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Effects of role model exposure on STEM and non-STEM student engagement

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Abstract

Studies examining factors (e.g., STEM stereotypes) that underlie the recruitment and retention of STEM students are critical as the demand for STEM professionals is rapidly increasing. This experimental study tested the effects of role model biographies that challenge common STEM stereotypes (i.e., STEM is for gifted individuals and for European American males) on 1035 STEM and non-STEM undergraduate students. Findings showed that role model exposure had positive effects on both STEM and non-STEM students' interest in STEM as well as their perceived identity compatibility between the self and STEM. Role model exposure had a positive impact on academic sense of belonging among STEM and non-STEM students, and a positive impact on academic self-efficacy among STEM students, but not non-STEM students.

Recent economic forecasts estimate the need for 1 million science, technology, engineering, and mathematics (STEM) graduates over the next decade to meet the growing demand for STEM professionals in the United States (President's Council of Advisors on Science and Technology [PCAST], 2012). Despite this significant need, the supply of U.S. STEM students is not projected to meet the need (Chen, 2013). At the current rate of growth, there needs to be an annual increase of 34% of undergraduate STEM graduates to meet the need for 1 million more STEM professionals in the United States (PCAST, 2012). Nationwide calls and campaigns have been made to both recruit and to retain students in STEM, including the Educate to Innovate campaign in 2009 and more recently, Federal STEM Education 5-Year Strategic Plan (National Science and Technology Council, 2013; The White House, 2009). Although student participation in many (but not all) STEM disciplines has steadily increased over the past decade (NSF, 2015), findings show that only 28% of undergraduates seek a major in STEM (Chen, 2013). More critically, among the students who initially select a STEM major, attrition is high, with about 48% of students leaving STEM majors to change to a non-STEM major or by leaving college altogether (Chen, 2013). Gender and racial disparities in STEM participation and in the STEM workforce are also pressing concerns—with women representing only 29%, Black or African American representing 4.7%, and Hispanic or Latino representing 6% of all science and engineering occupations (NSF, 2015).

Understanding the barriers that discourage non-STEM students (e.g., those majoring in humanities, social sciences) from pursuing and STEM students (i.e., those pursuing STEM majors) from persisting in STEM may be a crucial answer to the recruitment and retention problem. Many theories and studies have identified and investigated psychosocial factors that affect STEM recruitment and retention (e.g., Good, Rattan, & Dweck, 2012; Leslie, Cimpian, Meyer, & Freeland, 2015). For example, Eccles et al. (1983) Expectancy-Value Theory highlights the importance of psychosocial factors that are believed to promote or sustain STEM engagement, including interest and cultural stereotypes about subject matter and career, which encourage or discourage one's decision to pursue and persist in a given field of study (Eccles et al., 1983; Wigfield & Eccles, 2000). Also, findings show that psychosocial factors, such as interest and self-efficacy predict actual recruitment and retention of STEM students (Lent, Brown, Schmidt, Brenner, Lyons, & Treistman, 2003; Wang, 2013). Theories and research also highlight the role of negative ability stereotypes (e.g., that STEM success derives from innate talents and intelligence, and only certain members [e.g., men] can succeed in STEM fields) on students' interest in STEM, especially students from underrepresented groups (e.g., Good et al., 2012; Hong

& Lin-Siegler, 2012; Leslie et al., 2015; Roth, Eijck, Hsu, Marshall, & Mazumder, 2009). Further, research on perceived identity compatibility and belongingness among underrepresented groups also suggests that even when students enter STEM, these stereotypes might undermine their persistence in the field if they believe that they do not fit into these stereotypes (e.g., Good et al., 2012; London, Rosenthal, Levy, & Lobel, 2011). Taken together, research suggests the importance of investigating psychosocial factors, such as stereotypes, interest, and perceived identity compatibility among STEM and non-STEM students in promoting STEM recruitment and retention.

Testing theoretically driven strategies to increase non-STEM students' and sustain STEM students' interest in STEM is an important step in increasing the STEM student body. Past research aimed at increasing STEM interest of non-STEM students, and thereby addressing the *recruitment* issue has focused primarily on school-aged children (e.g., Hong & Lin-Siegler, 2012; Robinson & Kenny, 2003; Roth et al., 2009; Wyss, Heulskamp, & Siebert, 2012), while research aimed at sustaining STEM interest, thereby addressing the r*etention* issue has focused largely on underrepresented college students in STEM (e.g., women, racial minorities) (e.g., Alkhasawneh & Hargraves, 2014; Cheryan, Drury, & Vichayapai, 2013; Hernandez, Schutz, Estrada, Woodcock, & Chance, 2013; Linley & George-Jackson, 2013; Myers & Pavel, 2011; Stout, Dasgupta, Hunsinger, & McManus, 2011; Yelamarthi & Mawasha, 2010). Although the underrepresentation of women and racial minority students is a concern, the low enrollment and high attrition rates of STEM undergraduate students, regardless of gender and race contribute to low STEM graduates (Chen, 2013) and therefore it is important for studies to focus not only on these underrepresented groups but all college students in STEM and non-STEM fields. There are only two recent studies to our knowledge that explore both recruitment and retention issues among STEM and non-STEM students together in studies of college samples (Brown, Smith, Thoman, Allen, & Muragishi, 2015; Brown, Thoman, Smith, & Diekman, 2015). The opportunity to recruit non-STEM students into STEM fields remains possible at this stage given that some students decide their major upon entering or during college (Chen, 2013). Also, the college years are part of the most critical period where identity development takes place (Blimling, 2010). As students enter college and face new academic and social environment and challenges, students often develop new identities, values, and beliefs. For these reasons, interventions targeted for younger school-aged children may not have lasting effects that carry into college years, suggesting that interventions that promote STEM interest and persistence at the college level are needed. Also, the college years are when career decision-making processes often take place or are finalized (Blimling, 2010). Thus, the present study advances the existing literature by studying recruitment and retention issues with undergraduate STEM students as well as non-STEM students.

The current literature points to several stereotypes about STEM success that may be at the heart of low recruitment and retention issues in STEM, i.e., the stereotype that STEM is for gifted individuals and that STEM is for European American males (e.g., Hong & Lin-Siegler, 2012; Leslie et al., 2015; Stout et al., 2011). A critical question that remains in the literature is how might these stereotypes be addressed in ways that reduce negative recruitment and retention issues among students? In this article, we test whether role model biographies are an effective intervention for combatting these stereotypes.

STEM stereotypes

One of the factors that undermine students' interest and desire to pursue STEM is prevailing stereotypes about STEM careers and professionals (e.g., Hong & Lin-Siegler, 2012; Leslie et al., 2015). For one, awareness of stereotypes that successful STEM scholars are gifted individuals who succeed without much effort or struggles may be a barrier for all students in entering and remaining in STEM (Barman, 1997; Bodzin & Gehringer, 2001; Dar-Nimrod & Heine, 2006; Dweck, 2007; Hong & Lin-Siegler, 2012; Leslie et al., 2015). Such STEM stereotypes may deter anyone from considering a STEM major or career if one believes that he or she does not possess the natural gift for STEM (e.g., Hong & Lin-Siegler, 2012; Leslie et al., 2015; Smith, Lewis, Hawthorne, & Hodges, 2013). Even after students enter into STEM fields, if they face challenges and need to exert effort, they may feel that they do not fit in STEM fields because they lack natural innate talent (as effort may be perceived as indication of lack of innate talent; Cho & Schwarz, 2008; Tsay & Banaji, 2011), and may become discouraged from persisting in STEM. Hence, the stereotype that STEM is for the innately talented individuals can affect both recruitment of new students and retention of existing students in STEM fields.

