Pedagogical agents as social models for engineering: The influence of agent appearance on female choice

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Abstract. The current work examined the influence of pedagogical agents as social models to increase females' interest in engineering. Seventy-nine female undergraduate students rated pedagogical agents on a series of factors (e.g., most like themselves, most like an engineer, and most prefer to learn from). The agents were identical with the exception of differing by appearance/image in four aspects (age, gender, attractiveness, "coolness"). After selecting the agent from which they most preferred to learn, participants interacted with it for approximately 15 minutes and received a persuasive message about engineering. Results indicated that the women were more likely to choose a female, attractive, young, and cool agent as most like themselves and the one they most wanted to be like. However, they tended to select male, older, uncool agents as the most like engineers and tended to choose to learn about engineering from agents that were male and attractive, but uncool. Interacting with an agent had a positive impact on math-related beliefs. Specifically, the women reported more positive math and science related beliefs compared to their attitudes at the beginning of the semester and compared to a group of women who did not interact with an agent. Further, among the women who viewed an agent, the older version of the agent had a stronger positive influence on their math-related beliefs than the younger agent.

Introduction

Many females possess negative and unconstructive beliefs regarding engineering, both as an occupation in general and as a possible career. These misperceptions are instilled by a social fabric that pervades our society, represented not only within our educational systems but also in homes, within families, and in popular culture [1]. This perceptual framework generally stereotypes engineering and scientific fields as physically challenging, unfeminine, and aggressive [2] as well as object-oriented [3, 4]. As such, these beliefs have implications for how women perceive themselves and their competencies within the engineering and scientific realms.

As early as elementary age, females underestimate their math ability, even though their actual performance may be equivalent to that of same-aged boys [5, 6]. In addition, young females believe that math and engineering aptitudes are fixed abilities, attributing success or failure to extrinsic instead of intrinsic factors [7]. The extent of such gender-differentiating attitudes helps to explain the lower probability of women's completing an engineering or science related program and subsequently choosing other fields where interpersonal and organizational-related aspects have greater emphasis [8].

In order to change women's negative attitudes regarding engineering and science-related fields, it may be possible to use pedagogical agents as mechanism for persuasion. Extensive research [9] has demonstrated that people tend to apply human social rules to computer technologies. Females are particularly influenced by the communication and relational aspect of pedagogical agents and are more influenced by them than males [e.g.,10]. While empirical evidence has shown that pedagogical agents are effective to influence the transfer of learning [11, 12], metacognition [13] and motivation [14-17], there is limited evidence of their effectiveness as social models to influence attitudinal beliefs.

The purpose of this study is to investigate whether pedagogical agents can be used as social models [18] to influence college-age women's attitudes and beliefs about engineering. Of particular interest is the impact of the agents' appearance (or image) for its effectiveness. Research in social psychology would suggest that several appearance features are critical in determining how persuasive a social model would be in influencing young women's engineering-beliefs: age, gender, attractiveness, and coolness [18-20]. In general, people are more persuaded by models that are similar to them or similar to how they would like to be [21-24]. Therefore, agents who are young, female, attractive, and "cool" may be more influential in influencing young women's attitudes. However, people are also more persuaded by those they perceive as experts. Thus, agents who are older and seem to be like the typical or stereotypical engineer (i.e., male and uncool) may be particularly influential.

1. Research Questions

In this study, we address the following research questions:

- Which appearance-related agent features (agent age, gender, attractiveness, "coolness") do females choose in response to questions regarding respect, identification, wanting to be like, engineering-likeness, and serving as an instructor?
- What is the impact of the agent that participants choose to learn from on their mathematics beliefs?

2. Method

2.1 Participants

The sample consisted of 79 female students enrolled in eleven sections of an "Introduction to Educational Technology" course at a Southeastern public university. Participation in this study was a required activity for class participants, and they received course credit for participating. The mean age of the sample was 19.34 (*SD* = 1.41) years old. Eighty percent of the participants were White, 9% were Black/African American, 9% were Hispanic/Latino, 1% were Asian/Asian American, and 1% were Caribbean.

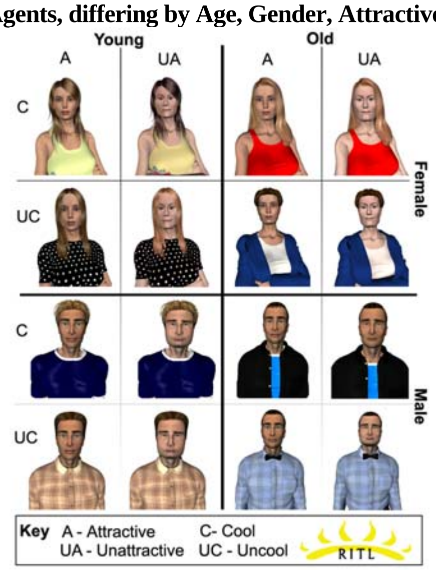
2.2 Materials

Pre-survey. The pre-survey assessed dependent variables in the areas of science/math: identity, utility, interest (as a major and as a job), current and future efficacy, engagement, and future interest. In addition, it included a scale assessing the participants' general self-esteem.

