

Am I a Science Person? A Strong Science Identity Bolsters Minority Students' Sense of Belonging and Performance in College

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Susie Chen¹ , Kevin R. Binning¹, Kody J. Manke², Shannon T. Brady³, Erica M. McGreevy¹, Laura Betancur¹, Lisa B. Limeri⁴, and Nancy Kaufmann¹

Abstract

Identifying as a “science person” is predictive of science success, but the mechanisms involved are not well-understood. We hypothesized that science identity predicts success because it fosters a sense of belonging in science classrooms. Thus, science identity should be particularly important for first-generation and racial-minority students, who may harbor doubts about belonging in science. Two field studies in college Introductory Biology classes ($N_s = 368, 639$) supported these hypotheses. A strong science identity predicted higher grades, particularly for minority students. Also consistent with hypotheses, Study 2 found that self-reported belonging in college mediated the relationship between science identity and performance. Furthermore, a social belonging manipulation eliminated the relationship between science identity and performance among minority students. These results support the idea that a strong science identity is particularly beneficial for minority students because it bolsters belonging in science courses. Practical and theoretical implications are discussed.

Keywords

science identity, belonging, minority, threat, performance

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The number of students in the United States receiving bachelor's degrees in science, technology, engineering, and mathematics (STEM) fields has steadily risen over time, increasing 20% from 2009 to 2014 (National Center for Education Statistics [NCES], 2014). However, substantial group-based disparities persist in who earns these degrees. For instance, though STEM degree attainment increased for all students over this time period, the increase for White students was three times greater than for Black and Hispanic students over the same time. In addition, students whose parents do not have a 4-year degree (i.e., first-generation college students) earn lower grades and drop out of college more frequently than students with at least one parent with a 4-year degree (Sirin, 2005).

The current studies argue that these disparities exist partly because many racial/ethnic-minoritized students and first-generation college students—whom we refer to as minority students for the purposes of this article—come to see themselves as not belonging in STEM. Reasons for why this occurs are multifaceted, including macro-level forces (e.g., structural inequalities) that feed into micro-level psychological experiences (e.g., anxiety during intergroup interactions).

These forces work together to produce cultural stereotypes and lay beliefs about who belongs and succeeds in science, with White individual—and White males in particular—seen as the most prototypical, normative STEM group members. For students seen as peripheral and non-prototypical, factors like belonging uncertainty (Walton & Cohen, 2007) and stereotype threat (Steele, 1997) hinder academic performance and perpetuate achievement gaps which reinforce STEM inequalities (e.g., Binning & Browman, 2020).

In the present research, we examine one individual difference that may mitigate the cycle of inequality and underperformance: a strong science identity (science ID). Identifying with the science domain—when being a “science person” is

¹University of Pittsburgh, PA, USA

²Carnegie Mellon University, Pittsburgh, PA, USA

³Wake Forest University, Winston-Salem, NC, USA

⁴University of Georgia, Athens, USA

Corresponding Author:

Susie Chen, Department of Psychology, University of Pittsburgh, 210 S. Bouquet St., 3425 Sennott Square, Pittsburgh, PA 15232, USA.
Email: susiechen@pitt.edu

seen as important to the self-concept—may buffer against the forces that conspire to make students, especially minority students, perform below their potential in STEM. Below, we review the science ID literature and its relationship to performance and belonging for minority and majority college students. We then present two studies that tested the impact of science ID on college performance in an important gateway science course, Introductory Biology.

Science Identity and Performance in Science Fields

Definitions of science ID emphasize both private and public identification with the science domain (Gee, 2000; Vincent-Ruz & Schunn, 2018). That is, a student has a strong science ID when both the student themselves and their important social reference groups (e.g., friends, family) perceive the student as a “science person.” Fostering a positive science ID is a goal of many educational programs, including those found in science museums (Leinhardt et al., 2011), children’s television (e.g., Sci-Girls; Dawson, 2014), formal science curriculums (Falk & Needham, 2011; Hulleman & Harackiewicz, 2009), and educational interventions (Ramsey et al., 2013).

