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BRIEF REPORT

When and Why Is Faculty Mentorship Effective for Underrepresented Students in STEM? A Multicampus Quasi-Experiment

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Objectives: Faculty mentorship can be one solution to addressing the participation and persistence gaps between underrepresented groups (URGs) and overrepresented group members in science, technology, engineering, and math (STEM). However, little is known about the mechanisms underlying effective STEM faculty mentorship. The present study (a) investigates if faculty mentorship impacts STEM identity, attitudes, belonging, and self-efficacy; (b) compares students' perceptions of women versus men faculty mentorship support functions; and (c) uncovers the mentorship support mechanisms underlying impactful faculty mentorship. ***Method:*** The present research sampled ethnic–racial minority URG undergraduate students pursuing STEM majors across eight institutions (N = 362; age = 24.85; 36.6% Latinx, 30.6% Black, and 4.6% multiracial; 60.1% women). The study's overall quasi-experimental design adopted a one-factor two-level (faculty mentorship status: yes, no) between-subjects design. Among the participants who reported having a faculty mentor, we also examined faculty mentor gender (women vs. men) as a between-subjects variable. ***Results:*** Faculty mentorship had a positive impact on URG students' STEM identity, attitudes, belonging, and self-efficacy. Furthermore, mentorship support functions indirectly predicted identity, attitudes, belonging, and self-efficacy among URG mentees who had women compared to men faculty mentors. ***Conclusions:*** Implications for how STEM faculty, regardless of their gender identity, can be effective mentors to URG students are discussed.

Public Significance Statement
Black, Latinx, Native American, and women students are disproportionately underrepresented in STEM. STEM faculty mentorship is one way to address this societal issue, but little is known about what constitutes effective mentorship for underrepresented students. Our research elucidates the underlying mentorship mechanisms that contribute to positive STEM outcomes, underscoring the important role faculty mentorship plays in ameliorating STEM inequities.

Keywords: STEM persistence, STEM identity, STEM belonging, STEM self-efficacy, STEM representation

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The corresponding data set can be accessed via https://osf.io/a64j2/?view_only=ed0f7eb784aa426e96e715831da68918.

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The data are available at https://osf.io/a64j2/.

The preregistered design is available at https://aspredicted.org/blind.php?x=RDX_DUS.

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Much empirical attention has targeted the efficacy of faculty mentorship in promoting participation among underrepresented groups (Black, Latinx, Native American, and women; URGs) in science, technology, engineering, and math majors (STEM; National Academies of Sciences, Engineering, & Medicine [NASEM], 2019). However, faculty mentorship to URG students does not unequivocally yield benefits because the quality of faculty mentorship varies. The present research contributes to this literature with data from a sample of ethnic–racial minority undergraduate students in STEM across eight higher education institutions that unpack the mechanisms underlying impactful mentorship. We (a) investigate if having faculty mentorship is positively associated with ethnic–racial minority students' STEM-related psychological outcomes; (b) compare URG students' perceptions of women versus men faculty mentorship support functions; and (c) examine if such functions underlie the role of gendered faculty mentorship in STEM outcomes.

Faculty Mentorship Among URG STEM Students

The overrepresentation of White and Asian men in STEM fields (National Science Foundation, National Center for Science and Engineering Statistics, 2019) coupled with pervasive cultural stereotypes about who does and does not belong in STEM (Eaton et al., 2020) create STEM environments for URG students that are often isolating (Grossman & Porche, 2014; Malone & Barabino, 2009), patronizing (Kuchynka et al., 2018), unwelcoming (Roli'Varma & Kapur, 2006), and "chilly" (Simon et al., 2017). Given the lack of belonging experienced by URG students, faculty mentorship may be one solution to combat these barriers. However, some research demonstrates that having a faculty mentor is associated with less STEM persistence (Chang et al., 2014), and other research reports no relation between having a STEM faculty mentor and URG students' STEM persistence (Schultz et al., 2011). These less-than-ideal results may emerge when mentors are unsupportive, engage in unequal treatment, and experience interpersonal mismatch (Limeri et al., 2019). When URG students do report high-quality faculty mentorship, it is associated with enhanced performance (Kendricks et al., 2013) and positive increases in identification with STEM, self-efficacy, valuing STEM, and long-term STEM engagement (Estrada et al., 2018). Notably, quality mentorship is a broad construct that often includes psychosocial support, which refers to feelings of mentor–mentee connection or similarity and mentor behaviors aimed at easing academic and social challenges, and career support, which refers to mentor behaviors aimed at mentee skill development, career guidance, and academic feedback (NASEM, 2019).

