expert-like agents are virtual models that portray advanced knowledge and competence in a subject domain (Baylor & Kim, 2005). From the design perspective, an expert-like agent can be operationalized through the image of a professor in his/her forties, who speaks in formal, authoritative, and professional manner. Peer-like agents are virtual models whose social characteristics are similar to learners' own attributes. Peer-like agents can be operationalized through the image of a casually-dressed student in his/her twenties, who speaks in friendly and emphatic manner (Baylor & Kim, 2005; Kim & Baylor, 2006; Kim, 2007).

The rationale to investigate the expert-like and peer-like agent stereotypes is straightforward. Arguably, expert-like and peer-like personas are two of the most commonly implemented agent stereotypes in multimedia learning environments (Kim, 2007; Baylor & Kim, 2005). Apart from the traditional role of teacher/expert virtual agent, peer-like agents such as learning companions has been increasingly integrated in e-learning environments (Kim, 2007; Baylor & Kim, 2005). On the one hand, it has been suggested that peer-like agents can benefit learning by simulating social aspects that are predominantly found in peer-to-peer interaction such as behavioral modeling, empathy relations, and positive influence on self-efficacy (Baylor & Kim, 2005). On the other hand, expert-like agents depicting teachers often exude expertise and confidence that may positively influence the learning outcome and behavior. Therefore, these developments raised a central question: Do expert-like and peer-like agents differently affect learning achievement and learning behavior?

There seemed to be a lack of research investigating on this notion. From the literature, only three empirical studies comparing the effects of peer-like and expert-like agent are found. In the first study (Kim et al., 2003), participants were exposed to either the peer-like or the expert-like agent. From the result, it was shown that the visual stereotypes of peer-like and expert agents did not affect learning performance. Participants however, correctly perceived the role of agent (i.e., expert or motivator) based on the visual features of the agents, which were consistent with the learners' stereotypic expectations. No measures for examining learners' task-related attitudes such as enjoyment, self-efficacy and anxiety were included in the study.

In another study (Veletsianos, 2010), participants were assigned to four experimental conditions differing by expert-like or peer-like agent (i.e., visual representation of punk-rock artist or scientist) and subject domain (i.e., nanotechnology or punk rock). Across the subject domains, it was found that participants in peer-like agent condition outperformed participants in expert-like agent condition. Interestingly, regardless of subject domains, participants rated the punk-rock artist agent as being more knowledgeable than the scientist agent. The researcher suggested that these counter-intuitive observations could be attributed to the similarity-attraction hypothesis. That is, participants could identify themselves better with the peer-like agent (i.e., artist agent); hence, they gave higher ratings and paid more attention to the artist agent than to the scientist agent. The study however did not include any measures for examining learners' task-related attitudes.

Finally, Rosenberg-Kima et al. (2008, Experiment 2) compared the effects of peer-like agent (i.e., young and "cool" female virtual model) and expert-like agent (i.e., male virtual model that resembled a prototypical engineer) on agent

perceptions and task-related attitudes of female participants. It was found that the visual stereotypes of pedagogical agents influenced different set of learning behaviors. Specifically, the peer-like agent enhanced the learners' self-efficacy and willingness to enroll in engineering courses while the expert-like agent influenced the learners' beliefs in the subject domain (i.e., perceived utility of engineering). No measures however, were included to examine the learning outcome.

Of the two studies that compared the effects of agent stereotypes on learning outcome, one study showed no difference in learning while the other demonstrated that peer-like agent promoted learning. Concerning the effects of agent stereotypes on learning behaviors, only one of the three studies included measures on task-related attitude (e.g., self-efficacy and perception in subject). Hence, the overall findings remain inconclusive. Therefore, this paper aims to extend the investigation by attempting to answer the following research questions: (1) How do expert-like and peer-like agents differently affect learning achievement? (2) How do expert-like and peer-like agents differently affect agent perceptions? (3) How do expert-like and peer-like agents differently affect task-related attitudes? In order to provide theoretical groundings for this study, three central hypotheses, which are the similarity-attraction hypothesis, expert hypothesis, and interference hypothesis, are reviewed in the following sections.

