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The Effect of Math Exemplars on Math Stereotypes: An Experiment With Black and Latinx Middle School Students

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Objectives: Math stereotypes targeting gender and ethnic-racial groups emerge early in life and are maintained through adolescence, including the middle school age period. These stereotypes undermine girls' and ethnic and racial minority (ERM) children's math interests and confidence, and intervening during middle school may contribute to preventing the impact of stereotypes on math pursuit and persistence. This study examines the impact of a bias-reducing intervention used with adults—exposure to counterstereotypical role models—on diminishing math stereotypes about gender and ethnicity/race among middle school students from ERM groups. ***Method:*** An experiment with middle school girls and boys from schools with predominantly Black and Latinx students examined the effect of exposure to women and men math professionals who vary in their gender and ethnic-racial group memberships on gender and ethnic-racial math stereotypes. The moderating role of math identity was also explored. ***Results:*** The main results showed that boy participants generally expressed stronger gender math stereotypes than girl participants, but exposure to ERM women math professionals reduced boy participants' gender math stereotypes. Further, math identity moderated the impact of exposure to women math professionals. After exposure to women (compared to men) math professionals, boys with weaker math identities and girls with stronger math identities exhibited reduced gender math stereotypes. However, no such effects emerged among boys with strong math identities and girls with weak math identities. ***Conclusions:*** This research underscores the importance of diversity in math professions, and it has implications for the role of intersectionality in addressing math stereotypes.

Public Significance Statement
Our research demonstrates that an intervention that exposes middle school children from ethnic-racial minoritized groups to counterstereotypical math professionals can reduce stereotypes (at least among some children). Counterstereotypical interventions are effective, practical, and cost-efficient strategies that can be seamlessly integrated into regular school activities. These interventions may have the added value of addressing the long-term detrimental effects of math stereotypes on students' confidence and interest in math and future pursuits in math and math-related careers.

Keywords: stereotypes, counterstereotypical exemplars, math education, middle school, intersectionality

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continued

Women and Black, Latinx, and Native American people are disproportionately underrepresented in mathematics compared to men and White and Asian people, respectively (National Center for Science and Engineering Statistics, 2023). The underrepresentation of gender and ethnic and racial minority (ERM) groups in mathematics appears to contribute to the development and expression of children's math stereotypes, namely, that White and Asian men are particularly good at math (Miller et al., 2018). The present research tests if a bias-reducing intervention used with adults—exposure to counterstereotypical exemplars (Dasgupta & Rivera, 2008; Rivera & Benitez, 2016)—is effective in decreasing the math stereotypes of middle school children from ERM groups. Surprisingly, the experimental literature is virtually silent about whether math counterstereotypical exemplars effectively reduce math stereotypes and, if so, among which children. This empirical issue is important to address because children's math stereotypes can have detrimental byproducts, namely, boys' negative perceptions of girls' math competence and abilities (Kurtz-Costes et al., 2008) and girls and ERM children's weak math self-concepts and lower math engagement (Wang & Degol, 2017; Wang et al., 2022). Another contribution of the present experiment is that it covaries the gender and ethnic-racial group membership of the math counterstereotypical exemplars, allowing us to move beyond single-dimension group membership perspectives and contribute to an emerging empirical literature on how math exemplars' intersecting group memberships shape children's understanding of and experiences with stereotypes. And, finally, this experiment explores if girls' and boys' individual differences in math identity moderate the stereotype-reducing effects of counterstereotypical exemplars.

Middle School Children's Math Stereotypes

Gender and ethnic/racial math stereotypes emerge early in life and are maintained through adolescence, including the middle school age period (Cvencek et al., 2011, 2015; Kurtz-Costes et al., 2014; Master et al., 2021; Miller et al., 2018; Nasir et al., 2017; Rowley et al., 2007; Starr et al., 2023). From a social role theory perspective (Eagly & Wood, 2012), gender and ethnic-racial labor divisions in who occupies math careers contribute to the existence of math stereotypes in the minds of children (Miller et al., 2015, 2018). The underrepresentation of women and ERM people compared to the overrepresentation of men and non-ERM people in math implies that girls, women, and ERM people are less capable at, and less associated with, math than boys, men, and non-ERM people, respectively (Carli et al., 2016; Rowley et al., 2007; for a review, see Kuchynka et al., 2022). Additional sources of children's math stereotypes include classroom environments, social interactions, and mass media (Long et al., 2010; Loverock & Hart, 2018; Miller et al., 2018; Steinke, 2012).

