Computing Whether She Belongs: Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science

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Computer science has one of the largest gender disparities in science, technology, engineering, and mathematics. An important reason for this disparity is that girls are less likely than boys to enroll in necessary "pipeline courses," such as introductory computer science. Two experiments investigated whether high-school girls' lower interest than boys in enrolling in computer science courses is influenced by stereotypes of the field. We further tested whether these stereotypes can be communicated by the physical classroom environment, and whether changing this environment alters girls' interest. In 2 experiments ($N = 269$), a computer science classroom that did not project current computer science stereotypes caused girls, but not boys, to express more interest in taking computer science than a classroom that made these stereotypes salient. The gender difference was mediated by girls' lower sense of belonging in the course, even beyond the effects of negative stereotype concerns, expectations of success, and utility value. Girls' lower sense of belonging could be traced to lower feelings of fit with computer science stereotypes. Individual differences in fit with stereotypes predicted girls' belonging and interest in a stereotypical, but not a nonstereotypical, classroom. Adolescence is a critical time for career aspirations. Girls may avoid computer science courses because current prevailing stereotypes of the field signal to them that they do not belong. However, providing them with an educational environment that does not fit current computer science stereotypes increases their interest in computer science courses and could provide grounds for interventions to help reduce gender disparities in computer science enrollment.

Keywords: stereotypes, STEM, gender, belonging, adolescence

The underrepresentation of women in computer science is an important problem in American education (Cohoon & Aspray, 2006; Margolis & Fisher, 2002). Computer science has one of the lowest percentages of women among science, technology, engineering, and mathematics (STEM) fields (currently 18% of bachelor's degrees), and this percentage has not increased over the past decade (National Science Foundation, 2013). Not only are women disproportionately excluded from some of the most lucrative and high-status careers (Kalwarski, Mosher, Paskin, & Rosato, 2007), these fields are disadvantaged from a lack of more diversified perspectives that could lead to better innovations (Hill, Corbett, & St. Rose, 2010). A critical component of solving this problem involves increasing girls' interest in taking introductory computer science courses (de Cohen & Deterding, 2009; Drury, Siy, & Cheryan, 2011). Gender differences in high school achievement in STEM do not explain the gender gaps in college enrollment,

signaling the need for more research into nonacademic (i.e., social) factors that influence girls' academic choices (Riegle-Crumb, King, Grodsky, & Muller, 2012).

In the present work, we build on previous studies on college students (Cheryan, Plaut, Davies, & Steele, 2009) and investigate a social factor that may affect high school students' interest in computer science: current stereotypes of the field of computer science. We examine whether and why these stereotypes deter adolescent girls from introductory computer science courses. First, these studies examine sense of belonging as an explanation for girls' deterrence alongside both Steele's (1997) work on negative stereotypes (Experiment 1) and Eccles's (1987) work on expectancy-value theory (Experiment 2). Second, these studies examine individual differences among girls, or why some girls are more deterred by these stereotypes than others.

We begin by describing adolescents' stereotypes about computer science, and why adolescence is a key time to examine effects of these stereotypes on girls' interest in computer science. We then discuss how a lack of belonging, and other factors such as concerns about negative stereotypes and lower expectations of success, might affect girls' interest in computer science. Finally, we discuss how individual differences in fit with stereotypes can explain which girls are particularly susceptible to the negative effects of these stereotypes.

Adolescents' Stereotypes About Computer Science

Computer scientists are stereotyped in contemporary American society as male, technologically oriented, and socially awkward (Cheryan, Plaut, Handron, & Hudson, 2013; Margolis & Fisher,

2002). Other stereotypes about the culture of computer science include a perception that it requires "brilliance" (Leslie, Cimpian, Meyer, & Freeland, 2015), and is isolating and does not involve communal goals such as helping or working with others (Diekman, Brown, Johnston, & Clark, 2010). These stereotypes can be transmitted by the media, role models, and academic environments (for a review, see Cheryan, Master, & Meltzoff, 2015). In this article, we focus on academic environments for three reasons. First, manipulating classroom environment provides a way to test how commonly held stereotypes of academic fields influence adolescents. Second, students spend significant time in academic environments such as classrooms, hallways, computer labs, and teachers' workspaces, and the design of these spaces may influence high-school students' interest in pursuing certain fields of study. Third, classroom environments may be a more practical target for change on the part of individual schools and teachers, compared with media or role models.

Previous studies with college students reveal that making stereotypes of the field salient in an academic environment decreases women's interest in computer science (Cheryan et al., 2009). For example, college women who entered a computer science classroom that included objects stereotypically associated with computer science (e.g., science fiction posters, stray electronic parts) reported less interest in computer science than women who entered the same classroom containing objects that were not stereotypically associated with computer science (e.g., art posters, general interest books; Cheryan et al., 2009). In contrast, the classroom environment did not affect men's interest (see also Cheryan, Meltzoff, & Kim, 2011).

Most previous research on stereotypes about the field of computer science has been conducted with college students. However, adolescence is a particularly important age to examine for both theoretical and practical reasons. In terms of theory, adolescence is a critical time for identity formation. Middle adolescence (ages 14–15) is when opposing self-attributes begin to bother students and remain a source of internal conflict, particularly for girls (Harter, 1990). In terms of practice, younger students are starting to make critical career choices (Weisgram & Bigler, 2006), and are at a key age in which to intervene to decrease gender disparities in STEM (Lupart & Cannon, 2002). Because the decision to forgo even one feeder course can effectively prevent students from majoring in STEM (Moses, Howe, & Niesz, 1999), investigating factors that encourage girls to enter introductory "pipeline" courses is crucial. Girls' sense of "belonging" in an academic environment may have a particularly strong influence on their interest.
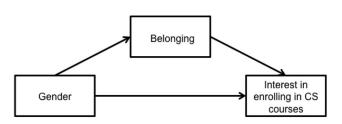
Effects of Computer Science Stereotypes on Belonging

Belonging in an academic environment refers to students' sense that they would fit in with the people, materials, and activities within that environment (Cheryan et al., 2009). The physical objects in an environment serve as cues about who belongs there. Objects are powerful because they can signal the culture of the people associated with that environment (Cheryan et al., 2009). When entering an environment for the first time, people interpret the cues in that environment for messages about whether they belong there (Murphy et al., 2007; Schmitt, Davies, Hung, & Wright, 2010). If the objects in a classroom environment signal the type of person that belongs in that environment, but the student does not see herself (or himself) as that type of person, then this creates a "mismatch" between person and environment. The more that people perceive a mismatch between the academic environment and their own identity, the less likely they are to feel that they belong there (Cheryan et al., 2009; Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012). Because computer science stereotypes are more compatible with the male gender role than the female gender role (Cheryan, 2012), girls are less likely to feel a sense of personal fit with these stereotypes. Fit with stereotypes is the extent to which there is a match between one's own characteristics and prevailing cultural stereotypes of the field. In turn, this reduced feeling of fit with stereotypes means that girls may feel less belonging in a classroom containing stereotypical objects than their male peers. In contrast, showing girls a classroom environment that counteracts prevailing stereotypes should remove that barrier and increase feelings of belonging.

Belonging is thought to be a fundamental human motivation, and lack of belonging can lead to negative effects on academic motivation and sense of well-being (Baumeister & Leary, 1995). Though the effects of belonging on interest should be evident broadly (among both girls and boys and across different career domains), sense of belonging in STEM has been shown to be a particularly strong predictor of women's STEM interest and motivation (Good, Rattan, & Dweck, 2012; Smith, Lewis, Hawthorne, & Hodges, 2013). Indeed, stereotypes associating STEM fields with males may make girls vigilant for cues about their belonging in STEM-related situations (Cohen & Garcia, 2008). When the cues reinforce stereotypes and signal that girls may not belong girls may have less interest than boys in entering that situation, as shown in Figure 1. For example, women who watched a video featuring a STEM conference in which women were underrepresented showed increased physiological and cognitive arousal and felt less belonging compared to women who watched a video with balanced representation; they were also less interested in attending the conference (Murphy, Steele, & Gross, 2007).

Beyond Belonging: Other Factors That Shape Interest

Other factors also play a role in explaining effects of academic stereotypes on girls' interest, such as expectations of success, utility value, and stereotype threat. Currently, girls report lower

Figure 1. Theoretical model indicating how stereotypes about computer science affect girls' interest in enrolling in computer science courses. When computer science stereotypes are salient, girls feel a lower fit with stereotypes than boys, which decreases girls' belonging, thereby decreasing girls' interest in enrolling in computer science courses. The empirical data reported in this article indicate that the belonging mediation held when controlling for negative stereotype concerns, expectations of success, and utility value.

self-efficacy than boys in STEM (Pajares, 2005), and some research has found that some girls place less value on the utility of math and physical science (Chow, Eccles, & Salmela-Aro, 2012). Both expectations of success and utility value predict enrollment interest, although utility value may be a stronger predictor of choices than expectations of success (Parsons, Adler, & Meece, 1984). Cultural stereotypes about occupational fields can affect how much those fields are valued (Eccles, 2011; Eccles et al., 1983), with girls being more likely to value fields stereotyped as appropriate for their gender. However, it is unclear whether changing academic stereotypes would affect girls' expectations of success or utility value.

Stereotype threat—students' concerns about being judged through the lens of a negative stereotype about their ability (Steele, 1997)—may be another important predictor of girls' interest in STEM (Thoman, Smith, Brown, Chase, & Lee, 2013). Negative stereotypes about girls' lower ability in STEM can harm their performance (Huguet & Régner, 2007), which may deter girls from choosing to pursue STEM (Davies, Spencer, Quinn, & Gerhardstein, 2002). Stereotype threat can reduce women's feelings of belonging in STEM (Murphy et al., 2007; Smith et al., 2013) and has a negative impact on students' expectations of success (Smith et al., 2013; Walton & Cohen, 2007). A stereotypical environment could increase girls' concerns about negative gender stereotypes, thus decreasing their interest.

