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ARTICLE

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Promoting sense of belonging and interest in the geosciences among undergraduate women through mentoring

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ABSTRACT

Efforts to diversify STEM fields have not completely eliminated higher rates of women leaving certain science, technology, engineering, and mathematics (STEM) disciplines, such as geosciences. A diverse mentorship network is linked to persistence in STEM among college students, but little is known about how it leads to persistence. In particular, does a student's sense of belonging mediate the relationship between the diversity of one's mentor network and persistence in a field? This longitudinal study investigated whether students' university sense of belonging mediates the relationship between the diversity of mentor networks and interest in geoscience. 253 college women in STEM majors from nine U.S. universities reported on the diversity of their mentor networks, university belongingness, and interest in geoscience from Spring 2018 to Spring 2019. Consistent with our hypotheses, mediation analysis revealed a statistically and practically significant indirect effect of the diversity of mentor networks on interest development through university belonging.

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Introduction

Diversifying the science, technology, engineering, and mathematics (STEM) workforce is a national priority to achieve equity and innovation goals (National Institute of Health [NIH], 2019; Valantine, Lund, & Gammie, 2016). Theory and empirical evidence indicate that gender diversity improves science by promoting creativity, impact, and transformative innovations (Nielsen et al.,

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2017; Peter et al., 2021). Therefore, promoting diversity and inclusivity in STEM fields (Nielsen et al., 2017) is not only a matter of equity, but it also has the potential to drive scientific progress and innovation. Yet, the underrepresentation of women and some racial/ethnic minority groups remains a significant issue in many STEM disciplines (National Center for Science and Engineering Statistics [NCSES], 2021). Two extreme examples concern computer science and engineering, where only 20% of bachelor's degree recipients in computer science and 19% in engineering are women (National Center for Science and Engineering Statistics [NCSES], 2021). Similarly, women continue to be underrepresented in earth systems and environmental sciences (hereafter referred to as the geosciences) at all levels of higher education and the workforce (National Center for Science and Engineering Statistics [NCSES], 2021). Although the percentage of undergraduate women in the geosciences has fluctuated over time, representation peaked at 49% in 2004 before dropping to 40.6% in 2017 (Chen, 2014; National Center for Science and Engineering Statistics [NCSES], 2021).

Exploring the factors that contribute to women's underrepresentation in some STEM fields has the potential to inform efforts to diversify the STEM workforce. Convergent lines of research are beginning to point to the joint influences of interest development, sense of belonging, and mentorship on women's persistence in male-dominated STEM fields, such as the geosciences. Therefore, the central focus of this study is on the relationship between the degree of diversity of mentor networks, university belonging, and interest development among undergraduate women pursuing geoscience-related STEM degrees.

Underrepresentation of women in STEM – a problem of precluded interest

Women pursuing degrees and careers in male-dominated STEM fields face a range of gendered obstacles, including negative gender stereotypes and perceived incongruity with the people, work, and social values in their field (Diekmann, Brown, Johnston, & Clark, 2010). For instance, one study found that the presence of masculine decorations in a STEM classroom strengthened negative gendered stereotypes of STEM fields, while changing decorations to be less masculine minimized the stereotypes (Cheryan & Plaut, 2010). Importantly, research indicates that perceptions of similarity to others in a degree/career field, which is linked to sense of belonging, is key to promoting deeper levels of interest and involvement in that field (Cheryan & Plaut, 2010). Therefore, gendered obstacles to perceived similarity with others and sense of belonging can preclude women's interest in entering or discourage continuing in male-dominated STEM fields (Berhe et al., 2022). Understanding the factors that cultivate interest are critical, as interest is linked to learning, academic

performance, and the choice to take advanced coursework in STEM fields (Hidi & Renninger, 2006; Schiefele, Krapp, & Winteler, 1992).

Interest development

There is a rich history of research on interest in educational settings (Bian, Leslie, Murphy, & Cimpian, 2018; Cheryan, Ziegler, Montoya, & Jiang, 2017; Master, Meltzoff, & Cheryan, 2021), where interest is defined as ‘a psychological state of engaging or the predisposition to reengage with classes of objects, events, or ideas over time’ (Hidi & Renninger, 2006). Hidi and Renninger (2006) identified four phases of increasing interest development that include: (1) short-term *triggered situational interest* that results from a cognitively or emotionally stimulating interaction in a content area, (2) medium-term *maintained situational interest* that results from sustained attention and interactions in a content area, (3) longer-term *emerging individual interest* that results from developing a disposition to repeatedly reengage with the content over-time, and (4) long-term *well-defined individual interest* that results from having fully developed a strong disposition to continually reengaging with a content area over a long period of time. And more developed levels of interest, in turn promote effort, learning, and academic choices (Bernacki & Walkington, 2018; Renninger & Hidi, 2019).

