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Women's career confidence in a fixed, sexist STEM environment

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Abstract

Background: Innovation in STEM (science, technology, engineering, and math) fields in the U.S. is threatened by a lack of diversity. Social identity threat research finds messages in the academic environment devalue women and underrepresented groups in STEM, creating a chilly and hostile environment. Research has focused on the mechanisms that contribute to STEM engagement and interest at the K-12 and undergraduate level, but the mechanisms that predict sustained engagement at the graduate level have not been studied.

Results: In a longitudinal study of doctoral students in STEM disciplines, we demonstrate that students' beliefs that their STEM colleagues believe intelligence is a fixed (vs. malleable) trait undermine women's engagement in STEM. Specifically, perceiving a fixed ability environment predicts greater perceptions of sexism, which erode women's self-efficacy and sense of belongingness and lead women to consider dropping out of their STEM career.

Conclusion: These findings identify one potential pathway by which women leave their STEM fields, perpetuating gender disparities in STEM.

Keywords: STEM, Gender, STEM persistence, Self-efficacy, Identity compatibility, Sense of belonging

Introduction

Advancing innovation in Science, Technology, Engineering, and Math (STEM) fields in the U.S. is often stymied by a lack of diversity among STEM students, faculty, and professionals. More specifically, the lack of diversity in STEM domains creates and maintains gender disparities in economic prosperity, numeric representation, professional advancement, and success, and limits the growth of the domains in which these disparities exist (e.g., Beede et al., 2011; Hill et al., 2010). According to recent reports, women have achieved some parity at the bachelor's level in mathematics but remain underrepresented at all degree levels in computer sciences and engineering and at the master's and doctoral level in most STEM domains (NSF, 2019). Despite the low numbers of women receiving graduate degrees in STEM fields and entering the professoriate, relatively few studies have focused on women in graduate education (for exceptions, see Carlone & Johnson, 2007; Clark et al., 2016; Gibbs et al., 2014). Given the persistent gender disparities in STEM domains, it is critical to examine how academic climate, particularly at the graduate level, can undermine women's engagement and investment in STEM fields.

Research on social identity threat and implicit biases highlights the prevalence and persistence of cues that threaten the full inclusion of women in STEM (National Academies of Sciences, Engineering, and Medicine, 2019). Although institutions of higher education have policies to prohibit overt bias, implicit biases persist (e.g., Moss-Racusin et al., 2012; Steinpreis et al., 1999; Trix & Psenka, 2003). Students may receive subtle and indirect messages that reflect general beliefs about what it means to be successful in an academic domain (e.g., valuing natural ability over effort) and that convey negative stereotypes about women's STEM abilities (e.g., Good et al., 2012; Moss-Racusin et al., 2012; Steinpreis et al., 1999). The message that ability is valued over effort (Leslie et al.,

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2015) and implicit stereotypes that women lack ability in STEM (Schuster & Martiny, 2017) create a double bind for STEM women who may, therefore, be doubly threatened in STEM contexts. Similarly, research has repeatedly demonstrated the stereotype threat phenomenon, in which evaluative settings (e.g., testing situations) are likely to make negative stereotypes about women's abilities in STEM more salient, leading to anxiety about appearing competent, which undermines performance (e.g., Marx, 2019; Steele, 1997). Implicit bias and stereotype threat likely interfere with women's self-confidence, academic efficacy, and sense of belonging, and can ultimately undermine their commitment to continue in their field of study.

Much of the existing literature on STEM engagement has concentrated on earlier stages of the pipeline (e.g., middle school, high school, college), when students tend to be forming their career identities (e.g., Christensen et al., 2015; Kang et al., 2019; Kim et al., 2018; Ladeji-Osias et al., 2016; London et al., 2011; Watters & Diezmann, 2013). While those early timepoints are critical in the initial formation of STEM interests, the mechanisms that predict initial interest in STEM at the K-12 and undergraduate levels may be different from the mechanisms that predict sustained engagement following initial career investment and demonstrated skill at the graduate level. For example, the high stakes evaluative climate of graduate education may lead to a consistently threatening situation (i.e., chronic stereotype threat) in which stereotypes about women's abilities become chronically salient and thus chronically undermine women's performance. Therefore, research on graduate students is critical for understanding how individuals at later stages of STEM engagement continue to engage with or disengage from their STEM disciplines despite their earlier investment and commitment to STEM. In addition, research has primarily focused on individual-level factors that impact STEM engagement, such as awareness of negative stereotypes about one's group or perceived compatibility between one's social identity and being in a STEM field (e.g., Appel et al., 2011; London et al., 2011; Spencer et al., 1999). To develop a more nuanced understanding of women's experiences in STEM fields, research on both the individual (feelings of competence and belonging) and situational factors (threatening cues in the environment) that influence women's persistence in STEM is necessary.