This article adds to the literature by directly comparing belonging, expectations of success, utility value, and stereotype threat (across two experiments), to examine their relative power in predicting girls' lower interest in computer science compared with boys when stereotypes are salient. We predict that belonging will have a particularly strong influence on interest because belonging is a fundamentally important motivator (Baumeister & Leary, 1995). We also examine a potentially important individual difference that may affect belonging—whether students feel that they personally fit the stereotype of a computer scientist.

Individual Differences in Fit With Academic Stereotypes

Although lack of fit with prevailing stereotypes has been theorized to explain girls' lack of interest in computer science (Cheryan, 2012), there has been no empirical examination of whether students who feel that they do not fit the stereotypes of the field feel less belonging and interest in computer science when it is depicted stereotypically than students who feel a greater fit with these stereotypes. We investigate effects of fit with stereotypes in two ways. First, we expect that girls' lower sense of belonging compared to boys can be traced back to their lower sense of fit with stereotypes. Second, when current stereotypes of the field are salient, girls who feel that they do not fit these stereotypes should show reduced belonging and interest in a computer science class compared to girls who feel greater fit with stereotypes. However, when computer science stereotypes are not salient, girls' feeling that they do not fit computer science stereotypes should have less impact on their belonging and interest in a computer science class.

The Present Research

How Academic Stereotypes Affect Adolescents' Interest and Belonging

Understanding the factors that explain girls' lower interest is crucial to remedying current gender disparities in computer science (Ceci, Ginther, Kahn, & Williams, 2014). Interest is a critically important motivational variable because it can affect subsequent learning and performance (Hidi & Harackiewicz, 2000). Interest may develop through four levels: triggered situational interest (immediate and spontaneous engagement in a topic), maintained situational interest, emerging individual interest, and well-developed individual interest (Hidi & Renninger, 2006). Our use of enrollment interest is similar to triggered situational interest in that we examine how factors in the immediate environment may increase interest in enrolling in a course. As enrollment interest is a powerful predictor of subsequent course enrollment (Eagan et al., 2013), actual course enrollment could then help to transform situational interest into well-developed individual interest, which is a more stable, dispositional interest in a particular domain (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008). Creating environmental conditions that trigger situational interest is a critical part of the process of developing deep interest in a topic (Hidi & Renninger, 2006).

Recently 10,000 schools across the United States requested help in adding computer science to their curriculum (Dudley, 2013), and the White House has announced initiatives to support computer science education in K–12 schools (Office of the Press Secretary, 2014). It is critical to address these changes in education in a scientific way. We experimentally examine how exposure to computer science stereotypes affects girls' belonging and interest in enrolling in computer science courses. Based on the findings of Cheryan and colleagues (2009), we predict that nonstereotypical classroom environments will increase girls' (but not boys') interest in enrolling in a computer science course. We examine belonging as a mediator in Experiments 1 and 2, compared with concerns about negative ability stereotypes (Experiment 1), expectations of success (Experiment 2), and utility value (Experiment 2). We also examine gender differences in fit with current stereotypes of the field, and whether fit with stereotypes predicts individual differences in girls' belonging and interest (Experiment 1).

Experiment 1: Effects of Classroom Environments on Girls' Interest in Computer Science Courses

In Experiment 1, we investigated effects of stereotypical and nonstereotypical classroom environments on high-school girls' interest in enrolling in introductory computer science courses. Critically, we approached this issue experimentally, to examine whether counteracting stereotypes can cause girls' enrollment interest to increase. We predicted that girls would be less interested in enrolling in computer science courses when the classroom environment was stereotypical than when it was nonstereotypical. We included a premeasure to examine students' feelings about computer science before they learned about the environment of the classroom. This allowed us to assess whether it was the stereotypical or the nonstereotypical environment that influenced girls' interest. We also predicted that girls would feel lower belonging in

the stereotypical classroom than boys, and a mediation analysis would reveal that girls' lower belonging mediated their lower interest in that course, more so than girls' concerns that they would be judged negatively in that environment because of gender stereotypes. We also included an individual difference variable, fit with stereotypes about computer science, to examine whether lack of fit with stereotypes predicted girls' lower belonging and interest in stereotypical settings.

Method

Participants. Participants were 165 students at two high schools in the Northwestern United States. Fifty-four students were from a private school (26 young women, 27 young men; 1 student did not provide gender; M_{age} = 15.67 years, SD = 0.91; age range: 14–17 years; 6% did not provide this information) and 111 were from a public school (51 young women, 55 young men; 5 students did not provide gender; M_{age} = 16.01 years, SD = 1.20; age range: 14–18 years; 13% did not provide this information). Students who did not provide gender were removed from analyses involving gender in both experiments. At the private school, 36% were freshmen, 32% were sophomores, and 32% were juniors (2% did not provide this information). Private school participants were 72% White, 2% Latino/a, 7% Asian/Pacific Islander, 11% multiple ethnicities, 4% Black, and 2% other (2% did not provide this information). At the public school, 47% were freshmen, 14% were sophomores, 20% were juniors, and 14% were seniors (5% did not provide this information). Public school participants were 29% White, 29% Latino/a, 24% Asian/Pacific Islander, 8% multiple ethnicities, 3% Black, and 3% other (5% did not provide this information). At the private school, 17% of students typically received need-based financial aid; at the public school, 65% of all students were typically eligible for free or reduced lunch.

Each student participated in only one experiment. Analyses showed that school did not significantly interact with gender or classroom environment on any of our dependent measures, Fs < 2.91, ps > .08, $\eta_p^2 s$ < .023, so we combined the school samples. Intraclass Correlations (ICCs) revealed that the proportion of variance in enrollment interest that was because of participants' actual classroom was negligible for all three measurements of interest ($ICC_{premeasure}$ = .004; $ICC_{stereotypical}$ = −.03; $ICC_{nonstereotypical}$ = −.04).

Students were recruited by using an opt-out information letter to parents, allowing for a high participation rate (at the public school, ~85% of eligible students participated across Experiments 1–2; the remaining students either opted-out with the letter, did not assent, or were absent). No parents at the private school opted out, although a few students declined to assent to participate. Students who assented to participate completed a survey during their grade-level meeting time (at the private school) or during their math class (at the public school).

We also asked participants how many computer science classes they had taken previously, M = 0.50, SD = 0.94. There was no difference between male and female participants in this study, $t(152)$ = 0.09, p = .93, d = 0.01.

Materials. This experiment utilized methodology used in previous research with adults (Cheryan et al., 2009). We manipulated classroom environments using two photographs created for this experiment. In designing these photographs, we decorated a small university classroom (i.e., 12 desks) using objects either identified as stereotypical or nonstereotypical of computer science in previous research. The stereotypical objects were Star Wars/Star Trek items, electronics, software, tech magazines, computer parts, video games, computer books, and science fiction books. The nonstereotypical objects were nature pictures, art pictures, water bottles, pens, a coffee maker, lamps, general magazines, and plants. Both classrooms also contained a table and chair at the front of the room, desks for students, a side table, and a storage unit in the corner.

To examine whether adolescent students associated the stereotypical objects with computer science more than the nonstereotypical objects, we conducted a pilot survey with a separate group of high school students (N = 106; 54 male, 50 female, two unidentified), who were given a list of these items and asked to rate how much they associated each object with computer science on 7-point scales (1 = *not at all* and 7 = *extremely*). Ratings for the stereotypical and nonstereotypical objects were averaged into separate composites. We assessed internal consistency using Cronbach's α, which indicated acceptable reliability (e.g., Clark & Watson, 1995) for both sets of objects: stereotypical: α = .74; nonstereotypical: α = .86. A 2 × 2 (Object Type × Gender) mixed-model analysis of variance (ANOVA) showed that the stereotypical objects were rated as significantly more stereotypical of computer science than the nonstereotypical objects (stereotypical: M = 5.28, SD = 0.88; nonstereotypical: M = 2.51, SD = 1.07), $F(1, 101)$ = 498.15, p < .001, d = 2.22. There was no main effect of gender, $F(1, 101)$ = 0.29, p = .59, d = 0.11, and no interaction between object type and participant gender, $F(1, 101)$ < 1, p = .34, η_p^2 = .009, indicating that both girls and boys associated the stereotypical objects more strongly with computer science than the nonstereotypical objects.

Procedure. Participants read an introduction stating, "We are interested in your thoughts about different potential classes you could take in high school. You will see different classrooms to get an idea of what they look like, and then you will be asked for your thoughts on those classes." Before they were told about the classrooms, participants first answered a series of premeasure questions including two items assessing their interest in enrolling in a potential high-school "Introduction to Computer Science" course, four items assessing feelings of belonging in this course, and four items assessing concerns about negative stereotypes in this course (see "Dependent measures" section below for items).

Participants then read, "Next, you will be looking at *two* classrooms that are being used to teach this course: Classroom A and Classroom B. Even if you are not sure you would take a computer science class, please give us your opinion about your preference for one classroom over the other." They were given more information about the two computer science courses (including photos of the two classrooms), and then answered the same questions about interest in enrolling, belonging, and concerns about negative stereotypes specifically for each course (see items below).

The information stated that both courses covered the same material (computer science) and were identical in terms of amount of homework, teacher gender (male), and gender proportion of students (50% male, 50% female). These were controlled to examine the effect of stereotypes above and beyond other assumptions they evoked, such as gender proportion or amount of homework. Participants then saw photos of the two classrooms. Classroom environment was thus manipulated within-subjects. The order of photos (and the order in which participants evaluated

each classroom for all of the dependent measures) was counter-balanced; there were no main effects or interactions of order on enrollment interest or belonging, $Fs < 0.58$, $ps > .45$, $ds < 0.09$. There was a main effect of order on negative stereotype concerns, $F(1, 141) = 7.48$, $p = .007$, $d = 0.31$, with participants expressing greater negative stereotype concerns overall when they rated the stereotypical classroom first ($M = 2.53$, $SD = 1.30$ vs. $M = 2.15$, $SD = 1.15$), but this did not interact with gender, $F(1, 141) = 0.09$, $p = .76$, $\eta_p^2 = .001$, or classroom environment, $F(1, 141) = 0.11$, $p = .74$, $\eta_p^2 = .001$.