Mentorship support functions differently for minority versus majority ethnic–racial groups in STEM. Emotional support, feelings of connection, and trust are more important for ethnic–racial minority compared to White students in STEM (Kendricks et al., 2013). Black students are more likely than White students to report the importance of having a personal connection with their mentor and to experience stronger psychological benefits such as confidence from a mentoring relationship (Ishiyama, 2007). Ethnic–racial minority students often receive inadequate recognition as a STEM group member (Carlone & Johnson, 2007), but they disproportionately benefit from validation from faculty members because it confirms positive self-perceptions of STEM capabilities (Rendon, 1994). Thus, we expect URG students to benefit most from mentorship that provide a source of affiliation, encouragement, and culturally responsive support (strong psychosocial support).

Which Faculty Provide URG Mentees With Mentorship Support Functions?

Because psychosocial and career support are conditional factors for impactful mentorship (NASEM, 2019), research has focused on investigating what types of mentor–mentee relationships are characterized by strong support functions. Contrary to some theoretical hypotheses (see Dennehy & Dasgupta, 2017), matching mentors and mentees on demographic characteristics, such as pairing women mentors with women mentees, does not consistently result in positive STEM outcomes for mentees (Hernandez et al., 2017). Most relevant to the present research, Blake-Beard et al. (2011) found in a representative survey of STEM trainees (N = 1,010; 868 women, 148 ethnic–racial minorities) that participants received more psychosocial and career support from same-gender and same-race mentors compared to other-gender and other-race mentors, respectively. However, demographically matched mentee–mentor relationships were *not* associated with self-efficacy and grade point average. Underlying relational dynamics as opposed to mentor–mentee matching based on demographic characteristics may be more optimal for predicting successful mentorship relationships (Allen et al., 2005; Sosik & Godshalk, 2000). Accordingly, our study explores which faculty mentors provide strong support functions for URG students.

Because women faculty have already successfully navigated STEM as a stigmatized group member, they can teach coping skills and strategies to learn how to thrive in environments that tend to be isolating, competitive, and unwelcoming for URG students. In addition, the shared stigmatized status of women faculty and ethnic–racial URG students in STEM may enhance mutual feelings of similarity, connection, and identification (e.g., stigma solidarity; see Craig & Richeson, 2016). Women faculty may be more effective mentors to URG students than men faculty because of gender prescriptions (people's desires for how women and men ought to behave) that emphasize the enactment of communal goals and behaviors (Allen et al., 2005; Sosik & Godshalk, 2000). Women tend to be more emotionally supportive and engage in more self-disclosures than men (Eagly, 2009), and these relational skills are core components of supportive mentorship (NASEM, 2019). Therefore, these gendered prescriptions may serve as an important source of mentorship effectiveness among women faculty because psychosocial support underlies positive outcomes for URG students (Kuchynka, Reifsteck, et al., 2022; NASEM, 2019). Even though women, compared to men faculty, may provide stronger psychosocially supportive mentorship, *all* URGs who experience strong support and connection with their mentor should benefit from mentorship. Therefore, as opposed to focusing on mentor–mentee (ethnicity-race and gender) demographic matching, our study evaluates supportive factors as the mechanisms underlying STEM psychological outcomes.

Overview of the Research and Hypotheses

One study with a sample of ethnically racially diverse URG students in STEM from eight different higher education institutions examined the role of faculty mentorship in four STEM-related psychological outcomes. We hypothesized that having a faculty

mentor, compared to no mentor, would be related to stronger identity, positive attitudes, belonging, and self-efficacy. In addition, we tested if women faculty mentors have a greater impact than men faculty mentors on students' STEM-related outcomes via relationship support functions (psychosocial and career support; see Figure 1).