Similarity-attraction hypothesis

The similarity-attraction hypothesis indicates that people are more likely to be attracted and pay more attention to social models whose characteristics and attributes are similar to their own (Berscheid & Walster, 1969). In human-computer interaction, participants perceived computer voice as more attractive, credible, and informative, when the computer agent matched the participants' personalities (Nass et al., 1995). Additionally, agents whose characteristics matched the college learners' attributes were shown to have influenced the learners to assign more positive reviews on the books presented by the computer (Nass & Lee, 2000).

In the context of multimedia learning environment, the similarity-attraction affects learner's consideration when choosing pedagogical agents. It was found that students of color were more likely to choose pedagogical agents that share the same ethnicity with them (Moreno & Flowerday, 2006), and college students preferentially chose agents whose gender and ethnicity matched their own (Kim & Wei, 2011). On the basis of similarity-attraction principle, Rosenberg-Kima et al. (2008) pointed out that learner's interest and self-efficacies in domain task will be enhanced when they observe virtual models whose characteristics resembled them successfully perform a particular task. Their experiment showed that female college learner' interests and self-efficacies in the subject domain were positively influenced by the presence of peer-like agent (i.e., young and "cool" female virtual model).

Based on the similarity-attraction principle, three hypotheses were proposed:

H1: Learners will assign higher ratings on lesson enjoyment with peer-like agent than with expert-like agent.

H2: Learners will be more attracted to peer-like agent than to expert-like agent.

H3: Learners will assign higher self-efficacy in learning task with peer-like agent than with expert-like agent.

Expert hypothesis

The expert hypothesis suggests that expert-like agent may positively influence learners' stereotypic perceptions and expectations of the agent, as the agent appear to be expert in the particular subject domain (Veletsianos, 2010). From the social psychological perspective, the idea of expert hypothesis can be related to people's social expectations of expert power and legitimate power (French & Raven, 1959). Pedagogical agents that resemble experts will be perceived as being competent and intelligent (Kim et al., 2003). Since people are also persuaded by those whom they perceive as experts (Chaiken & Maheswaran, 1994), learners will assign higher confidences and trust to the information that is presented by expert-like agent. That is, learners' beliefs in a particular subject domain may be more persuaded by expert-like agent, as they perceive the information source as being trustworthy and credible. This notion was prevalent in a recent study by Rosenberg-Kima et al. (2008). It was found that agents who appear to resemble male prototypical engineers (i.e., expert-like agent) were effective in influencing female college learner's beliefs in the subject domain (i.e., perceived utility of engineering).

Based on the expert hypothesis, two hypotheses were submitted:

H4: Learners will perceive expert-like agent to be more knowledgeable than peer-like agent.

H5: Learners will assign higher trust to the lesson presented by expert-like agent than to the lesson presented by peer-like agent.

Interference hypothesis

The interference hypothesis argues that the social cues exhibited by pedagogical agents can distract learners' attention away from learning materials (Moreno & Flowerday, 2006). This notion is related to the idea that interesting but irrelevant elements (i.e., seductive details) may lead learners' attention away from important information. The interference effect was evident in a study by Moreno & Flowerday (2006). It was found that learners scored lower in learning achievement, when they chose to interact with pedagogical agents that were similarly attributed (i.e., same ethnicity) with them. According to the researchers, the learners might have focused their attention on how the pedagogical agent represented them, rather than the salient information presented in the multimedia environment. Hence, the social cues presented by pedagogical agent exhibited seductive details that influenced the affective behaviors of learners, but at the same time interfered with the learning process of instructional materials. As pointed out in Moreno & Flowerday's study (2006), the effects of similarity-attraction led learners to choose pedagogical agents whose characteristics were similar to their own, but these attractions were harmful to the learning performances of learners.

Based on the interference hypothesis, the following hypothesis was proposed:

H6: Learners who are more attracted to agent will be more likely to score lower in learning achievement.

The role of learners' gender

The role of learners' gender must be taken into account in examining the effects of pedagogical agent, as male learners and female learners react differently to computer agents in human-computer interaction. For example, it has been shown that as compared to male learners, female learners were more likely to assign better positive ratings for pedagogical agents (Baylor & Kim, 2004; Kim & Wei, 2011). Therefore, learners' gender may potentially influence the effects of peer-like agent and expert-like agent on learners' perceptions, task-related attitudes and learning achievement.