Another common stereotype about STEM is that STEM careers are for certain social groups, i.e., European American males (Barman, 1997; Bodzin & Gehringer, 2001), and not others (non-European American males). This stereotype may be a barrier to the recruitment and retention for non-European American males. To women and racial minority students, this stereotype may signal to them that their group does not belong and is not successful in STEM, and thus they may see this stereotype as a barrier or deterrent, leading them to question their identity as STEM members (e.g., Good et al., 2012; London et al., 2011; Rosenthal, London, Levy, & Lobel, 2011; Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 201l; Settles, 2004; Settles, Jellison, & Pratt-Hyatt, 2009). There is evidence that among STEM women that perceptions of incompatibility between their gender and STEM identities (i.e., extent to which people perceive their identity as a woman or man to fit with their identity as a STEM member) was related to less sense of belonging, greater insecurity, and less motivation in STEM as well as greater expectations of dropping out of STEM (London et al., 2011).

Taken together, this past research points to the importance of challenging these two stereotypes to promote recruitment and retention in STEM. Yet, this work leaves us with the question of *how* to combat these stereotypes to promote STEM recruitment and retention.

STEM role models and academic outcomes

Students' exposure to role models who are not European American males and role models who obtained success through hard work and effort (rather than natural ability) can dispel the two stereotypes about STEM that were discussed in the previous section (e.g., Bagès & Martinot, 2011; Hong & Lin-Siegler, 2012; Marx & Ko, 2012; Marx & Roman, 2002; McIntyre, Paulson, & Lord, 2003; Rosenthal, Levy, London, Lobel, & Bazile, 2013; Stout et al., 2011; Young, Rudman, Buettner, & McLean, 2013). There are studies with school-aged students that have presented students with role model narratives to challenge the stereotype that STEM is for naturally gifted individuals (e.g., Bagès & Martinot, 2011; Hong & Lin-Siegler, 2012); however, to our knowledge, there are no studies on college samples using role models that aim to challenge the first stereotype that STEM is for naturally gifted individuals. Role model studies with college students have a primary aim of addressing the stereotype that associates STEM with men by providing information about successful females in STEM (e.g., Marx & Ko, 2012; Marx & Roman, 2002; McIntyre et al., 2003; Rosenthal et al., 2013; Stout et al., 2011; Young et al., 2013). It is crucial for studies to address both stereotypes that may hinder students' desire to pursue and remain in STEM with college samples since as noted earlier, the college years are a critical period when career identity development and career decision processes take place or are finalized (Blimling, 2010) and when students may switch to a STEM major (Chen, 2013). There is, however, some research with younger students that focused on challenging the stereotype about STEM abilities being innate and found promising results (e.g., Bagès & Martinot, 2011; Hong & Lin-Siegler, 2012). For instance, Hong and Lin-Siegler (2012) found that providing biographical information about renowned scientists, which emphasized how scientists' hard work and struggles led to their inventions and discoveries (e.g., informing students that it is through hard work that Newton discovered the Universal Law of Gravitation, not simply by observing an apple drop from a tree) had a positive impact on high school students' stereotypes about scientists as well as their interest in learning physics lessons. Likewise, Bagès and Martinot (2011) found that fifth grade children performed better on a math test when they were exposed to a role model who emphasized hard work compared to a role model who was described as being naturally gifted in math.

As noted above, there is some research on role models with college students addressing the second STEM stereotype that STEM is for European American males (Marx & Ko, 2012; Marx & Roman, 2002, McIntyre et al., 2003; Stout et al., 2011; Rosenthal et al., 2013; Young et al., 2013). These studies target this stereotype by providing information about successful females. Among women, exposure to female role models in STEM promoted positive academic and psychosocial outcomes (e.g., self-efficacy, STEM identification) as well as career aspirations (Marx & Ko, 2012; Marx & Roman, 2002, McIntyre et al., 2003; Stout et al., 2011; Rosenthal et al., 2013; Young et al., 2013). For example, in a study of college students who were prescreened for interest in a pre-med academic focus, Rosenthal et al. (2013) found that exposure to successful female physicians through online biographies increased pre-med female undergraduate students' interest and sense of belonging in pre-med, interest in becoming a physician, as well as greater perceived identity compatibility between being a woman and being in pre-med, which are critical constructs related to retention.

Challenging the stereotype about European male success in STEM can be accomplished not only by providing examples of female STEM success, but also successful non-European American males (European American female, African American male and female, Asian female, and Latino male and female). To our knowledge, past role model studies have not included both successful female STEM role models as well as successful non-European American male role models. The present investigation importantly does so that the role model biographies have broader applicability to students of many backgrounds, in addition to reaching female students.

The present study

The present study extends the small literature by exploring recruitment issues among non-STEM students and retention issues among STEM students together with college samples of STEM and non-STEM students (Brown, Smith, et al., 2015; Brown, Thoman, et al., 2015). The present study, however, builds on the role model literature to address recruitment and retention issues by uniquely challenging two STEM stereotypes (i.e., STEM is for the innately gifted and STEM is for European American males) known to undermine STEM investment for students of diverse backgrounds and through the presentation of a diverse set of role model narratives in a large sample of STEM and non-STEM students ($n = 1035$). This study extends the past role model research with college students (e.g., Rosenthal et al., 2013; Stout et al., 2011), which primarily focused on providing counter-stereotypic role models (i.e., females only) that challenge the stereotype that only men are successful in STEM (Spencer, Steele, & Quinn, 1999; Steele, 1997). The biographies in the present study uniquely include both successful women and successful non-European American men in STEM who obtained success through hard work (as opposed to natural talent), and thus simultaneously challenge the two stereotypes. It is important for studies to address both STEM stereotypes to address recruitment and retention issues beyond underrepresented groups. The stereotype about European American males in STEM may only apply to certain gender and racial/ethnic groups, while stereotype about natural abilities may apply to students regardless of gender and race/ethnicity. The present study is also unique in using a pretest–posttest design with a comparison group of students who received no role model exposure (control condition), which allows us to test changes in STEM interest as a function of role model exposure. Additionally, consistent with past research, this study examines the effects of the role model biographies on STEM-related outcomes, including STEM interest and perceived identity compatibility in STEM, which predict STEM recruitment and retention (Lent et al., 2003; Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011; Wang, 2013) but this study uniquely considers a wider variety of social and academic outcomes, such as academic sense of belonging, academic self-efficacy, academic expectation, and educational degree intention. These additional measures are related to STEM entrance and dropout (Lent et al., 2003; Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011; Wang, 2013), and may be proximal causes that lead to students eventually disengaging from STEM domain. Building on past successful research on role models, the present investigation adopts the web-based method of delivering the role model biographies and the use of a no information control condition used in Rosenthal et al. (2013).

Six fictitious online biographies were created for the present study to address the two overarching STEM stereotypes:

1. Role models in the biographies discussed their struggles as an undergraduate student and described how they succeeded through hard work and persistence to challenge the STEM stereotype that those who are successful in STEM are innately talented and intelligent individuals who do not need to exert effort or surmount obstacles. Also, each biography included an advice section where the role models' advice focused on the importance of hard work.
2. Role models in the biographies were from traditionally underrepresented groups in STEM (i.e., European American female engineer, African American female biology professor, African American male surgeon, Asian female computer scientist, Latino male data analyst, Latina female physicist) in order to challenge the stereotype of STEM professionals as European American males.

Hypotheses

Hypothesis 1. It was hypothesized that exposure to the role model biographies (described briefly above) would increase STEM interest of students across different fields of study, including STEM and non-STEM students. Challenging stereotypes through role model biographies was also expected to increase students' perceived identity compatibility between self and STEM (i.e., the extent to which students perceive their identity as an individual to fit their identity as a STEM member), which is related to expectations of dropping out of STEM (London et al., 2011; Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011) for both STEM and non-STEM students, as STEM stereotypes may reduce perceived identity compatibility between STEM and their identity among students who do not typically fit into these stereotypes (e.g., Settles, 2004; London et al., 2011).

