Introduction

In the field of learning sciences and technologies, a particularly valuable feature of computer-based animated agents is their potential to serve as social models to influence student attitude and motivation (e.g., Baylor, 2005; Baylor et al., 2005; Kim & Baylor, in press). In this experimental study, we investigate the role of agent *appearance* in influencing female students' negative and unproductive beliefs about engineering.

Such negative beliefs contribute to the fact that very few women pursue careers in engineering and other information technology fields (Shashaani, 1997). Fields such as law and medicine, which have historically included larger numbers of men than women, have achieved sex equity over the past 30 years. Conversely, math and engineering still include a relatively a small proportion of females (Goodman et al. 2002). For example, only 8.5% of all professional engineers are women, although women constitute 56.8% of the total workforce (Goodman et al. 2002). This absence of women in engineering is also evident at the postsecondary level, where men outnumber women 3 to 1 in engineering courses (American Association of University Women, 2000).

Women's under-representation in engineering and related fields may be due in part to the effects of occupational stereotypes regarding those fields. Engineering and scientific fields are generally stereotyped as physically challenging, unfeminine, and aggressive (Adams, 2001). They are perceived as object-oriented rather than people-oriented (Lippa, 1998). Engineering is viewed as a field lacking in social responsibility and contributing to environmental problems (Hersh, 2000), which has been demonstrated to have a significant impact on young women's choices (Ormerod, 1971). Additionally, the current under-representation of women in engineering may foster the impression that engineering is an abnormal career for women (Byrne, 1993).

Female students' levels of self-efficacy regarding engineering related fields (e.g., Bandura, 1997) may also affect their intentions to pursue careers in engineering and their perseverance in this pursuit. Self-efficacy refers to the belief that one is competent to meet situational demands (Wood & Bandura, 1989). Studies on the self-efficacy of women in engineering have shown that female students usually perceive themselves as relatively less competent than male students. Negative self-efficacy in math, science, and engineering begins early for female students. Girls as young elementary age tend to underestimate their math ability, even though their actual performance may be equivalent to that of same-aged boys. Additionally, girls believe that math and engineering aptitudes are fixed abilities, attributing success or failure to extrinsic instead of intrinsic factors. Self-efficacy is likely to affect educational outcomes for women engineering majors. Goodman and colleagues (2002) found that female engineering students who abandoned their major believed their male peers to have more ability and comprehension of concepts than they, even though 66% of these female students earned an A or B average. The most influential factor that determined attrition among female students was not course grades but level of self-confidence.

Pedagogical Agents as Social Models and Motivators

According to Bandura, (1986, 1997) much of our learning derives from vicarious experience. Social modeling of behaviors enables us to learn new behaviors, strengthens or diminishes previously learned behaviors, and reminds us to perform behaviors about which we had forgotten. Social models can influence people's evaluations of whether an attitude is good or bad (Goethals & Nelson, 1973). Observing a social model perform a behavior provides us with information relevant to self-efficacy through a process of social comparison (Bandura & Schunk, 1981). Therefore, social models may be particularly helpful in affecting attitudes and self efficacy of women in regard to engineering.

There are several difficulties with relying upon human social models to expose female students to productive beliefs about engineering and women's abilities. Such role models who are available might not necessarily be the best match for a student's needs. The logistics of arranging such opportunities can also be problematic. Furthermore, as Hersh (2000) notes, women in nontraditional fields may already face burdensome workloads that make it difficult to devote resources to serving as models for students.

Given these problems, pedagogical agents can potentially serve as simulated social models to impact female students' beliefs about engineering. A pedagogical agent is an anthropomorphic, animated character whose purpose is to provide teaching or mentoring within a computerized learning environment. Pedagogical agents have been found to positively influence users' interest and motivation (e.g., Baylor, 2002a; Baylor, 2002b; Baylor & Ryu, 2003; Baylor, 2005; Moreno, Mayer, Spires, & Lester, 2001). The positive effect of a pedagogical agent on motivation can also be explained social presence theory. According to Short, Williams, and Christie (1976), social presence is a subjective quality of the communication medium and is a function of both verbal cues (e.g. tone of voice) and nonverbal cues (e.g. facial expression, direction of gaze, posture, and dress). Hence, a pedagogical agent has a much greater social presence than messages from other computer-based media given that the agent can provide both nonverbal (e.g., appearance, deictic gestures, emotional expression) and verbal (e.g., voice, tone, delivery, message) cues, which can enhance its capacity to persuade and motivate.