Method

Participants, Design, and Procedure

We invited approximately 3,000 current and past students from the Garden State Louis Stokes Alliance for Minority Participation (GS-LSAMP) program (http://gslsamp.rutgers.edu/) to participate. GS-LSAMP is an eight-university and college alliance-based program in New Jersey aimed at increasing URG student recruitment, retention, and graduation in STEM (Clewell, 2006). Participation was voluntary, but participants were entered into a raffle to win one of 20 $25 gift cards. Four hundred twenty-five students responded to our invitation, and 362 participants completed the study. According to G*Power (Faul et al., 2007), 129 participants are needed to detect a medium effect size ($f^2 = 15$) for a multivariate analysis of variance (MANOVA) with two groups and four measurements at 95% power. Thus, our sample is more than adequately powered to test our hypotheses.

Table 1 lists participants' demographics. A total of 89% participants were URG (i.e., ethnic–racial minorities and/or women from all ethnic–racial backgrounds including Asian and White people) and 44.8% reported having a faculty mentor. The study's quasi-experiment adopted a faculty mentorship status (yes vs. no) between-subjects design. Among the participants who reported having a faculty mentor, we also examined faculty mentor gender (men vs. women) as a between-subjects variable.

The predictions and measures were preregistered at AsPredicted.org (GS-LSAMP Study 1, No. 37355; https://aspredicted.org/RDX_DUS). All study procedures were approved by the institutional review board. Participants with a faculty mentor first responded to a set of three randomly presented measures that evaluated the relationship with their faculty mentor. Then, all participants completed a set of four randomly presented STEM-related psychological measures and, finally, a demographics' questionnaire.

Measured Variables

Faculty Mentorship

Psychosocial Support. Eight items measured psychosocial support factors including perceived similarity, personal chemistry, connection, support, and role modeling (Dennehy & Dasgupta, 2017): "How much support have you been getting from your mentor?" Items were rated on a 5-point scale ($\alpha = .85$) ranging from 1 (*not at all*) to 5 (*extremely*).

Career Support. Three items adapted from the Leader Communication Exchange Scale (we changed "manager" to "mentor" and "professional" to "academic"; Omilion-Hodges & Baker, 2017) measured career support: "My mentor provides me with opportunities to improve my academic skills." Items were rated on a 5-point scale ($\alpha = .84$) ranging from 1 (*never*) to 5 (*always*).

Psychological Closeness. The Inclusion of Other in the Self scale (Aron et al., 2004) measured students' psychological closeness with faculty mentors (following Kuchynka, Reifsteck, et al., 2022; Dennehy & Dasgupta, 2017). Participants were asked, "Which of the pictures best describes your mentor–student relationship?," then presented with seven pairs of Venn diagram circles ranging from nonoverlapping to near-complete overlapping (or inclusion of mentors within students' self-concept).

STEM-Related Psychological Outcomes

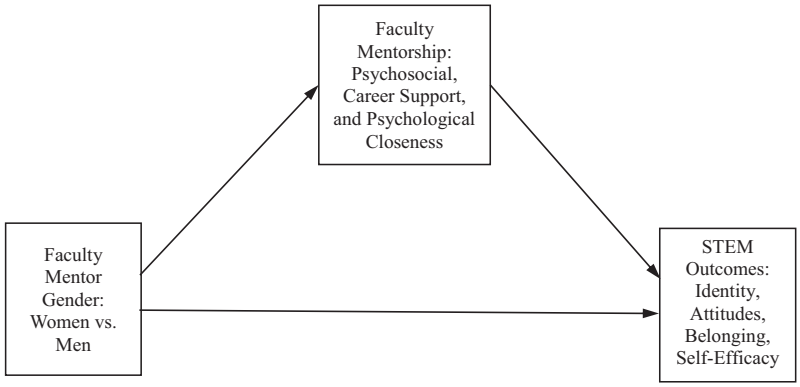
Identity. Three items measured centrality of STEM to the self (Dennehy & Dasgupta, 2017): "How important is STEM to you?" Items were rated on a 7-point scale ($\alpha = .88$) ranging from 0 (*not at all*) to 6 (*very much*).