Recent advancements in theory have elaborated the social influences that operate as inputs to promote interest development (Bergin, 2016). As shown in Figure 1, the social influence model of interest development posits that social support (i.e. the provision of information, opportunities, or resources) from a variety of sources (e.g. parents, peers/friends, and mentors) can promote developing deeper levels of interest (Bergin, 2016). More specifically, there are two routes by which social support can promote interest. One route indicates that social support from parents or peers can lead to exposure to an exhilarating topic. Combined with attention, exposure to an exhilarating topic can trigger

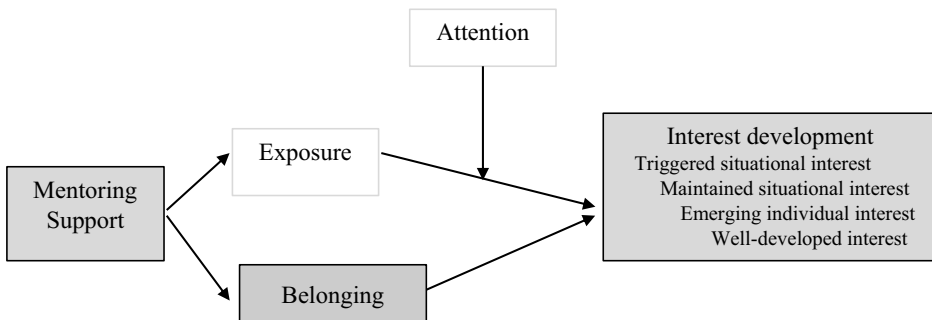


Figure 1. Theory model of mentoring support influences interest development by increasing exposure and belonging. In the current study, we will only focus on elements shaded in grey.

a person's situational interest in the topic. A second route indicates that social support from affinity group members (e.g. mentors in the STEM community) can promote perceived similarity with and a sense of belonging in that affinity group (e.g. STEM field of choice). And sense of belonging is, in turn, theorized to play a key role in promoting maintained, emerging, and well-developed interest.

Belonging

The need to belong, which can be defined as the pervasive human desire to have positive and close relationships with others, has been conceptualized as a basic human need (Baumeister & Leary, 1995). Theory and research indicate that the motivation to develop a sense of belonging with others and thereby satisfy the need to belong drives a variety of psychological processes and behaviors (Deci & Ryan, 2000). In academic settings, the sense of belonging has been classified and studied at different levels of abstraction: such as class belonging (Goodenow, 1993), professor's pedagogical caring (Lewis et al., 2017), social acceptance (Ribera, Miller, & Dumford, 2017), and university belonging (Museus, Yi, & Saelua, 2017; Shook & Clay, 2012). According to Freeman, Anderman, and Jensen (2007), social acceptance, professors' pedagogical caring, and class belonging are significantly and positively correlated and predictive of students' overall university sense of belonging. Importantly, research indicates that sense of belonging is positively correlated with a variety of academic outcomes, including engagement, motivation, academic performance, intention to persist in a STEM field, and educational attrition or dropout – particularly for women in STEM (Cheryan, Plaut, Davies, & Steele, 2009; Korpershoek, Canrinus, Fokkens-Bruinsma, & de Boer, 2020; Shook & Clay, 2012).

Belongingness promotes interest development

As noted above, the second route in the social influence model of interest development posits that sense of belonging plays an important role in mediating the effect of social supports on interest development. The importance of belonging in promoting interest development has been investigated in previous research. For example, research among high school students indicates that perceiving a greater sense of belonging to a field can significantly increase women students' interest, persistence, and intention to pursue a career in the STEM fields (Ito & McPherson, 2018). Furthermore, college STEM student's sense of belonging is a crucial factor linked to developing deeper levels of interest in a major (Museus, Yi, & Saelua, 2017) and ultimately retention in STEM fields (Good, Rattan, & Dweck, 2012). By contrast, Murphy, Steele, and Gross (2007) reported that undergraduate women experience more belonging uncertainty and become more sensitive to belongingness threats than their male peers,

which ultimately leads to a higher dropout rate from STEM majors. Women, as the minority group in some STEM fields such as geosciences, may also experience belonging uncertainty and lack of social connections to their discipline (Walton & Cohen, 2007). Research indicates that when women feel less valued, less welcomed, or feel pushed away by the chilly climate in STEM disciplines, they are more likely to lose their interest (Hausmann, Schofield, & Woods, 2007), switch to another field, or even drop out of college (Layous et al., 2017). While it is clear that belonging is linked to interest development, there has been scant research on the degree to which different sources of social support (e.g. access to a diverse network of mentors) promotes women's sense of university belonging and, in turn their interest in a specific STEM domain, such as the geosciences.

