Similarity and Contact Frequency Promote Mentorship Quality among Hispanic Undergraduates in STEM

Rachelle M. Pedersen, [ID][†]* **Carinna F. Ferguson,** [ID][‡] **Mica Estrada,** [ID][§]
P. Wesley Schultz, [ID][‖] **Anna Woodcock,** [ID][‖] **and Paul R. Hernandez** [ID][†]

[†]Department of Teaching, Learning, & Culture, Texas A&M University, College Station, TX 77840;
[‡]Department of Counseling and Learning Sciences, West Virginia University, Morgantown,
WV 26506; [§]Department of Social and Behavioral Sciences, Institute for Health and Aging,
University of California, San Francisco, San Francisco, CA 94143; [‖]Department of Psychology,
California State University, San Marcos, CA 92096

ABSTRACT

Mentoring relationships can be important for promoting the success and persistence of undergraduates, particularly for students from historically underrepresented groups in science, technology, engineering, and mathematics (STEM) disciplines. While mentoring is often cited as important for attracting and retaining students from underrepresented groups in STEM, little is known about the differential mentoring processes that can result from similar and dissimilar mentor–protégé pairs. The present study tests the process-oriented mentorship model (POMM) regarding how mentor–protégé similarities and the moderating role of contact frequency influence mentorship quality and STEM research career persistence intentions among faculty-mentored Hispanic STEM majors in their senior year of college. The results indicate that mentor–protégé similarity matters. Specifically, higher levels of mentor–protégé psychological similarity were related to higher levels of psychosocial support and relationship satisfaction. Hispanic students with a Hispanic faculty mentor reported engaging in more coauthoring opportunities than peers with non-Hispanic mentors. Among those with higher contact frequency, students with same-gender mentors had higher levels of relationship satisfaction than peers with different-gender mentors; however, there were no differences among those with low contact frequency. Additionally, protégés who reported coauthoring support were more likely to also report commitment to pursuing a STEM research career.

INTRODUCTION

As the demand for competitive innovations in science, technology, engineering, and mathematics (STEM) rapidly increases, so does the need for diversifying the pool of qualified STEM professionals (Valantine and Collins, 2015). Unfortunately, there are higher rates of attrition among students from historically underrepresented minority (URM) groups in STEM, as they experience more extensive barriers to success and persistence in STEM (Malcom and Feder, 2016). Mentoring, which we define as a relationship wherein a more experienced person (mentor) provides guidance, support, and encouragement for the personal or professional development of a less experienced person (protégé), has been shown to positively influence academic success and the retention of undergraduate STEM students (Jacobi, 1991; Crisp and Cruz, 2009; NASEM, 2019). The influence of a high-quality mentor can be particularly important during a URM student's senior year of college, a critical period in which decisions are being made about future careers (Green, 1991; Estrada *et al.*, 2018). Previous work has identified a mentor's pivotal role during the senior year for students from some URM groups in STEM, such as African-American students (Davis, 2009; Hernandez *et al.*, 2017), but our understanding of the development of
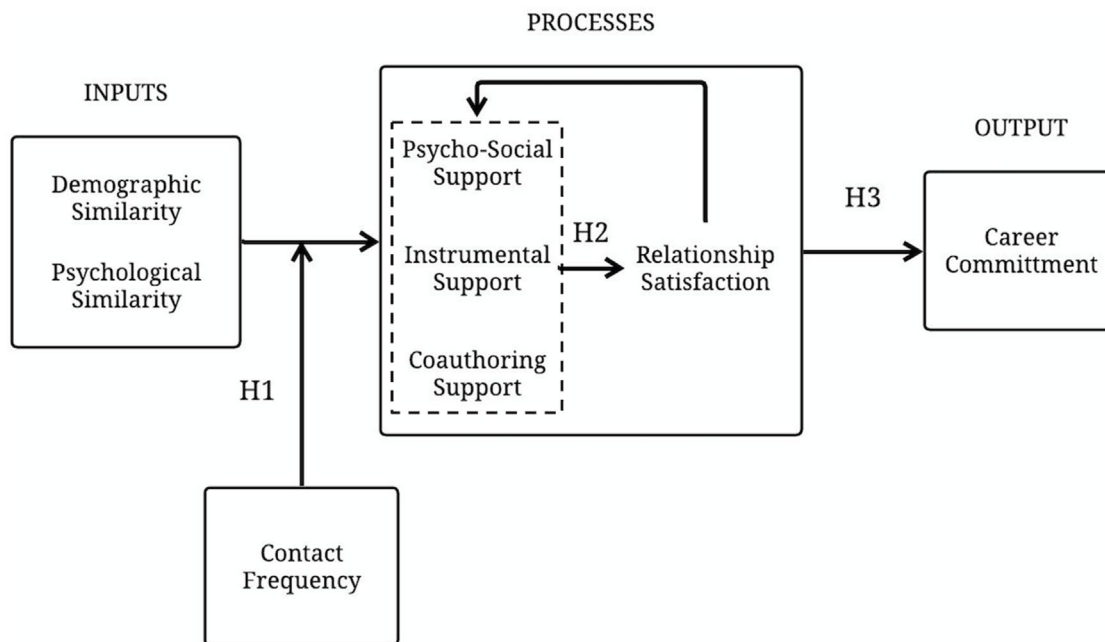
FIGURE 1. Process-oriented model of mentorship (POMM) and hypotheses.

high-quality mentoring relationships (and their benefits) specifically among Hispanic students in STEM fields at this critical period is still emerging and unclear (Luna and Prieto, 2009; NASEM, 2019). What is abundantly clear is that Hispanics are the second-largest (but fastest-growing) racial/ethnic group in the U.S. K–12 education system (27%) and that they aspire to STEM careers at rates comparable to their White peers (47% vs. 50%, respectively), but that they make up less than 14% of baccalaureate degree earners and less than 8% of the workforce in science and engineering disciplines (Hispanic Heritage Foundation, 2020; Hussar *et al.*, 2020; NCSES, 2021). Therefore, identifying policies and practices that can attract and retain Hispanic students in STEM disciplines is in the national interest for our economic, innovation, and equity goals (Crisp and Nora, 2012; Valantine and Collins, 2015; Estrada *et al.*, 2016). The current study aims to both deepen the knowledge base regarding mentoring Hispanic college students in STEM and investigate how mentor–protégé sociocultural similarities impact the formation and benefits of mentoring relationships (NASEM, 2019, recommendations 9.4 and 9.5).