Attitudes. Four semantic differentials ranging from −3 to +3 anchored by dislike–like, hate–love, boring–fun, and bad–good measured global appraisals of STEM (Dennehy & Dasgupta, 2017). Higher scores mean stronger positive attitudes toward STEM ($\alpha = .82$).

Social Belonging. Four items measured the degree to which participants felt a sense of belonging to their peers (Good et al., 2012): "I feel connected to my peers in STEM." Items were rated on a 7-point scale ($\alpha = .77$) ranging from 0 (*not at all true*) to 6 (*very true*).

Figure 1

Conceptual Model Depicting Effects of Faculty Mentor Gender on STEM Outcomes Mediated by Faculty Mentorship Variables



Note. STEM = science, technology, engineering, and math.

Table 1
Participants' Demographics

Variable	Descriptive statistic
Age (mean years)	24.85 (8.99)
Gender	
Female	60.1
Male	39.1
Other	0.8
Ethnic–racial group	
Black or African American	30.6
Latinx or Hispanic	36.6
Middle Eastern or North African	4.9
White or European American	9.8
Asian or Asian American	9.6
American Indian or Alaska Native	0.0
Multiracial	4.6
Other identity	1.9
Parent education	
Grade school	3.4
Middle school	5.5
High school	23.5
GED	1.1
Vocational	2.5
Some college	12.8
Finished college	18.7
Master's	10.5
Professional degree	1.8
Doctorate	1.6
Region born	
North America	53.5
South America	9.1
Central America	0.7
Caribbean	7.8
Europe	0.9
Africa	6.2
Middle east	1.8
Asia	3.7
Student status	
Past	52.6
Current	47.4
Current students' status	
First year or freshman	7.0
Second year or sophomore	22.2
Third year or junior	26.6
Fourth year or senior	32.9
Fifth year or more	11.4
Faculty mentorship	
Yes	44.8
No	55.2
Faculty mentor ethnicity	
Underrepresented group	23.4
Nonunderrepresented group	76.6
Faculty mentor gender	
Women	50.3
Men	49.1
Other	0.6

Note. Figures represent percentages, unless otherwise noted in parentheses after variable. For means, standard deviations follow in parentheses. Parent education refers to the highest level of education received by their primary parent (this item served as our measure of socioeconomic status). GED = General Education Development.

Self-Efficacy. Two questions assessed participants' appraisals of their talent and confidence (adapted from Stout et al., 2011): "Do you think you have a talent for STEM?" Items were rated on 7-point scale (r = .90) ranging from 0 (*not at all*) to 6 (*very much so*).

Demographics

Age (continuous) was an open-ended question and was measured in years. The remaining variables were categorical (e.g., gender), and each response option and values are described in Table 1.

Results

Table 2 lists the zero-order correlations as well as means and standard deviations among all measured variables.

Do Faculty Mentors in General Benefit URG Students' STEM-Related Psychological Outcomes?

This analysis tests the impact of faculty mentorship compared to no mentorship on outcomes. We ran a MANOVA with the four variables—STEM identity, attitudes, belonging, and self-efficacy—entered as the criteria and faculty mentor status (1 = *no faculty mentor*, 0 = *faculty mentor*) as the fixed-effects factor.[1] The multivariate effect of faculty mentorship was significant, $F(4, 349) = 5.28$, $p < .001$, $\eta_p^2 = .06$ (see Table 3, for means and standard deviations), so we ran pairwise comparisons for our hypothesis tests.

All hypotheses were supported. Students who had a faculty mentor had significantly stronger identities ($M_{diff} = 0.21$, $p = .006$, 95% CI [.06, .35]), positive attitudes ($M_{diff} = 0.28$, $p = .003$, 95% CI [.10, .47]), sense of belonging ($M_{diff} = 0.55$, $p < .001$, 95% CI [.26, .83]), and self-efficacy ($M_{diff} = 0.28$, $p = .004$, 95% CI [.09, .48]), compared to students who did not have a faculty mentor.

Does the Gender of the Faculty Mentor Moderate the Faculty Mentor–URG Student Relationship?