Mentoring

The social influence model of interest development posits that affinity group members can be an important source of support to promote belonging and thereby interest. And in academic STEM contexts, mentors (e.g. faculty members, graduate students, or peers) are typically the STEM affinity group members that provide social support (National Academies of Sciences Engineering and Medicine [NASEM], 2019). Mentoring is an inclusive term that can contain different sources of supportive social relationships. We adopted the definition of mentoring in academic settings as a relationship between a person with more experience (mentor; e.g. faculty member) and a person with less experience (mentee; e.g. undergraduate student), where the mentor aims to support the mentee's personal and professional development in the field (Crisp & Cruz, 2009; Hernandez et al., 2017). Research on mentoring indicates that mentors can provide at least three kinds of support functions, including: *psychosocial-emotional support* through acceptance, counseling, and trust; *instrumental support* through apprenticeship, coaching, and sponsorship; and *role modeling support* by highlighting their expertise, the relevance of their work, and the attainability of their success (Hernandez, 2019; National Academies of Sciences Engineering and Medicine [NASEM], 2019). A large multidisciplinary meta-analysis of dyadic mentoring relationships (i.e. studies of a primary mentor and mentee) found positive small-to-moderate correlations between support functions and sense of affiliation/belonging (Eby et al., 2013). However, very few of the studies were from college contexts, and fewer still focused on STEM disciplines or the experiences of women in STEM. Moreover, recent critiques of the mentoring literature make clear that the traditional focus on dyadic mentoring (i.e. a primary mentor and mentee) do not adequately describe the experiences or explain the benefits associated with mentoring – particularly for undergraduates in STEM fields (Higgins & Kram, 2001; Montgomery, 2017; National Academies of Sciences Engineering and Medicine [NASEM], 2019).

Mentor networks

Developmental network theory (DNT) uses social network theory to reframe and expand mentoring research from the focus on a single dyadic relationship between a primary mentor and a mentee to a network of mentoring relationships (Higgins & Kram, 2001). DNT indicates that mentees may have multiple mentors, and further that mentors may provide different types of support, be connected to one another, and span social settings (e.g. school, work; Higgins & Kram, 2001). Importantly, DNT distinguishes between mentor support functions (i.e. psychosocial, instrumental, role modeling) and the social network structures of a mentor network. Mentor network structures may vary along at least three lines: size, tie strength (i.e. emotional intensity of connections) and degree of diversity (i.e. variety of information and resources; Dobrow, Chandler, Murphy, & Kram, 2012). Although theory and research point to the potential importance of all three facets, we focus on the degree of diversity, as it is central to the current study.

Diversity of mentor networks

The degree of diversity of mentor networks can be characterized in at least two ways: network density and role diversity (Dobrow, Chandler, Murphy, & Kram, 2012). Density refers to the connections among mentors within a mentee's network, with lower density networks offering potentially more unique sources of information and support and higher density networks offering potentially fewer due to redundancy of perspectives and resources. Diversity can also be captured by characterizing the number of different social roles or arenas represented in a mentee's network (e.g. faculty member, graduate student, peer, etc.). Similar to density, mentees with more role diversity in their mentor networks may benefit by having access to a larger variety of information and support than mentee's with less diverse mentor networks.

Mentor network influences on belonging and interest development

Research on the influence of mentorship networks and the degree of diversity of mentor networks on mentee outcomes in college STEM contexts is only beginning to emerge. For example, a series of recent studies in a national sample of college biological science majors enrolled in summer undergraduate research experiences measured the diversity of connections between the undergraduate mentee, a potential graduate student mentor, and a potential faculty mentor (i.e. mentoring triads; Aikens et al., 2016, 2017). Mentees with higher degrees of role diversity, that is, access to graduate student mentor, faculty mentor, or both (i.e. 'closed' triad) had higher degrees of scientific belonging and identity, and higher interest in graduate school. However, women were less likely to have access to faculty

mentors (i.e. lower degree of diversity), and thus reported lower levels of lower levels of scientific belonging, identity, and interest in graduate school. Similarly, a recent longitudinal study followed college STEM majors from high school through the fourth year of college, measuring the degree of diversity of their mentor networks (i.e. faculty, college staff, graduate students, peers; Hernandez et al., 2020). A longitudinal structural equation model revealed that mentees with higher degrees of mentor network diversity had higher levels of scientific belonging and identity over time, controlling for prior levels of scientific belonging and identity. Although these studies provide useful insights, they either did not report on the unique experiences of women in STEM or studied women in gender-balanced STEM fields.