Math stereotypes can have detrimental downstream consequences on girls' and ERM boys' math interest, performance, and confidence, discouraging them from pursuing and persisting in math throughout their education (Okeke et al., 2009; Wang et al., 2017, 2022; Watt et al., 2017). Also, boys' gender math stereotypes can harm girls' math self-concept, interest, and participation, as well as their future intentions to pursue science, technology, engineering, mathematics (STEM) careers (Riegle-Crumb & Morton, 2017; Wolff, 2021). These effects likely emerge because boys' stereotypes create an unwelcoming and hostile math environment for girls (Leaper, 2015; also see Murphy et al., 2018).

The potential negative effects of math stereotypes reviewed above suggest that it is important to develop and test the effectiveness of interventions that target early adolescent ERM children's math stereotypes. Middle school children are in a developmental period in which they actively rely on social cues, such as cultural stereotypes, to make sense of themselves and others (Eccles, 2009; Patterson & Bigler, 2018). Boys and girls in middle school often face and are often vulnerable to contexts in which math stereotypes are expressed and applied (Master, 2021). However, most intervention science with middle school students has not focused on stereotypes as the outcome but on outcomes like STEM motivation, occupational aspirations, and academic choices (see reviews by Gladstone & Cimpian, 2021; Olsson & Martiny, 2018). Furthermore, among those that focus on stereotypes, almost nothing is known about the effect of interventions specifically on math stereotypes. Finally, to our knowledge, none of these math stereotype interventions has targeted Black and Latinx middle school students.

Another reason why it is important to focus on adolescents is that they exhibit malleability in bias expression (Banse et al., 2010), but sensitive periods for changing bias expressions are constrained as adolescents move into adulthood and become more resistant to incorporating bias-reduction information and knowledge (Czarnek et al., 2015; Fuhrmann et al., 2015; Krosnick & Alwin, 1989). These data suggest that middle school is an optimal period for stereotype reduction. Finally, and perhaps most importantly, adolescents' experiences and beliefs related to math in middle school could have long-term implications for their academic and career trajectories in math and STEM. For example, math interests and achievements in middle school predict STEM career aspirations at the end of high school (Watt et al., 2017), as well as college enrollment in and completion of STEM degrees (Maltese & Tai, 2010, 2011). Thus, it is important to reduce math stereotypes during early adolescence before children start to make consequential decisions after middle school (Wang et al., 2017). Here, we test an intervention rooted in exposure to math exemplars with a sample of middle school children from ERM groups.

The Efficacy of Exposure to Math Exemplars

The social cognitive development of stereotypes relies on mental representations, the knowledge about social categorization, and group memberships individuals encode in memory (Operario & Fiske, 2003).

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The data are available at https://osf.io/8q3j6/

The experimental materials are available at https://osf.io/8q3j6/

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As noted earlier, social role theory posits that these mental representations partly arise from social perceivers' observations of the occupational roles typically held by group members (Koenig & Eagly, 2014). Perceivers infer traits from roles and mentally associate them with the social group as well as generalize them to most group members (e.g., "Most software engineers are men, software engineers are competent in math, so men are competent in math"). Such associations are at the heart of stereotypes. However, when group members evince roles and traits that diverge from group stereotypes—counterstereotypical exemplars—perceivers' mental representations and their associations are attenuated, which in turn reduces the expression of stereotypes (Dasgupta & Asgari, 2004; Dasgupta & Rivera, 2008; Rivera & Benitez, 2016). Indeed, empirical evidence with adults has shown that exposure to counterstereotypical exemplars in laboratory experiments or natural settings weakens stereotypes and their effects (Dasgupta & Asgari, 2004; Lawson et al., 2022; Rivera & Benitez, 2016; Starr & Leaper, 2023) as well as the expression of prejudice (Dasgupta & Rivera, 2008). However, research on the impact of exposure to counterstereotypical exemplars on middle school children's stereotypes is limited. One study with mostly White and Asian elementary school–aged children showed that exposure to stories with counterstereotypical characters (i.e., girls liking math and boys liking reading) reduced implicit gender math stereotypes, but only among younger children (around 8 years old) and not among older children (around 10 years old). Notably, the latter group's age is approaching the middle school period (Block et al., 2022).