Dependent measures.

Attention check. We included five multiple-choice attention checks, including number of courses (two), student gender (equal numbers of males and females), teacher gender (both male), topic (computer science), and amount of homework (same). Overall, 91% of participants passed the number of courses question; 93% passed the teacher gender and course topic questions; and 97% passed the homework and student gender questions.

Choice. Students were asked to choose which of the two courses they would take.

Enrollment interest. Two items assessing students' interest in enrolling in each course were averaged to create the measure of enrollment interest (see Cheryan, Meltzoff, et al., 2011 for previous reliability and validity of scale). Students rated how much they would want to take this class, and how likely they were to choose this class ($1 = not\ at\ all$ and $7 = extremely$). Reliability of these items was high for both classrooms (stereotypical classroom: $\alpha = .92$; nonstereotypical classroom: $\alpha = .92$).

Belonging. Four items were averaged to assess how much students felt that they belonged in this class (see Cheryan et al., 2009 for previous reliability and validity of scale). Students rated how similar they were to the students who take this class, how much they thought they belonged in this class, how well they would fit in the general environment of this class, and how well they would fit in with the students in this class ($1 = not\ at\ all$ and $7 = extremely$). Reliability was high for both classrooms (stereotypical classroom: $\alpha = .94$; nonstereotypical classroom: $\alpha = .92$).

Negative stereotype concerns. We measured negative stereotype concerns by averaging four items (see Cohen & Garcia, 2005; Marx, Stapel, & Muller, 2005 for previous reliability and validity of scale items). Students rated how much they would worry that their ability to do well in the course would be affected by their gender, how anxious they would be about confirming a negative stereotype about their gender, how much they would worry that others would draw conclusions about their gender based on their performance, and how much they would worry that others would draw conclusions about them based on their gender ($1 = not\ at\ all$ and $7 = extremely$; stereotypical classroom: $\alpha = .88$; nonstereotypical classroom: $\alpha = .87$).

Fit with stereotypes. To explore whether individual differences in girls' perceived fit with the stereotypes of computer scientists predicted their enrollment interest and belonging, we also asked participants, "How much do you feel that you fit the stereotype of a computer scientist?" ($1 = not\ at\ all$ and $7 = very\ much$). Unlike the other primary dependent measures, this item was asked only once at the end of the survey.
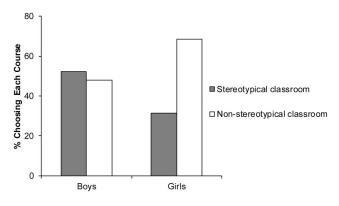
Final sample. Seven students were excluded from analyses for missing more than one attention check, and three additional students were excluded because of suspicious data (e.g., circling answers in a zigzag pattern; for a similar exclusion procedure, see Duckworth, Quinn, & Tsukayama, 2012). The pattern of results remained the same if these students were included. When students did not respond to all items in a given measure, their scores were determined by averaging any items that they did complete.

Results

Choice. As shown in Figure 2, there was a significant gender difference in classroom choice, $\chi^2(1, N = 146) = 6.34$, $p = .012$, $\varphi = .21$. Girls were more likely than boys to choose the nonstereotypical classroom (68% of girls, 48% of boys). Additional comparisons revealed that girls were more likely to choose to take the computer science course with the nonstereotypical classroom than the stereotypical classroom, $\chi^2(1, N = 73) = 9.99$, $p = .002$, while boys had no preference of classroom, $\chi^2(1, N = 73) = 0.12$, $p = .73$.

Enrollment interest. A 2×3 (Participant Gender × Classroom Environment [premeasure, stereotypical, and nonstereotypical]) mixed-model ANOVA (including Huynh–Feldt corrections because of significant sphericity and a large Greenhouse–Geisser, $\varepsilon > .75$) revealed a significant main effect of classroom environment, $F(1.55, 226.61) = 3.92$, $p = .031$, $\eta_p^2 = .026$, and a significant effect of participant gender, $F(1, 146) = 10.13$, $p = .002$, $d = 0.52$, qualified by a significant interaction (see Table 1 for descriptive statistics and Figure 3). As predicted by our hypothesis, there was a Gender × Classroom interaction, $F(1.55, 226.61) = 5.32$, $p = .010$, $\eta_p^2 = .035$. Simple effects for girls revealed a main effect of classroom environment, $F(2, 145) = 7.25$, $p = .001$, $\eta_p^2 = .091$. Planned comparison of ratings for each classroom to the interest premeasure revealed that girls were significantly more interested in the course in the nonstereotypical classroom compared with the stereotypical classroom, $F(1, 145) = 9.11$, $p = .003$, $d = 0.36$, and compared with premeasure interest, $F(1, 145) = 14.53$, $p < .001$, $d = 0.41$. There was no difference between girls' interest in the course with the stereotypical classroom and premeasure interest, $F(1, 145) = 0.27$, $p = .60$, $d = 0.06$. Cohen's d effect sizes for all repeated-measures analyses were calculated using Morris and DeShon's (2002) correction for dependence for within-subjects design. Simple effects for boys revealed no main effect of classroom environment, $F(2, 145) =$

Figure 2. Classroom choice in Experiment 1. Girls were significantly more likely than boys to choose to take a computer science course in a classroom that contained nonstereotypical objects. The two bars within each gender add to 100% because it was a forced choice.

Table 1
Descriptive Statistics for Outcome Variables in Experiment 1

Variable	Girls		Boys	
	M	*SD*	*M*	*SD*
Interest				
Premeasure	2.91$_a$	1.38	3.96$_b$	1.78
Stereotypical	2.80$_a$	1.59	3.69$_b$	1.96
Nonstereotypical	3.69$_b$	1.66	3.73$_b$	1.88
Belonging				
Premeasure	3.08$_c$	1.15	3.96$_d$	1.43
Stereotypical	3.09$_c$	1.40	3.79$_d$	1.68
Nonstereotypical	3.98$_d$	1.37	3.77$_d$	1.52
Negative stereotype concerns				
Premeasure	2.74$_e$	1.37	1.88$_g$	1.04
Stereotypical	2.99$_e$	1.48	1.94$_g$	1.27
Nonstereotypical	2.41$_f$	1.27	1.96$_g$	1.30

Note. Means for each variable sharing a common subscript are not statistically different at $p \leq .05$.

1.70, $p = .19$, $\eta_p^2 = .023$. There were no differences for boys for either classroom compared with the interest premeasure, $Fs < 1.93$, $ps > .16$, $ds < 0.16$, or for the stereotypical and nonstereotypical classrooms, $F(1, 145) = 0.02$, $p = .89$, $d = 0.02$.

Looking at these data another way, girls were significantly less interested than boys on the interest premeasure, $F(1, 146) = 16.12$, $p < .001$, $d = 0.66$, and when the classroom was stereotypical, $F(1, 146) = 9.12$, $p = .003$, $d = 0.50$, but there was no difference compared with boys when the classroom was nonstereotypical, $F(1, 146) = 0.02$, $p = .89$, $d = 0.02$. Schuirmann's (1987) two one-sided tests of equivalence (using a testing interval of 1/3 *SD*) revealed that girls and boys reported equal interest in the nonstereotypical classroom, $|t|s > 1.65$, $ps < .05$.

In addition to examining differences in average enrollment interest, another way to understand the effect on girls' enrollment interest is to examine the percent of girls who were above the scale midpoint (4). On the premeasure, only 13.3% of girls were above the midpoint, compared with 35.4% of girls who were above the midpoint of the scale in the nonstereotypical classroom. Offering a nonstereotypical image of computer science nearly tripled the number of girls who expressed positive interest in this course.
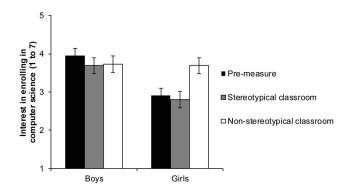
Belonging. A 2 × 3 (Participant Gender × Classroom Environment [premeasure, stereotypical, and nonstereotypical]) mixed-model ANOVA (including Greenhouse–Geisser corrections because of significant sphericity and a moderate Greenhouse–Geisser, $\varepsilon = .73$) revealed significant main effects of classroom environment, $F(1.46, 213.73) = 4.83$, $p = .017$, $\eta_p^2 = .032$, and participant gender, $F(1, 146) = 7.97$, $p = .005$, $d = 0.43$, qualified by a significant interaction (see Table 1 for descriptive statistics). As predicted by our hypothesis, there was a Gender × Classroom interaction, $F(1.46, 213.73) = 7.71$, $p = .002$, $\eta_p^2 = .050$. Simple effects for girls revealed a main effect of classroom environment, $F(2, 145) = 14.74$, $p < .001$, $\eta_p^2 = .169$. Planned comparison of ratings for each classroom to the belonging premeasure revealed that girls felt significantly more belonging in the course in the nonstereotypical classroom compared with the stereotypical classroom, $F(1, 145) = 11.10$, $p = .001$, $d = 0.40$, and compared with premeasure belonging, $F(1, 145) = 28.95$, $p < .001$, $d = 0.62$. There was no difference between girls' belonging in the course

with the stereotypical classroom and premeasure belonging, $F(1, 145) = 0.01$, $p = .94$, $d = 0.01$. Simple effects for boys revealed no main effect of classroom environment, $F(2, 145) = 1.28$, $p = .28$, $\eta_p^2 = .017$. There were no differences for boys for either classroom compared with the belonging premeasure, $Fs < 1.32$, $ps > .25$, $ds < 0.14$, or between the stereotypical and nonstereotypical classrooms, $F(1, 145) = 0.01$, $p = .95$, $d = 0.01$.