Consequently, 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 (e.g. Reeves & Nass, 1996) has demonstrated that people tend to apply human social rules to computer technologies. Further, young women are particularly influenced by the communication and relational aspect of pedagogical agents, and can be more influenced by them than males (e.g., Baylor et al., 2005).

Purpose of Study: Effects of Agent Characteristics on Engineering Beliefs

The purpose of this study was to investigate the impact of agent *appearance* on impacting female students' stereotypes and beliefs regarding engineering. Research in social psychology suggests 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" (Bandura, 1997; Chaiken, 1979; McIntyer, Paulson & Lord, 1998).

In general, people are more persuaded by models that are similar to them or similar to how they would like to be (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood, 1989). Therefore, agents who are young, female, and "cool" may serve as viable peer models and influence young women's attitudes. However, people are also persuaded by those they perceive as experts (e.g. Chaiken & Maheswaran, 1994; DeBono & Harnish, 1988; Hovland & Weiss, 1951). Thus, agents who are older and seem more like the typical or stereotypical engineer (i.e., male and uncool) may also be particularly influential.

This apparent contradiction is reconciled by evidence that different types of influence are exerted by peers and experts (Geothals & Nelson, 1973). When an attitudinal, value-related issue (e.g., self-efficacy) is the object of influence, people are more likely to be affected by a similar other. Conversely, when the issue involves potentially verifiable facts, an expert is more influential. Thus, in the present research, we hypothesized that interacting with a young, cool, female agent (i.e., peer-model) would positively affect stereotypic beliefs and self-efficacy regarding engineering. Conversely, we anticipated that interacting with an agent perceived as an expert engineer (e.g., male, uncool, old) would positively affect participants' perception of engineering as useful, worthwhile, and interesting.

Method

Participants

Participants included 109 female college undergraduate students enrolled in an introductory technology course. Only participants who agreed to participate in the study by signing the consent form were included. The average age of the sample was 19.72 years (*SD* = 1.96). Of the participants, 80.7% were Caucasian, 3.7% were African-American, 0% were Asian/Asian American, .9% were Native American, 11.9% were Hispanic/Latino, and 2.7% were multi-racial.

Research design and Independent Variables

The study employed a 2 (gender: male vs. female) x 2 (age: old vs. young) x 2 (coolness: cool vs. uncool) between subjects factorial design. Participants were randomly assigned into one of the eight agent conditions.

The agents were designed and previously validated to represent three different factors (gender: male or female; age: older (~45 years) or younger (~25 years); and "coolness:" cool or uncool). Coolness was operationalized to include the agent's clothing and hairstyle. For example, both of the young female agents have identical faces, but differ in "coolness" by their dress and hairstyle. In previous related work, we found that *attractive* agents were more influential as agent models for engineering (Baylor & Plant, 2005). Consequently, only agents that had been previous validated as attractive (operationalized by facial features) were employed in this study. The agents were created in Poser. One male and one female voice were recorded for all the agents using the same script and similar inflection and tone. The audio files were synchronized with the agents using Mimic2Pro to create lip synching and emotional expressions. Several deictic gestures, identical for all agents, were also included. A fully integrated environment was created using Flash MX Professional 2004.

