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Changing middle-school students' attitudes and performance regarding engineering with computer-based social models

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ABSTRACT

Women's under-representation in fields such as engineering may result in part from female students' negative beliefs regarding these fields and their low self-efficacy for these fields. In this experiment, we investigated the use of animated interface agents as social models for changing male and female middle-school students' attitudes toward engineering-related fields, their self-efficacy for these fields, and their math performance. Students interacted with either a female or a male computer-based agent or they did not interact with an agent. The female agent increased interest, utility beliefs, self-efficacy, and math performance compared to control and, for boys, decreased stereotyping. Mediational analyses indicated that the female agent facilitated interest and math performance by enhancing self-efficacy. The findings indicate that interface agents may be used effectively as social models for influencing attitudes and beliefs and supporting performance.

1. Introduction

Women have achieved increasing inclusion and success in professions that were formerly occupied primarily by men. Fields such as law and medicine, which were historically heavily male dominated, have achieved sex equity over the past 30 years (Goodman et al., 2002). However, women remain under-represented in the field of engineering. For example, only 8.5% of all professional engineers are women, although women constitute close to half of the total workforce (Goodman et al. 2002). A 2003 National Science Foundation (NSF) report indicated that women account for only 20% of the undergraduate enrollment in engineering programs even though they are more likely to attend college than men (also see National Science Board, 2006). This absence of women in engineering is also evident in doctoral programs where men are four times more likely than women to earn a doctoral degree in engineering (National Science Board, 2006). Thus, it is important to uncover ways to encourage greater participation by women in engineering-related fields.

The current work explores whether using computer-based, anthropomorphic interface agents can increase young women's interest and performance in engineering-related fields through social modeling. Previous work indicates that interface agents can positively influence college-age women's beliefs about and interest in engineering (Baylor & Plant, 2005; Rosenberg-Kima, Baylor, Plant, & Doerr, 2008). This work expands upon this previous work in several ways. First, we explore whether using interface agents as social models is effective for a younger audience of middle-school or junior high students. Catching young women at an early age is critical because decisions made early, such as which classes to take in high school and college, can have substantial implications for the ability and likelihood of women pursuing engineering in the future. Second, this work examines whether interface agents positively impact young women's performance in engineering-related fields and, specifically, mathematics. Although the previous work indicates that agents can positively influence attitudes, there is little evidence that they can positively impact performance. In addition, we examine whether any impact of the agents on the students' interest and performance that we find is due to the positive implications of the intervention on self-efficacy and stereotypes about women and engineering. Finally, we investigate how the interface agents and their message influence young men's interest and performance in engineering-related fields. Ideally, any approach that positively influences female students would also encourage male students (or at minimum not discourage them).

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1.1. Computer-based agents as social models and motivators

According to social learning theory (e.g., Bandura, 1977, 1986, 1997), much of our learning is derived from vicarious experience. In general, people are more influenced by social models that are similar to them or similar to how they would like to be (e.g., Bandura, 1986; Mussweiler, 2003; Schunk, 1987; Wood & Bandura, 1989). Observing another person modeling behaviors can facilitate learning new behaviors and strengthen desired behaviors as well as provide information relevant to self-efficacy through social comparison (Bandura & Schunk, 1981; Schunk, 1987; Schunk, Hanson, & Cox, 1987). When people see another person who is similar to them successfully perform a behavior it can bolster their belief that they too can successfully perform the behavior (Bandura & Schunk, 1981). Similar social models can also influence people's attitudes by helping them to discern whether their attitudes toward a specific thing ought to be favorable or unfavorable, and they can supply information about whether or not tasks are behaviorally appropriate for them (Goethals & Nelson, 1973; Schunk, 1987). Consistent with these ideas, there is evidence that the exposure to successful women in engineering-related fields can increase women's interest and performance in these fields. For example, the percentage of women who major in or get a degree in science and engineering fields is positively related to the percentage of female faculty members in the field (Sonnert, Fox, & Adkins, 2007). In addition, Marx and Roman (2002) found that young women performed better on math tests after being exposed to a highly competent female role model (also see McIntyer, Paulson, & Lord, 2003).