In this repeated-measures study, we explore the psychosocial processes of STEM engagement among a sample of men and women pursuing graduate study in STEM fields at a research-intensive university. We define STEM engagement as "the academic and social variables that are essential not only for retention but also for sustained investment and satisfaction in STEM fields" (London et al., 2011, p. 305). As shown in Fig. 1, the present study tests a conceptual model of how perceptions of threat at the institutional level (i.e., from one's STEM department) may be associated with a multitude of psychological processes that ultimately undermine women's engagement in STEM domains. More specifically, we examine how graduate students' perceptions of institutional-level messages valuing natural ability and intelligence over effort in STEM departments correlate with perceptions of sexism which, for women, are related to feelings of impostorism, which is manifested in lowered STEM self-efficacy and lowered sense of belonging in STEM. Finally, we examine whether these processes ultimately contribute to women considering leaving their STEM domain. We describe these environmental and individual-level factors in detail next.

Environmental factors impacting STEM engagement

Theories of intelligence

Valuing natural ability over effort reflects a specific theory of intelligence (Dweck, 1999). Dweck suggests that lay theories of intelligence can be categorized into two main groups: entity and incremental theories of intelligence. Individuals who hold an entity theory of intelligence believe that intelligence is fixed. In other words, entity-oriented individuals believe that one has a certain

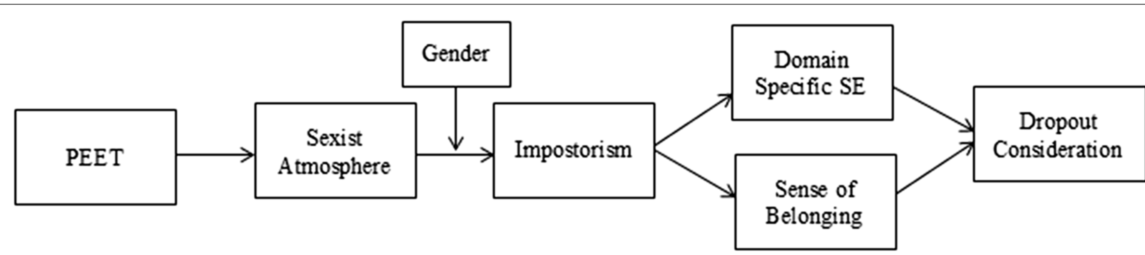

Fig. 1 Model of differential impact of perceived environmental entity theory (PEET) on consideration of dropping out STEM graduate program by gender

amount of intellectual ability and cannot change it. In contrast, individuals who hold an incremental theory of intelligence believe that intelligence is malleable, and therefore, that intelligence can be increased and success obtained through effort and hard work. Murphy and Dweck (2010) and Good and colleagues (2012), expanded on the notion of individual lay theories of intelligence to account for messages in the environment that suggest that natural ability is valued over hard work and effort. The extent to which an environment (e.g., organization or department) is perceived to support an entity (vs. incremental) theory of intelligence is referred to as perceived environmental theory of intelligence (PEET; Good et al, 2012; Murphy & Dweck, 2010).