We advance the counterstereotypical exemplars research in several new ways. First, we present an experimental test of exposure to counterstereotypical exemplars in math with middle school boys and girls. As discussed above, the middle school developmental stage is a critical sensitivity period for stereotype reduction. Second, our sample of middle school children is mostly Black and Latinx. It is important to test the effectiveness of interventions among Black and Latinx children because they face relatively unique stereotypes and stereotype-based threats in STEM (Joseph et al., 2017; Kuchynka et al., 2022). During middle school, children from various ethnic-racial groups, including Black and Latinx children, endorse the ethnic-racial math stereotype that White and Asian people are better at math than Black and Latinx people (Cvencek et al., 2015; Nasir et al., 2017; Rowley et al., 2007). In other words, Black and Latinx children not only endure stereotype-based perceptions from their peers (Del Toro & Wang, 2023) but also contend with barriers stemming from their own stereotype endorsement (Wang et al., 2022). Black and Latinx children's endorsement of ethnic-racial stereotypes about math is linked to lower self-concepts about math, reduced math achievements, lower cognitive efforts to study math, and fixed mindsets about math abilities (Evans et al., 2011; Okeke et al., 2009; Wang et al., 2022). These potential consequences of math stereotypes could further contribute to discouraging Black and Latinx children from pursuing and participating in math in both the short and long term.

Third, the exemplars in the intervention vary in their gender and ethnic-racial group memberships, so we test if their intersecting memberships have unique effects on either gender or ethnic-racial math stereotypes. Some research (see Castro & Collins, 2021) suggests that children may, for example, perceive the gender group categorization of Asian women as incongruent with math professionals, and thus, exposure to Asian women math exemplars may reduce gender math stereotypes. By comparison, children may perceive the ethnic-racial group categorization of Asian women as congruent with Asians' "natural" math abilities, and thus, exposure to Asian women math exemplars may not alter their ethnic/racial math stereotypes.

Last, we explore if the effect of math exemplars on reducing math stereotypes is contingent on boys' and girls' math identities. Math identity refers to the extent to which individuals believe that math is central to their self-concept and perceive themselves as prototypical of someone in math (Settles, 2004; Starr, 2018). Social identity development theory posits that children who identify with a group are aware of both ingroup and outgroup stereotypes (Nesdale, 2004). Consistent with this hypothesis, Starr and Simpkins (2021) showed that girls' and boys' stronger math identities exhibited in ninth grade were associated with 11th-grade girls' expression of weaker gender math stereotypes but with 11th-grade boys' expression of stronger gender math stereotypes. These results suggest that math identity motivates children to express stereotypes in ways that uphold their group's positive image. Further, they suggest that the strength of math stereotype expression after they are exposed to counterstereotypical math exemplars from the ingroup versus the outgroup may be contingent upon girls' and boys' math identities. Specifically, exposure to counterstereotypical women math exemplars may motivate girls with strong math identities to further distance themselves from gender math stereotypes but motivate boys with strong math identities to endorse even stronger gender math stereotypes. Given the scarcity of research on this topic, these hypotheses are exploratory.

The Present Research

The current experiment examines the impact of exposure to gender and ethnic-racial counterstereotypical math exemplars who vary in their gender and ethnic-racial group memberships on middle school children's gender and ethnic-racial math stereotypes with a large sample of mostly ERM middle school girls and boys. The main hypothesis is that exposure to counterstereotypical math exemplars (i.e., women and ERM math professionals) will reduce gender and ethnic-racial math stereotypes. Also, we explored if these effects are moderated by girls' and boys' math identities.

Method

Participants and Design

Four hundred thirty-seven middle school students participated in the experiment as part of the Mathematical Thinkers Like Me project, a multiyear intervention led by a network of math teachers, researchers, and educational resource developers that aimed to develop a new approach to teaching mathematics that combines an online, collaborative mathematics problem-solving platform with an emphasis on growing mathematical knowledge. Students who participated in the current experiment were all part of the Mathematical Thinkers Like Me project, but they were only first informed about the purpose of the experiment ("to read stories about people who pursued careers in math"; see the Math Exemplars section) and randomly assigned to an experimental condition at the time when the experiment was administered. Thus, prior to the experiment, student participants were exposed only to math activities on the online platform.

