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Why Do Women Opt Out? Sense of Belonging and Women's Representation in Mathematics

Catherine Good
Baruch College, City University of New York

Aneeta Rattan and Carol S. Dweck
Stanford University

Sense of belonging to math—one's feelings of membership and acceptance in the math domain—was established as a new and an important factor in the representation gap between males and females in math. First, a new scale of sense of belonging to math was created and validated, and was found to predict unique variance in college students' intent to pursue math in the future (Studies 1–2). Second, in a longitudinal study of calculus students (Study 3), students' perceptions of 2 factors in their math environment—the message that math ability is a fixed trait and the stereotype that women have less of this ability than men—worked together to erode women's, but not men's, sense of belonging in math. Their lowered sense of belonging, in turn, mediated women's desire to pursue math in the future and their math grades. Interestingly, the message that math ability could be acquired protected women from negative stereotypes, allowing them to maintain a high sense of belonging in math and the intention to pursue math in the future.

Keywords: stereotype threat, sense of belonging, math achievement, sex differences

Not long ago, it was proposed that Title IX, the law prohibiting sexual discrimination in education, should expand its reach beyond sports to science (Tierney, 2008). This would involve withholding federal monies from academic departments with relatively few female scientists on the faculty as a means of increasing gender parity. Critics of the proposal launched an effective counterargument. They claimed that gender gaps exist, not because of discrimination, but rather because of women's lack of desire to pursue math-based disciplines, such as physics or engineering. This position portrays women's versus men's desire to pursue certain subjects as an inherent part of their natures that lead inevitably to gender disparities in representation. However, there is much evidence within psychology to suggest that the desire to pursue a given course of study can be highly unstable and can be greatly influenced by environmental factors. Thus the question remains: Why might females be less willing to pursue math-based disciplines?

The purpose of the present research was, first, to test the hypothesis that both men's and women's feelings of membership and acceptance in the math domain—their sense of belonging—can predict their desire to pursue math in the future. However, different forces may be at work to affect men's and women's sense of belonging in math. Therefore, we also tested the hypotheses that two messages students may hear in their math environments (the message that math ability is a fixed trait and the stereotype that women have less of this ability than men) may be critical factors that work together to erode women's, but not men's, sense that they belong in math and, hence, their desire to pursue math in the future.

This issue is important because although the percentage of science, technology, engineering, and mathematics (STEM) degrees going to women has increased substantially over the past decade, there is still a sizable gender gap in certain disciplines (National Science Foundation, 2006). For example, in 2003 women earned only 24% of doctoral degrees in mathematics and 17% of doctoral degrees in engineering (National Science Foundation, 2006). In addition, White men overwhelmingly dominated the professoriate in these fields where, for example, less than 10% of the math faculty was female in 2000.

In the present study, we examine students at an elite university who are a very high-achieving group in math. These are the very men and women whom one would expect to be represented at the higher levels of mathematics study and of the mathematics-based professions.

Sense of Belonging to an Academic Domain

As we have suggested, a key factor driving students' intent to pursue math should be their personal sense that they belong in mathematics. Sense of belonging to an academic domain likely contains various components, but at its heart it reflects the feeling that one fits in, belongs to, or is a member of the academic community in question. In addition to viewing oneself as being inside a discipline rather than on the fringes of it, sense of belonging may also entail a sense of being valued and accepted by fellow

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Catherine Good, Department of Psychology, Baruch College, City University of New York; Aneeta Rattan and Carol S. Dweck, Department of Psychology, Stanford University.

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Correspondence concerning this article should be addressed to Catherine Good, Baruch College, CUNY, Vertical Campus Room 8-215, One Bernard Baruch Way, New York, NY 10010. E-mail: Catherine.Good@baruch.cuny.edu

members of the discipline. Thus, sense of belonging, as we conceptualize it, involves one's personal belief that one is an accepted member of an academic community whose presence and contributions are valued.

When sense of belonging is reduced, individuals may opt out of the domain—even when achievement remains high—to pursue studies and professional goals within a different discipline that better enables this sense of belonging to take root. Although women's assumed lack of desire to pursue math may serve as a readily available explanation for their departure from the field, it is possible that a lack of desire to remain in math may stem from a lowered sense of belonging rather than from a natural disinclination on the part of women.

The Importance of Sense of Belonging

As Baumeister and Leary (1995) argued, the need to belong—the need to form interpersonal attachments—is a fundamental human motive (Pickett, Gardner, & Knowles, 2004; Twenge, Baumeister, Tice, & Stucke, 2001). Though this past research highlights the importance of the need to belong, it leaves important questions unanswered. First, past research has largely focused on the implications of belongingness needs in *social* situations (e.g., Pickett et al., 2004) or one's social connections in an achievement situation (Walton & Cohen, 2007), but leaves unanswered how an "academic" sense of belonging may operate to affect motivation and achievement. Second, past research addresses the consequences of the general need to belong, but not the consequences of an individual's sense of belonging in a specific area. Certainly, individuals differ in the extent to which their fundamental need to belong is met through familial relationships, friendships, social memberships, and the like. Nevertheless, these general belongingness needs may have little to do with one's sense of belonging to a particular academic domain: Individuals both high and low in general belongingness needs may be equally vulnerable to the potential negative consequences of a low sense of belonging to an academic domain, especially when viable alternatives may lay at the ready. Thus, the purpose of this research was to study sense of belonging to an academic domain to better understand factors that might contribute to the representation gaps that exist between the sexes and, perhaps by extension, among various ethnic or racial groups.

Influences on Sense of Belonging: Negative Stereotypes and Fixed Views of Intelligence

If, as we hypothesize, sense of belonging is a critical factor for one's persistence in a domain, the natural question arises: What affects sense of belonging in that domain? To begin to answer this question, consider the societal cues and the culture of mathematics in which women and minorities find themselves.

The Potential Effects of Stereotypes and Stereotype Threat on Sense of Belonging

Stereotypes of women's lesser ability in math compared with men are alive and well, as illustrated by Harvard University's ex-president's suggestion that the representation gap between males and females may stem, in part, from the lack of capable women at the upper level of mathematics ability (Summers, 2005). As over a decade of research has shown, ability-impugning stereotypes such as these can trigger psychological processes that can undermine the performance of stereotyped individuals, including females in math (Dar-Nimrod & Heine, 2006; Good, Aronson, & Harder, 2008; Spencer, Steele, & Quinn, 1999; Steele & Aronson, 1995), especially on high-stakes tests like the SAT (Danaher & Crandall, 2008).

Negative stereotypes, however, may have the power to disrupt more than performance; they may also carry a strong message that certain groups are less valued or accepted. That is, the gender stereotype in math, when made salient, may lead women in particular to feel less like accepted members of the math community and thus to have a lower "sense of belonging" to math. Consequently, negative stereotypes may, in fact, influence women's representation in the math pipeline by means other than underperformance on high-stakes tests.

Although traditional stereotype threat theory primarily accounts for underperformance, sense of belonging to math may account for underparticipation above and beyond what deficits in performance on standardized tests can explain. It is not hard to imagine that stereotyped individuals may be less interested in and willing to pursue a domain of study in which their sense of belonging has been undermined, despite their high achievement. Past work has discussed the theoretical importance of feeling a sense of belonging to a domain (Steele, 1997) and has begun to examine the ways in which cues in the environment (such as the numerical representation of men vs. women) can make stereotypes salient, thereby lowering both trust within that context (Purdie-Vaughns, Steele, Davies, Ditlmann, & Crosby, 2008) and ambient sense of belonging for members of negatively stereotyped groups (e.g., Cheryan, Plaut, Davies, & Steele, 2009; Murphy, Steele, & Gross, 2007). However, research has yet to examine the longer term effects of belonging-relevant cues outside of a laboratory environment.

Theories of Intelligence and Sense of Belonging

Females who, despite the stereotype, find themselves in math-related disciplines must now face the "culture of talent" pervading these fields, a culture that may also undermine their sense of belonging. The United States and perhaps Western societies in general often view math ability as a talent, something that one is either born with or not (Williams & King, 1980). In fact, individuals may often console themselves about their mathematics shortcomings by falling back on the expression, "I'm not a math person." Perhaps nowhere is the belief in the fixed nature of math ability more entrenched than within the mathematics community itself, which relies on a "talent-driven approach to math" (Faulkner, 2008, as reported by Lewin, 2008; National Mathematics Advisory Panel, 2008). Research suggests that this mindset about the nature of intelligence as being a fixed trait (an "entity theory") can undermine achievement in the face of difficulty (Blackwell, Trzesniewski, & Dweck, 2007). That is, although an entity theory can be motivating in certain circumstances (Mendoza-Denton, Kahn, & Chan, 2008), research has shown that this concern can turn students away from challenges that might undermine their belief that they have high ability (Hong, Chiu, Dweck, Linn, & Wan, 1999; Nussbaum & Dweck, 2008; Rhodewalt, 1994; cf. Mangels, Butterfield, Lamb, Good, & Dweck, 2006; Mueller & Dweck, 1998) and can impair students' motivation and performance, especially in the face of setbacks (e.g., Blackwell et al., 2007; Martocchio, 1994; Wood & Bandura, 1989).