A Process-Oriented Model of Mentoring
Recent theoretical advancements and multidisciplinary syntheses of the empirical mentoring literature point to a process-oriented model of mentorship (POMM; Eby *et al.*, 2008, 2013). This model was developed from a meta-analysis of 173 mentoring studies across youth, college, and workplace contexts. The POMM demonstrated how antecedent factors (e.g., protégé demographic characteristics, mentor–protégé similarity) and correlate factors (e.g., contact frequency) relate to the functions or processes of mentoring (e.g., psychosocial support; see Figure 1, adapted version of POMM addressed in this study). Eby and colleagues (2013) identified two core mentoring processes: 1) psychosocial support through encouragement, coun-

seling, and social guidance; and 2) career support through coaching, technical skill development, and sponsorship. Some research in academic contexts indicates that collaborative coauthorship support, through opportunities to write and produce scholarship, is subsumed within career support (Tenenbaum *et al.*, 2001); however, other research indicates that coauthorship support is a distinct third mentoring function in academic contexts (Paglis *et al.*, 2006). Although a recent narrative synthesis of the literature identified two additional mentoring processes, role modeling and negative experiences (NASEM, 2019), these processes were not considered in the present study. Each of the processes discussed in this paper are hypothesized to enhance protégé satisfaction with the mentoring relationship (i.e., a proximal outcome of mentorship processes). Mentoring relationship satisfaction, in turn, is hypothesized to reciprocally reinforce the future provision of mentoring support and to positively influence subjective and objective outcomes.

Although multidisciplinary meta-analyses have revealed patterns of association that are consistent with the POMM (Eby *et al.*, 2013; Dickson *et al.*, 2014), studies from undergraduate contexts make up a relatively small proportion of the literature and fewer still are based on the experiences of students from underrepresented groups in STEM disciplines. The present study aims to address this gap by testing POMM-based hypotheses among Hispanic students in STEM majors.

Undergraduate Mentoring Relationships
Largely consistent with evidence from meta-analyses, narrative reviews of mentoring in college contexts indicate that having a mentor and the quality of the mentoring relationship are related to beneficial subjective outcomes (e.g., belonging, self-efficacy beliefs, career commitment) and, to a lesser degree, objective outcomes (e.g., performance and persistence). These relationships are found for mentorship that is both general (Jacobi, 1991;

Crisp and Cruz, 2009) and specific to STEM fields (Joshi *et al.*, 2019; NASEM, 2020). Although research on the impacts of mentoring among Hispanic undergraduates makes up a relatively small proportion of the literature, findings are promising. For example, research indicates that, for Hispanic students, having a mentor has been associated with a positive outlook toward the university environment (Bordes and Arredondo, 2005), higher levels of academic commitment and integration (Torres and Hernandez, 2009; Torres Campos *et al.*, 2009; Holloway-Friesen, 2021; Phinney *et al.*, 2011), higher grade point average (GPA; Campbell and Campbell, 2007; Phinney *et al.*, 2011), and persistence in college (Bordes-Edgar *et al.*, 2011). The present study aims to advance the literature on the benefits of mentoring for Hispanic students by studying how the qualities of the mentoring relationship, rather than the presence or absence of a mentor, relates to benefits such as STEM research career commitment.

Inputs and Correlates of Mentorship Quality

The POMM framework has identified a variety of factors, such as demographics (e.g., race/ethnicity), mentor–protégé demographic similarity (e.g., racial/ethnic match), or psychological similarity (i.e., shared outlook, perspective, and values), that may influence the quality of the mentoring relationship (Eby *et al.*, 2013). The concept of mentor–protégé demographic similarity (i.e., gender or race/ethnicity match) has been well studied, but the findings have been inconsistent and large-scale multidisciplinary meta-analysis have found associations with mentoring processes and outcomes to be negligible (Eby *et al.*, 2013). Among studies focused on the experiences of students from URM groups in higher education, mentor–protégé gender and racial/ethnic match has exhibited small positive associations with mentoring processes, such as psychosocial and career support (Ortiz-Walters and Gilson, 2005; Blake-Beard *et al.*, 2011), but has generally been found to be unrelated to academic outcomes (e.g., GPA, self-efficacy; Blake-Beard *et al.*, 2011). A recent study of Hispanic undergraduate STEM majors involved in research experiences found that, among women, matched-gender mentoring was weakly positively associated with the intent to pursue STEM graduate programs, while among men, matched-gender mentoring was weakly negatively associated with intentions (Morales *et al.*, 2021). In contrast, the concept of mentor–protégé psychological similarity has consistently shown a strong association with mentoring processes, such as support and relationship satisfaction across disciplines, in college contexts, and among students from URM groups (Ortiz-Walters and Gilson, 2005; Eby *et al.*, 2013; Hernandez *et al.*, 2017). Although the extant mentoring literature with URM students in STEM provides insight, few studies have distinguished between the experiences of Hispanic students and those of other URM groups in STEM. Caution in generalizations is warranted across URM groups, as students from these groups bring unique cultural experiences to and have distinct experiences in college STEM contexts and therefore may interpret their experiences in different ways (Rodriguez and Oseguera, 2015). For example, a longitudinal study of undergraduates in STEM found that African-American students reported experiencing higher levels of stereotype threat than their Hispanic peers; however, Hispanic students were more likely to experience declines in their scientific identity due to stereotype threat than their African-American peers (Woodcock *et al.*, 2012). To

date, no research has simultaneously examined the unique contributions of a broad range of mentoring inputs (e.g., demographics, demographic match, and psychological similarity) on mentoring processes and outcomes among Hispanic undergraduates in STEM disciplines. This is particularly important in higher education contexts, where research indicates that students from underrepresented groups frequently desire demographically similar mentors (Blake-Beard *et al.*, 2011), but faculty from underrepresented groups are typically overburdened with service and mentoring (Allen *et al.*, 2000; Umbach, 2006; Griffin and Reddick, 2011). Therefore, identifying key inputs, which transcends mentors' majority or minority status, to developing high-quality mentoring relationships may help programs and stakeholders make better use of their limited resources and human capital to optimally support students.

In addition to the basic findings regarding the importance of psychological similarity (more than demographic similarity), research indicates that other aspects of the mentoring relationship, such as mentor–protégé contact or interaction frequency (hereafter referred to as "contact"), need to be considered. That is, mentor–protégé contact may afford the opportunity to form a high-quality relationship but does not cause the formation of the relationship (Eby *et al.*, 2013). Contact frequency has been shown to have a small to moderate positive association with mentorship processes and relationship quality across disciplines and in college contexts (de Janasz and Gondshalk, 2013; Eby *et al.*, 2013). Furthermore, there is some evidence that contact frequency may strengthen or moderate the relationship between inputs (e.g., demographic match) and mentorship processes. For example, a recent study among faculty-mentored African-American undergraduates in STEM majors found a small positive association between gender match and coauthoring support among mentorship pairs with high levels of contact frequency, but no relationship between gender match and coauthoring among those with low levels of contact frequency (Hernandez *et al.*, 2017).