Post-survey. The post survey included all items from the pre-survey in addition to items regarding agent perceptions (e.g., competent, believable, helpful).

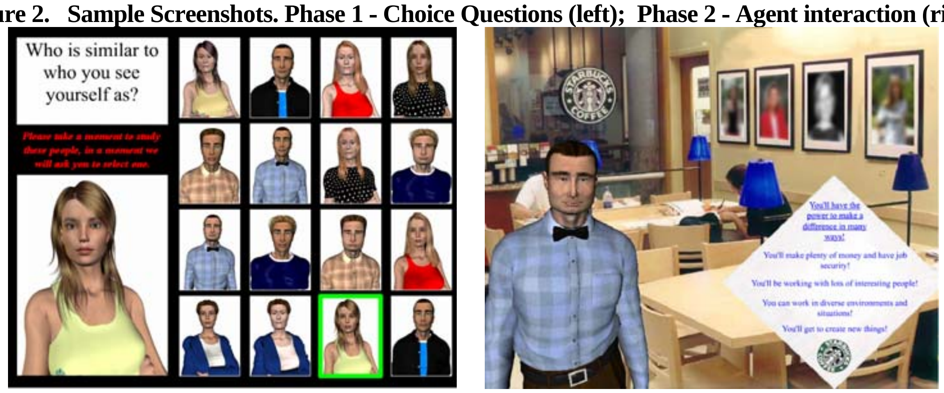
Agents. The agents (see Figure 1) were designed and previously validated to represent 4 different factors (<u>gender</u>: male, female; <u>age:</u> older (~45 years), younger (~25 years); <u>attractiveness</u>: attractive, unattractive; and "<u>coolness</u>:" cool, uncool). Attractiveness was operationalized to include only the agent's facial features, whereas "coolness" included the agent's type of clothing and hairstyle. For example, both of the young attractive female agents have identical faces, but differ in "coolness" by their dress and hairstyle. The agents were created in Poser3D. One male and one female voice were recorded for all the agents using the same script. The audio files were synchronized with the agents using Mimic2Pro. A single series of gestures was added to the agents to complete the agent animation process. A fully integrated environment was created using Flash MX Professional 2004, which allowed for a web browser presentation.

Figure 1. Validated Agents, differing by Age, Gender, Attractiveness, and "Coolness"



Research environment. In the first phase, the participant answered the following series of questions while being presented with the set of 16 agents (see Figure 2): "Who would you most respect and look up to?" "Who would you most want to be like?" "Who is similar to who you see yourself as now?" "Who most looks like an engineer?" "Who looks least like an engineer?"

Figure 2. Sample Screenshots. Phase 1 - Choice Questions (left); Phase 2 - Agent interaction (right)



The agents were randomly presented in one of four combinations that varied the screen layout of the agents to guard against agent selection based on location on the screen (e.g. participants choosing the middle agent). To encourage the participants to give thought to their answer, the participants could not make their choice before 10 seconds had passed. Participants could roll over each agent headshot to see a larger image of the agent. Participants confirmed their selection before proceeding to the next question. The final question "Who would you like to learn from about engineering?" determined which agent presented the persuasive message about engineering in the second phase.

In the second phase, the chosen agent (set in a coffee shop location) introduced itself and provided an approximately ten-minute narrative about four prominent female engineers, followed by five benefits of engineering careers. This script was validated as effective in Baylor & Plant (2004). Periodically, the participants were asked to click on the screen to continue the presentation. Regardless of the participant selection, the agent had identical message and animation.

2.3 Measures

Each dependent variable (with the exception of self-esteem and agent perceptions) was assessed separately for both math and science. Reliability for all scales as assessed by Cronbach's alpha was >.7.

- Identity: three 5-point Likert scale items
- Utility: four 7-point Likert scale items
- Interest (as a major and as a job): three 7-point Likert scale items
- Efficacy : five 5-point Likert scale items
- Engagement : three 7-point Likert scale items
- Self-Esteem : ten 4-point Likert scale items

2.4 Procedure

The pre-survey was distributed at the beginning of the semester. The survey took approximately fifteen minutes to complete. Near the end of the semester, participants accessed the online module through a web-browser during a regularly-scheduled classroom lab session. Following completion, participants answered the post-survey questions (with an image of the agent as a reminder). The whole session took approximately thirty minutes.