Method

Participants

56 business major students from a university in Malaysia participated in the present study in exchange for partial course credits. The students were made up of different ethnicities (43% Malays, 43% Chinese and 14% Indians). In an effort to generate a sample of novice learners, all participants recruited were university freshmen and had not taken any programming-related subjects. However, the participants had taken the subject of basic computer applications; hence, they were aptly proficient in computer usage. Among the participants, 23 students were male while 33 were female; and the overall average age was 18.5.

Instructional materials

The computer-based multimedia environment was developed using Microsoft PowerPoint 2010 to deliver multimedia slide shows (i.e., ppsx format) on program comprehension. Crazy Talk Animator Pro was used to develop the image animation of the pedagogical agents. As for agent speech, narrations were created and extracted from IVONA text-to-speech software (<http://www.ivona.com/en/>). Agents' lip movements were then synchronized with the extracted speech using Crazy Talk Animator Pro; and the resulting video files were exported and embedded into the multimedia learning environment (i.e., Microsoft PowerPoint 2010 ppsx format). *Figure 1.* illustrates the screen captures of the multimedia learning environments.



Figure 1. Multimedia learning environments

Subject domain

Participants were required to learn how to (1) comprehend computer algorithms of *if-statement*, *if-else statement* and *nested-if statement* and to (2) predict the output from C-Programming statements. Within the e-learning environment, participants must first study the fundamental program concepts such as *initial value*, *condition* and *statement*. To be able to predict program outputs, participants must form correct mental models on program algorithms by grasping the relationship between the *initial value*, *condition* and *statement*. Sample programs and flowcharts were included to highlight these relationships, and subsequent working demonstrations were presented on how to predict the program output (see Figure 1). The ability to identify programming concepts and to predict program outputs are consistent with the cognitive skills of *knowledge retention* and *comprehension* of Bloom’s taxonomy in computer sciences (Thompson et al., 2008).

Independent variables

The independent variables were two different agent personas—peer-like agent and the expert-like agent. Both agents were conceptualized by visual appearance and voice inflection. For the peer-like agent, the visual appearance resembled a female college student in her 20s, and her speech featured a soft and calm voice (IVONA-American English, Salli). As for the expert-like agent, the visual appearance resembled a female college lecturer in her 40s, and her speech featured a strong and authoritative voice (IVONA-American English, Kendra). Prior to the main study, 6 students were invited to simultaneously evaluate the agents based on their visual appearance and voice. The results of the pilot study were satisfactory; the peer-like agent was perceived as “resembling a college peer” while the expert-like agent was perceived as “resembling a college instructor.” Additionally, to increase the likelihood that participants in the main study will relate to the agents, both agents introduced themselves prior to the lesson modules. The peer-like agent introduced herself as Linda, a 20 years old college sophomore while the expert-like agent introduced herself as Dr. Linda, a 42 years old college lecturer. Other than the self-introduction dialogues, the remaining scripts for the learning modules were similar for both agents. Figure 2 presents the two agents used in the study.



Figure 2. Agent personas used in the learning environment

Dependent measures

In the present study, the dependent measures were learners' agent perceptions, task-related attitudes and learning achievement.

Learners' agent perceptions

Four items, each scaled from 1 (*strongly disagree*) to 7 (*strongly agree*) measured learners' perceptions on agent's attractiveness (*I like Linda*), agent's friendliness (*Linda is friendly*), agent's knowledge (*Linda is knowledgeable*) and agent's lesson credibility (*I can trust the lesson that is presented by Linda*). Instructions to fill up the surveys were inserted at three intervals within the multimedia lesson. Hence, for data analysis, the mean scores were calculated for each item.

Learners' task-related attitudes: Enjoyment, self-efficacy and anxiety

Three items, each scaled from 1 (*strongly disagree*) to 7 (*strongly agree*) measured learners' task related attitudes, such as lesson enjoyment (*I enjoy this lesson*), self-efficacy in learning task (*I am confident that I can understand this lesson*), and anxiety in learning task (*I feel anxious when listening to this lesson*). Instructions to fill up the surveys were inserted at three intervals within the multimedia lesson. Hence, for data analysis, the mean scores were calculated for each item.