Looking at these data another way, girls felt significantly less belonging than boys on the belonging premeasure, $F(1, 146) = 17.14$, $p < .001$, $d = 0.68$, and when the classroom was stereotypical, $F(1, 146) = 7.48$, $p = .007$, $d = 0.45$, but there was no gender difference in belonging for the nonstereotypical classroom, $F(1, 146) = 0.75$, $p = .39$, $d = 0.14$.

Negative stereotype concerns. A 2 × 3 (Participant Gender × Classroom Environment [premeasure, stereotypical, and nonstereotypical]) mixed-model ANOVA revealed significant main effects of classroom environment, $F(2, 284) = 4.47$, $p = .012$, $\eta_p^2 = .031$, and participant gender, $F(1, 142) = 17.79$, $p < .001$, $d = 0.66$, qualified by a significant Gender × Classroom interaction, $F(2, 284) = 5.50$, $p = .005$, $\eta_p^2 = .037$ (see Table 1 for descriptive statistics). Simple effects for girls revealed a main effect of classroom environment, $F(2, 141) = 9.25$, $p < .001$, $\eta_p^2 = .116$. Planned comparison of ratings for each classroom to the premeasure revealed that girls reported lower negative stereotype concerns in the course in the nonstereotypical classroom compared with the stereotypical classroom, $F(1, 142) = 18.10$, $p < .001$, $d = 0.50$, and compared with the premeasure, $F(1, 142) = 6.89$, $p = .010$, $d = 0.30$. Girls reported marginally lower negative stereotype concerns on the premeasure compared with the stereotypical classroom, $F(1, 142) = 3.61$, $p = .06$, $d = 0.21$. Simple effects for boys revealed no main effect of classroom environment, $F(2, 141) = 0.25$, $p = .78$, $\eta_p^2 = .004$. There were no differences for boys for either classroom compared with the premeasure, $Fs < 0.50$, $ps > .48$, $ds < 0.09$, or between the stereotypical and nonstereotypical classrooms, $F(1, 142) = 0.03$, $p = .85$, $d = 0.02$.

Looking at these data another way, girls reported significantly more negative stereotype concerns than boys on the premeasure, $F(1, 142) = 18.02$, $p < .001$, $d = 0.71$, when the classroom was stereotypical, $F(1, 142) = 21.08$, $p < .001$, $d = 0.77$, and when the classroom was nonstereotypical, $F(1, 142) = 4.35$, $p = .039$, $d =$

Figure 3. Interest in enrolling in the computer science course in Experiment 1. Girls were significantly less interested in the computer science course than boys in a premeasure and when the classroom contained stereotypical objects, but not when the classroom contained nonstereotypical objects. All error bars are ±*SE*.

.35, although the effect size was smaller for the nonstereotypical classroom.

Fit with stereotypes. As expected, girls were less likely than boys to report that they fit the stereotype of a computer scientist (girls: $M = 2.22$, $SD = 1.45$; boys: $M = 2.77$, $SD = 1.76$), $t(144) = 2.06$, $p = .04$, $d = 0.34$.

We further investigated whether girls' feelings of fit with the stereotypes correlated with enrollment interest in the premeasure, stereotypical classroom, and nonstereotypical classroom. As predicted, girls who reported greater fit with computer science stereotypes reported significantly more enrollment interest in the premeasure, $r(71) = .30$, $p = .011$, and the stereotypical classroom, $r(71) = .27$, $p = .023$, than girls who reported lower fit with the stereotypes. There was no correlation with enrollment interest in the nonstereotypical classroom, $r(71) = .04$, $p = .75$.

Using Fisher's r-to-z transformation, we compared the size of the correlations (Steiger, 1980). The correlation between girls' fit with stereotypes and enrollment interest in the premeasure was significantly larger than the correlation between fit with stereotypes and enrollment interest in the nonstereotypical classroom, $z = 1.78$, one-tailed $p = .037$. The correlation between fit with stereotypes and enrollment interest in the stereotypical classroom was marginally larger than the correlation between fit with stereotypes and enrollment interest in the nonstereotypical classroom, $z = 1.28$, one-tailed $p = .10$.

We also investigated whether fit with stereotypes correlated with belonging in the premeasure, stereotypical classroom, and nonstereotypical classroom. As predicted, girls who reported greater fit with stereotypes reported significantly higher belonging in the premeasure, $r(71) = .35$, $p = .003$, and the stereotypical classroom, $r(71) = .24$, $p = .042$, than girls who reported lower fit with the stereotypes. There was no correlation with belonging in the nonstereotypical classroom, $r(71) = .013$, $p = .91$.

Does belonging mediate gender differences in interest in the stereotypical classroom? Mediation analysis examines whether an independent variable (in this case, gender) exerts an effect on an outcome variable (in this case, enrollment interest) through one or more intervening variables (in this case, belonging); if the "indirect" effect of the independent variable on the outcome variable through the mediator differs from zero (as indicated by the confidence interval of a bootstrapping mediation test), then the mediator variable is said to mediate this effect (Hayes, 2009).

Using mediational procedures outlined by Baron and Kenny (1986), we investigated whether belonging in the stereotypical classroom explained the gender difference in interest in the stereotypical classroom with the Preacher and Hayes (2008) indirect macro with 5,000 bootstrap resamples (see Table 2 for correlations between interest and mediators). In Steps 1 and 2, girls (compared with boys) were less interested in the stereotypical classroom, $b = -.86$, $SE = .29$, $p = .004$, and felt less belonging in the stereotypical classroom, $b = -.67$, $SE = .25$, $p = .009$. In Step 3, belonging predicted interest upon controlling for gender, $b = .96$, $SE = .05$, $p < .001$. In Step 4, controlling for belonging eliminated the previously significant relationship between gender and interest, $b = -.22$, $SE = .17$, $p = .19$; 95% confidence interval (CI) for the indirect effect $[-1.12, -0.15]$. Significant mediation is indicated by the fact that zero falls outside the CI. Thus, girls' lower interest in the course with the stereotypical classroom than boys was

Table 2

Correlation Matrix in the Stereotypical Classroom in Experiment 1 by Participant Gender

Measure	1	2	3	4
1. Interest	—	.83***	−.003	.30**
2. Belonging	.84***	—	−.04	.30**
3. Negative stereotype concerns	−.14	−.27*	—	.15
4. Fit with stereotypes	.27*	.24*	.20†	—

Note. Correlations for girls ($n = 75$) are presented below the diagonal, and correlations for boys ($n = 74$) are presented above the diagonal.
† $p \leq .10$. * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

mediated by their sense that they would not belong in the stereotypical classroom.

Does belonging predict interest after controlling for other variables? We repeated the mediation analysis including negative stereotype concerns in a parallel multiple mediation analysis following the procedures of Preacher and Hayes (2008). Negative stereotype concerns did not mediate the effect; 95% CI for the indirect effect $[-.04, 0.22]$. However, belonging remained a significant mediator; 95% CI for the indirect effect $[-1.16, -0.19]$. Belonging mediated the gender difference above and beyond girls' concerns about being negatively stereotyped based on their gender.

We repeated the mediation analysis again including fit with stereotypes. First, we tested fit with stereotypes alone as a mediator, and it mediated the gender difference in interest in the stereotypical classroom; 95% CI for the indirect effect $[-0.45, -0.02]$. Second, because we expected that fit with stereotypes would affect belonging, we tested fit with stereotypes as a serial mediator with belonging following the procedure of Hayes (2013). This model tests the indirect effects of fit with stereotypes and belonging individually, as well as the indirect effects of a pathway from fit with stereotypes to belonging. In this case, fit with stereotypes alone did not mediate the effect; 95% CI for the indirect effect $[-.13, 0.006]$. However, fit with stereotypes as a serial mediator with belonging did mediate the effect; 95% CI for the indirect effect $[-.36, -.01]$. Belonging alone remained a significant mediator as well, 95% CI for the indirect effect $[-1.00, -.10]$. Thus, these results support the model that fit with stereotypes affected belonging, and this process along with belonging itself mediated the gender difference in interest in the stereotypical classroom.

Discussion

Girls' self-reported interest in enrolling in an introductory computer science course was significantly increased when the classroom environment was altered so that it did not fit high school students' current stereotypes of computer science. In contrast, boys' self-reported interest in computer science did not differ across the two classrooms. The fact that boys' interest in the course remained just as high in the nonstereotypical classroom is encouraging because it indicated that changes to the physical classroom environment could be used to attract girls to computer science without deterring boys in the process. Interestingly, the stereotypes exerted an effect on girls even though half of the students in the class were female, suggesting that these stereotypes are a deterrent to girls even when their

gender is well-represented in the environment. High-school girls' interest in enrolling in classes can thus be influenced by the design of classrooms, providing evidence for the ability of classroom environments to signal who belongs.

Which classroom was responsible for the effects? In the absence of any special input (i.e., on the premeasure), girls may expect that computer science environments will fit stereotypes because they are familiar with and endorse current stereotypes of computer scientists (Mercier, Barron, & O'Connor, 2006; Rommes, Overbeek, Scholte, Engels, & De Kemp, 2007). Indeed, the pilot study revealed that students associated the stereotypical objects with computer science more than the nonstereotypical objects; moreover, our experimental data show no statistical difference between the premeasure and the stereotypical condition in girls' enrollment interest and belonging. Thus, girls may carry with them the expectation that computer science fits the stereotypes and they, as a result, do not belong in computer science environments. However, when the classroom was redesigned to no longer reflect current stereotypes, girls felt significantly greater belonging and interest in that course. Showing girls computer science environments that defy the stereotypes increased their interest in enrolling in a computer science course over current levels (and over showing them a stereotypical classroom environment).