Outcomes of Mentorship

In addition to describing the factors that produce high-quality mentoring relationships, the POMM describes how mentoring processes may relate to protégé outcomes (e.g., research career commitment). Research in academic settings indicates that support and relationship satisfaction are positively related with academic success, a positive outlook toward the university, future career aspirations, and integration into STEM communities (Green and Bauer, 1995; Eby *et al.*, 2013; NASEM, 2019). Research on mentoring among students from URM groups in STEM majors has found small positive associations between mentoring support/satisfaction and both motivational outcomes (e.g., self-efficacy, identity, and community values) and STEM career behaviors (Haeger and Fresquez, 2016; Hernandez *et al.*, 2017; Estrada *et al.*, 2018). Although evidence for the POMM hypothesized relationship between mentoring qualities and academic outcomes is emerging, no studies have yet tested the full input–process–outcome model among Hispanic undergraduates in STEM.

Current Study

The present study aims to test hypotheses derived from the POMM about the input factors that influence mentorship processes, as well as the impact of mentorship processes on

STEM research career commitment among faculty-mentored Hispanic STEM majors in their senior year of college. As depicted in Figure 1, we hypothesized that the positive relationships between the mentoring inputs (i.e., psychological similarities and, to a lesser extent, demographic similarities) and the quality of mentorship (i.e., supports and relationship satisfaction), would be made stronger by more frequent contact (H1). Second, we hypothesized that protégé perceptions of supports would positively predict relationship satisfaction (H2). Third, we hypothesized that supports and relationship satisfaction would positively predict STEM research career commitment (H3).

METHODS

Participants

The current study used data from a national longitudinal study of undergraduates from groups historically underrepresented in STEM disciplines. The full longitudinal panel included 1420 college students pursuing degrees in a STEM field from 50 universities across the United States (Schultz *et al.*, 2011). The present study focused on self-identified Hispanic students (N = 472) who had a faculty mentor in their senior year (n = 212) and who completed survey measures related to mentorship qualities and outcomes (n = 186). The analytic sample of Hispanic students were high achieving (college GPA M = 3.37, SD = 0.40), majority female (67%), and majoring in a variety of STEM disciplines (58% biological sciences; 24% physical sciences, 12% behavioral/social sciences, and 6% engineering, technology, and mathematics disciplines).

Procedures

Initial recruitment of the longitudinal study involved a purposeful sampling strategy wherein participants recruited were either actively funded by minority science training programs or from a matched sample of unfunded minority students in foundational science courses. Participants were recruited into the study in the fall of 2005, 2006, or 2007 (i.e., cohorts 1–3) and responded to online surveys twice per year over the following 12 years. Participants received compensation ($25) in advance of their participation during each survey wave. This study was approved by the California State University San Marco's institutional review board (IRB# CSUSM-2005-085).

Measures

Faculty Mentorship. To assess faculty mentorship, participants read the following statement: "A mentor is someone who provides guidance, assistance, and encouragement on professional and academic issues. With this definition in mind, is there a faculty member you would consider a mentor?" (0 = no, 1 = yes). Only students who responded "yes" were asked a series of follow-up questions about inputs to and the processes of their mentoring relationships.

Mentor Demographic Characteristics and Demographic Similarities (Mentoring Input). Participants were asked about their mentors' demographics: gender (Female, Male) and race/ethnicity (African American/Black, Asian, Hispanic, Native American/Alaskan Native, White/non-Hispanic, unsure, other). Demographic information was used to derive mentor–protégé matched gender and matched racial/ethnic variables (0 = not matched, 1 = matched).

Psychological Similarity (Mentoring Input). The two-item perceived similarity scale was used to assess mentor–protégé psychological similarity (Turban and Jones, 1988). Participants rated their agreement with statements concerning similarities with their faculty mentors (i.e., "My mentor and I are similar in our outlook, perspective, and values." and "My mentor and I see things the same way.") on a scale from 1 (strongly disagree) to 5 (strongly agree). Responses were averaged to derive a composite score and, consistent with prior research (Turban and Jones, 1988), scale scores showed acceptable internal consistency reliability (Supplemental Table S1).

Contact Hours (Mentoring Correlate). Consistent with the mentoring literature (Eby *et al.*, 2013), participants reported the number of hours spent with their mentors on a weekly basis (i.e., "Approximately how many hours per week during the academic term do you spend with your mentor?"). Participant responses ranged from 0 to 40 hours per week.

Psychosocial and Career Support (Mentoring Process). A 15-item version of the Global Measure of Mentoring Practices Scale (Dreher and Ash, 1990) adapted to academic contexts (Tenenbaum *et al.*, 2001) was used. Participants responded to nine statements concerning the degree to which their faculty mentors provide *psychosocial support* (e.g., "To what extent has your mentor gone out of his or her way to promote your academic interests?") on a scale from 1 (not at all) to 5 (to a very large extent). Similarly, participants responded to five statements concerning *career support* (e.g., "To what extent has your mentor explored career options with you?") in an undergraduate context. To delineate between general career support and coauthoring support, one item concerning writing/coauthoring (i.e., "To what extent has your mentor helped you improve your writing skills?") was removed from the career support scale for all analyses. Responses were averaged to derive composite scores for each scale and, consistent with prior research (Tenenbaum *et al.*, 2001), scale scores showed acceptable internal consistency reliability (see Supplemental Table S1).

Evidence of measurement validity for the Global Measure of Mentoring Practices Scale in STEM contexts is limited, and no prior studies have examined measurement properties among Hispanic students in STEM (Hernandez, 2018). Therefore, we performed confirmatory factor analyses to provide novel evidence of measurement validity among Hispanic students in STEM disciplines (see Supplemental Tables S2 and S3).

Coauthoring Support (Mentoring Process). A five-item version of the Collaborative Coauthoring Scale (Bauer and Green, 1994) was used to assess faculty-mentored scholarship experiences in the last 6 months. Participants indicated whether they had participated in conference poster presentations, presented original research at an academic research fair or competition, given a presentation at a conference, submitted a paper for publication, or coauthored a paper accepted for publication (0 = no, 1 = yes). A coauthoring index was created by summing responses, with scores ranging from 0 to 5. Prior studies using the coauthoring scale have not provided evidence of internal structure measurement validity (Hernandez, 2018). We performed confirmatory factor analyses to provide novel evidence

of measurement validity among Hispanic students in STEM disciplines (see Supplemental Tables S2 and S3).