In environments where natural ability is valued over effort, faculty and peers may link that belief to the stereotype that women do not have natural ability in STEM. Under those stereotypes, women may experience devaluation, exclusion from discussions or social interactions, and less career advice and support. Providing evidence for this possibility, Leslie and colleagues (2015), show that environments that are entity-oriented (i.e., faculty indicate valuing natural ability over effort) also have disproportionately fewer women. Other work has shown that women trust entity-oriented environments less than incremental-oriented environments (Emerson & Murphy, 2015). Furthermore, in a study comparing outcomes for courses taught by faculty with entity vs. incremental mindsets, students learning from entity-oriented professors reported less motivation, more negative experiences, and exhibited wider racial achievement gaps in those courses (Canning et al., 2019). Therefore, perceiving that one's academic environment is entity-oriented may lead to perceiving higher levels of bias, including sexism, within one's academic environment, and perceiving higher levels of sexism will likely have a different impact on women's engagement in their STEM department compared to their male peers.

Sexism

Numerous studies have documented that, in general, the higher education institutional climate is less welcoming for women compared to men (e.g., Hill et al., 2010; Settles et al., 2006). For instance, women are exposed to fewer female exemplars of STEM success (e.g., NSF, 2019) and generally report a hostile and unwelcoming environment in their classes, labs, and workplaces (e.g., Hill et al., 2010; Settles et al., 2006). This "chilly climate" has been shown to undermine women's persistence in STEM fields (Ferreira, 2003; London et al., 2011; Valian, 2005) with fewer women completing graduate-level training in STEM (Shin et al., 2016). Experimental evidence demonstrates that the perception of a biased STEM environment may have a causal role in women's attitudes towards and aspirations in STEM (Moss-Racusin et al., 2018).

Among the factors present within this chilly STEM environment, one key factor may be cues communicating what others in one's STEM environment value. If one perceives that their group (e.g., women) is not valued within the STEM domain, then this may undermine their persistence in STEM. For instance, the STEM environment may convey stereotypical beliefs that: (1) women are less capable of success in STEM (e.g., Good et al., 2012; London et al., 2011; Settles et al., 2009; Valian, 2005); (2) women are not welcome in STEM fields (e.g., Ferreira, 2003; Valian, 2005); and (3) natural ability is valued over effort (Good et al., 2012; Leslie et al., 2015; Murphy & Dweck, 2010). These negative stereotypes suggest that women are less competent than men, leading to gender bias in evaluations of competence and potential for success, as well as in hiring decisions and salary recommendations (Moss-Racusin, et al., 2012; Steinpreis, et al., 1999). Evidence demonstrates that sexist biases persist among faculty (e.g., Moss-Racusin, et al, 2012), peers (e.g., Grunspan et al., 2016), and subordinates (Boring et al., 2016). These environmental cues of entity-oriented and sexist beliefs may shape individual-level feelings and experiences.

Individual factors impacting STEM engagement

Impostorism

The combination of an entity-oriented STEM field and stereotypes that women lack natural ability in STEM may converge to lead even successful women to discount their past accomplishments and question their future abilities (Clark et al., 2016). Academic impostorism reflects academic self-doubt, fear of one's inability to replicate successes, and fear of being discovered as lacking ability (London & Dweck, 2005). Impostorism may be particularly damaging, because impostors not only to doubt their current successes but also discount their past success and anticipate future failure (London & Dweck, 2005). Individuals who experience academic impostorism underestimate their academic skills and attribute their academic successes to external sources (such as luck) despite showing no actual performance differences on academic tasks compared to individuals who do not express impostorism (London & Dweck, 2005). Moreover, higher levels of academic impostorism predict greater stress and anxiety, lower academic self-efficacy, and lower sense of belonging among undergraduate students (Ewing et al., 1996; London & Dweck, 2005; Park et al., 2020). Tao and Gloria (2019) similarly found that impostorism predicted a more pessimistic view of finishing a graduate program, though this association was mediated by self-efficacy and perceptions of doctoral environment.

Importantly, impostorism occurs among individuals who have experienced success in a domain but come to doubt and question the veracity of that success. Women in STEM fields may be particularly vulnerable to developing academic impostorism (Dasgupta, 2011; King & Cooley, 1995; Kumar & Jagacinski, 2006; Legassie et al., 2008). Being a numeric minority in an academic field in which negative stereotypes about one's abilities are present and in which natural ability is valued over effort may activate the doubts impostors feel about their skills and successes. Individuals with impostor fears focus more extensively on failures and the potential for failure than on successes, making them more vulnerable to perceived failure and creating a disconnect between actual abilities and perceived abilities. On a social level, feeling like an impostor undermines one's sense of belonging (Park et al., 2020) and increases social anxiety (Kolligian & Sternberg, 1991). Accordingly, we expect that this sense of impostorism may have both academic and social consequences that negatively relate to self-efficacy and sense of belonging. We describe each of these mechanisms next.