The stereotypical environment was more of a deterrent for girls than boys. Girls felt lower belonging in the stereotypical environment than the nonstereotypical environment (with a small-to-moderate effect size of $d = 0.40$), and this lower belonging mediated the gender differences in interest in the stereotypical computer science course. The stereotypical classroom also increased girls' concerns about negative stereotypes about their gender; however, negative stereotype concerns did not predict girls' enrollment interest. Classrooms that communicate a greater sense of belonging to girls may be particularly effective in encouraging them to enter those courses.

We also found that individual differences in fit with stereotypes predicted girls' enrollment interest when stereotypes were salient. Girls who felt that they fit the computer science stereotypes reported greater interest in enrolling in the stereotypical classroom, but there was no relationship for the nonstereotypical classroom. The correlations between fit with stereotypes and enrollment interest in the premeasure and stereotypical classrooms were stronger than the correlation between fit with stereotypes and enrollment interest in the nonstereotypical classroom. This suggests that, when stereotypes are present or assumed, a lack of fit with those stereotypes can deter girls from computer science. However, when the stereotypes are neutralized by presenting an alternative image of computer science, then a feeling of personal incompatibility with stereotypes becomes less important. Thus, the nonstereotypical image of computer science can help reduce the barriers that dissuade girls who might otherwise be interested in computer science (i.e., the girls who are low in fit with stereotypes). The gender difference in fit with stereotypes also supports our theoretical model: in general, computer science appeals most to those who feel that they fit the stereotypes (as in the premeasure of enrollment interest), and, thus, girls (who are less likely to feel that they fit the stereotypes) report less belonging and interest in enrolling in computer science compared with boys.

Experiment 2: Effects of One Classroom Environment on Students' Interest in Computer Science

We made three changes to the procedures used in Experiment 1 to test the generalizability of the effects. First, we controlled for two factors shown to be important for girls' career aspirations in STEM: expectations of success and value placed on computer science (Eccles, 2011; Harackiewicz, Rozek, Hulleman, & Hyde, 2012). We examined whether belonging plays a critical role in shaping students' enrollment interest, above and beyond perceptions of their ability and how much they value computer science. Second, we used a different manipulation of classroom environment by describing the classrooms to students rather than showing photos. This manipulation ensured that effects were not because of something specific about the photos and generalized to other ways that students come to learn about stereotypes (e.g., hearing a description of the classroom). Third, we used a between-subjects design to examine whether exposure to a single classroom would affect girls' interest. This allowed us to capture the experiences of students who do not have multiple computer science courses to choose from.[1] As in Experiment 1, we hypothesized that a mediation analysis would reveal that the gender difference in enrollment interest in the stereotypical classroom would be mediated by girls' lower belonging in that course, even controlling for expectations of success and value placed on computer science.

Method

Participants. Participants were 104 students at the same public high school as Experiment 1 (48 young women, 56 young men; $M_{age} = 15.96$ years, $SD = 1.23$; age range: 14–21). Fifty percent were freshmen, 21% were sophomores, 20% were juniors, and 9% were seniors. Participants were 30% White, 27% Latino/a, 19% Asian/Pacific Islander, 14% multiple ethnicities, 9% Black, and 1% other.

We asked students how many computer science classes they had taken previously, $M = 0.78$, $SD = 1.35$. Girls reported having taken significantly fewer computer science classes than boys (girls: $M = 0.40$, $SD = 0.65$; boys: $M = 1.11$, $SD = 1.68$), $t(99) = 2.72$, $p = .008$, $d = 0.48$. There were no differences by participant

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[1] We also manipulated teacher gender to examine whether the effect would generalize to female teachers as well as male teachers. There was no significant main effect of teacher gender on enrollment interest, $F(1, 80) = 0.01$, $p = .94$, $d = 0.11$, and no interactions between other variables and teacher gender, $Fs < 2.06$, $ps > .15$, $\eta_p^2 s < .050$. The three-way interaction between Participant Gender × Classroom Environment × Teacher Gender on belonging was significant, $F(1, 80) = 4.33$, $p = .041$, $\eta_p^2 = .051$. Breaking this interaction down by teacher gender, when the teacher was male, the Participant Gender × Classroom Environment interaction on belonging was significant, $F(1, 38) = 8.28$, $p = .007$, $\eta_p^2 = .179$. When the teacher was female, the Participant Gender × Classroom Environment interaction was nonsignificant, $F(1, 42) = 0.01$, $p = .91$, $\eta_p^2 < .001$. When the teacher was male, the gender difference in belonging was significant for the stereotypical classroom, $F(1, 80) = 16.25$, $p < .001$, $d = 2.16$, but not for the nonstereotypical classroom, $F(1, 80) = 0.03$, $p = .86$, $d = 0.08$. Thus, the combination of a male teacher with stereotypical cues may have a particularly negative effect on girls' sense of belonging. For adolescents, the classroom environment may communicate more about what the class would be like and whether they would belong there than the gender of the people in it. It may be important for students to see their mentors as "like me" (Meltzoff, 2007) in ways that go beyond gender (e.g., in terms of race, personality characteristics/stereotypicality, or shared attitudes and experiences—see Cheryan, Siy, Vichayapai, Drury, & Kim, 2011).

gender in terms of year in school or self-reported math grades, ps > .28, ds < 0.12.

As in Experiment 1, the ICC revealed that the proportion of variance in enrollment interest that was because of differences in participants' actual classroom was negligible (ICC = −.04).

Procedure. Participants read a description of a single computer science course. The teacher was randomly assigned to be male or female. To ensure that teachers were seen as competent and therefore adequate role models (Lockwood, 2006), the teacher was described as having a graduate degree in computer science and years of experience teaching this course. Students were then randomly assigned to read one of two descriptions of the classroom, which contained a list of objects that were either stereotypical or nonstereotypical of computer science (thus, both teacher gender and classroom environment were manipulated between-subjects). The objects were the same as Experiment 1 and were listed as follows: "Electronics, Software, Computer parts, Tech magazines, Star Wars and Star Trek items, Computer books, Science fiction books, Video games" (stereotypical condition); "Nature pictures on the wall, Water bottles, Plants, Art on the wall, General magazines, Pens, Coffee maker, Lamps" (nonstereotypical condition).

Participants then answered questions about the course. The primary questions relevant to this experiment involved enrollment interest, belonging, and expectations and values.

Dependent measures.

Attention check. Three multiple-choice attention checks assessed number of courses (one), teacher gender, and topic (computer science). Overall, 68% of participants passed the number of courses question, 82% passed the teacher gender question, and 82% passed the course topic question.

Enrollment interest. Enrollment interest was measured with the two items used in Experiment 1, α = .94.

Belonging. Belonging was measured with the four items used in Experiment 1, α = .87.

Other variables. We also measured items drawn from expectancy-value theory (Eccles, 2011). Expectations of success were measured by averaging two items on a 7-point scale (see Eccles & Wigfield, 1995; Updegraff, Eccles, Barber, & O'Brien, 1996 for previous reliability and validity of scale): how well students thought they would do in this class, and where they would put themselves if they ranked all students from worst to best in computer science, α = .82. We also measured the value that students saw in computer science by averaging two items on a 7-point scale: how useful they thought computer science would be after they graduated, and the importance of being good at computer science (Updegraff et al., 1996), α = .78.

Final sample. Sixteen students were excluded from analyses for missing more than one attention check. However, the pattern of results remained the same if these students were included. Excluded students did not differ by either classroom environment condition or teacher gender condition. There were no significant differences by classroom environment condition in terms of year in school, χ^2(3, N = 88) = 2.03, p = .57, φ = .15; number of computer science classes taken, t(84) = 1.04, p = .30, d = 0.22; or self-reported math grades (1 = *Mostly As*, 2 = *As and Bs*, 3 = *Mostly Bs*, 4 = *Bs and Cs*, 5 = *Mostly Cs*, 6 = *Cs and Ds*, and 7 = *Mostly Ds or below*), t(83) = 0.24, p = .81, d = 0.05.

Results

Enrollment interest. A 2 × 2 (Participant Gender × Classroom Environment [stereotypical, nonstereotypical]) ANOVA revealed a main effect of participant gender on enrollment interest, F(1, 84) = 20.71, p < .001, d = 0.97, qualified by a significant interaction (see Table 3 for descriptive statistics). As predicted, there was a Participant Gender × Classroom Environment interaction, F(1, 84) = 3.86, p = .05, η_p^2 = .044. Girls were significantly less interested than boys when the course was in the stereotypical classroom, F(1, 84) = 21.72, p < .001, d = 1.47, but this gender difference was smaller in the nonstereotypical classroom, F(1, 84) = 3.27, p = .07, d = 0.53. Looking at this data another way, girls were marginally more interested in the course in the nonstereotypical classroom compared with the stereotypical classroom, F(1, 84) = 3.25, p = .08, d = 0.61, but there was no difference in boys' interest in both classrooms, F(1, 84) = 0.90, p = .35, d = 0.26 (see Figure 4).

To ensure results were not because of boys' greater experience with computer science courses, we repeated the analysis controlling for number of previous computer science courses. Even controlling for previous computer science enrollment, there was a significant interaction between participant gender and classroom environment, F(1, 81) = 5.26, p = .024, η_p^2 = .061.