Learning achievement

Learning achievements of participants were measured as total scores of retention and comprehension post-tests. The retention test required learners to label three terminologies (e.g., initial value, condition and statement) and relate them to the correct segments in a sample program code. The comprehension test asked learners to predict the output of twelve short program statements. These measures were consistent with the cognitive skills of *knowledge retention* and *comprehension* of Bloom's taxonomy in computer sciences (Thompson et al., 2008). The highest possible score for learning achievement was 15.

Procedures

Participants (n = 56) were randomly assigned to either one of the two computer laboratories—peer-like agent condition or expert-like agent condition. Both groups of participants were unaware of the different environments. Participants studied the multimedia presentation on their respective computer and headsets for 40 minutes. There were three intervals within the multimedia presentation; at each interval, computer-based instructions were given to participants to fill up the surveys for measuring learners' perceptions on agent and task-related attitudes. After the multimedia lesson, participants were given 30 minutes to complete the learning post-tests. Learning measures were scored blind with respect to experimental condition by two authors of this study. The observed difference between the scoring of both raters was minimal and easily resolved after discussion.

Results

Learner's perceptions on agent

The four items measured were learners' perceptions on agent's attractiveness (*I like Linda*), agent's friendliness (*Linda is friendly*), agent's knowledge (*Linda is knowledgeable*) and agent's lesson credibility (*I can trust the lesson that is presented by Linda*). The 2 (gender) X 2 (agent persona) ANOVA conducted on the items indicated:

- A significant main effect of agent persona on agent's perceived friendliness [$F(1,52) = 5.278, p = 0.03$, partial eta squared = 0.09]; learners perceived peer-like agent ($M = 4.95, SD = 1.30$) to be more friendly than expert-like agent ($M = 4.18, SD = 1.27$).
- A significant main effect on learners' gender on agent's perceived knowledge [$F(1,52) = 5.611, p = 0.02$, partial eta squared = 0.097]; female learners ($M = 5.26, SD = 1.13$) perceived agents as more knowledgeable than did male learners ($M = 4.42, SD = 1.35$).
- A significant interaction effect between learners' gender and agent persona on agent's lesson credibility [$F(1,52) = 5.473, p = 0.02$, partial eta squared = 0.095]. Subsequent t-test [$t(28) = 3.112, p = 0.004$] revealed that female learners ($M = 5.37, SD = 0.94$) were more trusting to the lesson presented by expert-like agent than did male learners ($M = 4.36, SD = 0.79$). Additional t-test [$t(31) = 2.034, p = 0.05$] also showed that female learners were more trusting to the lesson presented by expert-like agent ($M = 5.37, SD = 0.94$) than to the lesson presented by peer-like agent ($M = 4.71, SD = 0.93$).

Hypothesis 2, which predicted that learners will be more attracted to peer-like agent than to expert-like agent was not supported. In addition, hypothesis 4, which predicted that expert-like agent will be perceived to be more knowledgeable than peer-like agent, was also not supported. However, it was found that female learners significantly perceived agent as more knowledgeable than did male learners. Hypothesis 5, which predicted that learners will assign higher trust to the lesson presented by expert-like agent than to the lesson presented by peer-like agent, was supported only for female learners.

Learner's task-related attitudes: Lesson enjoyment, self-efficacy, and anxiety

The three items measured were learner's enjoyment on lesson (*I enjoy this lesson*), learner's self-efficacy in learning task (*I am confident that I can understand this lesson*), and learner's anxiety in learning task (*I feel anxious when listening to this lesson*). The 2 (gender) X 2 (agent persona) ANOVA conducted on the items revealed:

- A significant main effect of agent persona on lesson enjoyment [$F(1,52) = 5.071, p = 0.029$, partial eta squared = 0.089]. Learners assigned higher ratings on lesson enjoyment to the lesson presented by peer-like agent ($M = 5.04, SD = 0.81$) than to the lesson presented by expert-like agent condition ($M = 4.43, SD = 1.32$).
- A significant interaction effect between learners' gender and agent stereotype on learners' anxiety in learning task [$F(1,52) = 4.719, p = 0.034$, partial eta squared = 0.083]. Subsequent t-test [$t(28) = 2.257, p = 0.032$] revealed that female learners ($M = 2.29, SD = 1.19$) were less anxious in learning task with expert-like agent than did male learners ($M = 3.31, SD = 1.26$). In addition, t-test [$t(28) = 2.257, p = 0.032$] also showed that female learners were less anxious in learning task with expert-like agent ($M = 2.29, SD = 1.19$), than with peer-like agent ($M = 3.39, SD = 1.31$).

The results supported hypothesis 1, which predicted that learners will assign higher ratings on lesson enjoyment to the lesson presented by peer-like agent than to the lesson presented by expert-like agent. Hypothesis 3, which predicted that learners will assign higher self-efficacy in learning task with peer-like agent than with expert-like agent, was not supported. In addition, it was shown that female learners were significantly less anxious in learning task with expert-like agent than did male learners; and female learners were significantly less anxious in learning task with expert-like agent than with peer-like agent.

Learning achievement

Participants' learning achievements were assessed as total scores of retention and comprehension tests. The 2 (gender) X 2 (agent persona) ANOVA on learning achievement did not reveal any significant main effect or interaction effect. Hence, peer-like and expert-like agent did not differently affect learning performance.

Based on the interference hypothesis, it was predicted that learners who are more attracted to agent will be more likely to score lower in learning achievement (hypothesis 6). To test hypothesis 6, participants were categorized into two groups—*High Attraction* and *Low Attraction* learners, based on participant’s rating on agent’s attractiveness (i.e., as measured by item “*I like Linda*”). High Attraction learners assigned ratings greater than 1/2 standard deviation above the score mean, while Low Attraction learners assigned ratings less than 1/2 standard deviation below the score mean. A 2-Way ANOVA relating agent condition (i.e., peer and expert agent) and learner group (i.e., High Attraction and Low Attraction learners) on learning scores revealed a significant main effect for learner group [$F(1,39) = 6.569, p = 0.015$]. Subsequent t-test [$t(37) = 2.446, p = 0.019$] indicated that *High Attraction* learners [$M = 6.6, SD = 3.84$] performed significantly lower than *Low Attraction* learners [$M = 3.9, SD = 2.73$] in learning achievement. This result supported Hypothesis 6.

Discussion

The purpose of this study was to examine the effects of peer-like agent and expert-like agent on learners’ agent perceptions, task-related attitudes, and learning achievement. Three central hypotheses, which are the similarity-attraction hypothesis, expert hypothesis and interference hypothesis were posited as theoretical groundings of this study. Table 1 presents the summary of the results of the hypotheses tested in the present study.

Table 1. Summary of results of the hypotheses tested in this study

Hypotheses	Results
<p><i>Similarity-attraction hypothesis</i></p> <ol style="list-style-type: none"> Learners will assign higher ratings on lesson enjoyment with peer-like agent than with expert-like agent. Learners will be more attracted to peer-like agent than to expert-like agent. Learners will assign higher self-efficacy in learning task with peer-like agent than with expert-like agent. 	<p>Supported.</p> <p>Not supported.</p> <p>Not supported.</p>
<p><i>Expert hypothesis</i></p> <ol style="list-style-type: none"> Learners will perceive expert-like agent to be more knowledgeable than peer-like agent. Learners will assign higher trust to the lesson presented by expert-like agent than to the lesson presented by peer-like agent. 	<p>Not supported.</p> <p>Supported only for female learners.</p>
<p><i>Interference hypothesis</i></p> <ol style="list-style-type: none"> Learners who are more attracted to agent will be more likely to score lower in learning achievement. 	<p>Supported.</p>

Hypothesis 1, 2, and 3 (Similarity-attraction hypothesis)

Hypothesis 1 predicted that learners will assign higher ratings on lesson enjoyment with peer-like agent than expert-like agent. This hypothesis was supported in the present study. Possibly, this is because the peer-like agent was regarded as more friendly than expert-like agent (Kim, 2007). The peer-like agent that served as a social model for the participants might have simulated a sense of human-peer interaction (Kim & Baylor, 2006); which in turn, led to an increased satisfaction and enjoyment in the multimedia lesson of this study.