To test for mentees' perceptions of mentorship support from men versus women faculty mentors, we ran one MANOVA with the three relationship variables—psychosocial support, career support, and psychological closeness—entered as the criteria and faculty mentor gender (1 = men, 2 = women) as the fixed-effects factor. The multivariate effect of faculty mentor gender was significant, $F(3, 175) = 2.74$, $p = .045$, $\eta_p^2 = .045$ (see Table 3, for means and standard deviations), so we tested the pairwise comparisons.

Students who had women faculty mentors reported significantly stronger psychosocial support ($M_{diff} = 0.22$, $p = .02$, 95% CI [.03, .39]), stronger career support ($M_{diff} = 0.29$, $p = .009$, 95% CI [.07, .51]), and more psychological closeness ($M_{diff} = 0.53$, $p = .026$, 95% CI [.06, .99]) than students who had men faculty mentors.

Finally, participants' gender (excluding $n = 3$ participants who did not identify as a man or woman) did not moderate the role of faculty mentor gender in the three mentorship variables, $F(3, 160) = 0.63$, $p = .59$, $\eta_p^2 = .01$. These results indicate that perceptions of mentorship support do not differ as a function of ethnic–racial URG students' gender.

[1] Including covariates gender and ethnic–racial identity does not change the pattern of results but does increase the magnitude of the effect sizes.

Table 2
Zero-Order Correlations Among All Measured Variables

Variable	1	2	3	4	5	6	7
1. Faculty mentor	—						
2. Identity	.20*	—					
3. Attitudes	.22**	.57**	—				
4. Self-efficacy	.19**	.47**	.36**	—			
5. Belonging	.23**	.23**	.35**	.30**	—		
6. Psychosocial support	—	.28**	.22**	.20**	.35**	—	
7. Career support	—	.27**	.20**	.25**	.28**	.59**	—
8. Psychological closeness	—	.20**	.13	.19**	.24**	.67**	.51**

* $p < .05$. ** $p < .01$.

Does Mentorship Support Among Women Versus Men Faculty Members Indirectly Predict STEM Outcomes?

As per Figure 1's conceptual model, we tested if having women versus men faculty mentors benefit mentees' STEM outcomes because of psychosocial support, career support, and psychological closeness. These three faculty mentorship variables were strongly interrelated ($.51 < r\text{s} < .67$, all $p\text{s} < .001$; see Table 2) and internal consistency analysis (using standardized scores) was good ($\alpha = .88$), so we created a mean composite score of mentorship support. We used Hayes and Preacher' (2013) PROCESS macro (Model 4) with 10,000 bootstrap samples with bias-corrected bootstrapped standard errors for indirect effects to test four statistical models. In each model, we treated faculty mentor gender (1 = men, 2 = women) as the dichotomous predictor and selected mentorship support as the mediator and the outcomes were the four psychological outcomes. All direct effects were nonsignificant across the indirect effects models ($p\text{s} > .19$), except for attitudes ($b = -.26$, $SE = .12$, $p = .04$, CI [−.51, −.01]). Significant indirect effects emerged for identity ($b = .07$, $SE = .04$, CI [.01, .15]), attitudes ($b = .07$, $SE = .04$, CI [.01, .15]), belonging ($b = .17$, $SE = .08$, CI [.03, .34]), and self-efficacy ($b = .09$, $SE = .04$, CI [.02, .18]; see Supplemental Figures 1–4 of the indirect effects models). In sum, the data suggest that when URG mentees are paired with women versus men faculty mentors, psychosocial support, career support, and psychological closeness are mentorship mechanisms underlying increases in identity, attitudes, belonging, and self-efficacy.

Table 3
Descriptive Statistics as a Function of Mentor Status (Yes or No) and Mentor Gender (Male or Female)

	Mentor status		Mentor gender	
Variable	Yes	No	Women	Men
STEM identity	6.55 (0.04)	6.34 (0.06)	6.56 (0.08)	6.54 (0.07)
STEM attitudes	6.41 (0.06)	6.12 (0.07)	6.31 (0.09)	6.51 (0.09)
STEM belonging	5.52 (0.10)	4.98 (0.11)	5.48 (0.15)	5.57 (0.15)
STEM self-efficacy	3.72 (0.06)	3.44 (0.07)	3.72 (0.10)	3.75 (0.10)
Psychological closeness			4.90 (0.17)	4.37 (0.17)
Psychosocial support			4.33 (0.07)	4.11 (0.07)
Career support			4.57 (0.08)	4.29 (0.08)

Note. STEM = science, technology, engineering, and math. Means and standard errors in parentheses.