Several studies have found that students who identify with science are more likely to persist and perform well in science fields (Eccles & Barber, 1999; Osborne & Walker, 2006). In one survey of more than 600 science-oriented undergraduate and graduate students, Chemers et al. (2011) found students’ level of identification as a scientist was predictive of their commitment to a science career. This effect also occurs with racial/ethnic-minoritized students, as seen in a study by Chang and colleagues (2011). Surveying 1,745 underrepresented racial/ethnic-minoritized college students, they found that identification with the biomedical and behavioral sciences predicted students’ persistence in those majors beyond their first year. Similarly, among 1,420 largely racial/ethnic-minoritized participants, Stets and colleagues (2017) found that strong science ID near the end of college was associated with entering a science career.

Studies show an analogous influence of science ID on science interest and persistence among first-generation students. For example, Verdín and Godwin (2015) found that first-generation college students in engineering were more likely to persist on this career trajectory if they strongly identified as an engineer early in college. This is likely to occur because the same structural factors (e.g., poverty) that affect racial/ethnic-minoritized students can also cause first-generation students to feel less belonging (A. W. Astin, 1993; Yeager et al., 2016) and more isolation (Pascarella et al., 2004) in college. Studies show these factors impact academic performance, as forces like stereotype threat and belonging uncertainty affect both first-generation and racial/ethnic-minoritized students (Croizet & Claire, 1998; Stephens et al., 2012).

These studies illustrate that a strong science ID is associated with better outcomes in college science courses for

minority students who contend with doubts about belonging. However, one limitation of this work is that it has generally not examined differences in science ID’s effect between minority and majority group members. While evidence suggests that science ID may be beneficial for academic success, it is unclear whether this is the case for all students or particularly true for minority students. Furthermore, this work has not generally sought to understand *why* science ID may have beneficial effects. We argue that science ID is important for all students but likely especially important for minority students who contend with doubts about belonging,¹ as it potentially buffers them against these doubts that might otherwise undermine STEM performance and engagement.

Science Identity and Belonging

To understand the relationship between science ID and belonging, consider a situation in which a student performs unexpectedly poorly on a biology exam. Students from all backgrounds may find the experience threatening to their competence, but students from minority groups must also contend with anxiety that this performance “confirms” negative academic stereotypes attributed to their group memberships (Crocker & Major, 1989; Steele, 1997). Thus, rather than seeing this adversity as temporary and universal (e.g., “All students occasionally struggle”), this ambiguity may lead them to attribute their adversity to their group membership (e.g., “Students like me don’t do well in science”; Croizet & Claire, 1998; Steele & Aronson, 1995; Walton & Wilson, 2018). Attributing a poor outcome to internal, stable causes such as one’s ethnic identity or social class can hinder engagement by making persistence in science seem futile or threatening (see Dweck, 2008; Weiner, 1985). Minority students also tend to have fewer in-group role models, hindering their sense that “people like me” can do well in the domain (Dasgupta, 2011; Stout et al., 2011).

We argue that a strong science ID may serve as a psychological resource to forestall such harmful internal attributions and belonging uncertainty. Minority students may be aware that students from their group historically underperform, but possession of a strong science ID may bolster the belief that they *personally* still belong, making it more likely they are able to maintain engagement in the face of adversity. Functionally, a strong science ID may serve as an internal rebuttal to the insinuation that the student does not belong (“That professor might think I’m not the right fit for science, but I know I am”).

Thus, we argue that if science ID bolsters belonging in science in this way, it may be especially important for students who are more susceptible to doubts about belonging (Carlone, 2004; Seymour et al., 1997). To this point, correlational research has shown that doubts about belonging and discrimination can undermine students’ likelihood of forming positive science IDs in the first place (Aschbacher et al., 2010; Hazari et al., 2013). In the present research, we

aim to break this effect of belonging on science ID by considering science ID as a predictor variable, one that bolsters students' sense of belonging and consequently improves academic performance.