Hypothesis 2a. Although role models in the present study were STEM professionals, role models' discussion of their academic experiences in general on the road to a STEM career was expected to have a broader impact on students' academic engagement. Some of the key constructs related to academic engagement and success, such as academic self-efficacy (e.g., Lent, Brown, & Larkin, 1984; see Bandura, 1977 for review on self-efficacy), academic expectations (Pintrich & de Groot, 1990), academic sense of belonging (e.g., Walton & Cohen, 2007, 2011), and educational degree intention (Tinto, 1993) were expected to be positively affected by role model exposure.

Hypothesis 2b. Even though role model exposure was expected to have a positive impact on both STEM and non-STEM students, given that the STEM role models' discussion of their academic experiences were focused on STEM studies, it was expected that the positive effects of the role models on these general academic variables would be greater for STEM students than for non-STEM students.

Hypothesis 3a. The majority of the role models used in the present study were women in order to address the pervasive male STEM stereotype. Given that female STEM students have been shown to benefit from female STEM role models (e.g., Rosenthal et al., 2013; Stout et al., 2011), the present study also included gender-related variables for exploratory analyses. These variables included, perceived identity compatibility between gender and STEM, perceived identity compatibility between gender and non-STEM, endorsement of math-gender stereotypes, gender-based rejection sensitivity, and sense of belonging with one's gender. Consistent with past research and theorizing, role model exposure was expected to increase women's perceived identity compatibility between gender and STEM (Rosenthal et al., 2013), while not influencing perceived identity compatibility between gender and non-STEM. Because people are motivated to maintain positive social and personal identities (Tajfel & Turner, 1986), it was expected that exposure to successful female STEM role models would increase female students' sense of belonging to their own gender.

Hypothesis 3b. Our hypotheses for endorsement of math-gender stereotypes and gender-based rejection sensitivity were more exploratory. Given that our role model biographies were created to challenge the stereotypes, exposure to the role models may decrease the endorsement of gender-math stereotypes for men and women, and decrease the sensitivity to gender-based rejection among women. However, past research suggests that endorsement of global stereotypes and perceptions of stereotype threat in the environment are less likely to change from an intervention (Aronson, Fried, & Good, 2002; Stout et al., 2011).

Method

Participants

A total of 1035 participants (66.0% women, 31.3% men; $M_{age} = 19.92$) at a racially/ethnically diverse mid-sized state university were recruited across three semesters. Participants' field of study varied greatly, with 27.2% in STEM disciplines (e.g., biology, engineering, computer science, mathematics), and 70.0% in non-STEM disciplines (e.g., psychology, English). Although the National Science Foundation (NSF) includes social and behavioral sciences (e.g., psychology and sociology) in the STEM category, recent national reports on STEM recruitment and retention excluded social and behavioral sciences from the STEM category since workforce shortage in STEM generally does not apply to social and behavioral sciences (Chen, 2013; PCAST, 2012). Thus, in accordance with recent national reports, STEM category in the present study did not include social and behavioral sciences. Demographic information including participants' self-reported gender, major, race, year in college, age, SAT, and current undergraduate GPA separately by major (STEM vs. non-STEM) are presented in Table 1.

Procedure

Participants were invited to participate in an online study examining college students' beliefs, expectations, and

Table 1 Breakdown (%) of Self-Reported Gender, Race, Year in College, Age, SAT, and Undergraduate GPA by Major

Variable	STEM ($n = 282$)	Non-STEM ($n = 724$)
Gender		
Women	150 (53.2%)	532 (73.5%)
Men	132 (46.8%)	192 (26.5%)
Race		
European American/White	94 (33.3%)	305 (42.1%)
East Asian	80 (28.4%)	171 (23.6%)
South Asian	46 (16.3%)	71 (9.8%)
Hispanic/Latino	20 (7.1%)	70 (9.7%)
African American/Black	14 (5%)	60 (8.3%)
Other	27 (9.6	47 (6.5%)
Missing	1 (.4%)	–
Year in college		
Freshmen	100 (35.5%)	235 (32.5%)
Sophomore	86 (30.5%)	169 (23.3%)
Junior	44 (15.6%)	166 (22.9%)
Senior	41 (14.5%)	133 (18.4%)
Other	10 (3.5%)	18 (2.5%)
Missing	1 (.4%)	3 (.4%)
Age	$M = 19.58$ ($SD = 1.79$)	$M = 20.05$ ($SD = 2.46$)
SAT (range: 600–2400)	$M = 1822.91$ ($SD = 342.63$)	$M = 1674.55$ ($SD = 343.70$)
Undergraduate GPA	$M = 3.29$ ($SD = 0.50$)	$M = 3.12$ ($SD = 0.53$)

attitudes toward their future career paths in exchange for research credit, and were randomly assigned to either a role model ($n = 509$) or a control condition ($n = 526$). Participants in both conditions completed pretest and immediate posttest measures that included a measure of STEM interest, non-STEM interest, academic sense of belonging, gender sense of belonging, and mood, and additional post-test measures such as self/STEM perceived identity compatibility, academic self-efficacy, academic expectations, educational degree intention, gender/STEM perceived identity compatibility, gender/non-STEM perceived identity compatibility, math-gender stereotype endorsement, gender-based rejection sensitivity, gender sense of belonging, Protestant work ethic, impostorism, and ingroup bias. Participants in the role model condition additionally completed a recall test and manipulation check measures.

Participants in the role model condition were instructed to read 6 biographies (European American female engineer, African American female biology professor, African American male surgeon, Asian female computer scientist, Latino male data analyst, Latina female physicist) and were instructed to read for content and journalistic style as a cover story. Biographies were created to challenge the common stereotypes about STEM that are known to be related to recruitment and retention issues (i.e., stereotype that people in successful STEM careers are gifted individuals who do not need to work hard or overcome obstacles and stereotype that people in successful STEM careers are European American males (e.g., Barman, 1997; Bodzin & Gehringer, 2001; Dar-Nimrod & Heine, 2006; Hong & Lin-Siegler, 2012). These biographies were also created to be inspiring, relevant, and similar to the participants, which are essential characteristics of effective role models (e.g., Lockwood & Kunda, 1997; Rosenthal et al., 2013). Consistent with past research, participants in the control condition only completed the study measures and did not receive any reading material (Rosenthal et al., 2013).

Measures

STEM outcome variables

STEM interest

Participants completed a 4-item modified measure of STEM interest (Rosenthal et al., 2013) at both pretest and posttest. Two items measured interest and excitement for STEM career (e.g., "How interested are you in pursuing a career in STEM?") and two items measured interest and excitement for STEM major (e.g., "How do you feel about a major in STEM?"). Participants responded on a 7-point scale, ranging from 1 (*not at all interested/not at all excited*) to 7 (*highly interested/highly excited*) (Pretest: Cronbach's $\alpha = .96$; Posttest: $\alpha = .97$).

Non-STEM interest

Participants completed a 4-item modified measure of non-STEM interest (Rosenthal et al., 2013) at both pretest and posttest. Two items measured interest and excitement for non-STEM career (e.g., "How interested are you in pursuing a career that is not in STEM?") and 2 items measured interest and excitement for non-STEM major (e.g., "How do you feel about a major that is not STEM?"). Participants responded on a 7-point scale, ranging from 1 (*not at all interested/not at all excited*) to 7 (*highly interested/highly excited*) (Pretest: $\alpha = .94$; Posttest: $\alpha = .96$).