Together, this previous work indicates that in order to improve young women's beliefs, interest, and performance in engineering-related fields, it may be most effective to expose them to young, female social models with aptitude and enthusiasm for engineering. There are, however, difficulties with relying upon human social models to influence young women's beliefs about engineering. The logistics of arranging opportunities for young women to interact with social models can be problematic, especially if the desired model is a female engineer. As Hersh (2000) notes, women in nontraditional fields may already face burdensome workloads that make it difficult to devote resources to mentoring students.

One potential alternative source for persuasive human models is to employ computer-based anthropomorphic interface agents, which are 3-dimensional, fully animated, and expressive characters that provide mentoring within a computer-based learning environment. Such interface agents have been found to be effective in positively influencing students' interest and self-efficacy (e.g., Baylor, 2002a, 2005; Baylor & Kim, 2005; Baylor & Ryu, 2003; Kim & Baylor, 2006), metacognitive awareness (Baylor, 2002b), and attitudes (Baylor & Kim, in press). Recent research has demonstrated that interface agents can have a positive impact on female undergraduates' interest and even self-efficacy regarding engineering (Baylor & Plant, 2005; Rosenberg-Kima et al., 2008). Baylor and Plant (2005) had interface agents provide a persuasive message to undergraduate women that included information about successful women in the field of engineering and challenged existing stereotypes about women and engineering. After the intervention, the young 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 Rosenberg-Kima and colleagues (2008) used a very similar procedure but randomly assigned the young women to attractive interface agents that varied in age, gender, and whether they were "cool" or more "nerdy". They found that agents that were similar to the young women in age and who were "cool" in dress and hairstyle were the most effective in improving the young women's interest in engineering-related fields and self-efficacy regarding engineering-related fields. In addition, the female agents were more effective in challenging the young women's stereotypes that women were less successful and welcome in engineering-related fields and professions than men. These findings suggest that it may be possible to use a similar procedure to influence younger women as well.

1.2. Stereotypes and self-efficacy

In considering the factors that may influence women's interest and success in engineering-related fields, we considered two key potential factors: stereotypes and self-efficacy. Women and girls generally possess unproductive beliefs about math and the hard sciences. For example, they tend to sex-type science as a masculine pursuit (e.g., Hughes, 2002) and negate the utility of mathematics (Eccles, 1994). Such negative responses to math and the hard sciences may make young women less likely to pursue these areas and may lead them to stop taking classes in these fields from an early age. Engineering and scientific fields are generally stereotyped as unfeminine, aggressive, and as object-oriented rather than people-oriented (Adams, 2001; Lippa, 1998). Engineering is viewed as a field lacking in social responsibility and contributing to environmental problems (Hersh, 2000). Additionally, the current under-representation of women in engineering may foster the impression that engineering is an abnormal career for women (Byrne, 1993). Thus, stereotypic beliefs, in combination with awareness of existing under-representation of women in the field may discourage female students from pursuing engineering careers. However, if young women are reached at a young age, it might be possible to change their unproductive beliefs.

Female students' levels of self-efficacy regarding math, science, and engineering may also affect their intentions to pursue engineering careers. Female engineering students tend to believe they are less competent than their male peers (Goodman et al. 2002). Such negative self-efficacy beliefs about engineering-related skills begin early. Starting in elementary school, young girls frequently underestimate their math ability, even though their actual performance is typically equivalent to that of same-aged boys (Eccles, 1987, 1994; Seymour & Hewitt, 1997) and their computation skills are even slightly better than boys' in elementary school and middle school (Hyde, Fennema, & Lamon, 1990). Low levels of self-efficacy are likely to discourage young women from pursuing these areas and, if they begin early, the negative implications may resonate throughout their academic and professional careers.