All child participants provided assent, and parents provided consent. Given our research goals related to participants' gender, we excluded data from participants who did not provide a gender response or identify as a girl or a boy ($n = 38$), yielding a final sample of 399 participants (56.3% girls, $M_{\text{age}} = 12.55$, $SD_{\text{age}} = 0.54$). All participants were from two U.S. school districts with predominantly Black and Latinx students (school districts ranged from 76.8% to 99.1% Black and Latinx). We adopted a 2 (Math Exemplars' Ethnicity-Race: White and/or Asian vs. Black and Latinx) × 2 (Math Exemplars' Gender: Men vs. Women) between-participants experimental design.[1] A sensitivity analysis conducted with G*Power with 80% power and $\alpha = .05$ showed that this sample size can detect a small effect size of $f = 0.14$ (Faul et al., 2009). The hypotheses and experimental materials were registered in the Open Science Framework (https://osf.io/4p3nk/?view_only=f8ea947b87cc4566a383e062d6405ed1). The materials can be retrieved at https://osf.io/8q3j6/. Due to agreements with the school districts, data and codes are available only upon request from the corresponding authors.

Independent Variable

Math Exemplars

We drew from our previously validated research approach (Dasgupta & Rivera, 2008; Rivera & Benitez, 2016) and the above literature review to develop the math exemplars. As per the literature review above and consistent with social role theory (Koenig & Eagly, 2014), individuals who actually occupy specific jobs and careers shape the content of stereotypes about occupational roles and social groups. For example, increasing women's representation in senior leadership positions is associated with reduced gender stereotypical language about leadership within the organization (Lawson et al., 2022). Furthermore, from a social cognitive perspective, people's stereotypes stem from the mental representations of social groups (Operario & Fiske, 2003), but exposure to individuals who challenge these existing representations attenuates stereotypes. We thus reasoned that introducing concrete individual math professionals who diverge from the prototypical person in a math profession (i.e., ERM and women exemplars) should shift participants' mental representations of the group of math professionals and, in turn, change gender and ethnic-racial stereotypes about math (see Dasgupta & Rivera, 2008; Rivera & Benitez, 2016).

All math exemplars were individuals who worked in math or math-intensive fields (e.g., computer science). Black and Latinx math professionals were the ERM exemplars, and White and Asian math professionals were the non-ERM exemplars. The exemplars were identical across the conditions as it relates to the number of math exemplars as well as the inclusion of a picture of each math professional in a work-related setting (e.g., lab, office), the professional's first name and specific occupation, and a brief biography that described their upbringing, early personal experiences that sparked their interest in math, and professional backgrounds that led to their math career.

Participants were randomly assigned to one of four math exemplar conditions: White men, White and Asian women, Black and Latino men, and Black and Latina women. Afterward, participants were told that they were going to read stories about men and women who pursued careers in math. For example, participants who were presented with the Latina math exemplar read that her name was Maria and she was a professor of mathematics, then read the following biography:

> I grew up in the Bronx with a passion for solving math problems. Teachers were impressed with my math skills, so they encouraged me to attend a summer program in math. The program, teachers, and students changed my life. I discovered I was good at it, and I loved it.

The Supplemental Material includes the materials of all exemplars, including their pictures, names, occupations, and brief biographies.

On a computer screen, participants read the exemplars to themselves one at a time at their own pace and clicked an arrow to proceed to the next page. According to a well-established readability formula, the materials were comprehensible to middle school–aged students. Specifically, the Flesch–Kincaid Grade Level formula (calculated via the *KoRpus* R package; Michalke, 2012; Pitcher & Fang, 2007) indicates that our biographies were appropriate for an average grade level of 6.2 and an average age of 11.2.

Dependent Variables

Gender Math Stereotypes

Two items adapted from Blažev et al. (2017) and Moè et al. (2021)—(a) "It is possible that boys and men have more ability in math than do girls and women" and (b) "In general, boys and men may be better than girls and women at math"—were rated on a 5-point scale ranging from 1 (*disagree*) to 5 (*agree*). Higher value scores indicate stronger gender math stereotypes or stronger associations between boys/men and math relative to girls/women and math ($r = .72$).

Ethnic-Racial Math Stereotypes

We used the same two items from above, except that White and Asian children and adults replaced boys and men, and non-White and non-Asian children and adults replaced girls and women. Higher scores indicate stronger ethnic-racial math stereotypes or stronger associations between White/Asian people and math relative to non-White and non-Asian people and math ($r = .76$).

Moderator

Math Identity

Three items adapted from Stout et al. (2011) and four items adapted from Starr (2018) measured math identity centrality and typicality. A sample centrality item was "How important is math to you," and a sample typicality item was "I think I am a good example of someone who is good at math." All items were rated on a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely*). Higher scores indicate stronger math identities ($\alpha = .85$). See the Supplemental Material for a list of all items.