General Discussion

Faculty mentorship, compared to no faculty mentorship, among a sample of students from URGs in STEM was linked to stronger identities, positive attitudes, belonging, and self-efficacy. Each of these factors contribute to long-term STEM engagement, performance, and persistence (Byars-Winston et al., 2010; Kuchynka et al., 2020; Nauta et al., 1998; Zeldin et al., 2008).

Relationships with women faculty mentors relative to men faculty mentors were associated with higher levels of psychosocial support, career support, and psychological closeness that in turn predicted stronger STEM-related psychological outcomes. Because gender role expectations prescribe women to be more communal and supportive compared to men (Prentice & Carranza, 2002), it is predictable that psychosocially supportive mentorship was robustly linked to women mentors relative to men mentors. In contrast to past meta-analytic findings that demonstrate men mentors report *providing more* career support than women mentors across organizations including higher education (O'Brien et al., 2010), the present results indicate that URG mentees report *receiving more* career support from women compared to men mentors. These data suggest that women STEM faculty mentors are equipped to engage in traditionally masculine behaviors that comprise instrumental career development such as providing high-quality feedback that promotes STEM outcomes. Because ethnic–racial URG group members often feel like an outsider in STEM domains (Carlone & Johnson, 2007; Espinosa, 2011), supportive behaviors that address belonging-based needs from faculty members may be one of the most effective ways to integrate marginalized group members into a STEM community.

Our sample of mostly Black and Latinx students reported stronger psychological closeness with mostly White and Asian women compared to men faculty mentors, and students' gender did not moderate any main effects of faculty mentors' gender. Altogether, these data suggest that gender and racial demographic matching are not a prerequisite for developing feelings of similarity and connection with mentors. It should be noted that although URG students reported more mentorship support from women compared to men faculty mentors, URG mentees still reported relatively high levels of support from men faculty mentors (mean scores were above the scales' midpoints) and experienced comparable positive psychological outcomes (e.g., identity) in mentorship relationships with men faculty. In fact, on one of the four STEM psychological variables—attitudes—URG mentees paired with men mentors reported a stronger outcome compared to those with women mentors. It is plausible that URG students paired with men mentors are likely yielding benefits via alternative mechanisms not measured

in this study such as networking opportunities that facilitate new relationships with STEM in-group members.

Limitations and Constraints on Generality

Due to its quasi-experimental design, the present study cannot conclude causality because URG students were not randomly assigned to faculty mentorship. While the results indicate that mentees who reported having a faculty mentor experienced numerous mentorship- and STEM-based benefits compared to URG students who reported not having a faculty mentor, future research should experimentally evaluate faculty mentor–mentee relationships to infer causal processes. Second, our analytical approach combined ethnic–racial minority students with White and Asian women students into one sample because all are individuals from URGs in STEM. Although their ethnic–racial-based and gender-based stereotypes and lived experiences (see introduction) are unique sources of their underrepresentation in STEM (Eaton et al., 2020; Whitcomb et al., 2021), women and ethnic–racial minority students are the target of similar biases in STEM (e.g., they are both stereotyped to be less competent) that underlie their similarly low levels of belonging and its consequences on persistence in STEM (Kuchynka, Eaton, et al., 2022). From this perspective, psychosocially supportive mentorship should yield benefits for both ethnic–racial minority individuals and women, which is consistent with the present data. Third, and finally, our results are highly generalizable because participants were sampled from eight different higher education institutions that vary in size and demographic characteristics.

Conclusions

This research has promising implications for *all* faculty mentors who seek to promote positive STEM outcomes for their mentees. Ethnic–racial minority students may not require demographic matching to reap mentorship benefits. To further enhance these benefits, all STEM faculty should learn about psychosocial and career support, why it is particularly important for URG students, and how to adequately engage in supportive behaviors.

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