To summarize, theory and the extant literature indicate that part problem of the underrepresentation women in some STEM disciplines concerns precluded interest in these fields due to the social influences of negative gendered stereotypes about who belongs in those fields (Cheryan & Plaut, 2010). The social influence model of interest development posits that affinity group members, such as STEM community mentors, can promote interest in STEM by supporting women's sense of belonging (Bergin, 2016). Developmental network theory (Higgins & Kram, 2001) and research indicates that the degree of diversity of mentor networks can play a special role in promoting college student's scientific belonging and interest in STEM graduate school. However, to date we find no studies that have longitudinally tested the influence of the degree of diversity in mentor networks on interest development as mediated by university sense of belonging.

Current study

The current study addresses gaps in the literature by focusing on the longitudinal relationship between the degree of diversity of mentor networks, university sense of belonging, and interest development in a large sample of undergraduate women pursuing geoscience-related STEM degrees. We address the research question: Does university sense of belonging mediate the relationship between the degree of diversity of mentor networks and interest in geosciences? To answer this question, data for this study were drawn from a larger study of women STEM students' academic journeys in the United States, entitled 'Analysis of Women's Advancement, Retention, and Education in Service (AWARES)'. Starting in 2015, we recruited a sample of college women from nine universities in two regions of the United States: Colorado/Wyoming and North and South Carolina. Participants completed biannual surveys over four years, from 2015 through 2019. Approximately half of the study participants took part in a professional development and mentoring program (Fischer et al., 2018). Data used in the current study were collected during Spring 2018 (Wave 6), Fall 2018 (Wave 7), and Spring 2019 (Wave 8).

Methods

Methodology and design

The current study used a quantitative methodology in the form of a longitudinal correlational research design to assess the long-term influence of the degree of diversity of mentor networks (Wave 6) on the development of interest in geoscience (Wave 8) as mediated through university sense of belonging (Wave 7) and draw inferences from the current sample of undergraduate women in STEM majors to the larger population of similar undergraduate women in similar contexts (Shadish, Cook, & Campbell, 2002). Mediation analysis is used to identify the direct and indirect influence an independent variable (i.e. degree of diversity of mentor networks) on an outcome variable (i.e. geoscience interest), and can help explain the psychological mechanism(s) (i.e. university belonging) that underlie the relationship between the predictor and outcome (Shadish, Cook, & Campbell, 2002). The validity of inferences about the direction of influence in observational studies can be problematic, as it can be difficult to establish temporal precedence (i.e. whether the predictor or outcome came first) or eliminate all plausible alternative explanations for the relationship between the predictor and outcome (Shadish, Cook, & Campbell, 2002). However, longitudinal methods such as the one employed in this study can reduce threats to the validity of inferences by establishing temporal precedence (i.e. ensuring that the predictor came before the mediator, which in turn came before the outcome) and statistically controlling for potential confounds (Zhao, Lynch, & Chen, 2010), which can improve inferences about the indirect influence a predictor has on a distal outcome through a mediator (MacKinnon, 2012).

The current study used a longitudinal repeated measures design to address the main research question: Does university sense of belonging (Wave 7) mediate the relationship between the degree of diversity of mentor networks (Wave 6) and interest in geosciences (Wave 8), after statistically controlling for background characteristics and prior interest (Wave 1)? Our first hypothesis (H1) was that the degree of diversity of mentor networks positively predicts women's university sense of belonging (i.e. alternative hypothesis; the null hypothesis was that there would be no relationship between mentor network diversity and women's university sense of belonging). Our second hypothesis (H2) was that university sense of belonging positively predicts women's interest in the geosciences (i.e. alternative hypothesis; the null hypothesis was that there would be no relationship between university sense of belonging and interest in the geosciences). Finally, we hypothesized (H3) that the degree of diversity of mentor networks would have a positive indirect effect on geoscience interest development through university belonging (i.e. alternative hypothesis; the null hypothesis was that there would be no indirect effect).

Table 1. Participants' demographic information ($N = 253$).

Characteristics	n	Percentage (%)
Mentor Program participation	113	40.6
Cohort I (Fall 2015)	117	42.1
Race		
African American	19	7.51
Asian	15	5.93
European	149	58.89
Latina	14	5.53
Native American/Pacific Island	3	1.19
Multi-ethnicity	32	12.65
Other	21	8.30
University		
Colorado College	14	5.53
Colorado State University	56	22.13
Metropolitan State University of Denver	14	5.53
North Carolina A&T University	12	4.74
North Carolina State University	34	13.44
University of Colorado - Boulder	33	13.04
University of North Carolina – Charlotte	30	11.86
University of South Carolina	34	13.44
University of Wyoming	26	10.28
First Year of College at T1	153	60.47
Geoscience majors at T1	61	21.90

*Note: T1 indicating the baseline data collected at the first survey.