Self/STEM perceived identity compatibility

Inclusion of Others in Self (IOS) scale developed by Aron, Aron, and Smollan (1992) was modified to examine perceived identity compatibility between self and STEM (Rosenthal et al., 2013) at posttest. Participants responded on a pictorial scale ranging from 1, indicating less compatibility between self and STEM to 7, indicating greater compatibility between self and STEM.

General academic outcome variables

Academic sense of belonging

Modified version of Affective Commitment Scale (Allen & Meyer, 1990) was used to assess participants' academic sense of belonging at both pretest and posttest. Two items measured sense of belonging in one's major (e.g., "I feel a strong sense of belonging to others in my major or field of study"), 2 items measured sense of belonging in one's department/program (e.g., "I feel a strong sense of belonging to my department/program"), and 2 items measured sense of belonging in one's school (e.g., "I feel a strong sense of belonging to my school") Participants responded on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) (Pretest: $\alpha = .85$; Posttest: $\alpha = .91$).

Academic self-efficacy

Participants completed a 5-item measure of academic efficacy subscale of the Patterns of Adoptive Learning Scale at posttest (e.g., "I can do almost all the work in my classes if I don't give up") (Midgley et al., 2000). Participants responded on a 6-point scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*) ($\alpha = .92$).

Academic expectations

Academic expectations scale was adapted from Chemers, Hu, and Garcia (2001) to measure participants' expectations for future academic performance. Participants completed a 2-item measure of academic expectations at posttest (e.g., "I expect to do well in school"). Participants responded on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) ($\alpha = .93$).

Educational degree intention

Educational aspiration measure used in Uwah, McMahon, and Furlow (2008) was modified to assess participants' plans for highest degree completion at posttest ("What is the highest educational degree that you plan to complete?"). Response options included bachelor's, master's, doctorate, medical degree, and other. Responses were later coded as a range from 1 (*bachelor's*), 2 (*master's*) to 3 (*doctorate degree*: Ph.D., Ed.D., M.D., J.D., Pharm.D. D.D.S., D.M.D.).

Gender-related outcome variables

Gender/STEM perceived identity compatibility

A 1-item pictorial scale (Aron et al., 1992) was used at posttest to measure participants' perceptions of compatibility between their gender and being in STEM (Ahlqvist, London, & Rosenthal, 2013). Response ranged from 1, indicating less compatibility between gender and STEM to 7, indicating greater compatibility between gender and STEM.

Gender/non-STEM perceived identity compatibility

A 1-item pictorial Gender/STEM perceived identity compatibility scale (Ahlqvist et al., 2013) was adapted to measure perceived identity compatibility between gender and being in non-STEM at posttest. Similar to the gender/STEM perceived identity compatibility scale, response ranged from 1, indicating less compatibility between gender and non-STEM to 7, indicating greater compatibility between gender and non-STEM.

Math-gender stereotype endorsement

A 3-item measure of stereotype endorsement scale (Schmader, Johns, & Barquissau, 2004) was used at posttest to assess participants' endorsement of stereotypes about women's abilities in math (e.g., "It is possible that men have more math ability than do women"). Participants responded on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) ($\alpha = .83$).

Gender-based rejection sensitivity

Participants completed the gender-based rejection sensitivity measure at posttest (London, Downey, Romero-Canyas, Rattan, & Tyson, 2012). This measure consisted of 6 ambiguous scenarios depicting situations where gender rejection may be experienced (e.g., "Imagine that you are in your science class, and the professor asks a particularly difficult question. A few people, including yourself, raise their hands to answer the question"). Participants indicated the extent to which they feel anxious in those situations on a 6-point scale ranging from 1 (*very unconcerned*) to 6 (*very concerned*) and how much they anticipate rejection on a 6-point scale ranging from 1 (*very unlikely*) to 6 (*very likely*). Anticipation component of the measure was reversed coded and was multiplied with the anxiety component to create a score for each scenario ($\alpha = .84$).

Gender sense of belonging

Participants completed a 2-item measure of sense of belonging to one's gender at both pretest and posttest (e.g., "I feel a strong sense of belonging to other [women/men]") Participants responded on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) (Pretest: $\alpha = .47$; Posttest: $\alpha = .67$).

Demographic questionnaire

Toward the end of the study, participants reported their gender, major, age, race, year in college, SAT, and current undergraduate GPA.

Manipulation check measures

Perceptions of role models

Consistent with past research (e.g., Lockwood & Kunda 1997; Rosenthal et al., 2013) participants in the role model condition rated role model biographies' perceived relevance ("How relevant to you did you find the 6 biographies that you read about?"), similarity ("How similar do you think you are to the 6 people you read about?") and how inspiring the role models were ("How inspiring are the 6 people you read about?"). Additionally, participants rated role models' competence ("How competent do the 6 people you read about seem?"), likeability of the role models ("How likable are these people?"), and obtainability of the role models' success ("How likely do you think that you could accomplish what the 6 people you read about have accomplished?"). Responses ranged from 1 (*not at all relevant/not at all similar/not at all inspiring/not at all competent/not very likable/not at all likely*) to 10 (*completely relevant/completely similar/completely inspiring/completely competent/very likable/completely* *likely*). Participants also answered two questions about role models' impact on their STEM major interest ("How did reading the 6 biographies make you feel about majoring in STEM?"). Responses ranged from 1 (*a lot less interest in STEM/a lot less excited in STEM*) to 7 (*a lot more interest in STEM/a lot more excited in STEM*) ($\alpha = .94$). Lastly, participants rated whether the role models' success was due to natural ability, effort, or luck. Participants were asked to indicate what percentage of each of the qualities contributed to the role models' success. Because these questions were not relevant, participants in the control condition did not complete these measures.

Beliefs and mood

Protestant work ethic. To assess whether emphasis on hard work in the role model biographies had an effect on participants' attitudes toward hard work and success, an abbreviated 4-item measure of the Protestant work ethic scale (Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011) was used to assess participants' beliefs about the relation between hard work and success at posttest. Two items measured equalizer meaning of Protestant work ethic (anyone can succeed through hard work; e.g., "Anyone can work hard and succeed because people in different groups have similar abilities and the potential to do well") and 2 items measured justifier meaning of Protestant work ethic (unsuccessful individuals are to blame for not working hard enough; e.g., "Different groups do not face extra obstacles, such as discrimination, which would interfere with their ability to succeed"). Equalizer meaning of Protestant work ethic scale and justifier meaning of Protestant work ethic scale were analyzed separately as two separate scales. Participants rated agreement from 1 (*strongly disagree*) to 6 (*strongly agree*) ($\alpha = .84$ Equalizer; $\alpha = .69$ Justifier).

Impostorism. To assess whether the role models' discussion of their achievement had an impact on participants' own achievement beliefs and confidence, a 12-item measure of impostorism (London & Dweck, 2005; London et al., 2001) was used to assess participants' general confidence or worry about their ability to achieve and maintain success (e.g., "When people praise me for an accomplishment, I often get worried I won't be able to repeat that success") at posttest. Participants responded on a 6-point scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*) ($\alpha = .95$).

Mood. To measure whether exposure to positive role models had an effect on participants' mood, participants completed a 3-item measure of their current mood state by responding on a 7-point scale ranging from 1 (*terrific/completely happy/completely tense/anxious*) to 7 (*terrible/completely unhappy/completely calm/relaxed*) at both pretest and posttest (Pretest: $\alpha = .77$; Posttest: $\alpha = .81$).

Racial attitude

Given that the role model biographies depicted underrepresented role models successful in STEM, a feeling thermometer scale (Wolsko, Park, Judd, & Wittenbrink, 2000) was used to assess majority group (European American sample)'s attitudes toward other racial groups. Participants completed four feeling thermometer scales to rate how warmly they felt toward European Americans, African Americans, Asian Americans, and Latino Americans. Response ranged from 0° (*cold/unfavorable*) to 100° (*warm/favorable*). Scores were calculated by subtracting outgroup bias scores from ingroup bias scores.