Self-efficacy is also likely to affect educational outcomes for women who actually choose to become engineering majors. Goodman and colleagues (2002) found that female engineering students who abandoned their major believed their male peers had greater ability and superior comprehension of concepts than themselves, even though 66% of these female students earned an A or B grade point average. Among female students, the most influential factor that determined attrition was not course grades, but level of self-confidence. Therefore, promoting young women's self-efficacy for math, science, and engineering might support their performance in these areas.

1.3. The current work

The purpose of this study was to test whether computer-based interface agents can serve as effective social models to change middle-school students' attitudes and interest regarding engineering-related fields. Participants were randomly assigned to receive an interactive message from a female or male computer-based interface agent or they did not interact with an agent. In the agent conditions, the agent espoused gender-fair beliefs, told them about four successful women in engineering-related fields, and provided encouragement regarding their likely success in engineering-related fields. A questionnaire assessed all participants' interest in and stereotypes about math and the hard sciences as well as their self-efficacy for these fields. Finally, a math test assessed the implications of the exposure to the agent or no exposure for students' mathematical performance.

We examined both female and male students' responses to see if the message was effective for both groups and whether an agent was more effective when it matched the student's gender. One of the benefits of interface agents is that they can be designed to match participants across a range of factors, including gender. Participants who interacted with an interface agent, and particularly a same-gender agent, were expected to indicate more gender-fair beliefs about engineering-related fields and were also expected to report more positive self-efficacy, utility, and interest in engineering-related fields than students who did not interact with an agent. In addition, we were interested in whether the agents could positively influence the students' performance on a math test, as compared to the control group.

Finally, we were interested in examining *why* the interface agents were effective in improving interest and performance. In particular, we explored whether changes in stereotyping or self-efficacy accounted for the agent's impact on interest and performance using mediation analyses. We thought, for example, it was possible that increasing students' self-efficacy for math and the hard sciences would in turn improve their interest in engineering-related fields as well as their mathematic performance. Alternatively, it was possible that changing the students' beliefs about whether women were successful and welcome in engineering would produce the positive outcomes, although we suspected that, if this were the key factor, it would be particularly important for the female participants.

2. Method

2.1. Participants

One hundred and six middle-school students (58% female) in the Southeastern United States between the ages of 12 and 15 ($M = 13.63$, $SD = .88$) participated during a regularly scheduled computer class session in 2006. Of the participants, 54% were Caucasian, 27% were African–American, 2% were Asian/Asian American, 8% were Hispanic/Latino, 6% were multiracial, 1% defined their ethnicity as "other", and 2% did not report their race/ethnicity.

2.2. Design and procedure

The study employed a 2 (Participant Gender: male vs. female) $\times$ 3 (Interface agent: female vs. male vs. no interface agent) between subjects factorial design. The experiment was conducted in a regularly scheduled class session where participants interacted with either a female or a male computer-based agent or they did not interact with an agent. Following completion (or immediately, in the case of the control group), participants answered an online questionnaire that was designed to assess their stereotypes, attitudes, and self-efficacy regarding engineering-related fields and their mathematical performance.

2.3. Materials

Because mathematics and the hard sciences (e.g., chemistry and physics) are strongly related to the field of engineering, are important prerequisites for many types of engineering, and are familiar subjects for middle-school students, we measured participants' attitudes and beliefs regarding these engineering-related fields. Specifically, the dependent variables were perceptions of math and hard science as masculine fields and personally useful fields, as well as self-efficacy and career interest in these fields. In addition, we measured the participants' math performance.