Participants

The overall sample for this study consisted of 484 college women majoring in (or intending to major in) a STEM discipline with an expressed interest in geoscience degrees and careers. Participants were recruited from four universities in the Colorado/Wyoming Front Range and five universities in North and South Carolina. At the time of recruitment, participants were in their first or second year of college.

The present study focuses on data collected from Spring 2018 (Wave 6) to Spring 2019 (Wave 8). Of the total sample ($N = 484$), 147 participants were excluded from the analysis due to missing at least one of the variables used in the analysis and 84 participants were removed because they were no longer undergraduate students ($N = 253$). Among the 253 participants in the analytic sample, 42% participated in the mentoring program, 42% were recruited in Fall 2015 (Cohort 1), 38% self-identified as racial minorities, and 27% reported being first-generation college students (Table 1).

Procedures

All the participants were initially recruited via email (i.e. email addresses obtained from university registrar offices), in-person recruiting announcements in the introductory STEM courses (e.g. Physics 101), or recruitment flyers posted across the campuses. Students interested in participating in the study completed a screening survey and received gifts for their efforts (\$5 Starbucks cards). Only students who met the following criteria were invited to participate in the

study: 18+ years of age, first- or second-year college student, self-identified as women, pursuing a STEM major, and interested in the geosciences. The participants were recruited as two cohorts: Fall 2015 (Cohort 1) and Fall 2016 (Cohort 2). Participants were invited to complete longitudinal follow-up surveys every semester (Fall & Spring) thereafter until Spring 2019. Data collection was performed using Qualtrics, an online survey system. Participants received \$10 for their participation. All procedures were approved by the local IRB (#14-4829 H).

Measures

Degree of diversity of mentor networks

Participants were given the following definition of mentoring: 'A mentor is someone who provides guidance, assistance, and encouragement on professional and academic issues. A mentor is more than an academic advisor and is someone you turn to for guidance and assistance beyond selecting classes or meeting academic requirements.' With that definition in mind, participants were asked if there was (i) a faculty member, (ii) a graduate student, (iii) a peer, or (iv) other university staff members that they would consider a mentor (Yes [1] or No [0]). Our index of degree of diversity of mentor networks was the sum of their responses to the mentoring questions and ranged from zero to four. The degree of diversity of mentor networks data were collected in Spring 2018 (Wave 6).

University sense of belonging

We used the eight-item University Sense of Belonging scale (Shook & Clay, 2012). Participants reported their perceived sense of belonging to their university (e.g. 'I am enthusiastic about attending my university.') on a seven-point Likert scale from strongly disagree (1) to strongly agree (7). The scale scores were derived by taking the average of the eight items, with a higher score indicating a higher level of university sense of belonging. University sense of belonging scores, collected in Fall 2018 (Wave 7), exhibited acceptable Cronbach's α value of 0.88.

Interest in the geosciences

We used a two-item measure of interest in the geosciences, adapted from the interest development scale (Hulleman & Harackiewicz, 2009). Participants rated their level of interest (e.g. 'How interested are you in taking courses in Earth Systems or Environmental Sciences?') on a seven-point Likert scale from not at all interested (1) to very interested (7). Scale scores were derived by taking the average of the two items, with a higher score indicating a higher level of interest in the geosciences. Students' interest in the geosciences was measured every semester. Interest in geosciences scores exhibited high reliability at both baseline (Wave 1; Cronbach's $\alpha = 0.95$) and in Spring 2019 (Wave 8; Cronbach's $\alpha =$

0.92). Given the ongoing debate surrounding Cronbach's alpha and short scales, we followed the suggestion by Rammstedt and Beierlein (2014) and conducted a test-retest reliability analysis as an additional source of support for internal consistency (Wave 7 and Wave 8; Canonical correlation, $r = 0.75$; Wilks' lambda $p < .001$). The convergent findings point to an acceptably reliable measure of geoscience interest.

Control variables

Based on preliminary data analyses, we created dummy-coded indicators of (a) having participated in the mentoring and role modeling program, (b) university affiliation, and (c) cohort status as control variables (all measured at Wave 1).