Recall test

A total of 18 questions (three questions for each of the six biographies) were asked to ensure that participants had carefully read the biographies (e.g., "What was this person's race?").

Results

Recall test

The recall test revealed that on average participants correctly answered 9.96 out of 18 multiple-choice questions about the role model biographies. Thirteen participants scored 2 standard deviations below the mean on the recall test, indicating that they had not carefully read the biographies and thus were removed from all subsequent analyses. A total of 1,022 participants were included in the analyses.

Manipulation check

Prior to performing hypotheses testing, three sets of manipulation checks were analyzed.

Perceptions of role models

The first set of manipulation checks assessed participants' perception of the role models to determine whether the role model biographies were viewed as possessing the key features of effective role models. As expected, role models were rated as competent ($M = 8.26$, $SD = 1.98$), likable ($M = 7.55$, $SD = 1.82$), inspiring ($M = 7.42$, $SD = 2.08$), and participants perceived role models' success to be obtainable ($M = 6.30$, $SD = 2.50$). Participants also attributed role models' success to effort and hard work ($M = 64.08$, $SD = 17.18$), not natural ability ($M = 27.05$, $SD = 14.19$) or luck ($M = 8.94$, $SD = 9.69$), and reported that role models increased their interest in STEM major ($M = 4.78$, $SD = 1.14$). One sample *t*-test revealed that mean scores for competent, likable, inspiring, obtainable, effort and hard work, and impact of role models on STEM major interest were significantly greater than midpoint of each scale, while mean scores for natural ability and luck were significantly lower than midpoint of each scale, $t(363) = 26.51$, $p < .001$ for competent; $t(363) = 21.43$, $p < .001$ for likable; $t(363) = 17.65$, $p < .001$ for inspiring; $t(363) = 6.11$, $p < .001$ for obtainable; $t(363) = 15.64$, $p < .001$ for effort and hard work; $t(362) = -30.83$, $p < .001$ for natural ability; $t(363) = -80.84$, $p < .001$ for luck; $t(489) = 15.23$, $p < .001$ for STEM major interest. It is important to note that these manipulation check measures suggest that the biographies successfully increased participants' beliefs on hard work and effort, which was one of the major goals of the study. Role model condition participants did not rate the role models as significantly above the mean for being relevant ($M = 5.54$, $SD = 2.57$), $t(363) = .33$, *ns* or similar ($M = 5.54$, $SD = 2.44$), $t(363) = .34$, *ns*, which likely had to do with the study's goal of exposing non-STEM majors to role models in STEM.

Beliefs and mood

The second set of manipulation checks assessed whether participants' beliefs and mood were affected by the messages of the biographies. The overall MANCOVA on this second set of manipulation check measures, including equalizer meaning of Protestant work ethic, justifier meaning of Protestant work ethic, mood, and impostorism, while controlling for participants' pretest mood, SAT, and current undergraduate GPA was significant, $F(4, 901) = 3.80$, $p < .01$. Role model condition participants showed greater endorsement of the equalizer meaning of Protestant work ethic ($M = 4.80$, $SE = .05$) than did control condition participants ($M = 4.64$, $SE = .05$), $F(1, 904) = 4.19$, $p < .05$, thereby establishing the construct validity of the manipulation. An increase in equalizer meaning of Protestant work ethic suggests that role model biographies successfully increased students' belief that anyone can succeed through hard work, which is one of the key features of the biographies. There was no significant difference between conditions on endorsement of justifier meaning of Protestant work ethic (i.e. blame the victim), $F(1, 904) = .64$, *ns*, which is fitting since the biographies did not address failure in STEM. However unexpectedly, role model participants reported greater negative mood ($M = 3.64$, $SE = .02$) than control condition participants ($M = 3.54$, $SE = .02$), $F(1, 904) = 8.13$, $p < .01$. Although this is unexpected, the lack of positive mood boost for the role model condition helps rule out the possibility that the role model condition merely put participants in a better mood such that they reported more positive responses to our main dependent variables (greater interest in STEM). There was also no significant difference between conditions on impostorism, $F(1, 904) = .87$, *ns*, suggesting that brief one-time exposure to hard work and effort message of the biographies did not affect students' confidence about maintenance of their own success.

Racial attitude

The last manipulation check assessed whether role model exposure had an effect on racial majority group (European Americans)'s feelings toward racial minority groups (African American, Latino, and Asian). The overall MANOVA was significant, $F(3, 389) = 4.91$, $p < .001$. There was a significant effect of condition among European American sample, $F(1, 391) = 4.77$, $p < .05$ for ingroup bias against African Americans; $F(1, 391) = 5.02$, $p < .05$ for ingroup bias against Asian Americans; $F(1, 391) = 14.00$, $p < .001$ for ingroup bias against Latino Americans. European American sample in the role model condition showed less ingroup bias against African Americans ($M = 8.31$, $SE = 1.34$) than European American sample in the control condition ($M = 12.51$, $SE = 1.38$), less ingroup bias against Asian Americans ($M = 11.02$, $SE = 1.60$) than European American sample in the control condition ($M = 16.18$, $SE = 1.65$), and less ingroup bias against Latino Americans ($M = 6.00$, $SE = 1.26$) than European American sample in the control condition ($M = 12.76$, $SE = 1.29$).

Hypotheses testing

Hypotheses 1 and 2

Correlations, means, and standard deviations of all study variables by condition and major are presented in Table 2. A MANOVA and chi-square revealed no significant difference on pretest measures, including pretest STEM interest, pretest non-STEM interest, and pretest academic identification or demographic characteristics, including age, SAT, undergraduate GPA, year in college, race, gender, and major between conditions. Controlling for race, which was dummy coded, did not have a significant impact on any of the analyses and thus was not included in the analyses to follow.

To test the first hypothesis that role model exposure would have positive effects on STEM specific outcomes (Hypothesis 1) as well as general academic outcomes (Hypotheses 2a and 2b) for both STEM and non-STEM groups, a 2 (condition) $\times$ 2 (major: STEM vs. non-STEM) MANCOVA was conducted on STEM interest, non-STEM interest, self/STEM perceived identity compatibility, as well as general academic sense of belonging, academic self-efficacy, academic expectations, and educational degree intention. Pretest STEM interest, pretest non-STEM interest, pretest academic sense of belonging, SAT, and undergraduate GPA were entered as covariates. The overall MANCOVA was significant, $F(7, 882) = 2.11$, $p < .05$.[1] The main effects and interaction effects are presented in Table 3.

Hypothesis 1 (STEM specific outcomes). Consistent with Hypothesis 1, there was a significant difference between role model condition and control condition on STEM interest, $F(1, 888) = 17.40$, $p < .001$ and self/STEM perceived identity compatibility, $F(1, 888) = 8.85$, $p < .01$, such that participants in the role model condition showed greater interest in STEM ($M = 4.68$, $SE = .04$) than control condition participants ($M = 4.44$, $SE = .04$) and reported greater self/STEM perceived identity compatibility ($M = 4.31$, $SE = .08$) than control condition participants ($M = 4.00$, $SE = .08$). Role model exposure did not have a significant impact on non-STEM interest, $F(1, 888) = 2.82$, *ns.* There also was a main effect of major on STEM interest, $F(1, 888) = 7.01$, $p < .01$, such that STEM participants showed greater interest in STEM ($M = 4.65$, $SE = .06$) than non-STEM participants ($M = 4.47$, $SE = .03$). No other main effects were significant, and consistent with our hypothesis, the 2-way interaction between condition and major was not a significant predictor of STEM specific outcomes (see Table 3).