The prediction that learners will be more attracted to peer-like agent than to expert-like agent was not supported (hypothesis 2). However, this is possibly due to the fact that the participants were unable to make comparisons (i.e., of visual appearance and voice inflection) between the peer-like agent and the expert-like agent simultaneously. Hence, the results may differ, under other environments in which learners are able to visually consider different agents (Moreno & Flowerday, 2006; Kim & Wei, 2011).

The results of this study did not support the expectation that peer-like agent will enhance participants’ self-efficacy in learning task (hypothesis 3). Hence, this study failed to replicate the findings by Rosenberg-Kima et al. (2008). In Rosenberg-Kima’s experiment, the subject domain (i.e., Five Benefits of Engineering) was *motivational* rather than

cognitive in nature. That is, the objective of the presentation was to *motivate* female participants to enroll in future engineering courses. Secondly, in the experiment, the participant's enhanced self-efficacy (e.g., "I am confident that I could do well in math classes") was regarding *future* tasks (i.e., when and if they enroll to engineering courses), rather than *occurring* learning tasks. From the results of this study, the effects of peer-like agent on self-efficacy may not be robust enough, when the subject domain is *cognitively* focused (rather than *motivational*) and when the learning task is *occurring* (rather than *future* learning task).

Hypothesis 4 and 5 (Expert hypothesis)

It was predicted that participants will perceive expert-like agent to be more knowledgeable than peer-like agent (hypothesis 4). This hypothesis, however, was not supported in the present study. In line with previous finding (Kim et.al., 2003), image / voice stereotypes of peer-like agent and expert-like agent did not affect participants' perception on agent's knowledge. Rather, the perceptions on agent's knowledge are affected by scripts in the learning instructions (see Kim, 2007). Since the lesson presentation from both agents were similar, learners perceived the peer-like agent to be equally competent and knowledgeable as the expert-like agent. However, it was shown that female learners gave significantly higher ratings on agents' perceived knowledge than did male learners.

It was expected that learners will assign higher trust to the lesson presented by expert-like agent than to the lesson presented by peer-like agent (hypothesis 5). However, the results showed that the hypothesis was supported only for female learners. This scenario can be attributed to the prevalent gender bias in male participants (Carli, 1999). For instance, it was demonstrated that male audiences were less influenced by female expert; while female audiences were equally persuaded by male and female experts (Rhoades, 1981). Since the agent gender was female, the male participants might have resisted the informational influence by the expert-like agent.

This notion was also empirically proven by prior studies in human-computer interaction. In one study (Lee et al., 2000), it was shown that men demonstrated less conformity to the female-voiced computer than to the male-voiced counterpart whereas women did not show the corresponding tendency. In another experiment (Lee, 2004, Experiment 1), it was shown that female participants were persuaded more by virtual male representation than virtual female representation when the subject domain was masculine in nature. Lee concluded that the female learners displayed higher conformity to virtual characters that they perceived as expert in the particular subject domain. Male participants, however, were more persuaded by male characters than female characters, regardless of whether the subject domains were masculine or feminine in nature. The researcher argued that this observation was attributed to the tendency of male participants to resist female influence. This hypothesis was confirmed in the subsequent experiment by Lee (2004, Experiment 2). It was shown that though the subject domain was gender-neutral, male participants continued to be less persuaded by female virtual characters than male characters. In sum, it was found that the participants' gender moderated the social influence by virtual agents, and "while men exhibited greater conformity to the male-charactered partner [virtual agent] than to the female-charactered counterpart [virtual agent], women did not differentiate between male and female partners [virtual agents]" (Lee, 2004, pp.794).