Statistical assumptions and preliminary analyses

All the statistical analyses were conducted using STATA v.16.1. Prior to running regression and mediation analyses, we examined the data for outliers, missing data, and regression assumptions. A missing data analysis on the full sample for the variables used in this analysis showed that the data were missing consistent with Missing Completely at Random (MCAR; $\chi^2 = 25.88$, $df = 16$, $p > .05$) and thus missing data bias was not a concern (Little, 1988). Furthermore, there was no evidence of extreme outliers (e.g. leverage, Cook's D values were acceptably small; Judd, McClelland, & Ryan, 2017). Finally, distributional assumptions of regression were met (e.g. Q-Q plots showed normality for most of the variables, Cook-Weisberg test for heteroskedasticity was non-significant [$\chi^2 = 0.20$, $df = 1$, $p = .66$]). A comparison of the analytic and full samples indicated that there were no significant differences based on Cohort ($\chi^2 = 0.0001$, $df = 1$, $p = 0.99$), but there was a significant difference on participation in the mentoring program ($\chi^2 = 2.67$, $df = 1$, $p < 0.01$). Thus, we added mentoring program participation and year in school at baseline as control variables. Finally, the independence assumption was violated due to the students being nested within universities (see Figure 2 notes), thus, university status was controlled for using the fixed effects approach (Cohen, Cohen, West, & Aiken, 2013).

Results

Prior to formally testing our hypotheses, we examined the descriptive and correlational patterns in the data. On average, students reported having more than one type of mentor in their network ($M = 1.62$, $SD = 1.22$; Table S1). To better understand the components of participants' mentor networks, we examined the types of mentors and found that the most frequently reported mentoring resource was peer mentors ($n = 144$, 51.8 %), followed by faculty mentors ($n = 136$, 48.9 %), and graduate student mentors ($n = 65$, 23.4 %). Correlation analysis revealed that the diversity of

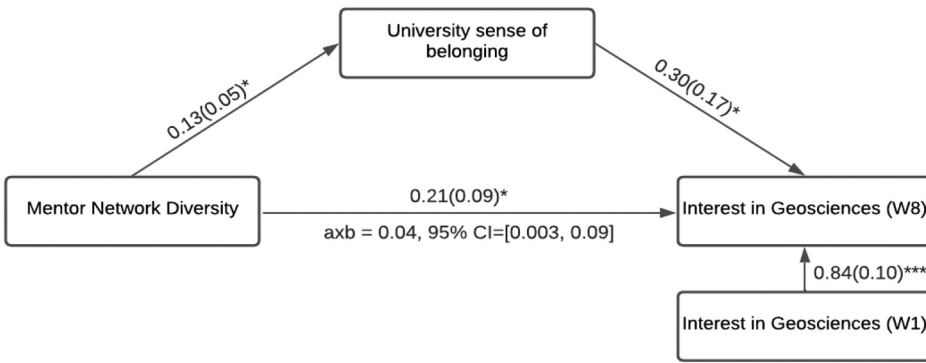


Figure 2. Mediation Analysis: The Effect of Diversity of Mentor Network (W6) on Interest in the Geosciences (W8) through University Sense of Belonging (W7), controlling for initial interest in the Geosciences (W1). The clustering effects were examined using Stata. The ICC presented the proportion of variance between universities to the total variance. The ICC revealed the variances of interests in geosciences located mainly among individuals ($ICC_{interest} < .01$) and the variance of university sense of belonging was also mainly explained at the individual level ($ICC_{belongingness} = .05$). Thus, we only included the initial interest as a covariable in the mediation analysis. Mediation analysis was conducted using Structural Equation Modeling, and Monte Carlo based confidence intervals around the indirect effects. The observed fit index values compared to cut-off values representing acceptable model fit, $\chi^2(5) = 97.20$, $p < .001$; CFI = .96; RMSEA = 0.13 with 90% CI [0.04, 0.25]; SRMR = 0.05 (Hu & Bentler, 1999). Standardized path coefficients are presented with standardized errors in parentheses. axb represents indirect effects. RIT (Indirect effect/Total effect) = 0.16, RID (Indirect effect/Direct effect) = 0.19. $*p < .05$, $***p < .001$.

mentor networks exhibited small positive correlations with university sense of belonging and interest in the geosciences; and further that belonging exhibited a small positive correlation with interest in the geosciences (Table S1). Next, we conducted a hierarchical regression analysis to test hypotheses one and two. Consistent with our first hypotheses, students with higher diversity of mentor networks reported statistically significantly a higher university sense of belonging (hypothesis 1 confirmed) and students with a higher university sense of belonging expressed significantly higher interest in the geosciences (hypothesis 2 confirmed), controlling for background variables and baseline interest (Table 2).

We performed a structural equation modeling-based mediation analysis to test the mediating role of university sense of belonging in the relationship between diversity of mentor networks and interest in the geosciences, controlling for initial interest. The Monte Carlo based mediation analysis (with 500 replications) revealed a statistically significant and positive indirect effect of diversity of mentor networks on interest in the geosciences through university sense of belonging (Figure 2; hypothesis 3 confirmed). The completely standardized effect size ($\beta = .04$, 95% CI [0.003, 0.09]) indicated that a one standard deviation increase in diversity of mentor networks was associated with a .04-

Table 2. Summary of the Hierarchical Regression Models with Diversity of Mentor Networks (W6) Predicting University Sense of Belonging (W7) and Geoscience Interest (W8, N = 253).