The dependent variables were all measured using a 7-point, Likert-type scale. Items for these scales were duplicated, so that half of the items in each scale referred to math and half referred to the hard sciences. Seven items measured participants' perceptions that engineering-related fields were masculine and that men performed better in these areas ($\alpha = .89$; e.g., "Mathematics is a masculine field"). Eight items assessed participants' beliefs about the utility of engineering ($\alpha = .88$; e.g., "I would have many good career opportunities if I was a hard science major"). Ten items assessed students' self-efficacy in engineering-related fields ($\alpha = .81$; e.g., "I have always done well in math"). Two items assessed students' interest in having a career in engineering-related fields ($\alpha = .60$; "How likely would you be to take a job in a hard sciences related field?"). Finally, eight multiple-choice word problems were taken from publicly available sample SAT items. These items were selected to test age-appropriate math skills and were used to assess the participants' math performance (e.g., Ms. Joyce has dinner with three of her friends. The four friends decide to split the cost equally. The bill comes to $32.80 and the women plan to leave a 15% tip. How much should Ms. Joyce pay for her share of the dinner? A. $5.25; B. $8.20; C. $9.43; D. $37.72). The test was designed to be quite challenging for the students but to tap skills and knowledge they would have been exposed to in their classes in order to allow for ample variability in responses.

2.4. Research environment

Each student was randomly assigned to one of the three conditions (Interface agent: female vs. male vs. no agent). In the first two conditions, the assigned agent introduced itself and provided a twenty-minute narrative about four female engineers, followed by five benefits of engineering careers. The scripted narrative was created to be age-appropriate and designed to promote self-efficacy for engineering-related academic subjects and to counteract stereotypes of engineering as antisocial, lacking social responsibility, and an anomalous career for women. The narrative emphasized the people-oriented and socially beneficial aspects of engineering and included positive statements about students' abilities to meet the demands of engineering careers. Periodically, the participants needed to respond to the agent in order to continue the presentation (i.e., participants mouse-clicked the next topic to be addressed by the agent). A highly similar script was validated as effective in Baylor and Plant (2005).

Fig. 1. Male and Female young, attractive, and cool agents.

In previous, related work, we found that attractive agents were more influential as social models for college students compared to less attractive agents (Baylor & Plant, 2005). In addition, we found that among attractive agents, young and "cool" agents were most influential (Rosenberg-Kima et al., 2008). Consequently, the agents for the current study were designed to be young (~25 years), cool (as manipulated by the agent's clothing and hairstyle), and attractive (as manipulated by the agent's facial features) but to vary by gender. Pre-testing of the agents confirmed that participants perceived them as young, cool, and attractive (Rosenberg-Kima et al., 2008). The agents (see Fig. 1) were created in Poser©.

Audio files of human female and male voices were synchronized with the agents using Mimic2Pro© to create lip-synching and emotional expressions. Several deictic gestures (e.g., pointing a finger) were also included. These gestures were identical for all agents. A fully integrated environment was created using Flash MX Professional©.

3. Results

To determine the impact of the agents by agent gender and student gender, a series of 2 (Participant gender: female vs. male) × 3 (Interface agent: female vs. male vs. no agent) between-groups ANOVAs were performed on each of the key dependent variables. Post-hoc tests were conducted where relevant (see Table 1).

The analysis of the gender stereotyping variable revealed a significant main effect for interface agent, $F(1, 100) = 3.85$, $p < .05$. Participants who interacted with a female agent expressed significantly less endorsement of the gender stereotype of engineering-related fields than participants who did not interact with an agent ($d = .57$; see Table 1). The male-agent condition fell in between and did not significantly differ from either the no-agent or female-agent condition. However, this main effect was qualified by a significant interaction between agent condition and participant gender (see Fig. 2), $F(1, 100) = 5.85$, $p < .01$. Follow-up tests revealed that for boys, interacting with either agent (female agent $M = 1.90$, $SD = 1.39$; male agent $M = 2.23$, $SD = 1.17$) significantly reduced their endorsement of the gender stereotype of engineering-related fields, compared to the control condition ($M = 3.83$, $SD = 1.40$), $F(1, 100) = 7.21$, $p < .01$. The girls'

Table 1
Effectiveness of Interface Agents.