In contrast, students who hold the mindset that ability is a malleable quality (an "incremental theory") are less focused on measuring and proving their abilities, and more focused on learning (i.e., improving their abilities; Blackwell et al., 2007; Dweck & Legget, 1988; Mangels et al., 2006; Robins & Pals, 2002). They seek challenges that can result in better learning (Hong et al., 1999; Nussbaum & Dweck, 2008; cf. Mueller & Dweck, 1998), and they remain highly strategic and effective in the face of setbacks, even showing enhanced motivation and performance (Mangels et al., 2006; cf. Grant & Dweck, 2003; Mueller & Dweck, 1998). In summary, much research, in both laboratory and real-world studies, shows that students' implicit theories of intelligence can have important effects on academic persistence and achievement and that incremental theorists often fare better than entity theorists in the face of ability-threatening academic challenges.

An individual's existing self-theory of intelligence, however, may not be the only source of entity or incremental information; the learning environment itself may convey these ideas (Murphy & Dweck, 2010). When individuals either hold a fixed view or find themselves in learning environments that they perceive to support the fixed view of math ability, they may question whether or not they have the requisite ability, and thus whether or not they belong in the domain. However, environments that support the idea of malleable ability may create opportunities for many more people to be valued members of the community, perhaps because belongingness depends less on inherent ability and more on one's dedication and commitment to learning in that domain.

Hypotheses

We hypothesized that both male and female students with a high sense of belonging to math would be more likely to intend to pursue mathematics as a domain of study in the future and would achieve higher grades than those with a low sense of belonging. However, we also hypothesized that, over time, females who perceived their math environment to send (a) messages that men have more math ability than women and (b) messages that math ability is fixed would experience lower sense of belonging. In contrast, females who perceived their math environment to send messages about acquirable ability should be less vulnerable, even when they perceive negative stereotypes to be prevalent in their environment. If skills can be acquired through effort over time, then the stereotype of lesser underlying ability may become less credible and certainly will become less threatening for their sense of belonging because skill deficits can be overcome.

Because sense of belonging has yet to emerge within the literature as a critical component affecting representation within an academic discipline and because the long-term effects of negative stereotypes combined with messages of fixed ability have not been well studied, women in the domain of mathematics provide an excellent test case to address these questions.

In Study 1, we conducted careful scale development to determine the factor structure and internal reliability of a new Sense of Belonging to Math scale. In Study 2, we examined the power of sense of belonging to math to predict students' intention to remain in the mathematics domain, over and above other factors known to affect continuation in math. Next, in Study 3, we measured the extent to which calculus students perceived that their academic environment portrayed (a) math as a fixed ability and (b) women as having less math ability than men. We then explored sex differences in the separate and combined effects of these perceptions on men's and women's sense of belonging in math over time. Finally, we examined the importance of sense of belonging as a mediator of the effect of these perceptions on women's intention to continue in math and on their math grades. By investigating sense of belonging as a key variable in both performance and decisions to pursue math in the future, as well as sex differences in the factors that influence sense of belonging, we seek to shed new light on the representation gap between men and women.

Study 1

The purposes of Study 1 were to (a) explore the factor structure of a new Sense of Belonging to Math measure and to determine its internal reliability and (b) confirm the factor structure identified in the exploratory analysis. A sense of belonging to math likely contains various components, such as one's feelings of membership and acceptance in the domain. In addition, one's affect may also reflect sense of belonging, for feeling happy and comfortable in a domain may reflect greater belongingness than chronically feeling nervous and distressed. Moreover, a hearty sense of belonging in students may also entail a sense of trust that one's peers, colleagues, and professors have their best interests at heart and will strive to ensure their learning and success. And finally, when members of an academic community truly feel a sense of belonging, they are likely to show active participation in that community rather than desiring to fade into the background and not be noticed. Thus, sense of belonging, as we conceptualize it, involves one's personal feelings of membership and acceptance in an academic community in which positive affect, trust levels, and willingness to engage remain high.

Method

Participants. A total of 997 participants (465 men and 532 women) at a highly selective university in the Northeast United States completed the Sense of Belonging to Math scale during their calculus course. The sample was randomly split in half so that we could conduct the exploratory factor analysis on one sample and the confirmatory factor analysis on a separate sample. In the first sample, this resulted in 499 participants (224 men, 275 women), of which 47% were Caucasian, 3% were African American, 21% were Asian, 5% were Latino, and 24% were "other" or unidentified. Participants who did not complete the entire survey were excluded from the analysis, leaving 409 participants. The second sample contained 498 college calculus students (241 men, 257 women), of which 45% of the participants were Caucasian, 4% were African American, 20% were Asian, 3% were Latino, and 28% were "other" or unidentified.

Procedure. Participants read the following instructions and then completed the 28-item Sense of Belonging to Math scale, which contained the five subscales proposed to comprise a sense of belonging to math:

> We would like you to consider your membership in the math community. By virtue of having taken many math courses, both in

> high school and/or at ___ University, you could consider yourself a member of the math community. Given this broad definition of belonging to the math community, please respond to the following statements based on how you feel about this group and your membership in it.

All items were preceded by the statement, "When I am in a math setting." For each item, participants rated their agreement on a 6-point Likert-type scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). See the Appendix for the complete scale.

Results

Exploratory factor analysis and internal reliability. To explore the factor structure of the sense of belonging measure, we conducted a principal components analysis using promax rotation and eigenvalues greater than 1.00. This yielded six components accounting for 40.15% (Membership), 10.93% (Acceptance), 6.50% (Affect, negative), 6.24% (Affect, positive), 5.40% (Trust), and 3.91 % (Desire to Fade) of the total variance, respectively.

As expected, most of the items from each subscale loaded together on distinct components. Not surprisingly, the items from the Membership and Acceptance subscales formed the strongest components, followed by Affect, Trust, and Desire to Fade.

Although we expected to identify five components representing the five subscales, a slightly different pattern emerged: Positively worded items and negatively worded items from the Affect subscale did not load on the same component, and some positive items from the Acceptance subscale loaded on the component containing positive affect. In addition, a key item from the Acceptance subscale did not attain a high loading (greater than .4) on any component. These component loadings are presented in Table 1.

Despite the fact that the positively and negatively worded items split apart and loaded on separate components—as is often the case when a subscale includes some reverse-coded items—the strong alphas for the Acceptance (α = .91) and Affect (α = .91) subscales suggest that the positively and negatively worded items in each subscale are in fact measuring the same construct.

After confirming a strong alpha for the Acceptance and Affect subscales, we conducted an additional principal components anal-

Table 1
Sense of Belonging to Math Scale: Exploratory Factor Analysis Using Principal Components Analysis With Promax Rotation: Component Loadings

Subscale	Item	Promax rotation 1	2	3	4	5	6
Membership							
	Belong	.942					
	Member	.955					
	A part of	.968					
	Connected	.957					
Acceptance (positive)							
	Accepted						
	Respected		.453				
	Valued		.545		.445		
	Appreciated		.534		.483		
Acceptance (reverse coded)							
	Disregarded (−)		.938				
	Neglected (−)		.813				
	Excluded (−)		.853				
	Insignificant (−)		.834				
Affect (positive)							
	At ease				.759		
	Comfortable				.809		
	Content				.848		
	Calm				.914		
Affect (reverse coded)							
	Anxious (−)			.882			
	Tense (−)			.864			
	Nervous (−)			.851			
	Inadequate (−)			.560			
Trust							
	Test is unbiased					.796	
	Don't have to prove worth					.614	
	Help me learn					.827	
	Faith in potential					.879	
Desire to Fade (reverse coded)							
	Fade (−)						.613
	Say little (−)						.899
	Wish invisible (−)						.488
	Active participant						.885

Note. All loadings greater than .40 are shown.

ysis with the items from these two subscales together to ensure that they are separate components. As Table 2 shows, every item obtained high loadings on the expected components when two components were extracted. In particular, the item "accepted," which, curiously, had low loadings in the previous analysis, had high reliability and loaded on the appropriate component.

Internal consistency of the Sense of Belonging scale. Our next step was to investigate the internal consistency of the five components separately as well as the composite Sense of Belonging to Math scale as a whole. Cronbach's alpha was .95 for Membership, .91 for Acceptance, .91 for Affect, .78 for Trust, and .81 for Desire to Fade. We then computed the composite sense of belonging by first creating subscale averages for each of the five components and then averaging them. The five-component Sense of Belonging to Math measure achieved substantial alpha (Cronbach's $\alpha = .81$). We also calculated Cronbach's alpha using the 28 items and again achieved a substantial alpha (Cronbach's $\alpha = .94$).

Confirmatory factor analysis. To confirm the factor structure of the sense of belonging measure, we conducted a confirmatory factor analysis using AMOS. To begin, we tested a second-order factor structure in which the second-order factor, Sense of Belonging, was indicated by five first-order factors (Membership, Acceptance, Affect, Desire to Fade, and Trust), which were in turn indicated by their individual items as identified in the exploratory factor analysis.