[1] A chi-square test showed no differences in the distribution of gender across the four conditions, $\chi^2(3, N = 399) = 3.55$, $p = 3.14$, and a one-way ANOVA showed no differences in age across the four conditions ($F = .11$, $p = .75$), suggesting that random assignment led to a balanced gender and age representation across groups.

Procedure

Participants first completed the math exemplars independent variable, followed by the dependent measures of gender math stereotypes and ethnic-racial math stereotypes (in this order), and, finally, a demographics questionnaire that measured race/ethnicity, age, and gender. The measure of math identity was completed in a separate session prior to the math exemplars' independent variable.

Data Analyses Plan

Our plan of analyses consisted of three main steps. First, we calculated zero-order correlations among all measured variables by participants' gender. Second, we ran two separate analysis of variance (ANOVA) tests to examine the three-way Child Participants' Gender × Math Exemplars' Ethnicity-Race × Math Exemplars' Gender interaction effects on gender and ethnic-racial math stereotypes. Significant interactions were decomposed with pairwise contrast analyses. Finally, we used PROCESS v4.3 Model 3 (Hayes, 2017) with 10,000 bootstraps to test the moderating role of girls' versus boys' math identity on the effect of math exemplars' gender on gender math stereotypes and the effect of math exemplars' ethnicity-race on ethnic/racial math stereotypes. For any three-way Child Participants' Math Identity × Child Participants' Gender × Math Exemplars' Ethnicity-Race or Gender interaction effects on math stereotypes, we tested conditional effects at low and high levels of math identity for girls versus boys.

Results

Table 1 lists the descriptive statistics and zero-order correlations among all the measured variables for girls and boys. As shown in Table 1, stronger gender math stereotypes were associated with stronger ethnic/racial math stereotypes among girls ($r = .68$, $p < .001$) and boys ($r = .61$, $p < .001$).

Effect of Participants' Gender and Math Exemplars on Math Stereotypes

Scores on the gender math stereotype and ethnic-racial math stereotype measures were submitted to two separate ANOVAs with participants' gender (0 = boys, 1 = girls), math exemplars' ethnicity-race (0 = non-ERM, 1 = ERM), and math exemplars' gender (0 = men, 1 = women) as independent variables. Table 2 summarizes the descriptive data on gender and ethnic-racial math stereotypes as a function of participants' gender and exemplars' condition, and Table 3 summarizes the results of the ANOVAs. In terms of gender math stereotypes, boys ($M = 2.25$, $SD = 1.13$) expressed stronger gender math stereotypes than girls ($M = 1.98$, $SD = 1.03$), $t(397) = 2.42$, $p = .02$. This is squarely consistent with past research with children (Miller et al., 2018; Starr & Simpkins, 2021). No main effects of either math exemplars' ethnicity-race or math exemplars' gender emerged, $ts(397) < 1.38$, $ps > .17$. However, the three-way Participants' Gender × Math Exemplars' Ethnicity-Race × Math Exemplars' Gender interaction was significant, $F(1, 391) = 3.97$, $p = .047$. Next, we conducted post hoc pairwise contrast analyses to decompose this interaction.

Boys exposed to ERM women math exemplars ($M = 2.15$, $SD = 1.14$) expressed weaker gender math stereotypes than boys exposed to ERM men math exemplars ($M = 2.71$, $SD = 1.23$), $SE = .24$, $t(391) = -2.40$, $p = .02$. Also, boys exposed to non-ERM men exemplars ($M = 2.12$, $SD = 1.06$) expressed weaker gender math stereotypes than boys exposed to ERM men exemplars ($M = 2.71$, $SD = 1.23$), $SE = .25$, $t(391) = 2.50$, $p = .04$. No other differences emerged ($|ts| < .13$, $ps > .99$). Girls' expression of gender math stereotypes did not vary as a function of math exemplar conditions ($|ts| < 1.40$, $ps > .35$; see Table 2 for descriptives). As noted above, girls, in general, expressed relatively low gender math stereotypes, regardless of math exemplar exposure.

In terms of ethnic/racial math stereotypes, no main or interaction effects were significant ($Fs < 1.90$, $p > .17$; see Table 3).

Does Math Identity Moderate the Effect of Participants' Gender and Math Exemplars on Math Stereotypes?