Relationship Satisfaction (Mentoring Outcome). The three-item satisfaction with mentor scale was used to assess relationship quality (Ensher and Murphy, 1997). Participants rated their agreement with statements concerning the quality of their relationship (e.g., "I am satisfied with my mentor.") on a scale from 1 (strongly disagree) to 5 (strongly agree). Responses were averaged to derive a composite score and, consistent with prior research (Ensher and Murphy, 1997), scale scores showed acceptable internal consistency (see Supplemental Table S1). Prior studies using this relationship quality scale have not provided evidence of internal structure measurement validity (Hernandez, 2018). We performed confirmatory factor analyses to provide novel evidence of measurement validity among Hispanic students in STEM disciplines (see Supplemental Tables S2 and S3).

Research Career Commitment (Outcome)

Participants responded to the question "To what extent do you intend to pursue a science related research career?" on a scale from 0 (not at all interested) to 10 (absolutely interested). This single-item measure of scientific research career commitment has been shown to relate to STEM graduate school applications, STEM graduate school enrollment, and postbaccalaureate STEM research career attainment (Estrada *et al.*, 2011, 2018; Hernandez *et al.*, 2017). Research career commitment was assessed at baseline (control variable) and senior year of college (outcome).

Preliminary Analyses

Before conducting substantive analyses, we performed confirmatory factor analyses to assess aspects of the measurement validity (i.e., internal structure and discriminant validity) of the psychosocial support, career support, coauthoring support, and relationship satisfaction constructs. Our analyses revealed good model fit and confirmed that the three support types and relationship satisfaction were distinguishable constructs (see Supplemental Tables S2 and S3).

Next, before addressing our hypotheses, we conducted a series of preliminary analyses to test the tenability of statistical assumptions. We tested for systematic missing data patterns among students with a faculty mentor using Little's MCAR test, which revealed that the missing data were consistent with missing completely at random ($\chi^2_{[df\,=\,76]} = 75.58$, $p = 0.49$). Given that participants were nested within 21 universities, we estimated intraclass correlation coefficients for the mentoring processes, relationship satisfaction, and research career commitment. The analyses revealed that career support and relationship satisfaction exhibited non-ignorable levels of between-university variability (i.e., 0.14 and 0.08, respectively). Therefore, university was recoded into a set of dummy variables and included as a control in analyses for those two outcomes. Outlier analyses using leverage values, studentized residuals, and Cook's *D* values (Judd *et al.*, 2011) revealed no extreme outliers. Finally, normality and homoscedasticity of residuals were assessed with QQ-plots and distributions of residual versus fitted values plots (Judd *et al.*, 2011)

Approach

All hypotheses were tested using multiple regression with robust standard error estimation. In addition, addressing H1 involved predicting a set of correlated outcomes (i.e., mentoring processes: psychosocial, career, and coauthoring support), and methodological research has shown that ignoring associations among outcomes can inflate type I error rate (Tabachnick *et al.*, 2007; Stevens, 2009). To control for type I error rate inflation, the mentoring processes were included as covariates when testing H1 (e.g., career and coauthoring supports were included as covariates in the model predicting psychosocial support). This approach allows us to assess of the unique impact of mentoring input variables, while accounting for correlations among mentoring processes. Finally, all continuous variables were standardized for ease of interpretation in substantive analyses. We interpret the regression coefficients using Cohen's guidelines for fully and partially standardized effects (Cohen, 1992).

RESULTS

First, we examined the descriptive statistics and patterns of bivariate associations (see Supplemental Table S1). Concerning mentor–protégé similarities, half of the sample had a same-gender mentor ($n = 93$), 29% had a Hispanic mentor ($n = 54$), and the average perception of psychological similarity was between "neutral" and "agree." Interestingly, the three metrics of similarity (gender match, race/ethnicity match, and psychological similarity) were not significantly correlated with one another or with contact frequency.

Main and Moderated influences of Inputs on Mentoring Processes

A series of multiple regression analyses were used to test main and moderated effects of mentoring inputs on the mentorship processes. First, psychosocial support was regressed on the mentoring inputs (i.e., protégé gender, mentor gender, mentor–protégé gender-match, race/ethnicity match, and perceived similarity), the correlated mentoring processes (career and coauthoring support), mentoring correlates (contact hours), and two-way moderation terms between contact and the match/similarity variables. The overall model was significant and explained a large proportion of variance in psychosocial support ($R^2 = 0.58$; Table 1, note a). Partially consistent with our expectations (H1), psychological similarity was a moderate positive predictor of psychosocial support ($\beta = 0.32$), indicating that higher levels of similarity were associated with receiving higher levels of support (Table 1). In addition, we found that female protégés reported receiving slightly more psychosocial support than their male peers. However, inconsistent with our expectations, contact hours did not moderate the relationship between mentoring similarities and support (H1).

Next, career support was regressed on all mentoring inputs, processes, correlates, moderation terms, and university indicator variables to control for nesting. The model explained a large proportion of variance in career support; however, inconsistent with our expectations (H1), none of the mentoring inputs or moderation terms were uniquely predictive of career support after controlling for the associations with psychosocial and coauthoring support (Table 1).

Next, coauthoring was regressed on all mentoring inputs, processes, correlates, and moderation terms. The overall model

TABLE 1. Summary of regression model tests and coefficients predicting mentoring processes (*N* = 186)[a]

Predictor	Psychosocial support		Career support		Coauthoring		Relationship satisfaction	
	β	95% CI [LL, UL]	β	95% CI [LL, UL]	β	95% CI [LL, UL]	β	95% CI [LL, UL]
1. Female status protégé	**0.28**	**[0.05, 0.52]**	–0.14	[–0.37, 0.09]	0.13	[–0.17, 0.42]	–0.15	[–0.36, 0.05]
2. Female status mentor	0.09	[–0.14, 0.31]	–0.003	[–0.20, 0.21]	**–0.33**	**[–0.63, –0.04]**	–0.05	[–0.26, 15]
3. Matched gender (M.G.)	0.12	[–0.11, 0.35]	–0.01	[–0.23, 0.20]	0.13	[–0.16, 0.42]	0.09	[–0.12, 0.30]
4. Matched race/ethnicity (M.R/E.)	–0.20	[–0.45, 0.04]	–0.01	[–0.25, 0.22]	**0.32**	**[0.02, 0.63]**	0.08	[–0.14, 0.30]
5. Contact (C)	0.09	[–0.03, 0.22]	–0.01	[–0.15, 0.13]	0.19	[–0.01, 0.39]	**–0.20**	**[–0.32, –0.08]**
6. Psychological similarity (P.S.)	**0.32**	**[0.18, 0.47]**	0.16	[–0.02, 0.34]	–0.04	[–0.21, 0.14]	**0.25**	**[0.12, 0.37]**
7. M.G. × C	–0.19	[–0.38, 0.01]	0.01	[–0.19, 0.21]	0.28	[–0.01, 0.579]	**0.20**	**[0.004, 0.40]**
8. M.R/E. × C	0.04	[–0.19, 0.28]	0.01	[–0.22, 0.24]	–0.11	[–0.39, 0.18]	0.10	[–0.09, 0.30]
9. P.S. × C	–0.05	[–0.15, 0.06]	0.09	[–0.01, 0.20]	–0.04	[–0.18, 0.10]	–0.001	[–0.09, 0.09]
10. Psychosocial support	—	—	**0.55**	**[0.40, 0.70]**	–0.08	[–0.25, 0.10]	**0.25**	**[0.12, 0.37]**
11. Career support	**0.50**	**[0.35, 0.65]**	—	—	**0.29**	**[0.13, 0.45]**	**0.34**	**[0.20, 0.49]**
12. Coauthoring	–0.04	[–0.13, 0.05]	**0.15**	**[0.04, 0.25]**	—	—	–0.04	[–0.13, 0.05]