Results indicated that each individual item achieved high-factor loadings onto the relevant first-order factor (all factor loadings > .49), and each first-order factor achieved high-factor loadings onto the second-order factor, sense of belonging (all factor loadings > .55). We next evaluated model fit indices, in particular the root-mean-square error of approximation (RMSEA) and the Tucker-Lewis index (TLI), to determine whether the data supported this second-order factor structure or whether a first-order factor structure should be investigated. Present standards suggest that RMSEAs below 0.06 suggest a good fit of the model to the data, particularly when the TLI value is greater than 0.95. For the present model, RMSEA = .09 and TLI = .72 (see Table 3). Thus, we tested a first-order factor structure in which the single factor, Sense of Belonging, was indicated by the observed values of Membership, Acceptance, Affect, Desire to Fade, and Trust. These observed values were created by averaging the scores on the individual items that comprised each subscale. Results indicated that each of the five observed factors achieved high-factor loadings (Membership = .56, Acceptance = .94, Affect = .78, Desire to Fade = .71, Trust = .49). Furthermore, the data fit the model well: RMSEA = .056, p-close = .35, and TLI = .95 (see Table 4). It was not surprising that the chi-square value of 12.86 was significant ($p = .03$) given the large sample size. In such situations, it is appropriate to examine the ratio between chi-square and degrees of freedom and to accept models that achieve a ratio less than 3. The ratio in our model was 2.57 ($df = 5$). In addition, Sense of Belonging achieved a Cronbach's alpha of .78 using the five subscales (see Table 5 for subscale correlations). Thus, the results of the confirmatory factor analysis suggest a first-order factor structure for Sense of Belonging that is composed of five factors: Membership, Acceptance, Affect, Desire to Fade, and Trust. This means that in all subsequent analyses, we did not test the impact of the five factors separately, but instead examined the impact of the composite Sense of Belonging.

Table 2
Exploratory Factor Analysis Using Principal Components Analysis and Promax Rotation: Acceptance and Affect Components

Subscale	Item	Promax rotation 1	Promax rotation 2
Acceptance			
	Accepted	.763	
	Respected	.805	
	Valued	.929	
	Appreciated	.885	
	Disregarded (−)	.759	
	Neglected (−)	.708	
	Excluded (−)	.695	
	Insignificant (−)	.607	
Affect			
	At ease		.514
	Comfortable		.548
	Content		.422
	Calm		.600
	Anxious (−)		.946
	Tense (−)		.949
	Nervous (−)		.949
	Inadequate (−)		.661

Note. All loadings greater than .40 are shown. Parenthetical minus signs indicate that the items were reverse coded.

Study 2

The next step in establishing the importance of sense of belonging to math in the representation gap was simply to examine the relation between sense of belonging to math and students' intent to pursue math in the future. We also assessed the relation between sense of belonging to math and other variables found in previous research to be related to math achievement and representation. We hypothesized that sense of belonging to math would predict intent to pursue math in the future even after controlling for other variables that also could be predictive, such as identification with mathematics, general sense of belonging to school, stigma consciousness, sensitivity to gender-based rejection, and general anxiety. Thus, Study 2 was designed to obtain test–retest reliability and construct validity for the Sense of Belonging to Math measure.

Method

Participants. A total of 133 participants (56 men and 77 women), recruited from the student population at a highly selective university in the Northeast United States, were invited to attend research sessions on two different occasions. They were paid $10 for their participation in each session.

Because participants had to report to the laboratory on two occasions to fill out a large number of questionnaires, considerable attrition was expected. A total of 73 participants attended both sessions of the study (30 men and 43 women). Of these, 38% of the participants were Caucasian, 21% were African American, 32% were Asian, 8% were Latino, and 1% were "other" or unidentified. It was important, however, to ensure that the participants who did return for Session 2 did not differ substantially from those who

Table 3
Confirmatory Factor Analysis: Second-Order Factor Structure: Factor Loadings for the Sense of Belonging to Math Scale

Second-order factor loading	First-order factor loading	Item
	Sense of Belonging	
.57	Membership	
	.95	Belong
	.94	Member
	.98	A part of
	.94	Connected
.98	Acceptance	
	.80	Accepted
	.76	Respected
	.74	Valued
	.71	Appreciated
	.70	Disregarded (−)
	.77	Neglected (−)
	.74	Excluded (−)
	.78	Insignificant (−)
.79	Affect	
	.85	At ease
	.89	Comfortable
	.78	Content
	.77	Calm
	.60	Anxious (−)
	.62	Tense (−)
	.59	Nervous (−)
	.57	Inadequate (−)
.55	Trust	
	.49	Test is unbiased
	.52	Don't have to prove
	.83	Help me learn
	.80	Faith in potential
.70	Desire to Fade (reverse coded)	
	.31	Fade (−)
	.74	Say little (−)
	.78	Wish invisible (−)
	.91	Active participant

Note. Model fit indices are as follows: $\chi^2(345, N = 498) = 1733.63$, $p = .00$; $\chi^2/df = 5.03$; comparative fit index = .77; Tucker-Lewis index = .72; root-mean-square error of approximation = .09; p-close = .00.
All $ps < .001$. Parenthetical minus signs indicate that the items were reverse coded.

attended only Session 1. First, males and females were equally likely to return for Session 2. Second, there were no differences between the two groups on any of the Round 1 questionnaires. The only exception was that female participants who attended both sessions of the study had slightly higher scores on the Stigma Consciousness Scale (Pinel, 1999) than those who attended only Session 1 ($p < .02$). However, this is not a difference that is theoretically meaningful.

Procedure. Participants completed the Sense of Belonging to Math scale as part of a battery of measures distributed over two research sessions.

Measures.

Sense of Belonging to Math (Sessions 1 and 2). Participants responded to the 28-item Sense of Belonging to Math scale, our new measure of belongingness that is specific to an intellectual domain. As discussed above, careful development and validation of the scale showed that it is composed of five factors: Membership (e.g., "I feel like I belong to the math community"); Acceptance (e.g., "I feel accepted"); Affect (e.g., "I feel comfortable"); Trust (e.g., "I trust my instructors to be committed to helping me learn"); and Desire to Fade (e.g., "I wish I could fade into the background and not be noticed"—reverse coded). Each item was preceded by the phrase, "When I am in a math setting" and was measured on a 6-point Likert scale (1 = *strongly disagree*; 8 = *strongly agree*). For the present sample, Cronbach's alpha was .85 for the composite scale ($N = 133$).

Table 4
Confirmatory Factor Analysis: First-Order Factor Loading: Factor Loadings for the Sense of Belonging to Math Scale

First-order factor loadings: Sense of belonging	Item
.56	Membership
.94	Acceptance
.78	Affect
.49	Trust
.71	Fade

Note. Model fit indices are as follows: $\chi^2(5, N = 498) = 12.86$, $p = .03$; $\chi^2/df = 2.57$; comparative fit index = .98; Tucker-Lewis index = .95; root-mean-square error of approximation = .05; p-close = .35.
All $ps < .001$.

As discussed below, Psychological Sense of School Membership (Goodenow, 1993), Social Connectedness (R. M. Lee & Robbins, 1995), Stigma Consciousness (Pinel, 1999), Gender-Based Rejection Sensitivity (London-Thompson, Downey, Rattan, & Tyson, in press), and Math Identification were also included in the battery of measures, although only females responded to the Stigma Consciousness and Gender-Based Rejection Sensitivity scales. The inclusion of these scales was important for two reasons. First, they could potentially affect students' intent to take math in the future as well as other variables related to math achievement and representation, such as math anxiety, math confidence, and perceived usefulness of math (Fennema & Sherman, 1976). Second, it was necessary to determine the unique power of the Sense of Belonging to Math measure to predict participants' intent to take math in the future as well as the math-related outcomes in the presence of other variables that could also be predictive of these outcomes. In summary, Psychological Sense of School Membership (Goodenow, 1993), Stigma Consciousness (Pinel, 1999), Gender-Based Rejection Sensitivity (London-Thompson et al., in press), and Math Identification were included as additional predictor variables for Intent to Pursue Math, Math

Table 5
Subscale Correlations

Variable	1	2	3	4	5
1. Membership	—		248	247	248
2. Acceptance	.543**	—	248	247	248
3. Affect	.359**	.730**	—	247	247
4. Desire to Fade	−.377**	−.656**	−.584**	—	246
5. Trust	.354**	.453**	.387**	−.383**	—

** $p < .001$.

Anxiety, Math Confidence, and Perceived Usefulness of Math (Fennema & Sherman, 1976).

Psychological Sense of School Membership (Goodenow, 1993), (Session 2). This 18-item scale captures students' perceived belonging to school ("I feel like a real part of________"; Cronbach's α = .88, N = 78).

Stigma Consciousness (Pinel, 1999), (Session 1). This 10-item scale measures the extent to which people expect to be stereotyped ("I never worry that my behaviors will be viewed as stereotypically female"; reverse coded; Cronbach's α = .64, N = 73).

Gender-Based Rejection Sensitivity (London-Thompson et al., in press), (Session 2). This scale measures the extent to which females anxiously expect to be rejected based on their gender:

> Imagine that you are in your science class, and the professor asks a particularly difficult question. A few people, including yourself, raise their hands to answer the question. How concerned/anxious would you be that the professor might not choose you because of your gender? (Cronbach's α = .91, n = 49).

Math Identification. In Session 2, participants responded to the following statement as part of the battery of measures: Overall, being good at math has little to do with how I feel about myself.

Math Anxiety (Fennema & Sherman, 1976), (Session 2). This 12-item scale measures the extent to which people feel anxious about math ("Mathematics usually makes me feel uncomfortable and nervous"; Cronbach's α = .93, n = 78).

Usefulness of Math (Fennema & Sherman, 1976), (Session 2). This 12-item scale measures the extent to which people find math useful in their lives ("I will use mathematics in many ways as an adult"; Cronbach's α = .92, n = 78).

Math Confidence (Fennema & Sherman, 1976), (Session 2). This 12-item scale measures an individual's confidence in his or her math ability ("I have a lot of self-confidence when it comes to math"; Cronbach's α = .95, n = 77).