Predictors	University Belonging				Geoscience Interest			
	Step-1		Step-2		Step-1		Step-2	
	b	SE	b	SE	b	SE	b	SE
Intercept	4.54***	0.20	4.35***	0.21	0.88*	0.43	-0.81	0.71
CC	-0.67*	0.27	-0.67*	0.27	0.21	0.56	0.47	0.56
MSUD	0.23	0.28	0.22	0.27	1.35***	0.57	1.26*	0.56
NC A&T	0.16	0.29	0.16	0.29	-0.27	0.60	-0.33	0.59
NCSU	0.47*	0.20	0.46*	0.19	-0.21	0.40	-0.39	0.40
UCB	0.09	0.20	0.10	0.20	-0.31	0.41	-0.35	0.40
UNCC	-0.21	0.21	-0.15	0.20	-0.06	0.42	-0.01	0.42
USC	0.18	0.20	0.15	0.19	-0.15	0.40	-0.21	0.40
UW	-0.25	0.21	-0.24	0.21	-0.19	0.44	-0.10	0.43
Mentor Prog.	-0.14	0.12	-0.19	0.12	0.58**	0.24	0.65**	0.24
Cohort	-0.13	0.12	-0.10	0.12	-0.12	0.25	-0.08	0.25
Interest W1	0.13**	0.05	0.13**	0.05	0.85***	0.10	0.80***	0.10
Div. M.N.	-	-	0.12**	0.04	0.20*	0.09	0.16	0.09
U. Belonging	-	-	-	-	-	-	0.39**	0.13

Note. Mentor Prog. = Participation in the mentoring program. CC = Colorado College, MSUD = Metropolitan State University at Denver, NC A&T = North Carolina A&T University, NCSU = North Carolina State University, UCB = University of Colorado Boulder, UNCC = University of North Carolina – Charlotte, USC = University of South Carolina, UW = University of Wyoming and Colorado State University was the reference category. Div. M.N. = Diversity of Mentor network. Interest W1 = Geoscience interest at baseline. U. Belonging = University sense of belonging. Hierarchical regression results predicting university sense of belonging (Step-1: $F(11, 241)=2.88$, $p=.001$, $R^2=.12$; Step-2: $\Delta F(1, 240)=7.58$, $p=.006$, $R^2=.114$, $\Delta R^2=.03$) and geoscience interest (Step-1: $F(12, 240)=9.15$, $p=.001$, $R^2=.31$; Step-2: $\Delta F(1, 239)=8.66$, $p=.004$, $R^2=.34$, $\Delta R^2=.02$). * $p<.05$, ** $p<.01$, *** $p<.001$

standard deviation increase in interest in the geosciences, because of the effect of mentor network diversity on university sense of belonging.

Discussion

It is a national priority to improve the representation of women, racial/ethnic minorities, and persons with disabilities in the U.S. STEM workforce, however, many STEM fields have made slow progress toward these goals (National Center for Science and Engineering Statistics [NCSES], 2021). Mentoring has been identified as part of the solution to promoting equity and diversity in STEM, but the types of mentor network structures that benefit students and the psychological processes linking mentoring to beneficial outcomes, such as developing deeper levels of interest in a STEM field are not well understood (National Academies of Sciences Engineering and Medicine [NASEM], 2019). The present study builds on an emerging body of research on mentor network theory (Higgins & Kram, 2001) and interest development theory (Bergin, 2016) in a sample of women pursuing geoscience-related in STEM degrees and careers.

This study provides a novel test of the mechanisms by which mentorship networks promote beneficial outcomes for mentees. Mentor network theory and research in related fields indicates that the size and diversity of one's

mentorship network can promote their sense of belonging (Dobrow, Chandler, Murphy, & Kram, 2012). For example, research with diverse samples of undergraduates in STEM have found that those with more diverse and connected mentors (i.e. faculty and graduate students) reported higher levels of science belonging and identity compared to peers (Aikens et al., 2016; Hernandez et al., 2020). Similarly, a recent study with racial majority students revealed that students with more diverse mentor networks reported higher levels of science belonging and identity (Hernandez et al., 2020). Consistent with expectations, we found that students with more diverse mentor networks reported higher levels of belonging at their university. Taken together, research indicates that having access to a diverse network of mentors can help students to cultivate a sense of belonging in school, which is a fundamental human need and motivator of achievement (Aikens et al., 2016; Thoman, Arizaga, Smith, Story, & Soncuya, 2014).

