Identification Matters: Effects of Female Peer Role Models Differ By Gender Between High and Low Mathematically Identified Students

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We investigated a peer role model intervention designed to alleviate underrepresentation of women in STEM. Half of the Calculus break-out sections at a large university were visited by a peer role model and half served as controls. The female peer role models were expected to increase the sense of belonging and mathematical self-efficacy of women highly identified with mathematics. Our results show that peer role models have the intended effect on women highly identified with mathematics, but also have a positive effect on men with low mathematical identification.

Key words: Calculus, Gender, Experimental, Self-Efficacy, Mathematical Belonging

In spite of the need for more workers with training in science, technology, engineering, and mathematics (STEM) (PCAST, 2012), retention in STEM majors and programs of study is a persistent problem in the United States (e.g., Bressoud, Mesa, & Rasmussen, 2015; Chen, 2013; Seymour & Hewitt, 1997). It is particularly troubling that under-represented groups such as women and ethnic minorities are disproportionately affected (Ellis, Fosdick, Rasmussen, 2016; Hill, Corbett, & St. Rose, 2010; Lewis, Stout, Pollock, Finkelstein, & Ito, 2016). The Calculus sequence is critical to student success in a STEM major, and students' experience in Calculus has been shown to dissuade students from continuing. At the site of our study, a large, urban, southwestern university, women are almost twice as likely as men to opt out of taking Calculus II after completing Calculus I. This is similar to national data showing that even after controlling for academic preparation, career intention, and instruction, women are one and a half times more likely than men to leave after Calculus I (Ellis et al., 2016). We need to better understand how different populations are differentially affected by their Calculus experiences.

Several factors have been suggested to be potential causes for the retention disparities between men and women. One factor that researchers in the laboratory have identified as important in the performance of women highly-identified with mathematics is stereotype threat (Steele & Aronson, 1995). Stereotype threat is a concern stereotyped individuals have about confirming a negative ability stereotype that exists about their group. For instance, women routinely contend with the stereotype that they are inferior in math and this concern lowers their math performance below their actual math ability (Spencer, Steele, & Quinn, 1999). Among these women, exposure to female peer role models enabled positive performance and psychosocial outcomes, such as greater self-efficacy (Marx & Roman, 2002). Peer role models are inspiring in-group members who defy negative ability stereotypes about their group (i.e., mathematically-capable female students) (Marx & Roman, 2002). Researchers have suggested that the lack of mathematical confidence, or self-efficacy, is a potential deterrent to women's persistence (Ellis et al, 2016). Furthermore, stereotypes contribute to the perception that gender and ethnic minority students do not fit with being a STEM major leading to the minority students' feeling of not belonging, greater insecurity, and greater expectation of dropping out of STEM (London, Rosenthal, Levy, & Lobel, 2011). The absence of female peer role models in the classroom contributes to feelings of not belonging (Lockwood, 2006). For under-represented students, including women, belonging is crucial (Good, Rattan, & Dweck, 2012;

Hill, Corbett, & Rose, 2010; Walton & Cohen, 2007).

Wilson et al. (2015) conducted a 5-institution study linking belonging with academic engagement among STEM majors. Students filled out surveys containing measures of belonging at multiple levels (class, major, and university) as well as measures of behavioral and emotional engagement in their academic pursuits. The results were that class and major belonging correlated with greater behavioral and positive emotional engagement and lower negative emotional engagement. Belonging remained a significant predictor even when other measures such as self-efficacy were included in the models. Furthermore, while belonging and self-efficacy are correlated, they also have distinct aspects that contribute separately to positive outcomes for students. While Wilson et al. (2015) looked at correlates for a single point in time, Walton and Cohen (2011) demonstrated that a short intervention can result in long term stabilization of feelings of belonging and raise the GPA of minority students who participated.

In Calculus classrooms, women are aware that their gender is in the minority and this contributes to a feeling they do not belong and this can feel threatening for STEM-intending students. In numerous past laboratory studies, researchers have found that exposure to similar others who represent success in STEM (i.e., math-talented peer female role models) can alleviate the negative effect on women's math performance (e.g., Marx & Ko, 2012; Marx & Roman, 2002; Marx, Stapel, & Muller, 2005). Because female peer role models defy the stereotype and highlight women's presence in STEM, more exposure to these peer role models may also has the potential to foster women's belief that they do belong in STEM and that they have the ability to succeed in math. The results presented here are part of a larger study that seeks to examine the effects of peer role models on sense of belonging and self-efficacy in the setting of university mathematics classrooms, as well as long-term effects such as a higher percentage of women continuing in higher level mathematics courses.

Setting & Participants

Participants were undergraduates of all racial/ethnic groups in Calculus I at a large university in the southwestern U.S. All were eligible to participate. The Calculus I classes are conducted in large lecture halls with graduate teaching assistants (GTAs) leading two 50-minute break-out sections each week. There were 16 break-out sections that were typically about 35-40 students. We recruited and trained 4 female upper-division STEM majors to serve as near peer role models (2 Hispanic and 2 non-Hispanic white STEM majors). These near peers made 2 in-class role model presentations in half of the breakout sections of the Calculus I classes. The other half of the Calculus I class served as the control. The role model presentations closely followed the structure that we have found through laboratory studies to be key components of a role model. Half of the break-out sections were visited by one of four female near-peer role models twice during the semester. These smaller sections supported the opportunity for students to form a more personal connection with the peer role model. The focus of past work on role models has been conducted among under-represented minorities who were pre-selected to be highly STEM identified. Those who are most likely to experience threat are those who are most vested or identified with the domain (i.e. STEM) (Schmader, Johns, & Forbes, 2008). In a Calculus classroom with high and low math identified students, we have the opportunity to test whether role models can be beneficial to minority students at all levels of math identification.