Self-efficacy and sense of belonging

Self-efficacy refers to an individual's belief or confidence in their ability to successfully complete a task or be successful in a specific domain (Bandura, 1977; Diekman, et al., 2010; Eccles, 1994; Lent et al., 1994; Pajares, 2005). Self-efficacy has been shown to predict student motivation and task performance (e.g., Bandura & Locke, 2003; Caprara et al., 2011), task and career confidence (e.g., Pajares, 2005), goals and persistence (e.g., Eccles, 1994; Lent et al., 1994), and vocational choices (e.g., Larose et al., 2006). In addition, higher self-efficacy in a given domain is related to higher levels of persistence and optimism in that domain (Adedokun et al., 2013; Tao & Gloria, 2019). Consistent with our theorizing, previous work has shown that women in STEM have lower self-efficacy compared to men (e.g., Mura, 1987; Strenta et al., 1994). Moreover, Larose and colleagues (2006) report that self-efficacy may be a stronger predictor of vocational choices for women than for men. Of particular importance to the present work, research has shown that women with higher self-efficacy have an increased likelihood of intending to persist in a STEM field (Marra et al., 2009). Therefore, lower levels of self-efficacy emanating from a sense of impostorism may ultimately lead to considering dropping out of or otherwise disengaging from one's STEM field.

Impostorism may also undermine women's sense of belonging (Rainey et al., 2018). Like self-efficacy, sense of belonging has also been shown to impact vocational choices (Rosenthal et al., 2013) and performance in STEM fields (Good et al., 2012). Importantly, low sense of belonging in one's STEM field has also been shown to undermine persistence in STEM (Good, et al., 2012; London et al., 2011). Furthermore, previous research has documented gender differences in sense of belonging in STEM fields, with women reporting lower sense of belonging compared to men (Good et al., 2012; Rainey et al., 2018). Of particular importance to the present work, Good and colleagues (2012) have demonstrated that women who perceived an entity-oriented academic environment (PEET) and gender stereotypes in their academic environment were more likely to report lower sense of belonging. These experiences of academic and social disengagement may ultimately lead to STEM disengagement. Providing evidence of this possibility, previous work suggests that two key pathways to STEM persistence are self-efficacy (e.g., Shaw & Barbuti, 2010; Simon et al., 2015) and sense of belonging (e.g., Hoffman et al., 2002; London et al., 2011).

Returning to our hypothesized model (Fig. 1), we predicted that perceiving one's academic environment as valuing ability over effort (i.e., PEET; Good et al, 2012; Murphy & Dweck, 2010) would highlight stereotypes about women's abilities in STEM, and these perceptions would be associated with perceiving higher levels of sexism in their academic environment. Women, but not men, reporting higher levels of perceived sexism should also report higher levels of impostorism, which would be negatively associated with self-efficacy and sense of belonging in STEM. Ultimately, this process should correlate with stronger consideration of dropping out of one's STEM field.

Methods

Procedure

Students enrolled in STEM doctoral programs at a university located in the Northeastern United States were recruited via email to participate in a longitudinal online study. Participants completed surveys prior to the start of the 2013 Fall semester (Time 1), at the end of the 2013 Fall semester (Time 2), and at the end of the 2014 Spring (Time 3) semester. Participants received $20 for participating in each survey and were additionally entered into a raffle to win a $100 prize for completing the Time 1 survey. This study was approved by the University Institutional Review Board.

Participants

One hundred and fifty-seven doctoral students in STEM programs completed the online survey at Time 1 (prior to the start of the Fall semester). Eighty-nine of those students completed the Time 2 survey (the end of the Fall semester), and 87 of the students who completed the survey at Time 1 completed the survey at Time 3, the end of the subsequent spring semester. A total of 114 students completed surveys at two or three time points (72.6%) exceeding the power analysis estimate for the number of participants required to observe the predicted effects with 95% probability ($N=89$).