Overview of Present Research

To extend the research on the relationship between science ID and performance, we addressed the two following research questions: (a) Is science ID differentially predictive of course performance for minority (racial/ethnic-minoritized; first-generation) and majority (White; continuing-generation) group students?; and (b) Is the differential effect of science ID on performance due to science ID conferring an increased sense of belonging? Although we focus on a domain-specific identity—science ID—and thus domain-specific belonging, we argue that science belonging contributes to general school belonging (e.g., Freeman et al., 2007).

To address these questions, we conducted two studies that measured the science ID of college students enrolled in Introductory Biology, an important gateway course taken by first-year students.² Analyses of historical data from this course found that the majority of enrolled students pursued careers in health and biology-related fields; importantly, students are required to earn at least a “C” in the course to continue in health science disciplines. The high-stakes nature and difficulty of the course, together with the fact that students tend to take the course in their first year, formed a potent combination of stressors we assumed would make having a strong science ID especially useful.

To test whether the benefits of science ID varied across groups, we created a categorization of who we expected to experience heightened belonging uncertainty in this course; as such, we compared minority students to majority students. This categorization followed from both the literature and historical course analyses; analyses of the prior 3 years of Introductory Biology at the university where the study was conducted indicated that racial/ethnic-minoritized students (e.g., Black, African American, Hispanic, Latino/a, Native American/American Indian) and first-generation college students of any racial/ethnic background scored lower in the course compared with their White, continuing-generation peers.³ An important consideration we encountered was how to categorize Asian/Asian American students, a group who traditionally faces positive academic stereotypes (see Cheryan & Bodenhausen, 2011). The same historical analyses indicated that in Introductory Biology, these students underperformed relative to their White classmates.⁴ Therefore, Asian/Asian American students were included in the minority group for analyses.

Study 1

Study 1 focused on our first research question (RQ1), which asked whether science ID was differentially predictive of

Table 1. Study 1 and Study 2 Demographics.

Variable	Study 1	Study 2
	(<i>N</i> = 368)	(<i>N</i> = 572)
	%	%
Women	70.92	75.00
First generation	12.77	14.16
White	66.85	75.52
Black/African American	7.34	6.29
Asian/Asian American	22.28	31.47
Hispanic/Latino/a	3.53	2.62
Native American/American Indian	0.00	0.00
Other	2.17	7.69
Majority: White, continuing-generation	58.70	57.52
Minority: Non-White and/or first generation	41.30	42.48

academic performance for majority and minority students. To examine this question, we used existing data from a study that was originally conducted to examine the possible effects of a values affirmation intervention (Miyake et al., 2010) but included the measures necessary to test our research question. Importantly, science ID was collected prior to the experimental manipulation of affirmation and did not interact with the manipulation; thus, the data were appropriate to examine RQ1.

Method

Participants. Participants were 368 students from two different Introductory Biology lecture sections at a large university. The majority of participants identified as women (*N* = 259; 70%), and White (*N* = 246; 67%; see Table 1 for additional demographics). All participants provided informed consent and agreed to allow access to their de-identified institutional data, accessed using an honest broker not involved in the research to maintain students' confidentiality. Instructors provided extra credit as incentive for completing the study.

Procedure. On the night before a course exam, students were emailed a Qualtrics survey which contained the science ID measure; after completing it, students were randomly assigned to see materials for either the affirmation intervention or the control condition.⁵ The survey was available until 10 min before the exam. These procedures occurred before the second exam for one course and the fourth exam for the other course.

Measures

Science ID. Science ID was measured with four items (e.g., “I am a science person”; adapted from Hazari et al., 2010).

Students indicated their agreement with the items from 1 = *strongly disagree* to 7 = *strongly agree*. Scores were aggregated to create a single science ID variable ($\alpha = .90$, $M = 5.43$, $SD = 1.20$). In the following analyses, science ID is defined and presented as a continuous measure (students characterized having either high [+1 *SD*] or low [-1 *SD*] science ID).

Academic performance. The primary dependent outcome was students' course grade, calculated as a percentage out of 100 ($M = 79.70$, $SD = 12.38$). Grades were obtained from the instructor.