2.5 Data analysis and Design

To determine which agent participants chose, based on the six social model characteristics/questions, four one-sample t-tests were conducted for each of the questions to explore whether the female participants' choices were influenced by the gender, age, coolness and attractiveness of the agents.

Given that the agents that participants chose to learn from were primary male, attractive and uncool, the analysis of agent impact was limited to agent age. The six key outcome measures were organized into four conceptually-related categories: identity/engagement, future interest (job or major), efficacy and utility, and were analysed separately. The impact of agent age on future interest and identity/engagement in mathematics were analyzed through two separate one-factor (age: young, old) MANOVAs. Two separate independent sample t-tests were conducted to assess the impact of chosen agent age (young, old) on math self-efficacy and math utility.

3. Results

Results are organized with respect to each of the two research questions.

3.1 Which appearance-related agent features (agent age, gender, attractiveness, "coolness") do females choose, according to social model characteristic (respect, identification, want to be like, engineering-likeness, and serving as an instructor)?

Four one sample t-tests were performed for each of the 6 questions and results are summarized in Table 1.

Table 1. Summary of Choices by Question and Agent Appearance

	Gender	***Age***	***Attractiveness***	***Coolness***	***Representative Agent (% selected)***
Who would you most respect and look up to?			**Attractive** > Unattractive (67% vs. 33%) **	**Uncool** > Cool (81% vs. 19%) ***	 (16%)
Who would you most want to be like?	**Female** > Male (79% vs. 21%) ***	**Young** > Old (85% vs. 15%) ***	**Attractive** > Unattractive (94% vs. 6%) ***	**Cool** > Uncool (79% vs. 21%) ***	 (72%)
Who is similar to who you see yourself as?	**Female** > Male (81% vs. 19%) ***	**Young** > Old (81% vs.19%) ***	**Attractive** > Unattractive (85% vs. 15%) ***	**Cool** > Uncool (71% vs. 29%) ***	 (53%)
Who most looks like an engineer?	**Male** > female (94% vs. 6%) *	**Old** > Young (63% vs. 37%) ***		**Uncool** > Cool (75% vs. 25%) ***	 (28%)
Who looks least like an engineer?	**Female** > Male (73% vs. 27%) ***	**Young** > Old (69% vs. 31%) **		**Cool** > Uncool (84% vs. 16%) ***	 (24%)
Who would you like to learn from about engineering?	**Male** > female (87% vs. 13%) ***		**Attractive** > Unattractive (69% vs. 31%),**	**Uncool** > Cool (64% vs. 36%) **	 (22%)

** p<.05; **p<.01; ***p<.001*

As shown above in Table 1, female participants tended to: 1) most respect agents that were attractive and uncool; 2) want to be like and 3) identify most with the agent that was female, young, attractive, and cool; 4) find that the older, uncool male agents looked most like an engineer, whereas the young cool females looked the least like engineers; and 5) want to learn from the male agents who were attractive and uncool.

3.2 What is the impact of the agent from which participants choose to learn?

Regardless which agent was chosen to deliver the message (i.e., the agent they selected to "learn from"), following the agent's message, women had significantly more interest in hard sciences as a job ($p<.01$), more efficacy in math ($p<.10$), could identify more with the hard sciences ($p<.10$), more engagement in the hard sciences ($p<.05$), more future interest in the hard sciences ($p<.01$), and believed hard sciences was more useful ($p<.001$) than prior in the semester.

In addition, the responses of the female participants who interacted with an agent were compared to a group of female participants who only completed the post-survey at the end of the semester (N=12). Compared to the group who simply completed the post-survey, the participants who viewed an agent had higher levels of math self-efficacy ($p<.05$), math identity ($p<.05$), math utility ($p<.01$), and future interest in a job in mathmatics (p <.05) at the end of the semester. In addition, they reported a higher general self-esteem ($p<.001$) than the no-agent group.

For the final question ("who would you like to learn from"), participants tended to select male agents that were attractive and uncool, but differing by age (young or old). Consequently, agent impact was limited to comparing the effects of agent influence by age (younger versus older).

The MANOVA for *future interest in math* indicated that there was an overall effect of the age of the agent on the future interest in math, Wilks's Lambda = .917, $F(2,76)=3.449$, $p<.05$. Univariate results revealed a main effect of agent age on future interest in math as a *major*, where those influenced by the older agent reported significantly more future interest in math as a major (M = -.663, SD = 2.258) compared to participants who had a younger agent (M = -1.712, SD = 1.677), $F(1,79)=5.096$, MSE = 4.150, $p < .05$. The effect size estimate is d = -.53 indicating a medium effect. Univariate results also revealed a main effect for the agent age on future interest in math as a *job*, where participants who learned from the older agent reported greater future interest in math as a job (M = .0435, SD = 1.632) compared to participants who had a younger agent (M = -.8485, SD = 1.253), $F(1,79)=6.918$, MSE = 2.210, p = .01. The effect size estimate is d = -.61, indicating a medium effect.