Hypotheses 2a and 2b (general academic outcomes). Consistent with Hypothesis 2a, there were positive effects of role model on academic sense of belonging, $F(1, 888) = 12.74$, $p < .001$ and academic self-efficacy, $F(1, 888) = 8.69$, $p < .01$ such that role model condition participants reported greater academic sense of belonging ($M = 4.55$, $SE = .04$) than control condition participants ($M = 4.37$, $SE = 03$), and greater academic self-efficacy ($M = 4.87$, $SE = .05$) than control condition participants ($M = 4.67$, $SE = .05$). However, no other effects reached statistical significance and the main effects of major did not reach statistical significance (see Table 3). As predicted (Hypothesis 2b), there was a significant 2 (condition) × 2 (major) interaction predicting academic self-efficacy, $F(1, 888) = 9.18$, $p < .01$. A Bonferroni corrected pairwise comparison revealed that STEM participants in role model condition showed greater academic self-efficacy ($M = 4.99$, $SE = .09$) than STEM participants in control condition ($M = 4.58$, $SE = .08$), $F(1, 888) = 12.45$, $p < .001$. However, this effect was not significant among non-STEM participants, $F(1, 888) = .008$, *ns.* No other interaction effects were significant (see Table 3).

Hypotheses 3a and 3b (gender-related outcomes). Correlations, means, and standard deviations of all gender-related outcome variables by condition and gender are presented in Table 4. Due to poor reliability of the gender sense of belonging measure, gender sense of belonging was not included in the analyses. To test the hypotheses that the role model exposure would have positive effects on gender/STEM perceived identity compatibility among women (Hypothesis 3a) and to test our exploratory hypothesis on gender-based rejection sensitivity and math-gender stereotype endorsement (Hypothesis 3b), a 2 (condition) × 2 (gender) MANCOVA was conducted on gender/STEM perceived identity compatibility, and gender/non-STEM perceived identity compatibility, gender-based rejection sensitivity, and math-gender stereotype endorsement with SAT and undergraduate GPA as covariates. The overall MANCOVA was significant, $F(4, 898) = 3.02$, $p < .05$.[2] The main effects and interaction effects are presented in Table 5.

There was a main effect of condition on gender/STEM perceived identity compatibility, $F(1, 901) = 23.98$, $p < .001$ and gender/non STEM perceived identity compatibility, $F(1, 901) = 7.82$, $p < .01$ such that role model condition participants reported greater gender/STEM perceived identity compatibility ($M = 4.50$, $SE = .10$) than control condition participants ($M = 3.83$, $SE = .10$) and greater gender/non-STEM perceived identity compatibility ($M = 4.58$, $SE = .09$) than control condition participants ($M = 4.21$, $SE = .09$). No other main effects of condition were significant (see Table 5). There was also a main effect of gender on math-gender stereotype endorsement, $F(1, 901) = 6.41$, $p < .05$, gender/non-STEM identity compatibility, $F(1,901) = 20.45$, $p < .001$, and gender-based rejection sensitivity, $F(1, 901) = 38.96$, $p < .001$ such that men reported greater endorsement of math-gender stereotypes ($M = 2.84$, $SE = .09$) than women ($M = 2.57$, $SE = .06$), while women reported greater gender/non-STEM perceived identity compatibility ($M = 4.70$, $SE = .08$) than men ($M = 4.09$, $SE = .11$) and greater gender-based rejection sensitivity ($M = 7.37$, $SE = .17$) than men ($M = 5.49$, $SE = .25$). No other main effects of gender were significant (see Table 5).

Confirming Hypothesis 3a, there was a significant 2-way interaction between gender and condition on gender/STEM identity compatibility, $F(1, 901) = 4.97$, $p < .05$ and unexpectedly on gender/non-STEM identity compatibility, $F(1, 901) = 7.05$, $p < .01$. A Bonferroni corrected pairwise comparison revealed that greater mean difference between conditions was observed among men, such that role model condition men reported greater gender/STEM perceived identity compatibility ($M = 4.73$, $SE = .16$) than control condition men ($M = 3.75$, $SE = .15$), $F(1, 901) = 18.99$, $p < .001$, and role model condition women reported greater gender/STEM perceived identity compatibility ($M = 4.28$, $SE = .11$) than control condition women ($M = 3.91$,

[1]A 3-way interaction between condition, major, and gender on STEM-related and general academic outcomes was not significant, $F(7, 878) = .96$, *ns.*

[2]A 3-way interaction between condition, major, and gender on gender-related outcomes was not significant, $F(4, 894) = 2.28$, *ns.*

Table 2 Correlations, Means, and Standard Deviation for All Major Study Variables by Condition and Major

Variables	1. STEM interest scale range 1–7	2. Non-STEM interest scale range 1–7	3. Self/STEM PIC scale range 1–7	4. Academic sense of belonging scale range 1–7	5. Academic self-efficacy scale range 1–6	6. Academic expectation scale range 1–7	7. Educational degree intention scale range 1–3
Role model condition: STEM ($n = 123$)							
1	–	–	–	–	–	–	–
2	−.40***	–	–	–	–	–	–
3	.53***	−.16	–	–	–	–	–
4	.33***	−.07	.22*	–	–	–	–
5	.29**	.10	.22*	.38***	–	–	–
6	.18*	.07	.17	.39***	.59***	–	–
7	.17	.15	.08	.20*	.27**	.29**	–
M	6.10	3.41	5.42	4.57	5.07	5.93	2.53
SD	.97	1.62	1.52	1.40	.94	1.23	.69
Control condition: STEM ($n = 154$)							
1	–	–	–	–	–	–	–
2	−.40***	–	–	–	–	–	–
3	.57***	−.22**	–	–	–	–	–
4	.18*	.01	.32***	–	–	–	–
5	.41***	−.11	.32***	.24**	–	–	–
6	.20*	−.14	.27**	.30***	.57***	–	–
7	.35***	−.11	.13	.01	.22**	.15	–
M	5.94	3.66	5.09	4.40	4.70	5.76	2.58
SD	1.17	1.61	1.63	1.26	1.05	1.25	.65
Role model condition: non-STEM ($n = 356$)							
1	–	–	–	–	–	–	–
2	−.55***	–	–	–	–	–	–
3	.65***	−.43***	–	–	–	–	–
4	.16**	.16**	.11*	–	–	–	–
5	.08	.12*	.23***	.21***	–	–	–
6	.09	.05	.14**	.40***	.48***	–	–
7	.20***	−.009	.18**	.13*	.21***	.16**	–
M	4.17	4.74	3.88	4.54	4.75	5.82	2.23
SD	1.82	1.68	1.92	1.40	.99	1.24	.76
Control condition: non-STEM ($n = 360$)							
1	–	–	–	–	–	–	–
2	−.53***	–	–	–	–	–	–
3	.59***	−.34***	–	–	–	–	–
4	.16**	.03	.26***	–	–	–	–
5	.02	.22***	.13*	.35***	–	–	–
6	.14**	.09	.22***	.41***	.44***	–	–
7	.18***	.02	.15**	.17**	.18***	.15**	–
M	3.70	4.82	3.49	4.47	4.71	5.77	2.23
SD	2.00	1.71	1.89	1.35	.91	1.19	.72

Note. $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$.
PIC = perceived identity compatibility.

$SE = .11$), $F(1, 901) = 5.39$, $p < .05$. A Bonferroni corrected pairwise comparison also revealed that role model condition men reported greater gender/non-STEM perceived identity compatibility ($M = 4.46$, $SE = .16$) than control condition men ($M = 3.72$, $SE = .15$), $F(1, 901) = 11.12$, $p < .01$. This effect was not significant among women, $F(1, 901) = .02$, *ns*. No other interaction effects were significant (Hypothesis 3b) (see Table 5).