Belonging. A 2 × 2 (Participant Gender × Classroom Environment [stereotypical, nonstereotypical]) ANOVA revealed a main effect of participant gender on belonging, F(1, 84) = 11.14, p = .001, d = 0.71, qualified by a marginal Participant Gender × Classroom Environment interaction, F(1, 84) = 2.97, p = .09, η_p^2 = .034 (see Table 3 for descriptive statistics).
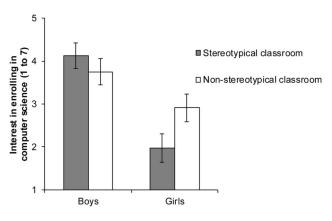
Does belonging mediate the gender effect on enrollment interest? We investigated whether girls' lower interest in the course with the stereotypical classroom than boys was mediated by their lower belonging in that course using the same analytic procedures as Experiment 1. In Steps 1 and 2, compared with boys, girls were less interested in the stereotypical course, b = −2.05, SE = .42, p < .001, and felt less belonging in that environment, b = −1.33, SE = .37, p = .001. In Step 3, belonging predicted interest upon controlling for gender, b = 0.86, SE = .12, p < .001. In Step 4, controlling for belonging significantly reduced the relationship between gender and interest, b = −0.90, SE = .32, p = .007, 95% CI for the indirect effect [−1.89, −0.51]. Thus,

Table 3
Descriptive Statistics for Outcome Variables in Experiment 2

Variable	Girls		Boys	
	M	*SD*	*M*	*SD*
Interest				
Stereotypical	2.10$_a$	1.00	4.15$_b$	1.70
Nonstereotypical	2.93$_{a,c}$	1.64	3.74$_{b,c}$	1.43
Belonging				
Stereotypical	2.80$_a$	1.30	4.13$_b$	1.18
Nonstereotypical	3.45$_{a,c}$	1.33	3.87$_{b,c}$	1.11

Note. Means for each variable sharing a common subscript are not statistically different at $p \leq .05$.

Figure 4. Interest in enrolling in the computer science course in Experiment 2. Girls were significantly less interested in the computer science course than boys when the classroom contained stereotypical objects, but this difference was smaller when the classroom contained nonstereotypical objects.

belonging was a significant mediator of gender differences in interest in the course with the stereotypical classroom.

Does belonging predict interest after controlling for other variables? We also compared whether belonging remained a mediator of the gender difference in interest in the stereotypical classroom after controlling for expectations of success and utility value of computer science (see Table 4 for correlations between interest and mediators). As in Experiment 1, we repeated the mediation analysis including expectations of success in a parallel multiple mediation analysis. Expectations of success did not mediate the effect; 95% CI for the indirect effect $[-0.66, 0.30]$. However, belonging remained a significant mediator; 95% CI for the indirect effect $[-1.80, -0.47]$. Belonging thus mediated the gender difference above and beyond expectations that students would succeed in the course.

We repeated the mediation analysis again including utility value in a parallel multiple mediation analysis. Utility value did mediate the effect: 95% CI for the indirect effect $[-1.10, -0.13]$, and belonging remained a significant mediator: 95% CI for the indirect effect $[-1.65, -0.48]$. Thus, both belonging and the value that students placed on computer science mediated the effects on interest.

Discussion

Experiment 2 revealed that girls reported more interest in enrolling in an introductory computer science course when the physical environment was nonstereotypical compared with stereotypical, with a moderate-to-large effect size of $d = 0.61$. In contrast, boys' self-reported interest in the course did not depend on the classroom environment. Girls and boys in this experiment only read a description of the course, indicating that effects were not because of something idiosyncratic about the photos used in Experiment 1. Moreover, the fact that girls and boys saw only one classroom generalizes these results to high schools that only offer a single computer science course.

Consistent with the previous experiment, belonging remained a mediator of the gender differences in interest in the computer science course with a stereotypical environment. When computer science

stereotypes were evident, girls felt lower belonging in the course than boys, and this lower belonging predicted their reduced interest. Moreover, belonging predicted interest in computer science even after controlling for girls' expectations of success and the value they placed on computer science. When students become uncertain of whether they belong in a particular field, or have the sense that they do not belong, they may be less interested in entering that field, even when they feel confident in their abilities and value the field. However, presenting a nonstereotypical environment increased girls' belonging, and resulted in girls' greater self-reported interest in taking the introductory computer science course.

General Discussion

Two experiments examined whether girls' lower interest than boys in enrolling in introductory computer science courses may be because of current stereotypes of the field. The results paint a consistent and compelling picture about the role of stereotypes in decreasing girls' enrollment interest. The first experiment showed that a computer science classroom that made current stereotypes salient caused girls to express less interest in an introductory computer science course than a classroom that reflected a new image of computer science (with effect sizes in the moderate range, $ds = .36-.41$). The two classrooms differed only in the objects present, yet girls made a conscious choice about which course to take based on whether the stereotypes were salient in that environment. In contrast, the objects in the classroom did not affect boys' interest in the course. The second experiment demonstrated again that stereotypical classroom environments negatively influenced girls' self-reported interest in taking an introductory computer science course. That is, girls were less interested in the stereotypical classroom than the nonstereotypical classroom (with a moderate-to-large effect size of $d = .61$), while boys showed no difference in interest.

Why did these stereotypes affect girls but not boys? Mediational analyses in both experiments indicated that gender differences in interest in the stereotypical classroom were driven by differences in how much girls and boys felt they belonged in that environment. When girls felt that they belonged in the environment, they became more interested in taking the course. This relationship held when

Table 4
Correlations in Experiment 2 by Participant Gender and Condition

Measure	1	2	3	4
Girls ($n = 41$)				
1. Interest	—	.73***	.50*	.48*
2. Belonging	.69***	—	.64**	.56**
3. Expectations	.31	.47*	—	.56**
4. Values	.41†	.19	.09	—
Boys ($n = 47$)				
1. Interest	—	.56**	.52**	.38†
2. Belonging	.85***	—	.66***	.61**
3. Expectations	.51**	.39†	—	.50*
4. Values	.64***	.52**	.48*	—

Note. Correlations for the stereotypical classroom condition are presented below the diagonal, and correlations for the nonstereotypical classroom condition are presented above the diagonal.
† $p \leq .10$. * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

controlling for other factors known to shape girls' interest in STEM, including negative stereotype concerns, expectations of success, and valuing of computer science. Further analyses in Experiment 1 showed that girls' lower sense of belonging could be traced to lower fit with stereotypes. Girls felt a lower sense of fit with stereotypes than boys, which predicted girls' reduced sense of belonging in the stereotypical classroom. Redesigning classroom environments to communicate a broader image of STEM fields may help to increase girls' belonging and subsequent interest in enrolling in STEM courses, without dissuading boys. These findings support a growing body of literature demonstrating that changing students' feelings of belonging can transform their academic motivation and outcomes (Cook, Purdie-Vaughns, Garcia, & Cohen, 2012; Walton & Cohen, 2007), and reinforce that belonging is a powerful mechanism for adolescents.

It is also worth noting that, while there were statistical differences on the group level, there are also individual differences among both girls and boys. Although a majority of girls preferred the nonstereotypical classroom to the stereotypical classroom, nearly a third of girls in Experiment 1 preferred the stereotypical classroom. Girls who felt that they fit the stereotypes of a computer scientist reported more enrollment interest in the stereotypical classroom compared with girls who did not feel that they fit stereotypes. Similarly, there can be variability in students' responses to stereotypes. Some girls may be very sensitive to the stereotypes conveyed by an environment, while others may be less concerned with stereotypes. Diversifying the stereotypes can help to reduce the barriers that prevent some girls (who might otherwise be interested) from pursuing computer science. On a practical level, the current findings may assist educators in identifying girls who are most deterred by stereotypes, and who might benefit the most from interventions that present a more diverse image of computer science. Future work should continue to examine the characteristics of girls who prefer a stereotypical environment, and whether they would be more likely to pursue computer science. In addition, many boys preferred the nonstereotypical classroom to the stereotypical classroom. Diversifying the stereotypes of computer science could create appeal for many boys as well as girls.

The classroom is where many students first get exposed to quantitative fields (Moses et al., 1999). Because successful entry into fields such as computer science often requires early course completion in technical subjects (Nagy et al., 2008; Sinclair & Carlsson, 2013), making initial sites of exposure welcoming to girls is critical to reducing current gender disparities. Many high school teachers decorate their classrooms, and some teachers may be inadvertently including cues that communicate to girls that they would not fit in that classroom, while other teachers may be decorating their classrooms in ways that effectively reduce gender disparities. If stereotypes about computer science deter girls from this course, then creating nonstereotypical classroom environments may be a valuable way for teachers to signal to girls that they belong in and should enter that environment.

Strengths and Limitations

These studies have several strengths. First, participants in both experiments included students from a diverse public high school and from a variety of backgrounds. Second, the replication of findings using a variety of methods (within-subjects and between-subjects; photographs and descriptions of classrooms; presence and absence of information about gender proportion of students) increases confidence and generalizability. Third, it is also worth emphasizing that the nonstereotypical environment did not deter boys' self-reported interest, suggesting that making classrooms and physical spaces more welcoming to girls in this manner will not simultaneously create an unwelcoming effect for boys.

One potential limitation in Experiment 1 is that the depiction of our stereotypical classroom may not seem to reflect the way that current real-world high school computer science classrooms appear. From a theoretical perspective, the purpose of these experiments was to manipulate the salience of current stereotypes to demonstrate effects of stereotypes on girls' interest. To do this, it was necessary to present participants with classrooms that signaled or did not signal these stereotypes to show a direct causal effect of the stereotypes on girls' interest in enrolling in the courses. Crucially, *the stereotypical classroom was no different from girls' interest at baseline*, suggesting that the stereotypical classroom represents students' default assumptions about computer science, while the nonstereotypical classroom changed interest compared with baseline. Thus, to reduce gender disparities in interest, current classrooms should ensure that their design signals to girls a broader image of the field.