DV	F	M	SD
Gender Stereotype	3.85*		
No agent		3.34[a]	1.42
Female agent		2.52[b]	1.51
Male agent		3.05[ab]	1.34
Utility	3.90*		
No agent		4.39[a]	1.64
Female agent		5.41[b]	1.25
Male agent		4.88[ab]	1.29
Self-efficacy	5.51**		
No agent		3.44[a]	.73
Female agent		4.07[b]	.79
Male agent		3.96[b]	.71
Career interest	5.26**		
No agent		2.70[a]	1.24
Female agent		3.48[b]	1.06
Male agent		2.70[a]	1.22
Math test scores	5.30**		
No agent		3.55[a]	1.73
Female agent		4.76[b]	1.65
Male agent		3.90[a]	1.64

Note: Significance of F values is identified by * at the .05 level and by ** at the .01 level. Differing superscripts indicate significant differences between means on post-hoc tests.

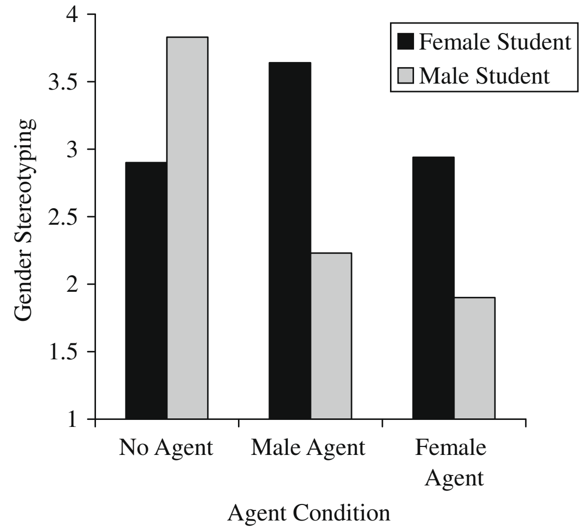

Fig. 2. Gender Stereotyping scores as a function of gender of participant and agent condition.

endorsement of the gender stereotype was intermediate relative to the boys ($M = 3.22$, $SD = 1.34$) and was not influenced by the agent condition, $F(1, 100) = 2.19$, $p = .12$.

The analysis for utility revealed a significant main effect of agent condition, $F(1, 100) = 3.90$, $p < .05$. Participants who interacted with a female agent expressed significantly more positive beliefs about math and hard sciences' utility than participants who did not interact with an agent ($d = .70$). The male-agent condition fell in between and did not significantly differ from either the no-agent or female-agent condition.

The analysis for self-efficacy revealed a significant main effect of agent condition, $F(1, 100) = 5.51$, $p < .01$. Participants who interacted with an agent expressed significantly greater self-efficacy for their performance in engineering-related fields than participants who did not interact with an agent (female vs. no agent, $d = .85$; male vs. no agent, $d = .72$). There was no significant difference between the female-agent and the male-agent conditions.

The analysis for career interest revealed a significant main effect of agent condition, $F(1, 100) = 5.26$, $p < .01$. Participants who interacted with a female agent expressed significantly greater interest in engineering-related careers than participants who did not interact with an agent, ($d = .71$) and than participants who interacted with the male agent ($d = .70$). There was no significant difference between the no-agent condition and the male-agent condition.

The analysis for math performance also revealed a significant main effect of agent condition, $F(1, 100) = 5.30$, $p < .01$. Participants' performance on the math test was significantly higher when they interacted with a female agent than when they did not interact with an agent, ($d = .71$). Participants who interacted with the female agent also performed better on the math test than those who interacted with the male agent ($d = .53$). There was no significant difference between the no-agent condition and the male-agent condition.