Discussion

Increasing STEM recruitment and retention are national concerns as the current and estimated supply of STEM workforce does not meet the rapidly growing demand for STEM professionals (Chen, 2013; National Science and Technology Council, 2013; PCAST, 2012; The White House, 2009). Studies targeting both STEM and non-STEM undergraduate

Table 3 MANCOVA Results for STEM-Specific and General Academic Outcomes

Main effect of condition	Role model condition Mean (SE)	Control condition Mean (SE)	Df	Error	*F*
STEM interest	4.68 (.04)	4.44 (.04)	1	888	17.40***
Non-STEM interest	4.36 (.04)	4.46 (.04)	1	888	2.82
Self/STEM PIC	4.31 (.08)	4.00 (.08)	1	888	8.85**
Academic sense of belonging	4.55 (.04)	4.37 (.03)	1	888	12.74***
Academic self-efficacy	4.87 (.05)	4.67 (.05)	1	888	8.69**
Academic expectation	5.82 (.06)	5.68 (.06)	1	888	2.94
Educational degree intention	2.38 (.04)	2.37 (.04)	1	888	.37

Main effect of major	STEM Mean (SE)	Non-STEM Mean (SE)	Df	Error	*F*
STEM interest	4.65 (.06)	4.47 (.03)	1	888	7.01**
Non-STEM interest	4.40 (.06)	4.41 (.03)	1	888	.03
Self/STEM PIC	4.26 (.10)	4.04 (.06)	1	888	3.12
Academic sense of belonging	4.42 (.05)	4.49 (.03)	1	888	1.38
Academic self-efficacy	4.78 (.06)	4.76 (.04)	1	888	.07
Academic expectation	5.65 (.08)	5.84 (.05)	1	888	3.74
Educational degree intention	2.41 (.05)	2.30 (.03)	1	888	3.28

	STEM		Non-STEM				
Condition × Major	Role model condition Mean (SE)	Control condition Mean (SE)	Role model condition Mean (SE)	Control condition Mean (SE)	Df	Error	*F*
STEM interest	4.73 (.08)	4.58 (.07)	4.64 (.04)	4.30 (.05)	1	888	2.56
Non-STEM interest	4.32 (.08)	4.48 (.07)	4.39 (.04)	4.44 (.05)	1	888	.90
Self/STEM PIC	4.41 (.14)	4.11 (.13)	4.21 (.08)	3.88 (.08)	1	888	.04
Academic sense of belonging	4.54 (.06)	4.31 (.06)	4.56 (.04)	4.43 (.04)	1	888	1.01
Academic self-efficacy	4.99 (.09)	4.58 (.08)	4.76 (.05)	4.76 (.05)	1	888	9.18**
Academic expectation	5.78 (.11)	5.53 (.10)	5.86 (.06)	5.82 (.07)	1	888	1.60
Educational degree intention	2.40 (.07)	2.42 (.06)	2.27 (.04)	2.32 (.04)	1	888	.07

Note. $*p < .05$; $**p < .01$; $***p < .001$.
PIC = perceived identity compatibility.

students are crucial given that increasing STEM graduates requires recruiting students into STEM as well as retaining existing STEM students (Brown, Smith, et al. 2015; Brown, Thoman, et al. 2015).

In this investigation, when students read about a diverse set of successful STEM professionals who attained their success through hard work, they reported higher interest in STEM and greater perceived identity compatibility between self and STEM (critical constructs related to recruitment and retention; Eccles et al., 1983; Lent et al., 2003; London et al., 2011; Settles, 2004; Wang, 2013; Wigfield & Eccles, 2000) compared to students who were not exposed to such models, while there was no effect on non-STEM interest. As expected, both STEM and non-STEM students seemed to benefit from the role model exposure as there was no significant interaction between condition and major in predicting STEM interest or identification. These findings suggest that the role model biographies used in the present study are an effective way to increase STEM interest and identity across a range of students and majors, and thereby addressing both STEM recruitment and retention issues.

Findings partially supported the hypotheses that role model exposure would increase general academic outcomes, including academic sense of belonging, academic self-efficacy, academic expectations, and educational degree intention. Reading about STEM role models increased students' sense of belonging in their academic environment (i.e., sense of belonging in their major, department, and school) compared to students who were not exposed to such role models. Although role models' narratives of their academic experiences were specific to STEM, discussion of their general academic experiences and learning philosophy as well as

Table 4 Correlations, Means, and Standard Deviation for All Gender-Related Variables by Condition and Gender

Variables	1. Math-gender stereotype endorsement scale range 1–7	2. Gender/STEM PIC scale range 1–7	3. Gender/Non-STEM PIC scale range 1–7	4. Gender-based rejection sensitivity scale range 1–36
Role model condition: women (*n* = 332)				
1	–	–	–	–
2	−.12*	–	–	–
3	.02	.33***	–	–
4	.20***	−.11*	−.08	–
M	2.53	4.30	4.72	7.61
SD	1.50	1.95	2.00	4.63
Role model condition: men (*n* = 147)				
1	–	–	–	–
2	−.03	–	–	–
3	−.05	.45***	–	–
4	.17*	−.10	−.09	–
M	2.76	4.73	4.46	5.07
SD	1.55	2.06	1.86	3.78
Control condition: women (*n* = 344)				
1	–	–	–	–
2	−.09	–	–	–
3	−.08	.32***	–	–
4	.07	−.12*	−.02	–
M	2.63	3.83	4.65	7.09
SD	1.48	1.85	1.84	4.12
Control condition: men (*n* = 171)				
1	–	–	–	–
2	.12	–	–	–
3	−.12	.24**	–	–
4	.18*	−.07	−.09	–
M	2.93	3.78	3.67	5.73
SD	1.61	2.06	1.81	4.10

Note. *$p < .05$; **$p < .01$; ***$p < .001$.
PIC = perceived identity compatibility.

discussion of their undergraduate institution, which was same as the participants' current institution may have increased students' sense of belonging in their own academic field and institution. Also, as predicted, role model exposure increased general academic self-efficacy, and this effect was qualified by a 2-way interaction between condition and major. Reading about successful STEM role models increased STEM students' academic self-efficacy compared to STEM students who were not exposed to such role models, while this was not found for non-STEM students. This is consistent with past research showing that STEM role models increase STEM-specific self-efficacy beliefs (e.g., Stout et al., 2011).

Although exposure to STEM role models had a positive effect on academic sense of belonging and academic self-efficacy, role model exposure did not have a significant effect on academic expectations or educational degree intention. Similar to academic self-efficacy beliefs, academic expectations focus on the broad academic outcome (e.g., "I expect to do well in school"), while self-efficacy beliefs focus more on the learning process (e.g., "I'm certain I can figure out how to do the most difficult class work") and the ability to accomplish through effort (e.g., "I can do even the hardest work in my classes if I try"). Reading about how role models succeeded through hard work and effort may have increased students' belief in their ability to learn and accomplish through hard work, but not their expectations for positive academic outcomes, which may be affected by various factors besides hard work and effort. The lack of positive effects of role model exposure on educational degree intention may be due to the measure we used. We asked participants to choose from a list of educational degrees and indicate which degree they plan to complete. It is possible that switching educational degree plan is not easily malleable via a brief one-time role model exposure. In hindsight, use of Likert-type scale to measure the extent to which participants want to pursue different levels of higher educational degrees would have been more appropriate.