Participants were required to be United States citizens. Demographic information for the 115 students included in model estimation is reported. The mean age of the sample was 25.8 (SD = 4.1). With regard to gender, 50.4% of our sample was female, 49.6% male. The majority of our sample was Caucasian/White (67.3%) with 9.7% Hispanic or Latino/a, 8.8% East Asian, 5.3% South Asian, 3.5% African American/Caribbean-American/Black, 0.9% American Indian/Native Alaskan, and 4.4% Multiracial or Other. Among the scientific disciplines represented in our sample, 51.1% were pursuing graduate education in the biological sciences, 23.7% in the physical sciences, 16.5% in engineering, and 8.7% in mathematics. These scientific disciplines did not differ significantly on any of the variables included in these analyses. Students' cumulative grade point average (GPA) for their most recently obtained degree and the year in which they entered their current graduate program were obtained for each participant from the Graduate School of the university. Approximately a quarter of our sample (28.7%) was in their first year in their current graduate program, 19.1% in their second year, 20.8% in their third year, 15.6% in their fourth year, and 15.8% in their fifth year or later.

Measures

Theory of intelligence

We measured theory of intelligence (TOI; Dweck, 1999) at Time 1 with a four-item scale ($\alpha=0.96$) assessing an individual's entity or incremental theory of intelligence. Participants were asked to rate their agreement with each item (e.g., "Your intelligence is something about you that you can't change very much.") on a scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). Responses to the four items are averaged to create a composite score representing an individual's own beliefs of the malleability or fixedness of intelligence, with higher scores reflecting a stronger endorsement of an entity theory of intelligence.

Perceptions of environmental entity theory

PEET (Good et al., 2012) was measured at Time 1. The four items ($\alpha=0.98$) were modified to refer to "people in my STEM field" instead of "people in my calculus class" (e.g., "People in my STEM field believe that you can't really change how intelligent you are"). Participants were asked to rate their agreement with each item on a scale of 1 (*strongly disagree*) to 6 (*strongly agree*), and higher mean scores correspond with more perceptions of one's STEM colleagues holding entity views of intelligence.

Sexist climate

Sexist Climate (Settles et al., 2006) was measured at Time 2 using a nine-item ($\alpha=0.86$) scale of participants' perceptions of sexist attitudes within their department. Items assess the extent to which sexism is present in their department (e.g., "Sexist remarks are heard in the classroom"). Participants were asked to indicate the extent to which they agreed or disagreed with each item on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*), with higher number reflecting perceptions of a more sexist departmental climate.

Academic impostorism measure

Academic Impostorism (London & Dweck, 2005) was measured at Time 2 using a 12-item scale ($\alpha=0.96$). Participants were asked to rate their agreement on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*) with statements reflecting impostorism self-beliefs (e.g., "I worry that people will discover that I'm not as intelligent as my accomplishments may seem").

Domain-specific self-efficacy

Self-efficacy was measured at Time 2 via a 32-item scale ($\alpha=0.95$) developed for this study. Items assessed the extent to which participants felt confident in their abilities to complete a variety of tasks necessary for success in a STEM graduate program (e.g., "writing a paper for publication," "giving a successful job interview," and "presenting research results to an audience of peers") on a scale ranging from 1 (*no confidence*) to 5 (*absolute confidence*). Items were averaged to create a composite score with higher values reflecting higher self-efficacy.

Belonging in field

Sense of Belonging was measured at Time 2 using six items ($\alpha=0.93$) adapted from the measure of belonging in university developed by Mendoza-Denton and colleagues (2002). The instructions were altered to ask participants to select the number that best describes their feelings toward their field of study for four items; 1 (*miserable to be there*) to 10 (*thrilled to be there*), 1 (*do not fit in*) to 10 (*definitely fit in*), 1 (*not welcome*) to 10 (*very welcome*), and 1 (*very uncomfortable*) to 10 (*very comfortable*); and to select the number that best describes their feelings toward their peers and classmates in their field for two items; 1 (*do not like them*) to 10 (*like them*) and 1 (*do not feel comfortable with them*) to 10 (*feel very comfortable with them*). To determine participants' sense of belonging in their field of study, responses to all six items were averaged.