The role model presentations consisted of:

1) an introduction establishing the role model's similarity to students and aptitude in

mathematics

2) a presentation of a mathematical topic, each topic related to helping people/the environment and was directly tied to mathematics being taught in the class but presented within some mathematical setting that was mathematically unfamiliar

3) explicit encouragement to persist in mathematics/STEM in order to understand the unfamiliar mathematics

The particular topics were chosen in effort to combat the notion that STEM careers are less likely than careers in other fields to fulfill communal goals (e.g., working with or helping other people) (Diekman, Brown, Johnston, & Clark, 2010).

Methodology

Following the second in-class role model presentation, all students (both intervention and control groups) filled out a questionnaire containing the *Mathematics Identification Questionnaire* (Brown & Josephs, 1999) and a modified version of Walton and Cohen's (2007) *Social Fit Measure* to assess sense of belonging in STEM. This measure contains questions such as, "I would feel comfortable in a math field" and "I feel that I would belong in a math field." We also combined Marx and Roman's (2002) Self-Appraised Math Ability Scale and a modified version of Schwarzer and Jerusalem's (1995) General Self-Efficacy Scale (GSE) to measure self-efficacy. The self-appraised math ability scale contains items such as "I deal poorly with challenges in math". All items in the GSE were worded to reflect mathematical self-efficacy (e.g., "I can always manage to solve difficult math problems if I try hard enough"). Responses were recorded on 1 (strongly disagree) to 7 (strongly agree) scale. Students then provided basic demographic information. In our analysis the sense of belongingness and self-efficacy dependent variables were regressed separately onto role model (yes vs. no), student sex (female vs. male), and the continuous variable math identification (centered).

Results

Sense of Belonging

Sense of belonging yielded a main effect of math identification, F (1, 120) = 41.73, p < .001, showing a positive relation between math identified and sense of belonging in math. Of more interest was the significant 3-way interaction between role model, student sex, and math identification, F (1, 120) = 14.06, p < .001. Among low identified female students, those exposed to role models indicated feeling just as low a sense of belonging in math (M = 4.12) as those in the control (M = 4.42), F < 1. Whereas among high identified female students, those exposed to role models indicated a higher sense of belonging in math (M = 5.60) than those in the control (M = 4.93). The benefit of role model exposure among high math identified female students was further confirmed by comparisons with male students. Specifically, among high math identified students in the control condition, we observed the classic lower sense of belonging for female compared to male students (*Mfemale* = 4.93 vs. *Mmale* = 5.59). In contrast, among high math identified students in the role model condition, female students had a higher sense of belonging in math than male students (*Mfemale* = 5.60 vs. *Mmale* = 4.95). These results suggest that role models are not as beneficial for low as compared to high STEM identified female students. Interestingly, however, low math identified *male* students seem to derive benefit from female role model exposure such that those who were exposed to the role

model had higher sense of belonging than those in the control ($M = 4.02$ vs. $M = 4.62$).

Self-Efficacy

Self efficacy also yielded a positive relation with math identification, $F(1, 120) = 33.29$, $p < .001$. There was also a role model by student sex interaction, $F(1, 120) = 4.75$, $p < .05$. This demonstrated that in the control condition female students had lower self-efficacy than male students ($Mfemale = 4.47$ vs. $Mmale = 5.17$). In contrast, this gender difference in self-efficacy closed in the role model condition ($Mfemale = 4.97$ vs. $Mmale = 4.95$).

This 2-way interaction was subsumed under a 3-way interaction between role model, student sex, and math identification, $F(1, 120) = 10.82$, $p < .01$. A closer look at this interaction showed a remarkably similar pattern of effects as that found for sense of belonging. Specifically, low identified female students, those exposed to role models indicated about the same level of self-efficacy ($M = 4.18$) as those in the control ($M = 4.28$), $F < 1$. Whereas among high identified female students, those exposed to role models indicated higher self-efficacy ($M = 5.76$) than those in the control ($M = 4.66$). Comparisons between female and male students within the high math identified students further confirmed the beneficial effect of role model exposure on female students. Specifically, in the control condition, we observed the classic gender gap in self-efficacy ($Mfemale = 4.66$ vs. $Mmale = 5.80$). In contrast, in the role model condition, female students had self-efficacy than male students ($Mfemale = 5.76$ vs. $Mmale = 5.14$). Again, mirroring what we found for sense of belonging, role models seem to have an opposite impact among those in with low math identification. In particular, whereas role models did not seem to benefit female students ($Mrole\ model = 4.18$ vs. $Mcontrol = 4.28$), role models seem to have some benefit for male students ($Mrole\ model = 4.75$ vs. $Mcontrol = 4.54$).

Discussion

We posited that female students' career trajectories would benefit from exposure to female peer role models who, through their own success in mathematics, illustrate that women do belong in STEM. The female peer role models were expected to increase the sense of belonging and mathematical self-efficacy of women highly identified with mathematics. Our results show that peer role models have the intended effect on women highly identified with mathematics, but also have a positive effect on men with low mathematical identification. We will discuss possible reasons for the positive effect in men. The results are being analyzed for a second semester to see whether role models can alleviate female students' negative mathematics experiences in order to increase their interest and persistence in mathematics.

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