We were interested in why these middle-school students performed better on the math test and were more interested in a career in engineering-related fields when they interacted with the female agent as compared to the control condition. Initial explorations determined that self-efficacy was related to both interest, $r = .55$, $p < .001$, and performance, $r = .42$, $p < .001$. In contrast, participants' endorsement of stereotypes was unrelated to both interest and performance, p's > .10. We suspected, therefore, that the improved performance and interest was due to the increase in self-efficacy that interacting with the female agent afforded the young students. Therefore, we conducted a mediation analysis to determine if the impact of the female agent on performance and interest were due to her influence on self-efficacy. As reported previously, participants who interacted with the female agent reported higher self-efficacy regarding engineering-related fields than students in the control condition. A regression was conducted predicting math performance with the female agent versus no-agent experimental conditions entered in the first step and self-efficacy entered in the second step. Although experimental condition predicted math performance in the first step, $t(1, 64) = 2.49$, $p < .05$, in the second step self-efficacy was a significant predictor, $t(1, 63) = 4.61$, $p < .001$, and condition was no longer significant, $p = .23$. A Sobel test confirmed that self-efficacy was a significant mediator of the effect of the female agent on math performance, $z' = 2.50$, $p < .05$. These findings indicate that the reason why the female agent resulted in improved performance on the math test, compared to the control condition, was that she increased the students' self-efficacy.

Finally, we assessed whether the female agent's effect on students' interest could be accounted for by increases in self-efficacy. A parallel regression was conducted predicting career interest with the female-agent versus no-agent experimental conditions entered in the first step and self-efficacy entered in the second step. Although experimental condition predicted interest in the first step, $t(1, 64) = 2.66$, $p < .02$, in the second step self-efficacy was a significant predictor, $t(1, 63) = 4.27$, $p < .001$, and condition was no longer significant, $p = .19$. A Sobel test confirmed that self-efficacy was a significant mediator of the effect of the female agent on interest, $z' = 2.42$, $p < .05$. These findings indicate that, similar to the findings for math performance, the reason why the female agent resulted in increased interest, compared to the control condition, was that she increased the students' self-efficacy.

4. Discussion

Supporting our hypotheses, the findings from this study indicate that anthropomorphic interface agents may be used effectively, at least in the short-term, as social models for influencing middle school students' attitudes and beliefs about mathematics and the hard sciences as well as their actual mathematical performance. However, the effectiveness of the agent depended on the characteristics of the agent, with the female agent tending to be the most effective regardless of participants' gender. Specifically, the female agent was significantly better than the no-agent condition in influencing both female and male students' beliefs about the utility of math and the hard sciences. In addition, female and male students who interacted with the female agent performed significantly better on the math test. For both utility and mathematical performance, the male agent fell in between and was not significantly different compared to the female condition and the no-agent condition. In addition, for both girls' and boys' interest in engineering-related careers, the female agent resulted in significantly greater interest than both the no-agent and the male-agent conditions. However, for students' self-efficacy, having an agent was better than not being exposed to an agent, regardless of the agent's gender. That is, both the male and the female agents were significantly better than the no-agent condition for increasing females and males' self-efficacy with regard to their performance in engineering-related fields.

Mediational analyses revealed that the effect of the female agent on the young students' math performance and interest in an engineering-related career was due to her influence on their self-efficacy. That is, by making the young students more confident in their engineering-related skills, the female agent helped to boost the students' scores on the math test and their interest in pursuing mathematics and the hard sciences. These findings highlight the importance of self-efficacy for performance and motivation and indicate that interventions targeting self-efficacy can aid performance and interest.

We found that the agents (both male and female versions) were effective in changing the male students' beliefs about whether engineering-related fields were better suited for men than for women. In contrast, the agents were not effective in changing the girls' gender-related perceptions of engineering-related fields. It is unclear why the message specifically designed to influence the girls was only effective for the boys. It may be that the messages that young girls receive over time, indicating the lower expectations people hold for their abilities in these fields, are so salient for them that a single persuasive communication is not enough to counteract previous messages. Alternatively, it may be that the message's arguments, which were effective in changing college-age women's gender stereotypic beliefs about engineering (Rosenberg-Kima et al., 2008), were not as compelling to younger women.