Intent to Pursue Math. In Session 1, participants responded to the following question as part of the battery of measures: "How likely are you to take math classes in the future?"

Results

Our goal was to determine the reliability and validity of the Sense of Belonging to Math scale. Thus, we conducted test–retest reliability analyses and predictive validity. The results of each analysis are discussed below.

Test–retest reliability. The correlation between Time 1 and Time 2 ratings was calculated for the composite Sense of Belonging to Math scale, which was calculated by computing the average of the five factors. The test–retest correlation was .87 for the composite Sense of Belonging to Math.

Predictive validity. Our final step was to determine the unique power of Sense of Belonging to Math to predict variables that are related to math achievement, such as participants' math anxiety, perceived usefulness of math, confidence in math, and intention to pursue math in the future. To this end, we regressed each of these variables on Sense of Belonging to Math, controlling for Psychological Sense of School Membership (Goodenow, 1993), trait anxiety, and math identification, all of which could potentially affect these math-related outcomes for females.

Consistent with our predictions, Sense of Belonging to Math was a significant predictor of intention to pursue math in the future, even after controlling for the other constructs (which were nonsignificant) (see Table 6) and even after excluding the Affect subscale, which significantly overlaps with the Math Anxiety scale, in the calculation of the Sense of Belonging construct. Importantly, math domain identification only emerged as a significant predictor of one's intent to pursue math in the future; nevertheless, Sense of Belonging to Math was the strongest predictor of intent to pursue math, even in the presence of math domain identification.

We also ran these analyses including Stigma Consciousness (Pinel, 1999) and Gender-Based Rejection Sensitivity (London-Thompson et al., in press) because these scales could influence females' willingness to pursue mathematics. Because these scales are only relevant to females, the results include only the females' data. The same pattern emerged (see Table 7). What is more, for females, Sense of Belonging to Math was the only variable that predicted intent to pursue math in the future and all three of the math achievement-related outcomes.

Discussion

The Sense of Belonging to Math scale was shown to have good test–retest reliability. Although other measures of "belongingness" exist in the literature (see Goodenow, 1993; R. M. Lee & Robbins, 1995), our measure is at best only moderately related to them. Furthermore, Sense of Belonging to Math was shown to have unique power to predict factors that are related to math achievement, even after controlling for other constructs that could also affect those outcomes. Specifically, the more the participants re-

Table 6
Predictive Validity: Standardized Regression Coefficients and Squared Multiple Correlations: Males and Females

	Predictor variable				
Criterion variable	Sense of Belonging	PSM	Anxiety	Math ID	Adj. R^2
Math anxiety	$-.70^{***}$	−.05	.08	−.05	.53
Usefulness of math	$.59^{***}$	.17	.16	.17	.43
Math confidence	$.77^{***}$	−.01	.01	.02	.58
Intent to pursue	$.42^{***}$	.20	.04	$.25^{*}$	.32

Note. Regression coefficients represent the effects of each variable controlling for each of the others in the model. PSM = Psychological Sense of School Membership; Math ID = Math Identification.
* $p < .05$. *** $p < .001$.

Table 7
Predictive Validity: Standardized Regression Coefficients and Squared Multiple Correlations: Females Only

	Predictor variable						
Criterion variable	Sense of Belonging	PSM	Stigma Consciousness	RS-Gender	Anxiety	Math ID	Adj. R^2
Math anxiety	$-.71^{***}$	−.13	−.07	.07	−.08	−.05	.52
Usefulness of math	$.55^{***}$	.23	−.21	.16	.07	$.28^{**}$	.59
Math confidence	$.79^{***}$	.01	.05	−.12	.14	−.02	.57
Intent to pursue	$.40^{**}$	.26	−.25	.25	−.04	.25	.39

Note. Regression coefficients represent the effects of each variable controlling for each of the others in the model. PSM = Psychological Sense of School Membership; RS-Gender = Gender-based Rejection Sensitivity; Math ID = Math Identification.
$^{**} p < .01$. $^{***} p < .001$.

ported feeling a sense of belonging in math, the more they reported an intention to pursue math in the future. In addition, the more the participants reported feeling a sense of belonging in math, the less they reported feeling anxious about math, and the more they reported a belief in the utility of math and confidence in their math abilities, even after controlling for other constructs (such as math domain identification, psychological sense of school membership, and anxiety) that could also affect those outcomes (Eccles & Jacobs, 1986). Most importantly, the power of Sense of Belonging to Math to predict one's intention to remain in the domain, even after controlling for math domain identification, provides evidence for the unique contribution of one's feelings of belonging over and above feelings of identification with the domain. Furthermore, this relationship persisted for women when factors uniquely applicable to females' outcomes, such as stigma consciousness and gender-based rejection sensitivity, were included. Taken together, these analyses provide support for the unique relation of sense of belonging to both men's and women's intent to remain in the math domain.

Study 3

The next step was to extend our investigation of sense of belonging to students taking a college math course (calculus) in order to investigate both the role that sense of belonging plays in students' academic choices and achievement and the factors that affect students' sense of belonging to math. To this end, we conducted a longitudinal study that investigated (a) how sense of belonging affected students' intent to pursue math in the future, as well as their math grades, and (b) how perceiving an entity theory and gender stereotyping coming from their math environment affected students' sense of belonging to math over time. As noted earlier, we predicted that females', but not males', sense of belonging to math would be vulnerable to the negative impact of stereotypes but that this susceptibility would be seen most clearly when women perceived their learning environment to convey messages of fixed ability. What is more, we predicted that when women's sense of belonging to math was undermined by these perceptions, their willingness to pursue math in the future and their math grades would suffer. To answer these questions, we first examined how students' sense of belonging changed over the course of the semester. Second, we tested whether any sex differences emerged in the ability for sense of belonging to predict men's and women's intentions to remain in the math domain. Third, we tested whether sex differences would emerge in whether students' perceptions of their learning environment would affect their sense of belonging. Finally, we conducted model invariance testing to determine whether our predictive model relating the environmental variables, sense of belonging, and intention to pursue math differed by sex.

Method

Participants. Permission was obtained from the mathematics department at a highly selective East Coast university to distribute surveys to calculus students on three different occasions during their calculus classes. In addition, during each of the three research sessions, participants' consent was obtained. A total of 534 females and 471 males taking college calculus participated in the study. They completed the Sense of Belonging scale (as well as other measures) during at least one of three time points during their calculus course. Because the questionnaires were administered in class at three specific time points agreed to by the instructors, participation depended on who was present in class on a particular day. A total of 401 females and 456 males completed the survey at Time 1; 337 females and 247 males at Time 2; and 296 females and 196 males at Time 3. Because reliable data analysis techniques allow for large amounts of missing data, all participants were included in the study, regardless of their rate of participation. The issue of missing data is addressed below in the Results section.

Fifty-five percent of the participants were Caucasian, 6% were African American, 24% were Asian, 6% were Latino, and 9% were "other" or unidentified. The average SAT math score was 720 for males and 705 for females. Because these scores are well above the national average (499 for females in 2009; The College Board, 2009), the sample represents males and females with a high skill level in math.

Procedure. As noted, surveys were distributed three times during the semester. The first survey distribution occurred approximately 3 weeks into the semester, before students had been exposed to much of their calculus course; the second survey distribution occurred near the middle of the semester; and the third occurred at the semester's end, just before final examinations. This design allowed us to track changes in students' perceptions and intentions over the course of the semester.

Measures.

Sense of Belonging to Math. The 28-item Sense of Belonging to Math scale was administered at all three time points. For the present sample, Sense of Belonging to Math achieved Cronbach's alphas ranging from .77 to .97 for each subscale and a Cronbach's alpha of .84 for the composite measure (as assessed at Time 3).

Perceptions of environmental entity theory (PEET) (Time 2). On an 8-point Likert scale (1 =*strongly disagree*; 8 =*strongly agree*), participants responded to four items designed to measure the extent to which they perceived an entity-oriented math environment (e.g., "People in my calculus class believe that people have a certain amount of math intelligence and they can't really do much to change it"). The items for this scale were modified from Dweck's (1999) Implicit Theories of Intelligence Scale. Cronbach's alpha for this scale was .97. Time 2 was chosen as the appropriate moment at which to measure students' perceptions of their learning environment because Time 1 did not allow participants enough experience with their calculus environment to provide meaningful responses to the PEET measure.

Perceptions of environmental stereotyping (PEST) (Time 2). There were six items designed to measure the extent to which students perceived gender stereotyping in their math environment (e.g., "People in my calculus class believe that females are as good as males in calculus"). These items were reverse coded so that high scores indicated a high perception of environmental stereotyping. Cronbach's alpha was .93. This scale was adapted from the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) and was measured on an 8-point Likert scale (1 = *strongly disagree*; 8 = *strongly agree*).[1]

Intent to Pursue Math (Time 3). Participants responded to one item designed to measure their intent to pursue math in the future (e.g., "How likely are you to take math classes in the future beyond Calculus II?"). This item was measured on an 8-point Likert scale (1 = *strongly disagree*; 8 = *strongly agree*). Because participants were enrolled in a two-course sequence (Calculus I and Calculus II), it was important to measure their intent to pursue math after completing Calculus II.

Interest in Math (Time 3) On an 8-point Likert scale (1 = *strongly disagree*; 8 = *strongly agree*), participants responded to four items designed to measure their interest in math (e.g., "I enjoy math"). Cronbach's alpha was .91.