Consistent with hypotheses that role model exposure would increase women's perceived identity compatibility between gender and STEM, reading about successful STEM role models who were mostly women increased women's

Table 5 MANCOVA Results for Gender-Related Outcomes

Main effect of condition	Role model condition Mean (SE)	Control condition Mean (SE)	Df	Error	*F*
Gender/STEM PIC	4.50 (.10)	3.83 (.10)	1	901	23.98***
Gender/Non-STEM PIC	4.58 (.09)	4.21 (.09)	1	901	7.82**
Math-gender stereotype	2.66 (.08)	2.75 (.08)	1	901	.77
Gender-based rejection Sensitivity	6.40 (.21)	6.46 (.21)	1	901	.03

Main effect of gender	Women Mean (SE)	Men Mean (SE)	Df	Error	*F*
Gender/STEM PIC	4.09 (.08)	4.24 (.11)	1	901	1.15
Gender/non-STEM PIC	4.70 (.08)	4.09 (.11)	1	901	20.45***
Math-gender stereotype	2.57 (.06)	2.84 (.09)	1	901	6.41*
Gender-based rejection sensitivity	7.37 (.17)	5.49 (.25)	1	901	38.96***

	Women		Men				
Condition × Gender	Role model condition Mean (SE)	Control condition Mean (SE)	Role model condition Mean (SE)	Control condition Mean (SE)	Df	Error	*F*
Gender/STEM PIC	4.28 (.11)	3.91 (.11)	4.73 (.16)	3.75 (.15)	1	901	4.97*
Gender/Non-STEM PIC	4.71 (.10)	4.69 (.11)	4.46 (.16)	3.72 (.15)	1	901	7.05**
Math-Gender stereotype	2.53 (.08)	2.61 (.09)	2.79 (.13)	2.89 (.12)	1	901	.009
Gender-based rejection sensitivity	7.64 (.24)	7.10 (.25)	5.17 (.35)	5.81 (.34)	1	901	3.83

Note. *$p < .05$; **$p < .01$; *** $p < .001$.
PIC = perceived identity compatibility.

perceived fit between being a woman and being in STEM. Unexpectedly and importantly, men's perceived identity compatibility between gender and STEM also increased. One possible explanation is that some of the biographies in the present study discussed how STEM fields are often perceived as traditionally male-dominant fields, and some of the role models were male, which may have strengthened men's perceived fit between being a man and being in STEM (Cheryan, Plaut, Davies, & Steele, 2009). This finding is important because it suggests that exposure to role models who were mostly female did not have a negative effect on men. Also unexpectedly, role model exposure increased men's perceived identity compatibility between gender and non-STEM. It is possible that exposure to success of underrepresented groups in STEM may have primed men to believe that they too could succeed in fields that they are traditionally underrepresented and thus increased perceived identity compatibility between being a man and being in non-STEM. Consistent with past research (e.g., Aronson et al., 2002; Stout et al., 2011) and theorizing, we found that role model exposure did not affect endorsement of math-gender stereotypes and gender-based rejection sensitivity.

Strengths and implications

The present study makes several notable contributions to the existing literature on role models and STEM. Past research on role models with college samples has primarily investigated the effects of female role models on female undergraduate students in STEM (e.g., Rosenthal et al., 2013; Stout et al., 2011) to address STEM *retention* issue among underrepresented groups, while studies focused on increasing STEM *recruitment* targeted younger students (e.g., Hong & Lin-Siegler, 2012; Wyss et al., 2012). Given that both low STEM enrollment and retention of college students are critical issues in the United States (Chen, 2013), the present study aimed to address both issues by recruiting a large sample of college students who are not pursuing STEM as well as those who are in STEM. Studying college samples is important given that decision to pursue a certain field of study or career are often made during college years and college students are close to entering the workforce or graduate school to prepare for the workforce. (Blimling, 2010; Chen, 2013). It is worth noting that the present study included data from students across three semesters so the findings are not specific to a particular cohort.

Also, the present study uniquely contributes to the past research by challenging two critical stereotypes that undermine STEM interest and retention among students across major, race, and gender. The present study developed a set of biographies to challenge the common stereotypes that those who succeed in STEM are innately talented individuals who do not need to work hard to succeed, and that successful

STEM professionals are European American males by using racially/ethnically diverse role models whose success was explained by hard work, thereby extending past research with college samples, which mostly focused on challenging the second stereotype with only female role models (e.g., Rosenthal et al., 2013; Stout et al., 2011).

It is also important to highlight that the role model exposure did not have a negative impact on the majority group (i.e., men). In fact, men also benefited from exposure to successful underrepresented role models, suggesting that exposure to underrepresented role models may benefit everyone.

Also, the present study used a pretest–posttest design with a control group to examine the effects of role model biographies that challenge the two STEM stereotypes. The inclusion of a wide range of STEM-related as well as general academic outcome variables, which are directly or indirectly related to STEM recruitment and retention (Eccles et al., 1983; Lent et al., 2003; Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011; Wang, 2013; Wigfield & Eccles, 2000) is another unique contribution of the present study.

As such, findings from the present study suggest several promising directions for future research. It is important to replicate the findings with graduate students in STEM, especially women and racial minority graduate students given that the underrepresentation of women and racial minority students is more serious at higher education levels (NSF, 2015). Also, conducting the present study during transition periods or critical time periods (e.g., beginning of freshman year, before declaring a major) may be crucial since this is a stressful and influential period for students as students' identities and beliefs are developed and crystalized (Bronfenbrenner, 1979; Gall, Evans, & Bellerose, 2000).

Findings from the present study have practical implications as well. The present study and past research showed that role model exposure through biographies is effective (Asgari, Dasgupta, & Stout, 2012; Hong & Lin-Siegler, 2012; Lockwood, 2006; Lockwood & Kunda, 1997; McIntyre et al., 2003 Rosenthal et al., 2013; Stout et al., 2011). Role model exposure through biographies is generally easier to implement compared to role model exposure through direct contact, where effective role models may not be readily available. The use of web-based delivery of role models as used in the present study and past research (Rosenthal et al., 2013) also allows for time- and cost-efficient implementation of role model exposure as role model biographies can be presented conveniently at any time at students' homes, school, or anywhere with a electronic device with internet access. Also, online presentation of the biographies increases the ecological validity of the study given that students heavily rely on online sources to acquire information about careers and education. Future work could consider expanding upon the current study with a longitudinal study (such as throughout college) with repeated exposure to role model biographies (such as during the first year of college) to understand the long-lasting effects of role model exposure as well as its effects on students' actual recruitment and retention in STEM over time. Also, participants in the control condition in the present study were not exposed to any biographies or reading materials, and therefore it is unclear whether the role model biographies used in the present study would yield a unique result when compared to other role model interventions. However, results from a wide range of manipulation checks suggest that the critical components of the current role model biographies (i.e., emphasizing hard work to challenge the belief about STEM being for naturally gifted individuals, and use of diverse role models to challenge the stereotype about successful STEM professionals being European American men) likely played a role in the effects. Future work can extend the present study by including other conditions such as biographies of European American men that only challenge the stereotype about innate STEM abilities or diverse role model biographies that do not challenge the stereotype about innate STEM abilities.

Conclusion

Increasing STEM recruitment and retention have been pressing concerns as the demand for STEM professionals in the United States has been increasing dramatically. The present study is unique in challenging two pervasive stereotypes about STEM associated with STEM recruitment and retention issues (i.e., stereotype that STEM is for gifted individuals and for European American males) by providing examples of racially/ethnically diverse role models whose success was attributed to hard work. Also, the present study included both STEM and non-STEM undergraduate students to examine STEM recruitment and retention issues. Findings from the present study demonstrated the benefits of role model biographies in increasing STEM interest and identity among undergraduate students across fields of study, and thereby suggesting a promising method of increasing STEM graduates to meet the growing need of STEM professionals in the United States.

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