Contrary to our hypothesis, the agents influenced female and male students similarly, with the female agent being more effective than the male agent for most of the outcome measures. It would be undesirable to expose male students to an intervention that improved girls' attitudes, beliefs, and performance, but impeded boys on these factors. However, the current findings indicate that interventions designed to support female students may benefit both genders equally. It is not entirely clear why the female agent was more effective for both the boys and the girls. It may be that middle-school students have frequent contact with female teachers, which may predispose them to view female social models as informative and authoritative. It is also possible that the female agent's positive impact was due to different factors for female and male students. The female students may have identified with the female social model and seeing the female model may have led the girls to view these disciplines as welcoming to women. The male students, in contrast, may have been persuaded by the attractive female model that math and science are appealing disciplines where they might meet desirable women, a belief that is generally not a part of the stereotype of these disciplines.

Female computer-based social models were especially effective for enhancing students' mathematical performance. For female students, exposure to the successful female social model may have mitigated stereotype threat (e.g., Steele, 1997; Steele & Aronson, 1995). Stereotype threat is a disruptive concern that one may confirm a negative stereotype about one's social group, which can result in impaired performance in relevant situations (e.g., McIntyer et al., 2003; Steele & Aronson, 1995). Mitigation of stereotype threat is unlikely to explain male students' enhanced performance. However, it is possible that the boys associated mathematics with attractive women after receiving the message from the attractive female agent, and this may have increased their motivation to do well in mathematics. It may also be possible that the boys felt more comfortable with the female agent that resembled their current teachers (most of whom were female), thus, they were more relaxed when answering the math questions.

Although this work provides some evidence of the efficacy of interface agents to improve motivation toward mathematics and the hard sciences, there were some limitations of this work. One limitation of this study was that the students who were in the no-agent group did not get a substitute treatment prior to filling the survey and answering the mathematical test. Thus, some of the differences between the agent and control condition may have been due to the existence of a treatment and not the agent itself. Nevertheless, for most of the dependent variables, only the female agent was significantly better than the no-agent condition, thus, the effects cannot be attributed solely to the existence of a treatment.

In addition, in this study, we only manipulated the agents' gender. Other characteristics of the agent such as voice (e.g., computer-based vs. human, tone, prosody), persona (e.g., its personality and affective state), age (e.g., child vs. adult agents), and nonverbal communication (e.g., emotional expressiveness and deictic gestures) were held constant in this study. Future studies should consider such design elements and how they may potentially interact with the agent's gender.

Finally, it is important to note that we only assessed the impact of our agents immediately following the intervention. It is unclear how long the influence of the intervention would last and whether it would continue to influence the students' responses beyond the initial session. It will be important in future work to examine the effect of the intervention longitudinally to see whether it continues to influence responses and whether periodic "booster" exposures help to extend the efficacy of the intervention.

4.1. Conclusion

The current contributes evidence of the usefulness of persuasive technologies. The results provide important support for the hypothesis that computer-based anthropomorphic interface agents can serve as effective social models for improving young students' stereotypes, self-efficacy, and performance within a traditionally masculine domain, at least in the short-term. This evidence builds upon previous social-psychological work indicating the important role of social models in attitude formation and self-efficacy judgments. Additionally, it augments work within the educational psychology and information technology literature that identifies interface agents as effective motivators and facilitators of learning.

Computer-based interface agents can be easily disseminated and modified to match the needs of differing groups of students or even individual students. Human social models, on the other hand, are less adaptable to the needs of students. Indeed, in fields such as engineering, adequate social models for students from under-represented groups might be scarce or absent within a student's immediate environment. The current work suggests that animated interface agents can not only promote academic interest and motivation, but also convey relevant and beneficial social information. Thus, anthropomorphic interface agents, as social models for female and male students alike, may represent a uniquely flexible and constructive device for facilitating students' success and enhancing the inclusiveness of traditionally restricted fields.

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