Math Grades. With students' permission, their final course grades in calculus were obtained from the mathematics department.

Results

Because measures were administered on three different occasions, complete data existed only for those participants who attended their calculus class on all 3 days during which the surveys were administered (n = 176 for females, n = 109 for males). However, the data were analyzed using AMOS 5.0, which uses maximum likelihood methods for estimating missing data on the basis of the "MAR" assumption that the data were missing at random (Little & Rubin, 2002).[2] Thus, the results presented below incorporate data from all 1,005 participants. It is important to note that a similar pattern of results was obtained when including only those males and females who participated in all of the three research sessions.[3]

Did men and women differ in their sense of belonging to math at any of the three time points? To answer this question, we ran a repeated measures analysis of variance (ANOVA) on Sense of Belonging to Math using three levels (Time 1, Time 2, and Time 3). A main effect of time emerged, $F(2, 664) = 26.22$, $p < .001$, such that participants' sense of belonging decreased in a linear fashion over time. Planned contrasts revealed a significant interaction between sex and time such that at Time 2, males' sense of belonging was significantly greater than females', $F(1, 332) = 4.44$, $p < .04$ (see Table 8 for means and standard deviations). This was the only gender difference to emerge.

Does sense of belonging to math predict men's and women's intent to take math in the future? To answer this question, we ran regression analyses in which we used sex, Sense of Belonging at Times 1 and 3, final course grade, SAT, and the Sex × Sense of Belonging interaction at Time 3 to predict intent to pursue math (all predictor variables were centered prior to analysis). Results showed that Sense of Belonging at Time 3 was a significant predictor of participants' intent to pursue math ($\beta = .26$), $t(1004) = 3.00$, $p = .003$, even after controlling for Sense of Belonging at Time 1 (*ns*), final grade in the course (*ns*), and math SAT scores ($p = .002$). The interaction between sense of belonging at Time 3 and sex was not significant. Nevertheless, we conducted regressions separately for each sex to explore any differences in patterns for the two sexes that might emerge. For the females, results showed that sense of belonging at Time 3 was a significant predictor of women's intent to pursue math ($\beta = .27$), $t(1004) = 2.41$, $p = .02$, even after controlling for sense of belonging at Time 1 (*ns*), final grade in the course (*ns*), and math SAT scores ($p = .06$). Thus, although women's initial sense of belonging did not predict their later desire to continue in math, the reduction in women's sense of belonging over time predicted their lower intentions to pursue math in the future above and beyond the grade they received in the course.

For males, none of the simultaneously entered variables emerged as significant predictors of their intent to take math in the future. However, we then conducted a stepwise regression using

[1] We conducted an ANOVA to determine whether classes varied in students' perceptions of negative stereotypes about women's math abilities. Results showed that there were significant differences across the 20 classes included in the study, $F(19, 584) = 1.60$, $p = .05$ ($M = 2.81$, $SD = 1.64$).

[2] Because our data did not satisfy the Missing Completely at Random (MCAR) requirements (as most missing data fail to do), we could not use methods such as listwise deletion or regression imputation (Little & Rubin 2002). Rather, we chose a technique based on the assumption that the missing data mechanism in our data set is MAR for the following reasons: First, we included in the model variables that were predictive not only of our missing values but also of the probability that those values would be missing. This procedure has been shown to increase the likelihood that data are MAR (Little & Rubin, 2002). Second, we assumed that for our data set, the probability that a value was missing did not depend on the value of that particular variable after controlling for the other variables in the model. Research has shown that when this condition is satisfied, the data are MAR (Little & Rubin, 2002). Nevertheless, even if this assumption failed, the procedures based on MAR assumptions would still be appropriate because research has shown that in a multivariate missing data pattern—as our data follows—methods that use the MAR assumption are more accurate predictors of missing values than methods that assume nonmissing at random data, or NMAR.

[3] The model fit analyses could not be conducted using the smaller sample because AMOS automatically estimates missing data and, thus, uses the full sample.

Table 8
Means and Standard Deviations

Participant	Sense of Belonging T1	Sense of Belonging T2	Sense of Belonging T3	Perceptions of environmental entity theory	Perceptions of environmental stereotyping
Female	3.96 (0.81)	3.86 (0.79)	3.89 (0.84)	3.94 (1.67)	2.80 (1.57)
Male	4.04 (0.75)	3.94 (0.78)	3.88 (0.79)	4.32 (1.69)	2.85 (1.73)

Note. T1, T2, T3 = Time 1, Time 2, and Time 3.

these variables to explore which, if any, variables might independently be related to males' intent to take math in the future. Results showed that sense of belonging at Time 1 was the only variable to emerge as a significant predictor of males' Intent to Pursue Math (β = .36), $t(470) = 4.18$, $p = .001$. Follow-up analysis revealed that males' sense of belonging at Time 1 was significantly correlated with their sense of belonging at Time 3 ($r = .78$, $p < .001$). But despite the strong relationship across the two time points, males' initial sense of belonging was a stronger predictor of their later intentions to pursue math.

Do perceptions of an entity-oriented environment (PEET) and stereotyping (PEST) measured at Time 2 predict men's and women's sense of belonging to math by the end of the semester (Time 3)?

To address this question, we conducted regression analyses in which we used sex, PEET, PEST, the interaction between PEET and PEST, and the interactions between sex, PEET, and PEST to predict Sense of Belonging to Math at Time 3, controlling for Sense of Belonging to Math at Time 1 and quantitative SAT. Even after controlling for Sense of Belonging to Math at Time 1 (β = .73), $t(1004) = 19.10$, $p = .001$, and SAT (β = .11), $t(1004) = 2.84$, $p = .005$, the analysis yielded marginally significant effects for PEST ($\beta = -.08$), $t(1004) = -1.78$, $p = .08$; PEET ($\beta = -.09$), $t(1004) = -1.89$, $p = .06$; and sex (β = .06), $t(1004) = 1.76$, $p = .08$; and a significant interaction between PEET and PEST ($\beta = -.14$), $t(1004) = -3.01$, $p = .003$. These effects were qualified by a significant three-way Sex $\times$ PEET $\times$ PEST interaction (β = .10), $t(1004) = 2.01$, $p = .05$. Together, all of the predictor variables accounted for 67% of the variance in participants' Sense of Belonging to Math at Time 3. To better understand the three-way interaction, we conducted the regression analysis described above separately for males and females.

For females, significant effects of SAT and Sense of Belonging at Time 1 emerged, as did the interaction between PEET and PEST (see Table 9). Together, all of the predictor variables accounted for 67% of the variance in females' Sense of Belonging to Math at Time 3.[4]

Using procedures outlined by Aiken and West (1991), we examined the significant interaction using simple slopes analyses. All variables were centered prior to the analyses. These analyses tested the simple slopes representing the effect of PEET on Sense of Belonging to Math at Time 3, evaluated at one standard deviation above and below the mean of PEST ($M = .009$, $SD = 1.67$). [5] The results of these analyses supported our main hypothesis and revealed that females who perceived lower levels of entity theory in their environment did not differ in their sense of belonging at Time 3 as a function of the amount of stereotyping they perceived (β = .01), $t(529) = 0.29$, $p > .70$ (see Figure 1). Furthermore, also as hypothesized, those participants who perceived greater amounts of stereotyping had a lower sense of belonging at Time 3 than those who perceived lesser amounts of stereotyping, but only if they perceived high levels of entity messages in their environment ($\beta = -.13$), $t(529) = -4.25$, $p < .001$.

For males, Sense of Belonging to Math at Time 1, perceptions of entity theories, and SAT emerged as the only significant predictors of Sense of Belonging to Math at Time 3 (see Table 9). Specifically, the more males perceived an entity environment, the lower their sense of belonging.

In summary, the results showed that by the semester's end, perceptions of the learning environment became significant predictors of women's sense of belonging to math. Specifically, the more women perceived fixed-ability environments and high gender stereotyping the more they were susceptible to lowered sense of belonging, whereas the more women perceived malleable-ability environments the more they maintained a sense of belonging to math even when they perceived their environments as highly gender-stereotypical. These longer term effects of women's perceptions of their learning environment on their sense of belonging to math could not be accounted for solely by their sense of belonging at the outset of the semester or by their prior math achievement. Rather, their perceptions influenced their sense of belonging to math above and beyond the strong effects of both initial sense of belonging and SAT.

The importance of both initial sense of belonging and prior ability also emerged for males. And as with the females, perceiving a fixed-ability environment predicted a lower sense of belonging.

What model best captures the determinants of men's and women's intent to pursue math in the future? To answer this question, we conducted model-invariance testing on our hypothesized model in which Sense of Belonging at Time 3 mediates the effects of perceiving an entity-oriented environment (PEET), perceiving stereotyping (PEST), and their interaction on Intention to Pursue Math in the Future. We also included the direct effect of SAT on Intent to Pursue Math and Sense of Belonging. Our approach first tested for model invariance across females and males. We then conducted chi-square difference tests to pinpoint the source of any noninvariance between the two groups. All analyses were conducted using the AMOS (2005) structural equa-

[4] Without including Sense of Belonging to Math at Time 1, the model accounted for 26% of the variance in Sense of Belonging to Math at Time 3.

[5] These analyses controlled for the effects of quantitative SAT and Sense of Belonging to Math at Time 1.