Dropout consideration

Dropout Consideration was measured at Time 3 using the item, "I have recently considered dropping out of my graduate program." Participants were asked to rate their agreement with each item on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*).

All participants completed the measures described above in the following orders: at Time 1, participants completed Theory of Intelligence and PEET. At Time 2, participants completed Domain Specific Self-Efficacy, Belonging in Field, Academic Impostorism, and Sexist Climate measures. The Sexist Climate measure was assessed last to ensure that it did not prime stereotype threat or trigger other environmental cues that would impact responses on the measures of self-efficacy, belonging, and impostorism. At Time 3 participants completed the Dropout Consideration item.

Statistical analyses

Analyses was conducted using Mplus Version 7 (Muthén & Muthén, 2012). We were missing 8.4% of the total data across the three timepoints (i.e., start of Fall semester, end of Fall semester, end of Spring semester). We utilized Mplus's (Version 7) full information maximum likelihood approach to minimize bias associated with sample attrition (Graham, 2009; Newman, 2014). This approach utilizes all available data to estimate model parameters and is recommended over many other approaches to handling missing data (e.g., listwise/pairwise deletion, mean imputation; Graham, 2009; Newman, 2014).

First, correlations among all study variables were calculated using Mplus. Then, a regression analysis was conducted in which one's own theory of intelligence and perceptions of environmental entity theory were entered as simultaneous predictors of perceptions of a sexist atmosphere, controlling for year in program. Next a full path analysis model was tested. See Fig. 1 for the hypothesized path model. Model fit for the path analysis was assessed by the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the root-mean-square error (RMSEA), with acceptable model fit indicated by a CFI and TLI > 0.90 and an RMSEA < 0.06 (Hu & Bentler, 1999; Kline, 2005). We conducted Chi-square tests of model fit, but we evaluated them with the caveat that this test can be overpowered in moderately sized samples, and thus reject even good fitting models. Simple slopes were calculated using the simple slopes online calculator for multiple linear regression two-way interactions (Preacher et al., 2006).

Results

Correlations among major study variables are presented in Table 1. To test our hypothesis that PEET would predict perceptions of a sexist atmosphere, while Theory of Intelligence (TOI) would not, we conducted a simultaneous multiple regression in which PEET and TOI were predictors, year in program was entered as a covariate, and perceptions of a sexist atmosphere was the dependent variable. The overall R^2 was 0.08 and was significant $F(2,94) = 3.46$, $p < 0.05$. Higher PEET predicted higher perceived sexist atmosphere within the department ($\beta = 0.31$, $t(95) = 2.53$, $p < 0.05$), while TOI did not significantly predict perceived sexist atmosphere ($\beta = 0.06$, $t(95) = 0.52$, $p = 0.60$). Therefore, we did not include TOI in the overall model.

To test our hypothesized model (see Fig. 1), we conducted a path analysis in which PEET at Time 1 predicted perceptions of a sexist atmosphere in the department at Time 2. Gender was entered as a moderator of the relationship between perceptions of a sexist atmosphere and impostorism (Time 2). Impostorism at Time 2 in turn predicted domain specific self-efficacy and sense of

Table 1 Descriptive statistics of main variables

Variable	1	2	3	4	5	6	7	8	9
1. Self-TOI	0.497***	− 0.08	− 0.345***	0.247*	0.287**	− 0.269*	− 0.044	0.028	0.497***
2. PEET	–	0.277*	− 0.040	0.215*	0.111	-0.185	− 0.052	− 0.078	–
3. Sexist Climate		–	0.166	− 0.198	− 0.134	0.113	0.039	0.190	
4. Impostorism			–	− 0.308**	− 0.466***	0.295*	0.009	0.015	
5. Sense of Belonging				–	0.282**	− 0.303*	0.179	− 0.102	
6. Self-efficacy					–	− 0.362**	− 0.136	0.169	
7. Drop-out Consideration						–	− 0.095	− 0.042	
8. Last College GPA							–	− 0.183	
9. Year in Program	0.497***	− 0.08	− 0.345***	0.247*	0.287**	− 0.269*	− 0.044	0.028	0.497***
M	4.16	3.53	1.91	3.21	8.13	3.59	2.73	3.59	2.89
SD	1.32	1.39	0.73	1.27	1.32	0.60	2.10	0.33	1.75

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

belonging in field (both at Time 2), which in turn predicted considering dropping out of one's graduate program (Time 3). As year in program related to several model variables, including perceptions of a sexist climate ($r=0.19$, $p=0.08$) and self-efficacy ($r=0.17$, $p=0.12$), year in program was controlled for in all model paths.