In PROCESS v4.3 Model 3 (Hayes, 2017), we entered math exemplars' gender as the main predictor (men = 0, women = 1), math identity as the first moderator, participants' gender as the second moderator (boys = 0, girls = 1), and gender math stereotypes as the dependent variable. The three-way interaction was significant ($b = -.78$, $SE = .30$, $t = -2.56$, $p = .01$, 95% CI [−1.37, −0.18]). As per Figure 1, among boys with low math identities, exposure to women math exemplars ($M_{est} = 1.91$, $SE = .16$) yielded weaker gender math stereotypes than exposure to men math exemplars ($M_{est} = 2.46$, $SE = .19$; $b = -.58$, $SE = .25$, $t = -2.28$, $p = .02$, 95% CI [−1.08, −0.08]). Further, among boys in the women exemplars conditions, those with stronger math identities expressed lower gender math stereotypes ($M_{est} = 2.39$, $SE = .16$) than those with weaker math identities ($M_{est} = 1.91$, $SE = .16$; $b = .32$, $SE = .15$, $t = 2.19$, $p = .03$, 95% CI [0.03, 0.61]). No other effects emerged among boys ($bs < 3.25$, $ps > .23$).

As illustrated in Figure 2, among girls with strong math identities, exposure to women exemplars ($M_{est} = 1.90$, $SE = .11$) led to expressing somewhat weaker gender math stereotypes than exposure to

Table 1
Descriptives and Zero-Order Correlations Among All Measured Variables

Variable	Girl (*ns* = 206–225)					Boy (*ns* = 157–174)				
	M	*SD*	1	2	3	*M*	*SD*	1	2	3
1. Gender math stereotypes	1.89	1.03	—			2.25	1.13	—		
2. Ethnic/racial math stereotypes	2.15	1.14	.68*	—		2.21	1.17	.61*	—	
3. Math identity	3.24	0.73	.01	.10	—	3.31	0.77	.08	.02	—

Note. *N*s = 363–399. Sample sizes vary because only a subset of participants (*n* = 363) completed the measure of math identity.
* $p < .001$.

Table 2

Means (and Standard Deviations) of Gender Math Stereotypes as a Function of Participants' Gender, Math Exemplars' Ethnicity-Race, and Math Exemplars' Gender

	Girl		Boy	
Exemplar gender	ERM exemplar	Non-ERM exemplar	ERM exemplar	Non-ERM exemplar
Women exemplars	2.01 (0.91)	1.80 (0.97)	2.15 (1.14)	2.11 (1.02)
Men exemplars	1.98 (1.02)	2.09 (1.18)	2.71 (1.23)	2.12 (1.06)

Note. $N = 399$. ERM = ethnic and racial minority.

men exemplars ($M_{\text{est}} = 2.09$, $SE = .10$; $b = -.43$, $SE = .23$, $t = -1.89$, $p = .06$, 95% CI [−0.88, 0.02]). No other effects emerged among girls ($bs < 3.25$, $ps > .22$).

We ran the same PROCESS v4.3 Model 3 (Hayes, 2017) from above but entered ethnic-racial math stereotypes as the dependent variable. The three-way interaction was not significant ($b = .19$, $SE = .34$, $t = 0.57$, $p = .57$, 95% CI [−0.47, 0.86]).

General Discussion

An experiment exposed ERM middle school students to counterstereotypical math exemplars who varied in gender and ethnic-racial group membership and tested its effect on their expression of gender and ethnic/racial math stereotypes. As it relates to gender math stereotypes, boys generally expressed stronger stereotypes than girls, which is consistent with past research (Starr et al., 2023), and support for our main prediction emerged mostly among these boys. Specifically, boys in the ERM women exemplars condition expressed weaker gender math stereotypes than those in the ERM men exemplars condition. Also, but surprisingly, boys in the non-ERM men math exemplars condition expressed weaker gender math stereotypes than those in the ERM men exemplars condition. This unexpected effect may have emerged because of ERM boys' gender and ethnic-racial identification with the ERM men exemplars. The achievements of ERM men math professionals may have affirmed boys' ERM group image that in turn simultaneously strengthened ingroup liking and outgroup disliking (Aboud, 2003; also see Rivera et al., 2024). One downstream consequence of these ingroup favoritism processes is boys' expression of stronger gender math stereotypes.

The experimental data also revealed that exposure to women math exemplars reduced gender math stereotypes among boys with a weak math identity but not among those with a strong math identity. A potential explanation is that the presence of women math exemplars poses a threat to strongly math-identified boys who are motivated to maintain men and boys' dominance in math, thus leading them to uphold gender math stereotypes (Pratto et al., 2000; Rowley et al., 2007). Weakly math-identified boys may not experience such threats because math dominance is less or not relevant to their image, so they are more amenable to the stereotype-reducing benefits of exposure to women math exemplars.