Table 9
Effects of Perceiving an Entity-Oriented Environment and Stereotyping on Sense of Belonging to Math at Time 3: Females and Males

Participant	Predictor variable					Adj. R^2
	PEET	PEST	PEET × PEST	SAT	SOB (composite or factor measured at Time 1)	
Females	$-.08^{\dagger}$	$-.08^{\dagger}$	$-.13^{**}$	$.09^{*}$	$.72^{***}$	.67
Males	$-.14^{*}$	$-.03$	$-.004$	$.12^{*}$	$.74^{***}$	.67

Note. PEET = perception of environmental entity theory; PEST = perception of environmental stereotyping; SOB = sense of belonging.
$^{\dagger} p < .10$. $^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$.

tion modeling program. These analyses used the maximum likelihood method of parameter estimation, and all analyses were performed on the variance-covariance matrices. Furthermore, because of the difficulties that arise when interaction terms are introduced in a latent variable analysis, we used the observed variables.

Model invariance. To determine whether the same model is applicable across males and females, we conducted multigroup invariance testing. To begin, we fit the model for the pooled sample allowing all parameters to vary (Model 1) (see Table 10 for model fit statistics). We then compared this model with one in which we constrained the covariances, variances, and factor loadings to be equal across groups (Model 2) and conducted a chi-square difference test. Results indicated that Model 1 achieved moderately acceptable fit indices, suggesting that the hypothesized model fit the sample well enough to proceed with the multigroup invariance testing. Furthermore, the chi-square difference test between Models 1 and 2 was found to be highly significant, $\Delta\chi^2(16, N = 1005) = 47.09$, $p < .001$, indicating noninvariance across groups. A significant chi-square difference test indicates that the parsimony achieved with the more restrictive model (Model 2) resulted in a significant worsening of the model fit. Therefore, we reject Model 2 and conclude that differences exist in the model between the male and female samples. Thus, we proceeded to pinpoint the source of the noninvariance.

Our first step was to inspect the path loadings to determine whether any loadings differed across males and females. Although all paths were significant for the females (all *p*s $< .01$), for the males, the path from the interaction of PEET and PEST to Sense of Belonging and the path from SAT to Intent were both nonsignificant (*p*s $> .5$), suggesting that these paths may be a source of noninvariance across the two groups. Thus, we conducted a chi-square difference test between Model 2 in which all parameters are constrained and Model 3 in which the path from the interaction of PEET and PEST to Sense of Belonging was allowed to vary. The chi-square difference test between Model 2 and Model 3 was found to be significant, $\Delta\chi^2(1, N = 1005) = 6.89$, $p < .01$, indicating noninvariance in the path from the interaction term to Sense of Belonging. We next allowed the path from SAT to Intent to vary (Model 4) and conducted a chi-square difference test between Model 2 and Model 4, which was also found to be significant, $\Delta\chi^2(2, N = 1005) = 8.51$, $p < .025$, indicating noninvariance in both the path from the interaction term to Sense of Belonging and in the path from SAT to Intent (see Figure 2 for standardized path loadings and significance levels for Model 4).

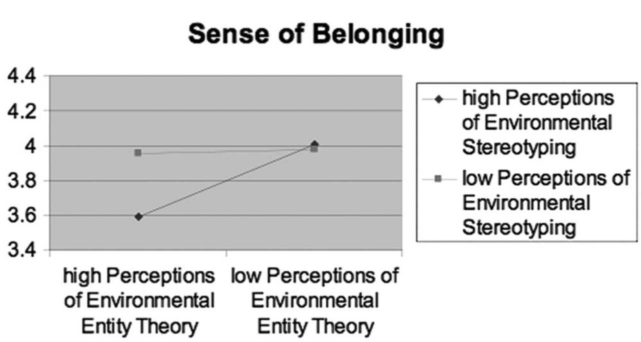

Figure 1. Regression of PEET on sense of belonging to math at Time 3 at values that are one standard deviation above and below the mean of PEST. PEET = perceptions of environmental entity theory; PEST = perceptions of environmental stereotyping.

In summary, males and females differed in these parameters in our hypothesized model. Importantly, although the interaction between PEET and PEST was a significant predictor of females' sense of belonging, it was not a significant predictor of males' sense of belonging. Furthermore, SAT was a significant predictor of females' but not males' intention to pursue math in the future.

What model best captures the determinants of men's and women's math grades? To address the question of grades, we again conducted model-invariance testing on our hypothesized model in which Sense of Belonging at Time 3 mediates the effects of perceiving an entity-oriented environment (PEET), perceiving stereotyping (PEST), and their interaction on one's final math grade. We also included the direct effect of SAT on math grade. Because previous exploration of the data suggested that Sense of Belonging might not completely mediate the effects of PEET on students' math grades, we also included this direct effect in the model. Our process of first testing for model invariance and then testing for the source of the noninvariance was the same as described above.

Our initial inspection of the path loadings to determine whether any loadings differed across males and females showed that all paths were again significant for the females (all *p*s $< .005$). For the males, however, the path from the interaction of PEET and PEST to Sense of Belonging, the path from SAT to grades, and the path from PEET to grades were all nonsignificant (all *p*s $> .10$), suggesting that these paths may be a source of noninvariance across the two groups. Thus, we conducted a chi-square difference test between Model 2 in which all parameters are constrained and Model 3 in which the path from the interaction of PEET and PEST to Sense of Belonging was allowed to vary. The chi-square difference test between Model 2 and Model 3 was found to be highly

Table 10
Model Fit Indices for the Path to Intent to Pursue Math

Model	Fit indices								
	χ^2	*df*	*p*	χ^2/df	NFI	CFI	TLI	RMSEA	p-close
1: All parameters free	8.24	6	.22	1.37	.96	.99	.91	.02	.96
2: All parameters constrained	55.33	22	.00	2.52	.73	.80	.62	.04	.92
4: Source of Invariance	46.82	20	.00	2.34	.77	.84	.66	.04	.95

Note. NFI = normed fit index; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root-mean-square error of approximation.

significant, $\Delta\chi^2(1, N = 1005) = 7.45$, $p < .01$, indicating noninvariance in the path from the interaction term to Sense of Belonging. We next allowed the path from SAT to grades to vary (Model 4) and conducted a chi-square difference test between Model 2 and Model 4. The test was found to be highly significant, $\Delta\chi^2(2, N = 1005) = 8.80$, $p < .05$, indicating noninvariance in the path from the interaction term to Sense of Belonging and in the path from SAT to grades. Next we allowed the path from PEET to grades to vary (Model 5) and conducted a chi-square difference test between Model 2 and Model 5. This test was found to be highly significant, $\Delta\chi^2(3, N = 1005) = 9.87$, $p < .025$, indicating noninvariance in the paths from (a) the interaction term between PEET and PEST to Sense of Belonging (b) from SAT to grades, and (c) from PEET to grades.

Importantly, although the interaction between PEET and PEST was a significant predictor of females' sense of belonging ($p < .001$), it was not a significant predictor of males' sense of belonging (*ns*). Furthermore, females' perceptions of entity views in their environment led to *higher* grades ($p < .003$), but for males, their entity perceptions had no impact on their final grade (*ns*). And finally, although the path from SAT to grades was originally found to be nonsignificant for males in the completely free model (Model 1), this path was significant for both males and females in Model 5. Thus, we ran an additional chi-square difference test between Model 5 and Model 4, $\Delta\chi^2(1, N = 1005) = 0.92$, *ns*. The nonsignificant chi-square difference test indicates that the parsimony achieved with the more restrictive model (Model 5) did not result in a significant worsening of the model fit. Therefore, we accept the more restrictive model (Model 5) and conclude that differences do not exist in the path from SAT to grades between the male and female samples.

In summary, the results of this process indicated noninvariance between males and females in the hypothesized model. Specifically, males and females differed in the path from the interaction term between PEET and PEST to Sense of Belonging, and the path from PEET to grades (see Table 11 for model fit statistics and Figure 3 for standardized path loadings and significance levels for Model 4).

General Discussion

The primary purpose of the present research was to investigate a new variable that is important for understanding representation in an academic discipline, namely, sense of belonging to the discipline—one's personal belief that one is an accepted member of an academic community whose presence and contributions are valued. Furthermore, this research established both the impact of women's perceptions of their learning environment on their sense

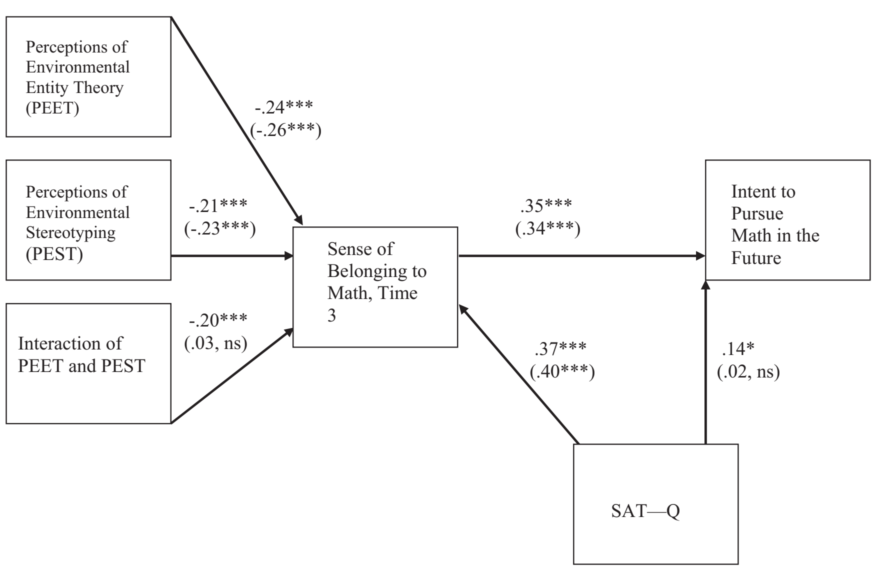

Figure 2. Model 4: The path to intent for females' and males' standardized regression weights (males' weights appear in parentheses). SAT—Q = SAT-Quantitative score. ** $p < .05$. *** $p < .001$.