These results supported all hypotheses, and model fit indices indicated that the hypothesized model fit the data well ($\chi^2[21]=20.46$, $p=0.49$; CFI $=1.00$; TLI $=1.00$; RMSEA <0.001). Standardized model parameters are presented in Fig. 2. Higher PEET within one's STEM department at Time 1 predicted higher perceptions of a sexist atmosphere within the department at Time 2 ($\beta=-0.16$, $z=-1.95$, $p=0.05$). The relationship between perceptions of a sexist atmosphere and one's feelings of academic impostorism (Time 2) was moderated by gender, with perceptions of a sexist atmosphere in one's department predicting higher sense of impostorism for women ($b=0.68$, SE $=0.26$, $t(28)=2.72$, $p=0.01$) but not for men ($b=-0.17$, SE $=0.25$, $t(28)=-0.64$, $p=0.53$). Neither the main effects of gender ($\beta=0.16$, $z=1.59$, $p=0.11$) nor sexist atmosphere ($\beta=-0.09$, $z=-0.64$, $p=0.54$) were significant in the presence of the significant interaction between the two ($\beta=0.32$, $z=2.41$, $p=0.02$). Higher impostorism predicted lower domain specific self-efficacy ($\beta=-0.31$, $z=-3.24$, $p=0.001$) and sense of belonging in field ($\beta=-0.49$, $z=-6.11$, $p<0.001$; both measured at Time 2). Lower domain specific self-efficacy ($\beta=-0.23$, $z=-2.01$, $p<0.05$) and sense of belonging in field ($\beta=-0.24$, $z=-2.12$, $p<0.05$), in turn, predicted a higher probability of considering dropping out of one's graduate program at Time 3.

Discussion

Results of the present work demonstrated that perceptions of an entity-oriented environment within one's STEM department were associated with higher perceptions of sexism by both men and women. However, perceptions of sexism within one's academic department were detrimental for women, but not men, with higher perceived sexism associated with a higher sense of academic impostorism for women. Higher academic impostorism was associated with lower self-efficacy and sense of belonging, both of which correlated with a higher likelihood of considering dropping out of one's graduate program. These findings extend previous work demonstrating the impact of institutional-level (e.g., perceived chilly and hostile STEM environment) as well as individual-level (feelings of competence and belonging) factors on women's persistence in STEM. Most importantly, this is the first time that both institutional-level and individual-level factors have been combined in a single model to show how they jointly influence women's persistence in their STEM fields. Moreover, the present work extends previous work by examining a sample of graduate students, which is a group that has remained relatively understudied, but is important to understand given the data showing that women become increasingly underrepresented at more advanced levels of STEM education (NSF, 2019).

These findings contribute to a growing body of literature aiming to understand the persistent and pervasive underrepresentation of women in STEM. Despite the removal of legal and structural barriers to educational attainment in all domains in the U.S., the numeric underrepresentation of women in STEM fields remains. As reviewed previously, the endorsement of a fixed theory of intelligence and stereotypes that link certain groups to underachievement by an organization can be implicitly communicated (Emerson & Murphy, 2015; Leslie et al., 2015). Understanding the psychological mechanisms and effects of these threats is key to addressing the barriers to achievement and eliminating their effects. The present work contributes to the existing work aiming to understand these processes by examining mechanisms at different levels, ranging from the academic environment to the individual level, including assessments of perceived environmental/institutional threat, individual-level competence beliefs, confidence, and belonging, as well