Hypothesis 6 (Interference hypothesis)

Grounded on the interference hypothesis, it was predicted that participants who are more attracted to peer-like agent will be more likely to score lower in learning achievement (hypothesis 6). The results of this study supported this hypothesis. Regardless of agent type (i.e., peer or expert agent), learners who reported higher attraction to agents scored significantly lower in learning achievement than learners who reported less attraction to agents. One interpretation is that the participants who were more attracted to the agents were more likely to focus their attention on the social characteristics of the agents, thereby interfering with the learning process (Moreno & Flowerday, 2005).

Implications for instructional design

From the instructional design perspective, a number of inferences can be made from this study. Firstly, visual and voice characteristics of agent will influence learners' stereotypic expectations of the agent. For example, the agents' visual and voice inflection led participants to perceive peer-like agent to be more friendly; while expert-like agent

were perceived to be more credible. Additionally, agent stereotypes affect different types of task-related attitudes from learners. Hence, to tap into effectiveness of virtual stereotypes, instructional designers must target the learning behaviors that they hope to affect.

Though the visual and voice characteristics of peer-like agent and expert-like agent did not directly affect learning performance in this study, there were certain effects on learners' psychological behaviors. For instance, the results from this study suggests that expert-like agent invokes better credibility, as well as reducing subject anxiety particularly for female learners. Plausibly, it might be that learners who interacted with expert-like agent might have gained perceived support that comes from an authoritative relationship (i.e., college lecturer), which reduced the level of task-related anxiety (Huang et al., 2010). On the other hand, peer-like agents whose social characteristics are similar to learners' attributes can increase enjoyment during learning tasks.

It should be cautioned that agents may potentially distract learners' attention away from the learning content. Hence, for subject domains which are focused on *cognitive* rather than *affective* processes, instructional designers should carefully limit the amount of social cues presented in software agents rather than add them for reasons of appeal or entertainment (Moreno & Flowerday, 2006). This notion is supported by Kim & Wei (2011), who pointed out that "when an application is geared toward improving users' cognitive tasks, the presence of an agent might not be warranted. However, for applications that are focused on users' affect and choice (e.g., promoting ideas and products), agent presence can be a viable option in the design."

The final implication is that the social influence by virtual agents is moderated by learner's gender. For instance, female learners tend to give favorable agent ratings than do male learners. Also, due to the tendency of male participants to resist female influence by computer agents (Lee et. al., 2000, Lee, 2003), the displayed credibility by female virtual agents may not be effectively imposed on male learners. Additionally, previous study showed that learners working with the male agents were more satisfied with their performance and reported that the agents better facilitated self-regulation (Baylor & Kim, 2003). Moreover, learners perceived the persona of the male agents more favorably than that of the female agents, which reflect the stereotypic expectations that men are generally more influential than women in terms of expertise and legitimate power (Kim, 2005). Combining the findings of this study and the reviews of literature, the general recommendation here is that male virtual characters may be more advantageous for both female and male learners in an e-learning environment, particularly when the learning task is focused on technical domain that involves potentially verifiable facts (e.g. computer programming).

Conclusion

In sum, the results of this study showed that learners' social stereotypes and expectations of pedagogical agents mirrored the human to human relationship in the real world, which affects learners' perceptions, task-related attitudes and learning achievement. Additionally, this study lent support to the premise that different agent stereotypes may have different roles in activating stereotypic beliefs in learners' mind, which may be beneficial in influencing different sets of learning behaviors. Hence, the effectiveness of agents' personas and their stereotypic influences on learning behaviors are dependent on the learning context, learning goals and the target learners.

There were limitations of this study that can be controlled in further research. The limited sample size and the short duration of treatment (e-learning) might have contributed to the results of this experiment. Therefore, increasing the sample size and duration of treatment may provide a more realistic representation of results. Additionally, similar research should be extended to participants with other ethnicities and cultural backgrounds. Also, the participants of this study were selected because they lacked domain knowledge. Whether similar results would be obtained with more knowledgeable participants remains to be addressed. Lastly, further studies should confirm if the effects of virtual agents on male and female learners would vary, if agent gender and subject domains are manipulated. As pointed out by Moreno & Flowerday (2006) that the "psychology of design is a lot more complex than the technology of design," evidently this line of research should be extended to further explicate the relationship between agent's design and learners' psychological behaviors and cognitive outcome.

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