The present study also tested a key aspect of Bergin's theory of social influences of interest development, which posits that a sense of belonging mediates the relationship between affinity group members (e.g. a network of mentors) and interest development (Bergin, 2016). Consistent with theory and prior research (Hernandez et al., 2017; Thoman, Arizaga, Smith, Story, & Soncuya, 2014), university sense of belonging mediated the relationship between diversity of mentor networks and interest in geosciences. Higher diversity of mentor networks predicted higher future levels of university sense of belonging, and higher belonging predicted growth in geoscience interest.

In conclusion, these novel findings highlight the importance of considering the broader network of mentors, not just a single (typically faculty mentor), in promoting beneficial outcomes for students from historically underrepresented groups in STEM fields. The study provides new insights into the mechanisms by which diversity of mentor networks can promote a sense of belonging and deeper levels of interest in STEM fields, which may help to inform interventions aimed at improving equity and diversity in STEM.

Limitations and future directions

Although this study extended research in mentor network and interest development theories, there were several limitations to the generalization of this work. First, most of the participants were in the third or fourth year of college at the time the data on mentor networks and university belonging were collected. As documented in previous research, students in the third or fourth year of college may have a higher sense of belonging to their university than early-year college students (Freeman, Anderman, & Jensen, 2007; Good, Rattan, & Dweck, 2012). Future research should attend to the relationships between mentoring, university belonging, and interest development in STEM fields at earlier points, such as the transition to college or over the entire college tenure. Second, our

measure of mentor network diversity focused on the career stage categories of the mentors, which is a fairly narrow measure of diversity. Future studies should incorporate a broader range of mentor network characteristics, such as connections within the network and the type and strength of support from the various mentors in their network.

These results provide insights for several paths for future studies. Future research would benefit from using multiple data sources, such as individual interviews and focus groups, to capture the precise relationship between mentor network characteristics, sense of belonging, and students' interest development. Multiple data sources would be useful to identify the most efficient way of expanding social network connections for undergraduate women in different types of institutions. Further, future studies should track the diversity of mentor networks and sense of belonging at multiple time-points to test causal ordering and reciprocal relations. In addition, future research should examine these relationships across different disciplines. It is probable that these relationships hold for other disciplines, such as the Arts and Humanities. Furthermore, researchers and practitioners should examine the roles that other types of support and experiences play in promoting university sense of belonging and its role in university retention.

Conclusion and practice implications

In conclusion, this study addressed gaps in the literature at the intersection of mentor network and interest development theories (Bergin, 2016; Higgins & Kram, 2001). Specifically, mentor network theory posits that the structure of mentor networks (e.g. degree of diversity) should influence mentee's subjective outcomes (e.g. interest) and interest development theory posits that social influencers (e.g. mentors) influence sense of belonging, which in turn promotes deeper levels of interest in a topic. Consistent theory and prior research (Aikens et al., 2016; Thoman, Arizaga, Smith, Story, & Soncuya, 2014), diversity of mentor networks (Wave 6) exerted a positive indirect influence on deeper levels of geoscience interest (Wave 8) through its positive influence on university belonging (Wave 7; hypotheses 1–3 supported).

These findings have several practical implications. First, consistent with critiques of the dyadic focus of the extant mentoring literature (i.e. a focus on a primary mentor – mentee relationship), the present study shows the importance of capturing the diversity of the broader network of mentors that influence mentee's career development (Higgins & Kram, 2001; Montgomery & Page, 2018). Second, mentors and mentoring programs should make note that cultivating a deeper sense of belonging was key to promoting deeper levels of interest. This finding suggests that mentors and mentoring programs should carefully evaluate how they can promote a culture of inclusion and belonging

among mentees (National Academies of Sciences Engineering and Medicine [NASEM], 2019).

Finally, the findings indicate that one mechanism for promoting belonging can be through helping mentees grow the diversity of their mentor networks. Recent experimental and longitudinal evaluations of mentoring programs have shown that mentor support mapping activities (Christou et al., 2017; Montgomery, 2017) and strategic introductions to near-peer or step-ahead mentors can help undergraduates, particularly those from underrepresented groups in STEM, grow their mentor network and experience the positive benefits of mentoring on career development (Dennehy & Dasgupta, 2017; Hernandez et al., 2020). Given the limitations on faculty time, infrastructure to prepare peers or more advanced students for mentoring roles can be crucial. For example, peer mentors can grow and develop a strong commitment to the mentoring field through peer-led study groups (Barnard et al., 2018), peer-facilitated workshops (Preszler & Mays Hoopes, 2009), or peer review process (Pon-Barry, Packard, & St John, 2017).

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Data availability statement

All data, metadata, and supplemental materials files are available from the online Texas Data Repository (doi: <https://doi.org/10.18738/T8/HC451Y>).

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