Table 11
Model Fit Indices for the Path to Grades

Model	Fit indices χ^2	df	p	χ^2/df	NFI	CFI	TLI	RMSEA	p-close
1: All parameters free	7.63	4	.11	1.90	.97	.98	.79	.03	.82
2: All parameters constrained	56.29	21	.00	2.68	.75	.80	.61	.04	.87
4: Sources of noninvariance free	47.40	19	.00	2.50	.79	.84	.65	.04	.91

Note. NFI = normed fit index; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root-mean-square error of approximation.

of belonging in math and, importantly, the impact of sense of belonging on women's intent to remain in math. Specifically, this research tested, and supported, the hypotheses that (a) students' sense of belonging can predict their desire to pursue math in the future and (b) two messages women may hear in their math environments—the messages that math ability is a fixed trait and that women have less of this ability than men—may work together to erode women's sense that they belong in math and, hence, their desire to pursue math in the future (as well as their actual math achievement).

To this end, Studies 1–2 validated the new Sense of Belonging to Math scale and established it as a new measure of belongingness not previously investigated. Moreover, Study 2 provided evidence for the power of sense of belonging to math to predict both men's and women's intention to remain in the mathematics domain. In particular, we showed that sense of belonging to math predicted men's and women's intention to pursue math, as well as math-related variables, such as math anxiety, math confidence, and perceived usefulness of math. That these results were significant even after controlling for other belonging-related constructs (such as domain identification or psychological sense of school membership) and other potential predictors for women (such as stigma consciousness and gender-based rejection sensitivity) provides evidence that the new measure of sense of belonging is unique in its relationship to math representation. Importantly, that Sense of Belonging to Math uniquely predicted these variables even after controlling for math domain identification provides support for the theoretical distinction between belonging and identification. Thus, these results establish students' sense of belonging to math as a new and an important predictor not only of factors related to math achievement (such as math anxiety, confidence, and usefulness) but also, importantly, of men's and women's intentions to remain in the discipline.

Study 3, a longitudinal study that followed college students in their calculus course, showed that females' sense of belonging to math not only predicted women's academic choices and achievement, but it was also sensitive to women's perceptions of their academic environment. Specifically, we found that the more women perceived their math environments to convey either a high degree of stereotyping or a fixed view of math intelligence, the lower was their sense of belonging. In addition, the more women perceived both a fixed-ability environment and high gender stereotyping, the more susceptible they were to a lowered sense of belonging; in contrast, the more women perceived a malleable-ability environment, the more likely they were to maintain a sense of belonging to math even when they perceived their environments as highly gender-stereotyped. This suggests that perceiving a malleable view of intelligence in the learning environment may protect women's sense of belonging from negative stereotypes. Thus, women's sense that they were valued members of the math com-

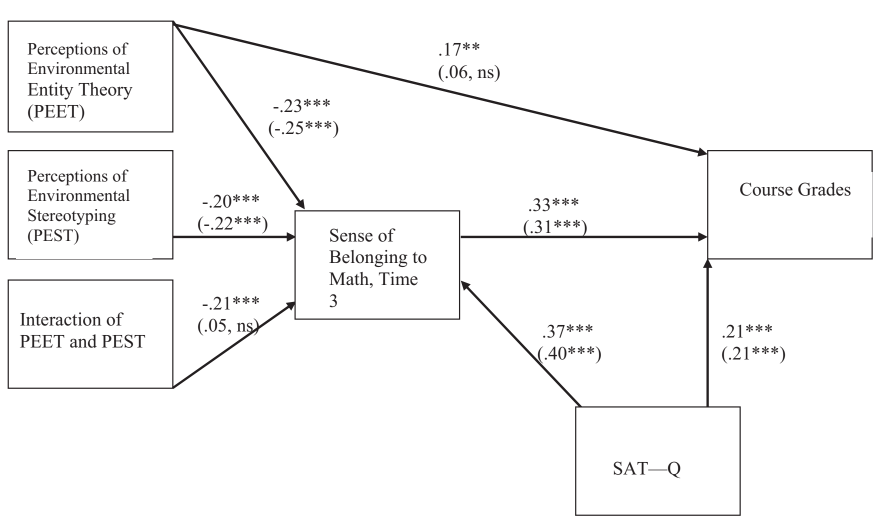

Figure 3. Model 4: The path to grades for females' and males' standardized regression weights (males' weights appear in parentheses). SAT—Q = SAT-Quantitative score. $^{**}p < .01$. $^{***}p < .001$.

munity was significantly influenced by what they thought their math community believed about the fixed versus malleable nature of mathematical ability and about women's ability relative to men's.

Importantly, we found that sense of belonging to math mediated the effects of these fixed versus malleable ability perceptions and stereotype perceptions on both women's intention to pursue math in the future and their math grades. That is, the more women perceived stereotyping and a fixed view of intelligence, the more they experienced a lowered sense of belonging over time, which, in turn, led to a decreased intention to pursue math in the future and to lower course grades in math. This means not only that women's perceptions of their learning environment can impact their sense of belonging but also, importantly, that their sense of belonging to math can have real consequences for their career aspirations and achievement. The results of our studies establish women's sense of belonging to mathematics as a key variable in both their performance and their decisions to pursue math in the future, and, consequently, provide a new perspective on the causes of the representation gap between men and women in math and science domains.

We then conducted multigroup invariance testing to determine where in our hypothesized model males and females differed. Importantly, we found that for females, but not males, higher SAT scores were related to a greater intent to pursue math in the future. Importantly, the interaction between perceptions of entity theories and perceptions of stereotypes was a significant predictor of females' sense of belonging to math, but not of males'. Furthermore, these analyses also showed that for females, but not for males, perceptions of entity theories in the learning environment predicted significantly higher grades. We discuss this surprising finding below.

Can Entity Perceptions Be Beneficial?

Despite the protective effects of perceiving an incremental view of math intelligence, our data showed a surprising trend that future research should explore. To begin, an exploration of the interaction between PEST and PEET suggests that the more women perceived an entity-oriented environment and a low level of stereotyping, the better they performed in their calculus class. This means that in a nonthreatening environment (in which women are seen as the equal of men), perceiving an entity-oriented environment can sometimes be motivating (Mendoza-Denton et al., 2008). However, the entity-oriented environment that women perceived became a detriment to their final course grade when they also perceived a high level of gender stereotyping. Thus, on the one hand, it appears that a message of fixed ability can sometimes prove motivating in a supportive environment, such as one that is free of gender stereotypes. In such environments, students may believe that they can demonstrate their high fixed ability. On the other hand, perceiving less supportive environments, such as those that combine messages of fixed ability and gender stereotypes, hampered women.

In summary, feeling that your ability is on the line can sometimes be motivating, but only if your learning environment is seen as being relatively free of gender stereotypes.

Self-Theories of Math Intelligence Versus Perceptions of Others' Theories

Past research has focused on students' own theories of intelligence as predictors of their achievement and has repeatedly shown that when students hold an entity view of intelligence, they are at risk for decreased achievement, especially in the face of challenge (Blackwell et al., 2007; see Dweck, 1999, for a review). Our findings highlight the importance of students' *perceptions* of their learning environment for their math achievement and career trajectories. Students' perceptions of their colleagues' beliefs about math ability are undoubtedly filtered through their own beliefs and expectations; in fact, our data showed that their own theories of math intelligence were significantly correlated with their perceptions of entity messages in the learning environment ($r = .50$). Despite this strong correlation, students' perceptions of entity messages varied across the classes involved in the study, whereas their own theories did not. Nevertheless, we found support for our models even after controlling for students' own theories of intelligence.

Incremental-oriented environments can protect against stereotype threat. Although past research has shown that explicitly orienting students toward the view that they can increase their intelligence can go a long way toward reducing students' vulnerability to stereotype threat (e.g., Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003), we suggest in the present study that implicit messages perceived in the learning environment may be just as powerful in protecting students from the negative effects of stereotype threat.

Furthermore, the past research did not address a number of critical issues. First, in these studies (Aronson et al., 2002; Blackwell et al., 2007; Good et al., 2003), the researchers went to great lengths to explicitly and consistently teach students that intellectual skills are attainable, whereas the present work shows that the messages that students simply pick up from their learning environment can have important impact. We also examined in the present research the separate and combined effects of perceptions of stereotyping and theories of ability emanating from a real-world academic setting.

Second, in these past studies, researchers failed to consider the important role of sense of belonging; specifically, how sense of belonging may be impacted by a belief in the malleability of intelligence, and the important mediating role that sense of belonging plays in the relationship between theories of intelligence, stereotype threat, and achievement. We addressed these shortcomings in Study 3, and thus raised the interesting question of whether the positive benefits reported by Aronson, Good, and their colleagues can be attributed to the malleability instruction, per se, or perhaps (also) to an increased sense of belonging that the malleability instruction conferred.