[a]Summaries of model tests are as follows: psychosocial support $F(11, 174) = 19.79$, $p < 0.001$, $R^2 = 0.58$; career support $F(27, 154) = 63.37$, $p < 0.001$, $R^2 = 0.63$; coauthoring $F(11, 174) = 6.30$, $p < 0.001$, $R^2 = 0.19$; relationship satisfaction $F(28, 153) = 61.19$, $p < 0.001$, $R^2 = 0.73$. Bolded coefficients are statistically significant at alpha level < 0.05. Coefficients for values for dummy-coded school indicators predicting career support and relationship satisfaction are not shown for the sake of parsimony. 95% CI = confidence interval around regression coefficient (β) values.

was significant and explained a moderate proportion of variance in coauthoring support (Table 1, note a). Partially consistent with our expectations (H1), protégés with Hispanic mentors experienced slightly more coauthoring support than their peers with non-Hispanic mentors (see Table 1). In addition, protégés with male mentors reported slightly more coauthoring support than those with female mentors (see Table 1). Inconsistent with expectations, contact hours did not moderate the relationship between mentoring similarities and support (H1).

Finally, the mentoring proximal outcome of relationship satisfaction was regressed on all mentoring inputs, processes, correlates, moderation terms, and university indicator variables to control for nesting. The model explained a large proportion of variance in satisfaction (Table 1, note a) and partially consistent with our expectations (H2), psychosocial support, career support, and psychological similarity were moderate to strong positive predictors of satisfaction. The findings indicate that higher levels of similarity and support were associated with higher levels of satisfaction (Table 1). Furthermore, the analyses revealed that contact hours moderated the relationship between mentor–protégé matched-gender status and relationship satisfaction (H1; Table 1). A simple slopes graph revealed that, for those with high contact, protégés with a same-gender mentor reported higher relationship satisfaction that those with different-gender mentors ($M_{Matched} = 0.08$; $M_{Different} = –0.21$). However, for those with low contact, there was no significant difference in relationship satisfaction for protégés with same- or different-gender mentors ($M_{Matched} = 0.02$; $M_{Different} = 0.13$; Figure 2).

Influence of Mentoring Processes on Research Career Commitment
To test our third hypothesis, research career commitment was regressed on the mentoring processes and relationship satisfaction, controlling for mentoring inputs and baseline research career commitment. The overall model explained a moderate proportion of variance in commitment, $F(5, 180) = 4.83$, $p < 0.001$, $R^2 = 0.16$. Partially consistent with our expectations (H3), coauthoring exhibited a small positive association with research career commitment, β = 0.16, 95% CI [0.03, 0.29],

after controlling for the influence of baseline commitment, β = 0.31, 95% CI [0.11, 0.51].

DISCUSSION
The current study aimed to address gaps in the mentoring literature about factors that help Hispanic college seniors in STEM fields both develop high-quality faculty mentoring relationships and experience the benefits related to mentorship (Luna and Prieto, 2009; NASEM, 2019). Guided by the POMM framework and the extant literature on mentoring Hispanic undergraduates (Ortiz-Walters and Gilson, 2005; Eby *et al.*, 2013; Hernandez *et al.*, 2017; Estrada *et al.*, 2018), we hypothesized that the benefits of mentor–protégé demographic and psychological similarities on support and satisfaction would be made stronger by higher levels of contact frequency. The regression results were both nuanced and only partially consistent with our expectations. Specifically, protégés' perceptions of psychological similarity with their mentors showed consistent (i.e., not moderated by contact) moderate unique associations with affective facets of the mentoring relationship (i.e., psychosocial support and satisfaction); but psychological similarity was not uniquely associated with skills-focused facets of mentorship (i.e., career and coauthoring support). These findings were partially consistent with associations found among African-American undergraduates in STEM (Hernandez *et al.*, 2017), which also showed constant positive associations between psychological similarity and affective facets of mentorship. Taken together, these findings support theoretical work based on the similarity-attraction paradigm, which proposed that perceived or psychological similarities are foundational for the development of affective relationship qualities, such as liking and friendship (Ensher and Murphy, 1997; Harrison *et al.*, 1998; Ensher *et al.*, 2002; Gehlbach *et al.*, 2016; Menges, 2016). Furthermore, it is probable that psychological similarity and affective aspects of mentoring relationships are mutually or reciprocally reinforcing. For example, identification of similarities leads to deeper levels of personal self-disclosure—an aspect of psychosocial support (Brockner and Swap, 1976), which in turn may afford the opportunity to identify additional similarities and develop stronger relational bonds.
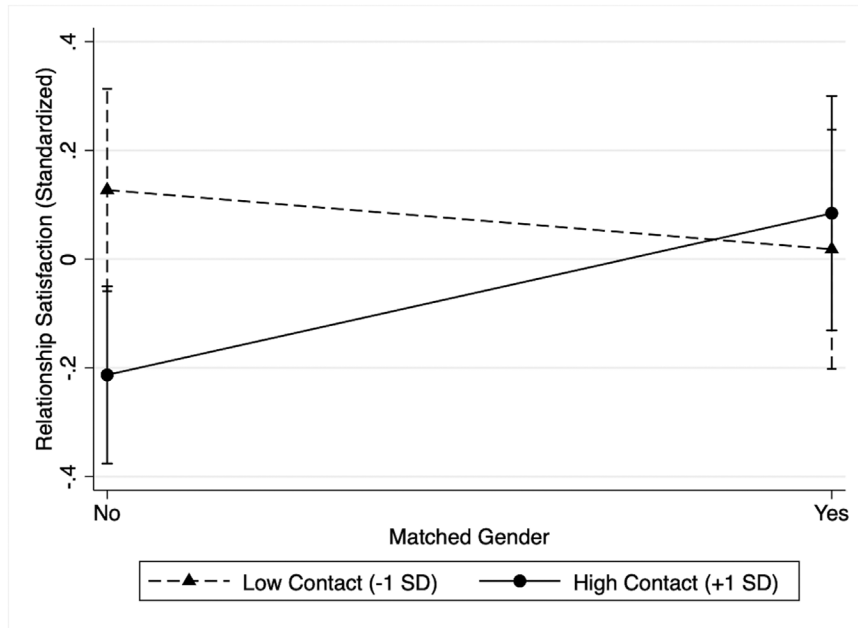
FIGURE 2. Simple slopes graph of the matched gender by contact moderation on relationship satisfaction. Error bars represent 95% confidence intervals.