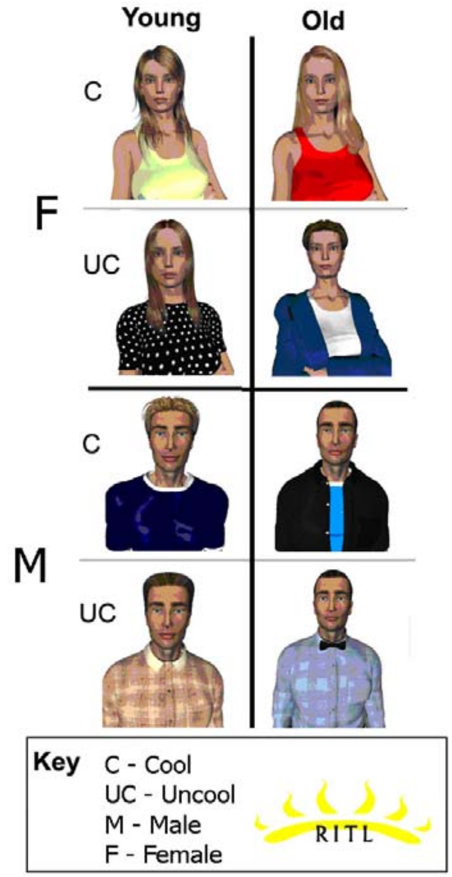

Figure 1. Validated Agents, differing by Age, Gender, and "Coolness"

Dependent measures

There were three dependent variables in this study: a) participants' endorsement of the traditional engineering stereotype; 2) motivation (interest, utility, and engagement) towards engineering; and 3) self-efficacy regarding engineering. For all items students rated their level of agreement with each statement on a 7-point scale, ranging from strongly disagree (1) to strongly agree (7).

The stereotype inventory consisted of four items to assess female students' stereotype concerning engineering-related fields. For example, "People would make fun of me, if I were a math major." The reliability of the stereotype items was .86.

Students' motivation to pursue engineering was measured according to three dimensions. First, *interest* in taking engineering related classes was measured using four items. For example, "I will take a math course as an elective." The reliability of interest items was .83. Second, *utility* of engineering was measured with eight items. For example, "Hard science courses are very useful for me." The reliability of utility items was .84. Third, the degree to which they found engineering *engaging* was measured with six items. For example, "I am really interested in math." The reliability of engagement items was .82.

The self-efficacy inventory included 10 items to assess students' self-efficacy in engineering related fields. For example, "I am confident that I could do well in math classes." The reliability of self-efficacy items was .89.

Research environment

One of the eight agents was randomly presented to each student. The assigned agent (set in a coffee shop location) introduced itself and provided a twenty-minute narrative about four female engineers, followed by five benefits of engineering careers. This script was validated as effective in Baylor & Plant (2004; 2005). Periodically, the participants interacted with the agent to continue the presentation.

Figure 2. Sample Screenshot

Procedure

The experiment was conducted in a regularly-scheduled classroom lab session where students accessed the online module through a web-browser. Following completion, participants answered the online post-survey questions.

Results

The descriptive statistics for all dependent variables are presented in Table 1 according to the eight conditions.

Table 1. Descriptive statistics for the dependent variables

Dependent variables [a]	Measures		Cool: Female Young (n=20)	Cool: Female Old (n=12)	Cool: Male Young (n=22)	Cool: Male Old (n=10)	Uncool: Female Young (n=12)	Uncool: Female Old (n=12)	Uncool: Male Young (n=13)	Uncool: Male Old (n=10)
Stereotype (traditional)		*M*	3.11	2.04	2.95	3.48	2.46	2.71	3.40	2.98
		SD	1.34	1.02	1.71	2.07	1.47	1.44	1.51	1.12
Motivation	Interest	*M*	2.85	2.15	3.23	2.15	1.98	2.00	2.40	2.53
		SD	1.40	1.40	1.85	1.33	1.40	1.38	1.38	1.24
	Utility	*M*	4.48	3.76	5.07	4.36	4.44	3.88	4.06	4.63
		SD	1.08	1.66	.98	.93	1.16	1.31	.74	.88
	Engagement	*M*	3.84	3.72	4.17	3.27	3.64	3.35	3.65	3.35
		SD	1.41	1.45	1.50	1.16	1.65	1.82	.78	.94
Self-efficacy		*M*	3.78	3.28	4.15	3.23	2.90	3.51	3.35	3.45
		SD	.92	1.41	1.35	1.16	1.75	1.35	.72	1.52

Notes:
a: Possible range for all dependent variables was 1-7

The effect of agent appearance on endorsement of the engineering stereotype

To determine the effects of agent appearance on student endorsement of the traditional engineering stereotype, a factorial univariate analysis of variance (ANOVA) was performed. A 2 (female vs. male) x 2 (young vs. old) x 2 (cool vs. uncool) between-groups ANOVA on stereotype scores revealed a significant main effect for agent gender, $F(1,103)=4.44$, $p < .05$. Participants who interacted with a female agent were significantly less likely to endorse the traditional stereotype of engineers (e.g., geeky, less social, etc.) (M = 2.66, SD = 1.36) than those who interacted with a male agent (M = 3.16, SD = 1.62), d = .34, a small-moderate effect.