Girls in general expressed relatively low gender math stereotypes. However, among those who strongly identified with math, exposure to women math exemplars led to expressing (somewhat) lower gender math stereotypes compared to exposure to men math exemplars. No such effect emerged among girls who weakly identified with math. Strongly identified girls view math as important to their self-concept and perceive themselves as relatively close to math prototypes (Dasgupta & Asgari, 2004; Settles, 2004; Starr, 2018), so they may be more motivated to attend to women math exemplars who may serve as role models. Exposure to men math exemplars, on the other hand, may remind strongly identified girls of the extant gender inequities in math, threatening their intentions to pursue math. Expressing gender math stereotypes justifies gender inequities in math (Laurin et al., 2011) and protects their math self-image from threats to future math pursuits (Bell & Burkley, 2014; Kim et al., 2012). However, these underlying processes are tentative because the effects were marginally statistically significant, so further investigation is required.

Taken together, this current experiment demonstrates that the single (gender) and intersecting (gender and ERM/non-ERM) group memberships of math exemplars can benefit most ERM boys and possibly some ERM girls. These findings are aligned with intersectionality theory (Cole, 2009; Crenshaw, 1997), which posits that individuals' experiences are a function of unique, interlocking, and coconstructed social identities (e.g., gender, race, ethnicity, class) that result in complex interactions and experiences. Our data have implications for ERM girls, who face both gender and ethnic/racial

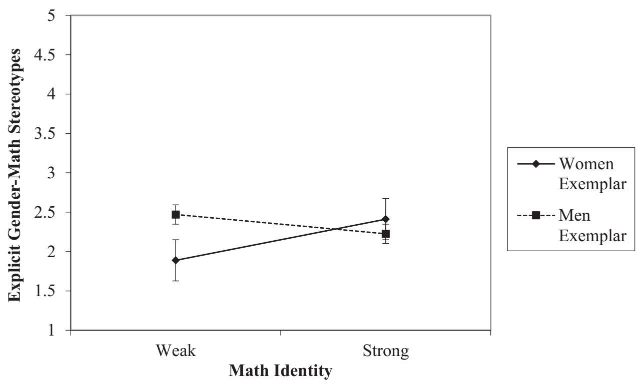
Table 3

Analysis of Variance Among Participants' Gender, Math Exemplars' Ethnicity-Race, and Math Exemplars' Gender

	Gender math stereotype			Ethnic/racial math stereotype		
Variable	F	p	η_p^2	F	p	η_p^2
Participants' gender	6.50	.01	.02	1.9	.17	.001
Math exemplars' ethnicity-race	2.05	.18	.005	1.79	.18	.003
Math exemplars' gender	2.03	.15	.008	0.37	.55	.006
Participants' Gender × Math Exemplars' Ethnicity-Race	1.65	.20	.004	0.48	.49	.001
Participants' Gender × Math Exemplars' Gender	0.33	.57	.001	0.33	.57	.0006
Math Exemplars' Ethnicity-Race × Math Exemplars' Gender	0.04	.85	.0002	0.07	.79	.0003
Participants' Gender × Math Exemplars' Ethnicity-Race × Math Exemplars' Gender	3.97	.047	.01	1.26	.26	.003

Figure 1

Boys Only: Math Identity Moderating Math Exemplars' Gender's Effect on Gender Math Stereotypes



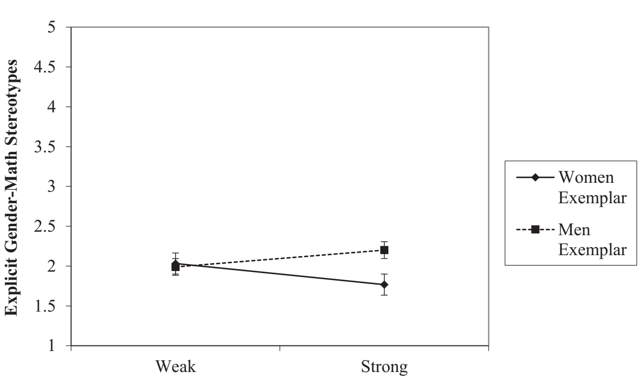
Note. $N = 157$.

math stereotypes and thus may experience unique and compounding consequences (Brown & Leaper, 2010; Joseph et al., 2017; Ong et al., 2011). While ERM boys and Asian (non-ERM) girls may also face math-based biases, they may counteract these experiences by endorsing the positive stereotype that men and Asians, respectively, are relatively good at math (Castro & Collins, 2021; Evans et al., 2011; Gibson et al., 2014; Shin et al., 2016). Our results also suggest that in middle schools with predominantly ERM populations, girls pursuing math may face additional challenges stemming from the gender math stereotypes expressed by their boy peers.