Our study also revealed that demographic similarities have nuanced associations with affective and career-related mentoring support. For example, among Hispanic undergraduates in STEM, having a Hispanic faculty mentor was consistently, uniquely, and positively associated with coauthoring support. This novel finding extends a pattern seen among a predominantly White sample of college students in STEM (Blake-Beard et al., 2011), as well as graduate students of color (i.e., African American, Native American, and Hispanic), which found small positive associations between matched race status and mentorship support (Ortiz-Walters and Gilson, 2005). However, this finding deviates from negligible associations found between matched race/ethnicity status among a sample of African-American students in STEM (Hernandez et al., 2017). The benefits associated with having a same-gender faculty mentor are weaker and more nuanced. That is, Hispanic protégés with a same-gender faculty mentor reported slightly higher levels of relationship satisfaction than those with a different-gender mentor; however, this pattern only manifested among those with high contact frequency.

Taken together, these findings indicate that, for Hispanic undergraduates in STEM, the benefits associated with mentor–protégé demographic or psychological similarity are contingent on both the type of support and the amount of time spent interacting with the faculty mentor. That is, no one type of similarity or configuration of similarities was associated with all facets of mentorship quality. Rather, our research indicates that Hispanic protégés in STEM can benefit from a variety of similarities with their faculty mentors. The implication of this finding for mentors and protégés alike is that their efforts to mutually explore and identify shared similarities to enhance the formation and maintenance of these critical relationships has benefits (Robinson et al., 2019).

A second aim of this study was to test the POMM-derived hypothesis that mentoring support functions would promote relationship satisfaction, over and above the influence of mentoring inputs (Eby et al., 2008, 2013). Partially consistent with expectations, protégés who experienced both psychosocial and career support were more likely to report satisfaction with their mentors, but coauthoring support was unrelated. This finding is consistent with patterns found among African-American college seniors in STEM (Hernandez et al., 2017). Finally, we aimed to test the hypothesis that protégés' experiences of support and satisfaction would uniquely predict their scientific research career commitment, over and above prior commitment (Eby et al., 2008, 2013). When protégés reported coauthoring support, they were more likely to also report commitment to pursuing a STEM research career. This pattern of results is consistent with associations found between coauthoring and commitment among African-American undergraduates in STEM, wherein coauthoring was found to have a positive effect on STEM persistence (Hernandez et al., 2017). Taken together, the patterns appear to indicate that protégés' relational satisfaction (a proximal predictor of subjective and objective outcomes) is more contingent on general types of support (i.e., empathy, challenging assignments) than on specific support related to scholarship among undergraduates. However, scholarship-specific support, such as coauthoring, is uniquely important for helping protégés (particularly protégés of color) crystallize their scientific research career aspirations.

Although this study addresses several gaps in the literature on mentoring Hispanic undergraduates in STEM, there were several factors that limit the scope or generalizability of our findings. First, this study used a cross-sectional design to assess the relationships between mentoring inputs, mentoring processes, and subjective mentoring outcomes in a sample of Hispanic students in STEM in their senior year of college. Future longitudinal work is needed to determine whether the patterns observed are consistent (or change) throughout a student's undergraduate tenure. Specifically, longitudinal work may aid in explaining the inconsistencies in the literature around relationship duration (contact hours) and demographic similarities (Turban et al., 2002; Eby et al., 2013), as the results in this study found these hypothesized relationships to be nonsignificant. Furthermore, our focus on the senior year of college may not generalize well to earlier time points in the college tenure, as career plans may have solidified by this time. While some studies have assessed the impact of mentorship qualities in students earlier in their college tenure (e.g., Hernandez et al., 2020), future studies should consider the impacts of mentorship in URM populations at earlier times in college. Second, given that the current sample is made up primarily of students in the biological sciences, future research should be conducted

within other STEM majors to examine any variation across disciplines. Third, mentoring supports measured in this study only included positive interactions, which do not reflect the full range of mentoring processes—including role modeling and negative experiences (NASEM, 2019). In addition, our measure of coauthoring support is well aligned with research mentor interactions (a common situation in STEM disciplines); however, some students in our study may not have been conducting research with their identified faculty mentors. Thus, future studies should clarify whether the student protégés are conducting research with their faculty mentors to more fully illuminate the nature of coauthoring support. Furthermore, the present study measured limited aspects of psychological similarity (i.e., outlook and values), but other facets of psychological similarity (attitudes, preferred activities, personality traits, self-regulatory style, humor, etc.) may be relevant to mentor–protégé relationship quality (Montoya *et al.*, 2008; Gehlbach *et al.*, 2016; Robinson *et al.*, 2019). Future studies should measure a wider range of similarity-related facets.

Although the findings of this study are nuanced, the implications of the work are clear. First, the POMM is a robust theoretical framework for informing future research and practice in mentoring. The POMM provides a useful framework for generating hypotheses about the inputs to and outcomes of mentoring relationships—although more work is needed on moderating factors. Similarly, practitioners can use the POMM to identify factors within their purview that can enhance the development of high-quality supportive and satisfying mentoring relationships. Second, faculty mentors and their Hispanic protégés can benefit from engaging in deliberate efforts to explore and find shared similarities (demographics or psychological) to enhance the quality of their relationships. For example, practitioners and mentors could integrate activities such as "Birds of a Feather" matching or the career informal interview (Gehlbach *et al.*, 2016; Branchaw *et al.*, 2020) to afford mentors and protégés the opportunity to identify similarities and engage in self-disclosure. Shared similarities help protégés form stronger emotional and career-related bonds with their mentors. Third, given that increased coauthoring support helps Hispanic students in STEM to solidify their scientific research career commitment, efforts should be made to expand these opportunities. Coauthoring support (conference posters or papers, publications, etc.) appears to provide an optimal opportunity for mentors and protégés to synthesize their collaboration and give and receive constructive feedback and helps protégés strengthen their commitment to the field.

ACKNOWLEDGMENTS

REFERENCES

Allen, W. R., Epps, E. G., Guillory, E. A., Suh, S. A., & Bonous-Hammarth, M. (2000). The black academic: Faculty status among African Americans in U.S. higher education. *Journal of Negro Education*, *69*(1/2), 112–127.