The effect of agent appearance on motivation toward engineering

Student motivation was analyzed through a factorial MANOVA, with interest, utility, and engagement as the three dependent measures. The MANOVA indicated that there was statistically significant main effect of agent gender on students' overall motivation, Wilks' Lambda=.920 F(3,101)=2.943, p < .05, η^2=.08. Follow-up univariate ANOVAs indicated no significant differences in any of dependent measures. Given that there univariate results revealed no significant differences, a discriminant analysis was conducted to investigate the nature of the relationship among the dependent variables, as suggested by Field (2004). The results of the discriminant analysis indicated that utility, and to a somewhat lesser extent, interest, most differentiated the male agent as more influential than the female agent.

The effect of agent appearance on self-efficacy

A 2 (female vs. male) x 2 (young vs. old) x 2 (cool vs. uncool) between-groups ANOVA on student self-efficacy revealed a significant interaction between agent age and agent coolness, $F(1,103)=4.43$, $p < .05$. Results indicated that if the agent were young, it had a more positive effect on self-efficacy if it were *cool* compared to *uncool (M* =3.97, *SD* =1.16 *vs. M*=3.14, *SD*=1.31, respectively, *d*=.67, a moderate-large effect*)*; however if the agent were old, it was more beneficial for self-efficacy if it were *uncool* compared to *cool (M* =3.48, *SD* =1.39 *vs. M*=3.26, *SD*=1.27, respectively, d=.17, a small effect*)*.

Discussion

The current study examined the implications of agent appearance for influencing young women's stereotypes, motivation, and self-efficacy regarding engineering-related fields. Previous work with agents as social models indicated that young women would be more persuaded by agents that were similar to them or similar to how they would like to be (e.g., peer models - female, young, cool) (e.g., Baylor, 2005; Baylor & Kim, in press). However, agent persuaders who are perceived as knowledgeable and experts (e.g., stereotypical engineers - male, old, uncool) can be highly influential on issues related to facts and information (see Baylor & Kim, in press).

Overall, female students who interacted with the female agent reported a more positive endorsement stereotype of engineering than those who interacted with the male agent. Thus, the agent who was similar to the participants in terms of gender (female) was more influential for changing their stereotypic beliefs. Given that previous work indicates that young women tend to view the typical engineer as male (Baylor & Plant, 2005), the greater effectiveness of the female agents may have also been due to the female agents seeming *less* stereotypical as an engineer than the male agents. Thus, the very presence of the female agent who presented herself as an engineer may have been sufficiently influential to influence participants' stereotypic beliefs. Improving young women's perceptions of the stereotypical engineer could lead them to see engineers as the type of people with whom they would want to work, which may be an important step in increasing interest in pursuing engineering.

In contrast to the findings for stereotype endorsement, the male agents were more effective than the female agents in influencing the young women's motivation to pursue engineering and, particularly, their perceptions regarding the utility of engineering-related fields. Because the male agents were likely perceived as more prototypical engineers (as found in Baylor & Plant, 2005) and as having greater expertise, they may have been more influential in changing the young women's perceptions of the usefulness and value of engineering-related classes and careers.

Because women tend to have negative perceptions regarding their ability to pursue engineering related fields, improving young women's self-efficacy regarding engineering was a particularly important goal of the current work. Results indicated that if the agent were young, it was far more effective in increasing the women's efficacy if it was cool compared to uncool. In contrast, if the agent were old, the uncool agent was slightly more effective than the cool agent. Thus, the agents were more effective if they were either peer models who were similar to how the students viewed themselves (i.e., young and cool) or similar to the stereotypical engineer (i.e., old and uncool). For self-efficacy, it appears that either the perception of similarity (peer model) or expertise (stereotypical engineer) increased the effectiveness of the agent.