Implications for the Stereotype Threat Model

Because of the importance of sense of belonging for mediating the effects of perceptions of stereotyping on women's academic intentions and achievement, the findings of this research have many important implications for the stereotype threat literature. First, the stereotype threat literature has been focused primarily on consequences for students' achievement. But as this study shows, perceptions of negative stereotypes can also undermine stereotyped individuals' sense of belonging to the domain in which they are stereotyped and their desire to continue in that domain in the future. Although the potential impact of stereotype threat on belonging has been discussed in past studies (Murphy et al., 2007), this study is the first that we know of to track sense of belonging over time in a real-world setting, to demonstrate its sensitivity to stereotype threat and to show its impact on women's desire to participate in mathematics in the future.

Second, this study also contributes to the stereotype threat literature because of its focus on the longitudinal impact of perceiving negative stereotypes about one's group. Most researchers experimentally manipulate stereotype threat and then measure its immediate impact. Our study, in contrast, sheds light on the long-term consequences of being enmeshed in a stereotype-laden environment. In particular, women's sense of belonging to math degraded over time due, in part, to the negative stereotypes that the women perceived—as the semester wore on, not only did women's perceptions of stereotyping come to show a stronger and stronger relation to their sense of belonging, but their sense of belonging became increasingly important for their subsequent intent to pursue the domain and their achievement in math.

Third, this study adds to the growing body of literature focused on reducing the impact of stereotype threat by identifying a practical method of alleviating its effects in real-world contexts. In particular, our data show that when sense of belonging is protected by learning environments that convey a malleable view of intelligence, students may be less vulnerable to the impact of negative stereotypes on achievement and intention to remain in the domain.

Consequences for the Mathematics Pipeline

These findings can shed light on the reasons that women continue to be underrepresented in math and science professions—especially at the highest levels. Females' lowered sense of belonging—perhaps in response to their perceptions of their learning environments—can make an academic community an uncomfortable, unwelcoming place to be, causing them to drop out of the domain. When the domain is something as fundamental as mathematics, domain avoidance essentially shuts the door to careers in science, engineering, and technology.

Moreover, the importance of students' sense of belonging for their academic aspirations and trajectories is clear at earlier points as well, for our research is showing that girls' sense of belonging to math can predict their math grades and desire to take math in the future as early as middle school (Good, Rattan, & Dweck, 2010). Furthermore, as in the present study, girls' perceptions of fixed-ability messages and stereotypes in their math classrooms undermined their sense of belonging. This has important implications for girls' futures as mathematicians and scientists, because it is precisely in the middle-school years that girls' confidence in and liking of mathematics begins to wane.

Limitations and Future Directions

Causal effects of messages in the learning environment. Despite the contribution of the present studies to the understanding of females' achievement and representation in math, the present study does have some limitations that future research needs to, and is beginning to, address. To begin with, this was not an experimental study, and thus conclusions about the causal relationship between students' perceptions of their learning environment, their sense of belonging, their aspirations, and their achievement should be made with caution. That said, the fact that perceptions of the environment were measured prior to sense of belonging, that females' perceptions predicted sense of belonging by the end of the semester (but not earlier), and that we controlled for initial sense of belonging all support the directionality of the effect.

In addition, a recent study that experimentally manipulated the entity and incremental messages in the learning environment supports the findings of the present study (Good et al., 2010). In this study, participants were randomly assigned to one of two learning environments in which they watched an educational video that taught new math concepts from either an entity or incremental perspective. They then solved math problems under either stereotype threat or nonthreat conditions. Results showed that when females learned the new math concepts from an entity perspective, they performed less well on the math test in the stereotype threat condition than in the nonthreat condition. However, when they learned the new math concepts from an incremental perspective, there were no differences between the stereotype threat and the nonthreat conditions on the math test.

Causal effects of sense of belonging for aspirations and achievement. A second limitation of the study is that, in a similar vein, we did not test the effects of manipulating students' sense of belonging on their aspirations and math achievement, and thus the causal relationship between these variables is unclear. Perhaps it is the case that females' aspirations to pursue math lead them to feel a stronger sense of belonging. To rule out this possibility, we tested variations of the structural equation models described in Study 3 in which the role of sense of belonging and intent to pursue math were interchanged. In each case, we failed to find support for these models, and thus we have stronger faith that sense of belonging does in fact lead to greater intent to pursue math.

Nevertheless, it would be interesting to experimentally manipulate sense of belonging to math to test the causal effects on intent to pursue math and math achievement. Two preliminary studies have shown that when sense of belonging to math was either subtly primed—through a word-search task that included self-related words (*myself*), math words (*algebra*) and belonging words (*member*, *accepted*)—or directly manipulated—by having participants help compose letters to younger students that described in positive terms what it means to belong to the math community—females reported a greater intent to pursue a math major, to pursue a math-related career, and to seek out friends who enjoy math than did those in the control conditions (Good, 2010).

Sources of incremental and entity messages. Third, although our study highlights the importance of students' perceptions of the messages conveyed in their learning environment, it does not shed light on how messages about the nature of math ability or about gender stereotypes in math might be communicated to students. Because perceptions of the incremental nature of math intelligence protected females' sense of belonging, intent to pursue math, and math achievement even when they perceived a high level of gender stereotyping, it is particularly important to better understand how entity and incremental messages may be communicated in the classroom.

One source of these messages may be instructors' implicit theories of intelligence. For example, as research is beginning to show, teachers with entity and incremental theories differ in the way they evaluate students' abilities: either through comparison to other students (normative evaluations) or through observation of personal improvement (individual evaluations) (Butler, 2000; K. Lee, 1996; cf. Plaks, Stroessner, Dweck, & Sherman, 2001). These different methods of evaluation have important implications, for it has been found that students of math teachers who, in line with an entity perspective, emphasize normative evaluation rather than individual progress over time come to value math less over time (Anderman et al., 2001). Additionally, teachers' beliefs about the nature of math intelligence have consequences for their other pedagogical practices (Rattan, Good, & Dweck, in press). Specifically, compared with participants (acting in the role of teacher) who were oriented toward an entity view of math intelligence, those who were oriented toward an incremental view were more likely to endorse such teaching practices as telling students they can improve if they work hard in math, providing students with challenging math tasks, and not telling students that some people are math people and some people are not.

Although it will always be important to work on reducing stereotyping in educational environments, stereotypes have proved difficult to eradicate. Thus, focusing efforts on communicating an incremental view of math intelligence in mathematics classrooms can be an important path for educators to take in their quest to increase females' representation and achievement in math and science domains.

Conclusion

In summary, students' sense of belonging is an important variable to study when considering the causes and cures of the representation gap in math and science domains. Students who believe that their colleagues view math ability as acquirable are able to maintain a high sense of belonging, which in turn reduces the power of perceived stereotypes to impair females' desire to pursue math and their achievement in math. Consequently, supporting females' sense of belonging by communicating an incremental view of math intelligence in educational environments may begin to address pipeline issues for women in science, math, engineering, and technology. Doing so may help eliminate the culture of "talent" and the mentality of the "weed-out system" that pervades many of these classrooms and that can send fixed-ability messages to women. Learning environments that foster a culture of potentiality in which anyone can develop their skills may create room for many more females to feel that they belong in these fields and, thus, to encourage many more females to pursue math and science degrees.

Although the studies in this article focus specifically on females' aspirations and achievement in math, the issues addressed easily apply to members of any group who face messages of limited ability in an achievement domain. Nearly every indicator of academic achievement points to a disturbing crisis in the educational welfare of Black and Latino Americans. As with women, a message of expandable versus fixed ability may have a role to play in fostering a sense of belonging to academics and reducing the harmful effects of stereotypes (Aronson, 1998; Blackwell et al., 2007; cf. Aronson et al., 2002; Good et al., 2003).

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Appendix

Math Sense of Belonging Scale

Today we have some questions we would like you to answer about your experience with math courses and in the math academic community. When we mention the math academic community, we are referring to the broad group of people involved in that field, including the students in a math course.

We would like you to consider your membership in the math community. By virtue of having taken many math courses, both in high school and/or at _________, you could consider yourself a member of the mathematics community. Given this broad definition of belonging to the math community, please respond to the following statements based on how you feel about that group and your membership in it.

There are no right or wrong answers to any of these statements; we are interested in your honest reactions and opinions. Please read each statement carefully, and indicate the number that reflects your degree of agreement.

Strongly Disagree					Strongly Agree		
1	2	3	4	5	6	7	8

When I am in a math setting,

1. I feel that I belong to the math community.
2. I consider myself a member of the math world.
3. I feel like I am part of the math community.
4. I feel a connection with the math community.
5. I feel like an outsider.
6. I feel accepted.
7. I feel respected.
8. I feel disregarded.
9. I feel valued.
10. I feel neglected.
11. I feel appreciated.
12. I feel excluded.
13. I feel like I fit in.
14. I feel insignificant.
15. I feel at ease.
16. I feel anxious.
17. I feel comfortable.
18. I feel tense.
19. I feel nervous.
20. I feel content.
21. I feel calm.
22. I feel inadequate.
23. I wish I could fade into the background and not be noticed.
24. I try to say as little as possible.
25. I enjoy being an active participant.
26. I wish I were invisible.
27. I trust the testing materials to be unbiased.
28. I have trust that I do not have to constantly prove myself.
29. I trust my instructors to be committed to helping me learn.
30. Even when I do poorly, I trust my instructors to have faith in my potential.

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