Bauer, T. N., & Green, S. G. (1994). Effect of newcomer involvement in work-related activities: A longitudinal study of socialization. *Journal of Applied Psychology*, *79*(2), 211.

Blake-Beard, S., Bayne, M. L., Crosby, F. J., & Muller, C. B. (2011). Matching by race and gender in mentoring relationships: Keeping our eyes on the prize. *Journal of Social Issues*, *67*(3), 622–643.

Bordes, V., & Arredondo, P. (2005). Mentoring and 1st-year Latina/o college students. *Journal of Hispanic Higher Education*, *4*(2), 114–133. https://doi.org/10.1177/1538192704273855

Bordes-Edgar, V., Arredondo, P., Kurpius, S. R., & Rund, J. (2011). A longitudinal analysis of Latina/o students' academic persistence. *Journal of Hispanic Higher Education*, *10*(4), 358–368.

Branchaw, J. L., Butz, A. R., & Smith, A. R. (2020). Evaluation of the second edition of entering research: a customizable curriculum for apprentice-style undergraduate and graduate research training programs and courses. *CBE—Life Sciences Education*, *19*(1), ar11.

Brockner, J., & Swap, W. C. (1976). Effects of repeated exposure and attitudinal similarity on self-disclosure and interpersonal attraction. *Journal of Personality and Social Psychology*, *33*(5), 531–540. https://doi.org/10.1037/0022-3514.33.5.531

Campbell, T. A., & Campbell, D. E. (2007). Outcomes of mentoring at risk college students: Gender and ethnic matching effects. *Mentoring & Tutoring*, *15*(2), 135–148. https://doi.org/10.1080/13611260601086287

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Crisp, G., & Cruz, I. (2009). Mentoring college students: A critical review of the literature between 1990 and 2007. *Research in Higher Education*, *50*(6), 525–545. https://doi.org/10.1007/s11162-009-9130-2

Crisp, G., & Nora, A. (2012). *Overview of Hispanics in science, mathematics, engineering and technology (STEM): K–16 representation, preparation and participation*. San Antonio, TX: Hispanic Association of Colleges and Universities.

Davis, D. J. (2009). The academic influence of mentoring upon African American undergraduate aspirants to the professoriate. *Urban Review*, *42*(2), 143–158. https://doi.org/10.1007/s11256-009-0122-5

de Janasz, S. C., & Godshalk, V. M. (2013). The role of e-mentoring in proteges' learning and satisfaction. *Group & Organization Management*, *38*(6), 743–774. https://doi.org/10.1177/1059601113511296

Dickson, J., Kirkpatrick-Husk, K., Kendall, D., Longabaugh, J., Patel, A., & Scielzo, S. (2014). Untangling protégé self-reports of mentoring functions: Further meta-analytic understanding. *Journal of Career Development*, *41*(4), 263–281. https://doi.org/10.1177/0894845313498302

Dreher, G. F., & Ash, R. A. (1990). A comparative study of mentoring among men and women in managerial, professional, and technical positions. *Journal of Applied Psychology*, *75*(5), 539.

Eby, L. T., Allen, T. D., Evans, S. C., Ng, T., & Dubois, D. (2008). Does mentoring matter? A multidisciplinary meta-analysis comparing mentored and non-mentored individuals. *Journal of Vocational Behavior*, *72*(2), 254–267. https://doi.org/10.1016/j.jvb.2007.04.005

Eby, L. T., Allen, T. D., Hoffman, B. J., Baranik, L. E., Sauer, J. B., Baldwin, S., ... & Evans, S. C. (2013). An interdisciplinary meta-analysis of the potential antecedents, correlates, and consequences of protégé perceptions of mentoring. *Psychological Bulletin*, *139*(2), 441–476. https://doi.org/10.1037/a0029279

Ensher, E. A., & Murphy, S. E. (1997). Effects of race, gender, perceived similarity, and contact on mentor relationships. *Journal of Vocational Behavior*, *50*(3), 460–481.

Ensher, E. A., Grant-Vallone, E. J., & Marelich, W. D. (2002). Effects of perceived attitudinal and demographic similarity on protégés' support and satisfaction gained from their mentoring relationships. *Journal of Applied Social Psychology*, *32*(7), 1407–1430.

Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., ... & Zavala, M. (2016). Improving underrepresented minority student persistence in STEM. *CBE—Life Sciences Education*, *15*(3), es5. https://doi.org/10.1187/cbe.16-01-0038

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE—Life Sciences Education*, *17*(1), ar9. https://doi.org/10.1187/cbe.17-04-0066

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology*, *103*(1), 206.

Gehlbach, H., Brinkworth, M. E., King, A. M., Hsu, L. M., McIntyre, J., & Rogers, T. (2016). Creating birds of similar feathers: Leveraging similarity to improve teacher–student relationships and academic achievement. *Journal of Educational Psychology*, *108*(3), 342.

Green, S. G. (1991). Professional entry and the adviser relationship: Socialization, commitment, and productivity. *Group & Organization Studies*, *16*(4), 387–407. https://doi.org/10.1177/105960119101600404

Green, S. G., & Bauer, T. N. (1995). Supervisory mentoring by advisers: Relationships with doctoral student potential, productivity and commitment. *Personnel Psychology*, *48*(3), 537–562. https://doi.org/10.1111/j.1744-6570.1995.tb01769.x

Griffin, K. A., & Reddick, R. J. (2011). Surveillance and sacrifice. *American Educational Research Journal*, *48*(5), 1032–1057. https://doi.org/10.3102/0002831211405025

Haeger, H., & Fresquez, C. (2016). Mentoring for inclusion: The impact of mentoring on undergraduate researchers in the sciences. *CBE—Life Sciences Education*, *15*(3), ar36.

Harrison, D. A., Price, K. H., & Bell, M. P. (1998). Beyond relational demography: Time and the effects of surface-and deep-level diversity on work group cohesion. *Academy of Management Journal*, *41*(1), 96–107.

Hernandez, P. R. (2018). *Landscape of assessments of mentoring relationship processes in postsecondary STEMM contexts: A synthesis of validity evidence from mentee, mentor, institutional/programmatic perspectives* (Paper commissioned by the Committee on the Science of Effective Mentorship in STEMM). Retrieved October 15, 2021, from www.nap.edu/catalog/25568/the-science-of-effective-mentorship-in-stemm

Hernandez, P. R., Agocha, V. B., Carney, L. M., Estrada, M., Lee, S. Y., Loomis, D., … & Park, C. L. (2020). Testing models of reciprocal relations between social influence and integration in STEM across the college years. *PLoS ONE*, *15*(9), e0238250. https://doi.org/10.1371/journal.pone.0238250

Hernandez, P. R., Estrada, M., Woodcock, A., & Schultz, P. W. (2017). Protégé perceptions of high mentorship quality depend on shared values more than on demographic match. *Journal of Experimental Education*, *85*(3), 450–468.