The current work adds to the growing empirical evidence of the impact of agent *appearance* (Baylor, 2005). The findings from the current work highlight the importance of employing agents that are similar to the participants as well as agents who are perceived as experts. It may be that the most effective approach would be to use multiple agents (e.g., have a stereotypical engineer and a peer model both interact with participants). Future research should also consider the additive effects of other important agent persona features (e.g., voice, message, non-verbal communication).

References

Adams, J. (2001, October 26). Are traditional female stereotypes extinct at Georgia Tech? *The Technique.*

American Association of University Women. (2000). *Tech savvy: Educating girls in the new computer age*. Washington, DC: American Association of University Women Educational Foundation.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, N.J.: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman and Company.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology, 41*(3), 586-598.

Baylor, A. L. (2002a). Agent-based learning environments for investigating teaching and learning. *Journal of Educational Computing Research, 26*(3), 249-270.

Baylor, A. L. (2002b). Expanding preservice teachers' metacognitive awareness of instructional planning through pedagogical agents. *Educational Technology, Research & Development, 50*, 5-22.

Baylor, A. L. (2005). *The Impact of Pedagogical Agent Image on Affective Outcomes*. Proceedings of Workshop "Affective Interactions: The Computer in the Affective Loop" at the International Conference on Intelligent User Interfaces, San Diego, CA.

Baylor, A. L., & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education*, 15(1).

Baylor, A. L., Kim, S., Son, C., & Lee, M. (2005). Considering Pedagogical Agents Gestures and Facial Expression with Learning Outcomes. *Proceedings of the Association for Educational communication and Technology,* Orlando, FL.

Baylor, A. L. & Plant, E.A. (2005). Pedagogical agents as social models for engineering: The influence of appearance on female choice. 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. 65-72). Amsterdam, The Netherlands: IOS Press.

Byrne, E. M. (1993). *Women and science: The snark syndrome.* Washington, DC: Falmer Press.

Chaiken, S. & Maheswaran, D. (1994). Heuristic processing can bias systematic processing: Effects of source credibility, argument ambiguity, and task importance on attitude judgment. *Journal of Personality and Social Psychology, 66*(3), 460-473.

DeBono, K. G., & Harnish, R. J. (1988). Source expertise, source attractiveness, and the processing on persuasive information: A functional approach. *Journal of Personality and Social Psychology, 55*(4), 541-546.

Goethals, G. R., & Nelson, R. E. (1973). Similarity in the influence process: The belief-value distinction. *Journal of Personality and Social Psychology, 25*(1), 117-122.

Goodman, I. F., Cunningham, C. M., Lachapelle, C., Thompson, M., Bittinger, K., Brennan, R. T., & Delci, M. (2002). *Final report of the women's experiences in college engineering project.* Cambridge, MA: Goodman Research Group, Inc.

Hersh, M. (2000). The changing position of women in engineering worldwide. *IEEE Transactions of Engineering Management, 47*(3), 345-359.

Hovland, C. I., & Weiss, W. (1951). The influence of source credibility on communication effectiveness. *Public Opinion Quarterly, 15*, 635-650.

Kim, Y., & Baylor, A. L. (in press). A social-cognitive framework for pedagogical agents as learning companions. *Educational Technology Research & Development*.

Lippa, R. (1998). Gender-related differences and the structure of vocational interests: The importance of the people-things dimension. *Journal of Personality and Social Psychology, 74*, 996-1009.

Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*(2), 177-213.

Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review, 110*, 472-489.

Ormerod, M. B. (1971). The "social implications" factor in attitudes to science. *British Journal of Educational Science, 41*(3), 335-338.

Schunk, D. H. (1987). Peer models and children's behavioral change. *Review of Educational Research. 57*, 149-174.

Shashaani, L. (1997). Gender differences in computer attitudes and use among college students. *Journal of Educational Computing Research, 16*(1), 37-51.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications. London: Wiley.*

Wood, J. V. (1989). Theory and research concerning social comparisons of personal attributes. *Psychological Bulletin, 106*, 231-248.

Wood, R., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of Personality and Social Psychology, 56*(3), 407-415.

Acknowledgments

This work was supported by the National Science Foundation, Grant HRD-0429647.