As it relates to ERM math stereotypes, neither main nor interaction effects of math exemplars emerged. In retrospect, we likely observed null effects because most of our sample consisted of ERM middle school children (upwards of 99.1% in some schools; see the Participants and Design section). According to social categorization and self-categorization theories (Hogg, 2016), a salient intergroup context is a prerequisite to expressing stereotypes, a context that was essentially nonexistent in our participating schools with mostly ERM-student bodies. Moreover, a vast majority of teachers from the participating school districts were ERM group members and thus may have served as chronically salient math exemplars. If this was the case, the experimental manipulation intended to make math exemplars temporarily salient may not have been powerful enough to reduce ERM math stereotypes. Taken together, this rationale suggests that our predicted effects may emerge in schools with ethnic-racial heterogeneous student populations and math teachers who mostly come from non-ERM groups.

Figure 2

Girls Only: Math Identity Moderating Math Exemplars' Gender's Impact on Gender Math Stereotypes



Note. $N = 206$.

Practical Implications

Math interest and confidence predict children's participation and pursuit of math and more broadly STEM (Wang et al., 2017; Watt et al., 2017). However, despite the nonexisting gender differences in the national assessment of mathematics among U.S. children in eighth grade, girls consistently show less math interest and confidence than boys (National Science Board, National Science Foundation, 2023). Gender math stereotypes expressed by boys (and men) appear to be one source of girls' (and women's) reduced math interest, confidence, and pursuit (Cheryan et al., 2015; Cyr et al., 2024; Riegle-Crumb & Morton, 2017; Wolff, 2021). The present experiment represents a promising intervention to address the gender math stereotypes of children. Past interventions with children are based on multistep persuasion approaches, including elaborate training about the existence and inaccuracy of gender math stereotypes (Cyr et al., 2024). Notwithstanding their importance, they can be costly and time-consuming to many middle schools that spend significant amounts of time "teaching to the test" (Kuchynka et al., 2022). Exposure to math exemplars is a relatively brief, accessible, and versatile approach that can be seamlessly incorporated into school settings and sustained throughout the school year (to maintain long-term stereotype-reducing effects). Counterstereotype exemplars can be displayed in textbooks, in course materials, and by guest speakers. Further, when considering a math exemplar exposure intervention, educators and schools should include math professionals with intersecting gender and ethnic-racial group memberships.

Limitations and Future Directions

Readers may question whether the current experimental effects reflect a Hawthorne effect—that is, participants altered their stereotype expressions due to a perceived awareness of the intervention's goals. However, as outlined in the Participants and Design section, all participants were enrolled in the Mathematical Thinkers Like Me intervention, but they were not informed of the present study's focus on stereotype reduction and equity enhancement prior to their participation. Instead, they engaged solely in math-related activities via an online platform that sought to grow their mathematical knowledge. Therefore, it is unlikely that the findings were driven by the Hawthorne effect.

Future research should test the effect of math exemplars with a sample of students who vary in their ERM and non-ERM identities. This design will allow a test of how the gender and ethnic-racial identities of children interact with the gender and ethnic-racial group memberships of the math exemplars to shape ethnicity/race math stereotypes. Also, in the absence of baseline measures, future experiments should adopt a pre–post study design to provide a more rigorous test of immediate and longitudinal changes after exposure to math exemplars. Finally, future research should include measures of intersecting math stereotypes (e.g., Black women's associations with math) to provide deeper empirical insights into the complex and nuanced processes rooted in the intersectionality experiences of children.

Conclusion

This research has the potential to inform bias intervention and implementation science in the classroom. The present intervention is the first of its kind to test the impact of math exemplars on ERM boys' and girls' math stereotypes. Stereotype-reducing interventions like the present one that targets children are imperative given that at least some of them embrace math stereotypes, which can strengthen with age and education phases (Miller et al., 2018) as well as have long-term detrimental academic and career pursuit consequences. The present data inform the development of practical interventions in everyday classrooms that can ultimately play a vital role in shaping children's math interests, confidence, and pursuit over time.

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