Hispanic Heritage Foundation, Student Research Foundation, & Google. (2020). *Hispanics in STEM*. Retrieved October 15, 2021, from https://www.studentresearchfoundation.org/wp-content/uploads/2020/04/Hispanics_STEM_Report_Final-1.pdf

Holloway-Friesen, H. (2021). The role of mentoring on Hispanic graduate students' sense of belonging and academic self-efficacy. *Journal of Hispanic Higher Education*, *20*(1), 46–58. https://doi.org/10.1177/1538192718823716

Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., … & Dilig, R. (2020). *The condition of education 2020 (NCES 2020-144)*. Washington, DC: U.S. Department of Education.

Jacobi, M. (1991). Mentoring and undergraduate academic success: A literature review. *Review of Educational Research*, *61*(4), 505–532. https://doi.org/10.2307/1170575

Joshi, M., Aikens, M. L., & Dolan, E. L. (2019). Direct ties to a faculty mentor related to positive outcomes for undergraduate researchers. *BioScience*, *69*(5), 389–397. https://doi.org/10.1093/biosci/biz039

Judd, C. M., McClelland, G. H., & Ryan, C. S. (2011). *Data analysis: A model comparison approach*. New York, NY: Routledge.

Luna, V., & Prieto, L. (2009). Mentoring affirmations and interventions: A bridge to graduate school for Latina/o students. *Journal of Hispanic Higher Education*, *8*(2), 213–224. https://doi.org/10.1177/1538192709331972

Malcom, S., & Feder, M. (2016). *Barriers and opportunities for 2-year and 4-year STEM degrees: Systemic change to support students' diverse pathways*. Washington, DC: National Academies Press. https://doi.org/10.17226/21739

Menges, C. (2016). Toward improving the effectiveness of formal mentoring programs: Matching by personality matters. *Group & Organization Management*, *41*(1), 98–129.

Montoya, R. M., Horton, R. S., & Kirchner, J. (2008). Is actual similarity necessary for attraction? A meta-analysis of actual and perceived similarity. *Journal of Social and Personal Relationships*, *25*(6), 889–922. https://doi.org/10.1177/0265407508096700

Morales, D. X., Grineski, S. E., & Collins, T. W. (2021). Effects of mentor–mentee discordance on Latinx undergraduates' intent to pursue graduate school and research productivity. *Annals of the New York Academy of Sciences*, *1499*(1), 54–69. https://doi.org/10.1111/nyas.14602

National Academies of Sciences Engineering and Medicine (NASEM). (2019). *The Science of Effective Mentorship in STEMM*. Washington, DC: National Academies Press. https://doi.org/doi: 10.17226/25568

NASEM. (2020). *Promising practices for addressing the underrepresentation of women in science, engineering, and medicine: Opening doors*. Washington, DC: National Academies Press. https://doi.org/10.17226/25585

National Center for Science and Engineering Statistics (2021). *Women, minorities, and persons with disabilities in science and engineering: 2021 (Special Report NSF 21-321)*. Retrieved October 7, 2021, from https://ncses.nsf.gov/wmpd

Ortiz-Walters, R., & Gilson, L. L. (2005). Mentoring in academia: An examination of the experiences of protégés of color. *Journal of Vocational Behavior*, *67*(3), 459–475. https://doi.org/10.1016/j.jvb.2004.09.004

Paglis, L. L., Green, S. G., & Bauer, T. N. (2006). Does adviser mentoring add value? A longitudinal study of mentoring and doctoral student outcomes. *Research in Higher Education*, *47*(4), 451–476. https://doi.org/10.1007/s11162-005-9003-2

Phinney, J. S., Torres Campos, C. M., Padilla Kallemeyn, D. M., & Kim, C. (2011). Processes and outcomes of a mentoring program for Latino college freshmen. *Journal of Social Issues*, *67*(3), 599–621. https://doi.org/10.1111/j.1540-4560.2011.01716.x

Robinson, C. D., Scott, W., & Gottfried, M. A. (2019). Taking it to the next level: A field experiment to improve instructor-student relationships in college. *AERA Open*, *5*(1), 2332858419839707. https://doi.org/10.1177/2332858419839707

Rodríguez, L. F., & Oseguera, L. (2015). Our deliberate success. *Journal of Hispanic Higher Education*, *14*(2), 128–150. https://doi.org/10.1177/1538192715570637

Schultz, P. W., Hernandez, P. R., Woodcock, A., Estrada, M., Chance, R. C., Aguilar, M., & Serpe, R. T. (2011). Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. *Educational Evaluation and Policy Analysis*, *33*(1), 95–114.

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). New York, NY: Routledge.

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). *Using multivariate statistics* (Vol. 5, pp. 481–498). Boston, MA: Pearson.

Tenenbaum, H. R., Crosby, F. J., & Gliner, M. D. (2001). Mentoring relationships in graduate school. *Journal of Vocational Behavior*, *59*(3), 326–341.

Torres, V., & Hernandez, E. (2009). Influence of an identified advisor/mentor on urban Latino students' college experience. *Journal of College Student Retention: Research, Theory & Practice*, *11*(1), 141–160. https://doi.org/10.2190/CS.11.1.h

Torres Campos, C. M., Phinney, J. S., Perez-Brena, N., Kim, C., Ornelas, B., Nemanim, L., … & Ramirez, C. (2009). A mentor-based targeted intervention for high-risk latino college freshmen: A pilot study. *Journal of Hispanic Higher Education*, *8*(2), 158–178.

Turban, D. B., Dougherty, T. W., & Lee, F. K. (2002). Gender, race, and perceived similarity effects in developmental relationships: The moderating role of relationship duration. *Journal of Vocational Behavior*, *61*(2), 240–262.

Turban, D. B., & Jones, A. P. (1988). Supervisor-subordinate similarity: Types, effects, and mechanisms. *Journal of Applied Psychology*, *73*(2), 228.

Umbach, P. D. (2006). The contribution of faculty of color to undergraduate education. *Research in Higher Education*, *47*(3), 317–345. https://doi.org/10.1007/s11162-005-9391-3

Valantine, H. A., & Collins, F. S. (2015). National Institutes of Health addresses the science of diversity. *Proceedings of the National Academy of Sciences USA*, *112*(40), 12240–12242. https://doi.org/10.1073/pnas.1515612112

Woodcock, A., Hernandez, P. R., Estrada, M., & Schultz, P. W. (2012). The consequences of chronic stereotype threat: Domain disidentification and abandonment. *Journal of Personality and Social Psychology*, *103*(4), 635–646. https://doi.org/10.1037/A0029120