The MANOVA for *math identity and engagement* indicated that there was as overall effect of the age of the agent on future interest in math, Wilks's Lambda = .921, $F(2,76)=3.271$, $p<.05$. Univariate results revealed a main effect for the agent age on *math identity*, indicating that participants who learned from an older agent reported a higher level of math identity (M = .4783, SD = 1.216) than participants who learned from a younger agent (M = -.202, SD = 1.193), $F(1,79)=6.106$, MSE = 1.456, $p< .05$. The effect size estimate was d = -.57, indicating a medium effect. Univariate results also revealed a main effect for the agent age on *math engagement*, indicating that participants who had an older agent reported higher level of math engagement (M = .4638, SD = 1.856) compared to participants who had a younger agent (M = -.5859, SD = 1.848), $F(1,79)=6.167$, MSE = 3.433, $p < .05$. The effect size estimate is d = -.57, indicating a medium effect.

An independent sample t-test revealed that participants who selected an older agent reported higher levels of *math efficacy* compared to participants who had a younger agent. (M = .6304 vs. M = .1333), $t(77)=-1.919$, p = .05. The effect size estimate is d = .45, indicating a medium effect. An independent sample t-test revealed that participants who selected an older agent reported higher levels of *math utility* compared to participants who had a young agent (M= 1.03 vs. M=.52), t (77) =-1.72, p=.05. The effect size estimate is d =.40, indicating a medium effect.

These findings indicate that participants who learned from the older agents were more strongly influenced than those who learned from the younger agents. It may be that because the older agents were perceived as more like engineers, as indicated by the participants' ratings at the beginning of the session, they were more effective models. Interestingly, whereas participants were more influenced by the older agents and rated them as more competent than the younger agents, they also rated the younger versions as more believable (p<.1) and helpful (p<.1) than the older ones.

4. Discussion

The findings from the current study indicate that pedagogical agents may be useful tools for modelling positive attitudes toward engineering to young women. In general, the women who interacted with a pedagogical agent developed more positive math and science related beliefs compared to their ratings earlier in the semester as well as compared to a group of young women from the same course who did not interact with an agent. In addition, the present study provided insight into the types of agents that women choose to learn from and the types of agents that were more effective in influencing the women's attitudes regarding math and engineering.

Previous work examining social modelling would indicate that the young women should be more influenced by agents that were similar to them or similar to how they would like to be (e.g., female, attractive, cool). However, persuaders who are perceived as knowledgeable and experts can also be highly influential. As anticipated, when the young women in the current study were asked to select the agents who were most like them and who they most wanted to be like, they tended to pick young, female, attractive, and cool agents. However, they also selected the young, female, cool agents as being least like an engineer. When asked to select who they would most like to learn from about engineering, the women in the current study were far more likely to pick male agents who were uncool but attractive. Interestingly, it was also the male, uncool agents that they tended to rate as most like an engineer. However, their selections for the most typical engineer also tended to be older.

Because so few of the participants selected female agents (only 13%), it was difficult to compare the efficacy of the female compared to male agents. In addition, there was a strong tendency to select attractive, uncool agents from whom to learn. Therefore, it is difficult to pit the efficacy of a similar agent (i.e., young female, attractive, cool) against the efficacy of an agent perceived as an expert on the topic (i.e., stereotypical engineer – male, old, uncool). In order to examine this issue more thoroughly, it will be important in future work to conduct studies where young women are randomly assigned to various agents. However, because the women's choice of agent from whom to learn varied by age, it was possible to explore whether the older or younger agents were more effective. Counter to the idea that similar agents would be more effective, the young women who selected and viewed the *older* compared to younger agents had more future interest in mathematics, greater self-efficacy in mathematics, were more engaged and identified with mathematics, and saw mathematics as having more utility.

Although these findings would seem to suggest that similarity is not as influential as expertise, it is important to note that the agents talked about four prominent female engineers who varied in age. Thus, the impact of hearing the older, therefore, perhaps more typical engineer agent discuss young and old successful female engineers may have constituted a particularly effective persuasive tool.

This study adds to the growing empirical evidence of the importance of interface agent *appearance* [25]. It is important to note that the pedagogical agents in this study were intentionally scripted to control for message, interactivity, animation, and expression. Future research must also consider the additive effects of other important agent persona features (e.g., voice, message, animation), particularly as they serve as front-ends to intelligent tutoring systems that influence attitude and other learning-related outcomes.

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