A related limitation is that stereotypes may affect girls' interest differently when encountered among all the other variables occurring in a natural environment. An advantage of using an experimental design is that it supports making inferences about causation; however, more research is needed in real classrooms, which are less controlled and more complex. The current experiments fall into Stage II (controlled laboratory experiments, classroom-based demonstrations, and "design experiments") of Marley and Levin's (2011) three stages of programmatic educational research. The next step involves applying these findings to randomized classroom trials in real-world environments. Research with college students suggests that redesigning real-world classrooms in stereotypical or nonstereotypical ways has similar effects to what we found here (Cheryan et al., 2009), as does the design of online virtual classrooms (Cheryan et al., 2011). If findings from real high-school classrooms prove to be consistent with those found here, changing the physical classroom environment represents a cost-effective and easily implementable intervention that could be tried by high school computer science teachers to reduce gender disparities in their courses.

Another limitation is that we measured self-reported interest. Although self-reported interest is highly correlated with actual academic choices (Eagan et al., 2013), future work should look at the effects of redesigning classrooms on actual enrollment. Because students often change majors and could be drawn into the computer science major by an effective course (Alon & DiPrete, 2015), prompting girls to consider enrolling in computer science as a course (and then to consider computer science as a potential major) is important.

A related limitation is that girls' interest, even when it was boosted in the nonstereotypical classroom, remained at low-to-medium levels overall. Although levels of interest were similar to those found in previous studies (e.g., Cheryan et al., 2011; Davies et al., 2002), these findings indicate that changing environmental cues may not be enough to boost girls' interest from very low to very high. In Experiment 1, changing stereotypes conveyed by the classroom tripled the number of girls who showed positive interest (above the scale midpoint), but the majority of girls remained below the midpoint. Thus, the current work provides one concrete recommendation for increasing girls' interest, but it may need to be accompanied by other changes

as well. Stereotypes about the "geeky" culture of computer science may be only one of many barriers that need to be lifted before more girls show positive interest in computer science (see Cheryan et al., 2015), especially in light of their stronger interests in other fields (Riegle-Crumb et al., 2012; Wang, Eccles, & Kenny, 2013).

A fourth limitation involves methodological concerns: the sample sizes were small and some scales used few items. These limitations reflect typical challenges of conducting research with adolescents in schools: surveys must be brief enough to retain students' attention, and obtaining permission from administrators, teachers, parents, and students can be challenging. Future research that replicates the findings with a larger sample, with more extensive scales, and with students from other parts of the country would be useful.

Future Directions

The current work also suggests several interesting avenues for future directions. The focus in the present studies was on stereotypical and nonstereotypical environments, but what would happen if the physical environment were stereotypically feminine? On one hand, a feminine environment could allow some girls to feel increased belonging, which could then increase their interest. On the other hand, there is some reason to conjecture that such a blatant manipulation could backfire and be offensive (Betz & Sekaquaptewa, 2012; Siy & Cheryan, 2013). Moreover, such a division may itself reinforce gender stereotypes (Halpern et al., 2011) and steer boys away from these classes (Bosson, Prewitt-Freilino, & Taylor, 2005). A second area for future work is to examine how changes in environments affect students who have already enrolled in these classes. It is possible that stereotypical objects may have more powerful effects on students seeing them for the first time, compared with students who have been in that classroom for an extended period.

Another future direction relevant to both theory and practice would be to examine how STEM stereotypes affect adolescents from underrepresented racial groups. Similar to gendered stereotypes about computer science, computer science is also stereotypically associated with Whites and Asians (Margolis, Estrella, Goode, Holme, & Nao, 2008; Walton & Cohen, 2007; see also Cvencek, Nasir, O'Connor, Wischnia, & Meltzoff, 2014), and these stereotypical representations may send messages to Black and Latino/a students that they do not belong in computer science. Girls who are Black and/or Latina may be even less likely to feel that they belong, because they possess both gender and racial identities that do not fit current stereotypes of computer scientists.

Conclusion

Recent initiatives are working to bring computer science to hundreds of thousands of high school students (Dudley, 2013; Office of the Press Secretary, 2014). However, unless we can encourage more girls to enroll in these courses, these efforts will be ineffective at reducing the underrepresentation of women in computer science. Understanding the factors that prevent girls from enrolling in introductory computer science courses (where they are currently underrepresented) and that could help them feel welcome in mandatory computer science courses, is an important step in reducing gender disparities. By the time they are adolescents, girls are aware of the negative stereotypes about their ability in math and science (Cvencek, Meltzoff, & Greenwald, 2011; see

also Huguet & Régner, 2007). They also know that STEM fields are dominated by males (Goode, Estrella, & Margolis, 2006; Mercier et al., 2006). However, our findings demonstrate that cues indicating that they are welcome and belong in this environment can increase girls' self-reported interest in computer science, despite these prevailing stereotypes. The current studies showed that redesigning the classroom signaled a different image of computer science that encouraged girls to enroll in these important classes. Intentionally designing and changing high school physical environments (classrooms, computer labs, and offices) may play a significant role in communicating a feeling of belonging to girls and help to reduce current gender disparities in STEM courses.

References

Alon, S., & DiPrete, T. A. (2015). Gender differences in the formation of field of study choice set. *Sociological Science, 2,* 50–81. http://dx.doi.org/10.15195/v2.a5

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51,* 1173–1182. http://dx.doi.org/10.1037/0022-3514.51.6.1173

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117,* 497–529. http://dx.doi.org/10.1037/0033-2909.117.3.497

Betz, D. E., & Sekaquaptewa, D. (2012). My fair physicist? Feminine math and science role models demotivate young girls. *Social Psychological & Personality Science, 3,* 738–746. http://dx.doi.org/10.1177/1948550612440735

Bosson, J. K., Prewitt-Freilino, J. L., & Taylor, J. N. (2005). Role rigidity: A problem of identity misclassification? *Journal of Personality and Social Psychology, 89,* 552–565. http://dx.doi.org/10.1037/0022-3514.89.4.552

Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological Science in the Public Interest, 15,* 75–141. http://dx.doi.org/10.1177/1529100614541236

Cheryan, S. (2012). Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not? [Commentary]. *Sex Roles, 66,* 184–190. http://dx.doi.org/10.1007/s11199-011-0060-z

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology, 6,* 49. http://dx.doi.org/10.3389/fpsyg.2015.00049

Cheryan, S., Meltzoff, A. N., & Kim, S. (2011). Classrooms matter: The design of virtual classrooms influences gender disparities in computer science classes. *Computers & Education, 57,* 1825–1835. http://dx.doi.org/10.1016/j.compedu.2011.02.004

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology, 97,* 1045–1060. http://dx.doi.org/10.1037/a0016239

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles, 69,* 58–71. http://dx.doi.org/10.1007/s11199-013-0296-x

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *Social Psychological and Personality Science, 2,* 656–664. http://dx.doi.org/10.1177/1948550611405218

Chow, A., Eccles, J. S., & Salmela-Aro, K. (2012). Task value profiles across subjects and aspirations to physical and IT-related sciences in the

United States and Finland. *Developmental Psychology, 48,* 1612–1628. http://dx.doi.org/10.1037/a0030194

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7,* 309–319. http://dx.doi.org/10.1037/1040-3590.7.3.309

Cohen, G. L., & Garcia, J. (2005). "I am us": Negative stereotypes as collective threats. *Journal of Personality and Social Psychology, 89,* 566–582. http://dx.doi.org/10.1037/0022-3514.89.4.566

Cohen, G. L., & Garcia, J. (2008). Identity, belonging, and achievement: A model, interventions, implications. *Current Directions in Psychological Science, 17,* 365–369. http://dx.doi.org/10.1111/j.1467-8721.2008.00607.x

Cohoon, J. M., & Aspray, W. (2006). A critical review of the research on women's participation in postsecondary computing education. In J. M. Cohoon & W. Aspray (Eds.), *Women and information technology: Research on underrepresentation* (pp. 137–180). Cambridge, MA: MIT Press. http://dx.doi.org/10.7551/mitpress/9780262033459.003.0005

Cook, J. E., Purdie-Vaughns, V., Garcia, J., & Cohen, G. L. (2012). Chronic threat and contingent belonging: Protective benefits of values affirmation on identity development. *Journal of Personality and Social Psychology, 102,* 479–496. http://dx.doi.org/10.1037/a0026312

Cohoon, J. M., & Aspray, W. (2006). A critical review of the research on women's participation in postsecondary computing education. In J. M. Cohoon & W. Aspray (Eds.), *Women and information technology: Research on underrepresentation* (pp. 137–180). Cambridge, MA: MIT Press. http://dx.doi.org/10.7551/mitpress/9780262033459.003.0005

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math-gender stereotypes in elementary school children. *Child Development, 82,* 766–779. http://dx.doi.org/10.1111/j.1467-8624.2010.01529.x

Cvencek, D., Nasir, N. S., O'Connor, K. O., Wischnia, S., & Meltzoff, A. N. (2014). The development of math–race stereotypes: "They say Chinese people are the best at math. [Advance online publication]. *Journal of Research on Adolescence,* n/a. http://dx.doi.org/10.1111/jora.12151

Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming images: How television commercials that elicit stereotype threat can restrain women academically and professionally. *Personality and Social Psychology Bulletin, 28,* 1615–1628. http://dx.doi.org/10.1177/014616702237644

de Cohen, C. C., & Deterding, N. (2009). Widening the net: National estimates of gender disparities in engineering. *The Journal of Engineering Education, 98,* 211–226. http://dx.doi.org/10.1002/j.2168-9830.2009.tb01020.x

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science, 21,* 1051–1057. http://dx.doi.org/10.1177/0956797610377342

Drury, B. J., Siy, J. O., & Cheryan, S. (2011). When do female role models benefit women? The importance of differentiating recruitment from retention in STEM. *Psychological Inquiry, 22,* 265–269. http://dx.doi.org/10.1080/1047840X.2011.620935