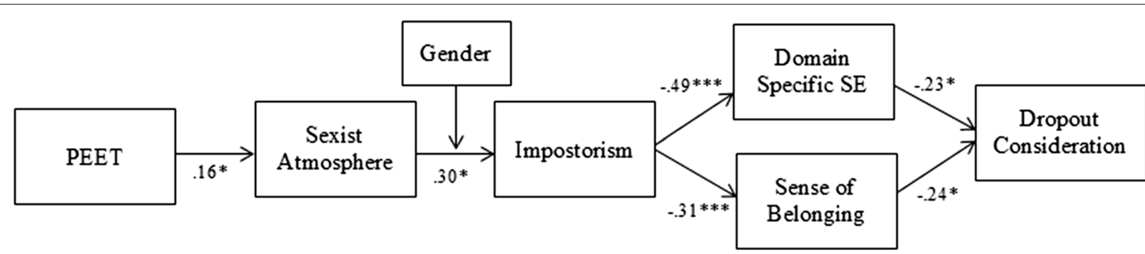

Fig. 2 Model of differential impact of perceived environmental entity theory (PEET) on consideration of dropping out STEM graduate program by gender with standardized path coefficients. Fit indices indicated good model fit ($\chi^2[21]=20.79$, $p=0.47$; CFI $=1.00$; TLI $=1.00$; RMSEA <0.001). $^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

as how these interconnected mechanisms converge to ultimately undermine women's persistence in STEM.

Developing an understanding of the experiences of women in graduate STEM program is important for helping us to develop policies and interventions aimed at broadening the participation of women in STEM fields. Recruiting and maintaining diversity in STEM domains has broad economic benefits (NSF, 2019), creates role models for STEM success that can promote engagement of new generations of women (Rosenthal et al., 2013), and reduces gender pay inequity, given that the pay differential in STEM domains is lower than in other domains (Noonan, 2017). Accordingly, the results of the present research suggest that STEM graduate programs should take steps to ensure that the departmental climate conveys a value for work ethic and persistence rather than brilliance or natural ability to support higher levels of social and academic engagement among women in STEM. These cultural changes may positively impact women's persistence in their STEM fields. The present findings point to interventions aimed at encouraging faculty to convey to their students that hard work and effort are valued in their STEM fields. Future work should investigate whether existing interventions which target student beliefs about intelligence (e.g., Aronson et al., 2002; Paunesku et al., 2015) could be adapted to encourage faculty to adopt incremental beliefs about intelligence and then convey these beliefs to their students.

Although there are several strengths to the present study, there are some limitations to this work. One limitation of this study is that it is correlational, and therefore, causality may not be implied. It is possible that perceptions of PEET and perceptions of sexism developed jointly, although we assessed them at different timepoints based on the evidence that fixed intelligence environments have fewer women and are less trusted by women (Emerson & Murphy, 2015; Leslie et al., 2015). In addition, the present work was conducted at only one university, so the extent to which these results will generalize to other institutions is unknown; however, this study was conducted at a mid-sized public university similar in size and demographic composition to many universities across the United States. Future research should aim to test causal relationships between the proposed environmental-level and individual-level factors and examine how this model might be different for women of color in STEM fields, who face additional barriers and require intersectional approaches for program retainment (Liu et al., 2019).

Conclusion

Although female undergraduates receive half of all bachelor's degrees in STEM fields, women receive less than half of all graduate degrees in STEM fields and are less likely than men to work in a STEM occupation (NSF, 2019). Gender parity in STEM fields is crucial to both scientific innovation and reducing the gender pay gap (Noonan, 2017). In this longitudinal study of doctoral students in STEM, we found that students' perceptions of a fixed ability environment correlated with greater perceptions of sexism, which were negatively related to women's self-efficacy and sense of belongingness and led women to consider dropping out of their STEM career. This study outlines one process that may contribute to the "leaky pipeline" of women in STEM fields, with implications for graduate programs and professional environments alike.

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Authors' contributions
BL and NM were Co-PIs on the research funding grant, BL designed the project, SC, CD, NM contributed to data collection, analysis, and interpretation, SC, CD, EMI drafted and revised the manuscript, and BL oversaw the project and approved the final manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Please contact the corresponding author with questions regarding data availability.

Declarations

Competing interests
We have no known conflicts of interest to disclose.

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