Duckworth, A. L., Quinn, P. D., & Tsukayama, E. (2012). What *No Child Left Behind* leaves behind: The roles of IQ and self-control in predicting standardized achievement test scores and report card grades. *Journal of Educational Psychology, 104,* 439–451. http://dx.doi.org/10.1037/a0026280

Dudley, B. (2013, March 13). Code.org update: Film reaches 12 million, draws 10,000 schools. *The Seattle Times.* Retrieved from http://blogs.seattletimes.com/brierdudley/2013/03/13/code-org-update-film-reaches-12-million-draws-10000-schools/

Eagan, M. K., Jr., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Making a difference in science education: The impact of undergraduate research programs. *American Educational Research Journal, 50,* 683–713. http://dx.doi.org/10.3102/0002831213482038

Eccles, J. S. (1987). Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly, 11,* 135–172. http://dx.doi.org/10.1111/j.1471-6402.1987.tb00781.x

Eccles, J. (2011). Gendered educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *International Journal of Behavioral Development, 35,* 195–201. http://dx.doi.org/10.1177/0165025411398185

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75–146). San Francisco, CA: Freeman.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21,* 215–225. http://dx.doi.org/10.1177/0146167295213003

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102,* 700–717. http://dx.doi.org/10.1037/a0026659

Goode, J., Estrella, R., & Margolis, J. (2006). Lost in translation: Gender and high school computer science. In J. M. Cohoon & W. Aspray (Eds.), *Women and information technology: Research on underrepresentation* (pp. 89–114). Cambridge, MA: MIT Press. http://dx.doi.org/10.7551/mitpress/9780262033459.003.0003

Halpern, D. F., Eliot, L., Bigler, R. S., Faber, R. A., Hanish, L. D., & Hyde, J., . . . Martin, C. L. (2011). The pseudoscience of single-sex schooling. *Science, 333,* 1706–1707. [http://dx.doi.org/10.1126/science.1205031

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100,* 105–122. http://dx.doi.org/10.1037/0022-0663.100.1.105

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science, 23,* 899–906. http://dx.doi.org/10.1177/0956797611435530

Harter, S. (1990). Self and identity development. In S. S. Feldman & G. R. Elliot (Eds.), *At the threshold: The developing adolescent* (pp. 352–387). Cambridge, MA: Harvard University Press.

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs, 76,* 408–420. http://dx.doi.org/10.1080/03637750903310360

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York, NY: Guilford Press.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research, 70,* 151–179. http://dx.doi.org/10.3102/00346543070002151

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41,* 111–127. http://dx.doi.org/10.1207/s15326985ep4102_4

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: AAUW. Retrieved from http://www.aauw.org/learn/research/upload/whysofew.pdf

Huguet, P., & Régner, I. (2007). Stereotype threat among schoolgirls in quasi-ordinary classroom circumstances. *Journal of Educational Psychology, 99,* 545–560. http://dx.doi.org/10.1037/0022-0663.99.3.545

Kalwarski, T., Mosher, D., Paskin, J., & Rosato, D. (2007). Best jobs in America [Electronic version]. CNNMoney.com. Retrieved from http://money.cnn.com/magazines/moneymag/bestjobs/index.html

Leslie, S. J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science, 347,* 262–265. http://dx.doi.org/10.1126/science.1261375

Lockwood, P. (2006). "Someone like me can be successful": Do college students need same-gender role models? *Psychology of Women Quarterly, 30,* 36–46. http://dx.doi.org/10.1111/j.1471-6402.2006.00260.x

Lupart, J., & Cannon, E. (2002). Computers and career choices: Gender differences in grades 7 and 10 students. *Gender, Technology and Development, 6,* 233–248. http://dx.doi.org/10.1177/097185240200600204

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing.* Cambridge, MA: MIT Press.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing.* Cambridge, MA: MIT Press.

Marley, S. C., & Levin, J. R. (2011). When are prescriptive statements in educational research justified? *Educational Psychology Review, 23,* 197–206. http://dx.doi.org/10.1007/s10648-011-9154-y

Marx, D. M., Stapel, D. A., & Muller, D. (2005). We can do it: The interplay of construal orientation and social comparisons under threat. *Journal of Personality and Social Psychology, 88,* 432–446. http://dx.doi.org/10.1037/0022-3514.88.3.432

Meltzoff, A. N. (2007). 'Like me': A foundation for social cognition. *Developmental Science, 10,* 126–134. http://dx.doi.org/10.1111/j.1467-7687.2007.00574.x

Mercier, E. M., Barron, B., & O'Connor, K. M. (2006). Images of self and others as computer users: The role of gender and experience. *Journal of Computer Assisted Learning, 22,* 335–348. http://dx.doi.org/10.1111/j.1365-2729.2006.00182.x

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7,* 105–125. http://dx.doi.org/10.1037/1082-989X.7.1.105

Moses, M. S., Howe, K. R., & Niesz, T. (1999). The pipeline and student perceptions of schooling: Good news and bad news. *Educational Policy, 13,* 573–591. http://dx.doi.org/10.1177/0895904899013004005

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18,* 879–885. http://dx.doi.org/10.1111/j.1467-9280.2007.01995.x

Nagy, G., Garrett, J., Trautwein, U., Cortina, K. S., Baumert, J., & Eccles, J. S. (2008). Gendered high school course selection as a precursor of gendered careers: The mediating role of self-concept and intrinsic value. In H. M. G. Watt & J. S. Eccles (Eds.), *Gendered occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 115–143). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/11706-004

National Science Foundation. (2013). TABLE 5–1. *Bachelor's degrees awarded, by sex and field: 2001–2010.* Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013, Division of Science Resources Statistics. Retrieved from http://www.nsf.gov/statistics/wmpd/2013/sex.cfm

Office of the Press Secretary. (2014). *Fact sheet: New commitments to support computer science education.* The White House. Retrieved from http://www.whitehouse.gov/the-press-office/2014/12/08/fact-sheet-new-commitments-support-computer-science-education

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 294–315). Cambridge, United Kingdom: Cambridge University Press.

Parsons, J. E., Adler, T., & Meece, J. L. (1984). Sex differences in achievement: A test of alternate theories. *Journal of Personality and Social Psychology, 46,* 26–43. http://dx.doi.org/10.1037/0022-3514.46.1.26

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40,* 879–891. http://dx.doi.org/10.3758/BRM.40.3.879

Riegle-Crumb, C., King, B., Grodsky, E., & Muller, C. (2012). The more things change, the more they stay the same? Prior achievement fails to explain gender inequality in entry into STEM college majors over time. *American Educational Research Journal, 49,* 1048–1073. http://dx.doi.org/10.3102/0002831211435229

Rommes, E., Overbeek, G., Scholte, R., Engels, R., & De Kemp, R. (2007). 'I'm not interested in computers': Gender-based occupational choices of adolescents. *Information, Communication & Society, 10,* 299–319. http://dx.doi.org/10.1080/13691180701409838

Schmitt, M. T., Davies, K., Hung, M., & Wright, S. C. (2010). Identity moderates the effects of Christmas displays on mood, self-esteem, and inclusion. *Journal of Experimental Social Psychology, 46,* 1017–1022. http://dx.doi.org/10.1016/j.jesp.2010.05.026

Schuirmann, D. J. (1987). A comparison of the two one-sided tests procedure and the power approach for assessing the equivalence of average bioavailability. *Journal of Pharmacokinetics and Biopharmaceutics, 15,* 657–680. http://dx.doi.org/10.1007/BF01068419

Sinclair, S., & Carlsson, R. (2013). What will I be when I grow up? The impact of gender identity threat on adolescents' occupational preferences. *Journal of Adolescence, 36,* 465–474. http://dx.doi.org/10.1016/j.adolescence.2013.02.001

Siy, J. O., & Cheryan, S. (2013). When compliments fail to flatter: American individualism and responses to positive stereotypes. *Journal of Personality and Social Psychology, 104,* 87–102. http://dx.doi.org/10.1037/a0030183

Smith, J. L., Lewis, K. L., Hawthorne, L., & Hodges, S. D. (2013). When trying hard isn't natural: Women's belonging with and motivation for male-dominated STEM fields as a function of effort expenditure concerns. *Personality and Social Psychology Bulletin, 39,* 131–143. http://dx.doi.org/10.1177/0146167212468332

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52,* 613–629. http://dx.doi.org/10.1037/0003-066X.52.6.613

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87,* 245–251. http://dx.doi.org/10.1037/0033-2909.87.2.245

Stephens, N. M., Fryberg, S. A., Markus, H. R., Johnson, C. S., & Covarrubias, R. (2012). Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students. *Journal of Personality and Social Psychology, 102,* 1178–1197. http://dx.doi.org/10.1037/a0027143

Thoman, D. B., Smith, J. L., Brown, E. R., Chase, J., & Lee, J. Y. K. (2013). Beyond performance: A motivational experiences model of stereotype threat. *Educational Psychology Review, 25,* 211–243. http://dx.doi.org/10.1007/s10648-013-9219-1

Updegraff, K. A., Eccles, J. S., Barber, B. L., & O'Brien, K. M. (1996). Course enrollment as self-regulatory behavior: Who takes optional high school math courses? *Learning and Individual Differences, 8,* 239–259. http://dx.doi.org/10.1016/S1041-6080(96)90016-3

Walton, G. M., & Cohen, G. L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology, 92,* 82–96. http://dx.doi.org/10.1037/0022-3514.92.1.82

Wang, M.-T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science, 24,* 770–775. http://dx.doi.org/10.1177/0956797612458937

Weisgram, E. S., & Bigler, R. S. (2006). The role of attitudes and intervention in high school girls' interest in computer science. *Journal of Women and Minorities in Science and Engineering, 12,* 325–336. http://dx.doi.org/10.1615/JWomenMinorScienEng.v12.i4.40