Academic history. From the university registrar, we obtained students' ACT or SAT scores and high school GPA. Scores were transformed to *Z*-scores and averaged into a single composite of previous academic performance. Students with unavailable scores ($N = 16$) were assigned the mean composite score (similar to the procedure in Sherman et al., 2013).

Demographic characteristics. University records and students' end-of-course survey responses identified students' gender, race, and parental education level.⁶ Students selected their racial identity from the following options (multiple selections permitted): Black or African American, Hispanic or Latino/a, Asian or Asian American, White/Caucasian, Native American/American Indian, or Other.⁷

Results

Analytic approach. As described, our focus and analyses specifically considered the relationship between *pre*-manipulation science ID and later academic outcomes; we then tested for moderation or interactions with intervention effects (which we ultimately found no evidence of).⁸ All analyses were conducted using the PROCESS v.2 SPSS macro (Hayes, 2012) to test for two-way and three-way interactions among condition (intervention, control), science ID (high, low), and minority status (majority, minority) on the outcome variable. We tested all effects using a non-parametric bootstrapping (5,000 samples) method and controlled for gender, classroom, and the composite index of previous academic performance.

Gender and classroom covariate variables were mean-centered (Irwin & McClelland, 2001) to improve clarity in interpreting results. As the data were collected from two separate classes, we ran analyses to determine whether class section moderated class performance results, the main outcome of interest. Since there was no difference between classes ($t = -0.87$, $p > .10$), we collapsed across them for the final analyses and included dummy codes for instructor. Table 2 presents correlations between all variables of interest.

In the analysis involving the affirmation condition, we controlled for the exam scores completed prior to distributing the affirmation intervention.⁹ This was done to provide

Table 2. Correlations Between Variables of Interest for Study 1.

Study 1 Variables	1.	2.	3.	4.	5.
1. Instructor	1				
2. Minority status	.05	1			
3. Condition	.00	-.01	1		
4. Science ID	-.00	-.05	.04	1	
5. Class grade	-.06	-.10	.02	.42*	1

* $p < .05$.

the strongest possible test for affirmation: we limited the inferential tests of affirmation to performance that came *after* the affirmation—that is, to performance that could have plausibly been affected by the manipulation—while reducing error and controlling for any error in random assignment.

RQ1: Is science ID differentially predictive of course performance for minority and majority group students? To address RQ1, we analyzed the main effect of science ID on course grade across all students and included all control variables. In-line with previous research, science ID was significantly associated with higher performance in the class, $B = 3.55$, $SE = 0.43$, $t(356) = 8.27$, $p < .001$, 95% confidence interval (CI) = [2.71, 4.40] (Figure 1).

There was also a significant Science ID \times Minority Status interaction on course performance, $B = 2.55$, $SE = 0.87$, $t(356) = 2.94$, $p = .004$, 95% CI = [0.85, 4.26] (Figure 1). Simple slopes analysis revealed the effect of science ID on performance was roughly two times greater for minority, $B = 5.03$, $SE = 0.69$, $t(356) = 7.43$, $p < .001$, 95% CI = [3.68, 6.38], than for majority students, $B = 2.48$, $SE = 0.54$, $t(356) = 4.59$, $p < .001$, 95% CI = [1.42, 3.54]. For every 1-point increase in science ID, minority students experienced a 5% boost in grade, while majority students only saw a 2.5% boost. Thus, science ID had a greater impact on grade for minority students.

This interaction also revealed how high science ID buffered the achievement gap. For students with low science ID, results indicated a significant difference in grade between majority and minority students, $B = -4.82$, $SE = 1.42$, $t(356) = -3.38$, $p < .001$, 95% CI = [-7.62, -2.02], such that majority students had a 5% higher grade than minority students. However, this gap disappeared among students with high science ID, $B = 1.20$, $SE = 1.45$, $t(356) = 0.83$, $p = .408$, 95% CI = [-1.65, 4.05].

Discussion

Study 1 addressed RQ1 regarding whether science ID had a differential benefit for minority students compared with majority students. Results revealed science ID had a larger effect for minority students, such that grade differences

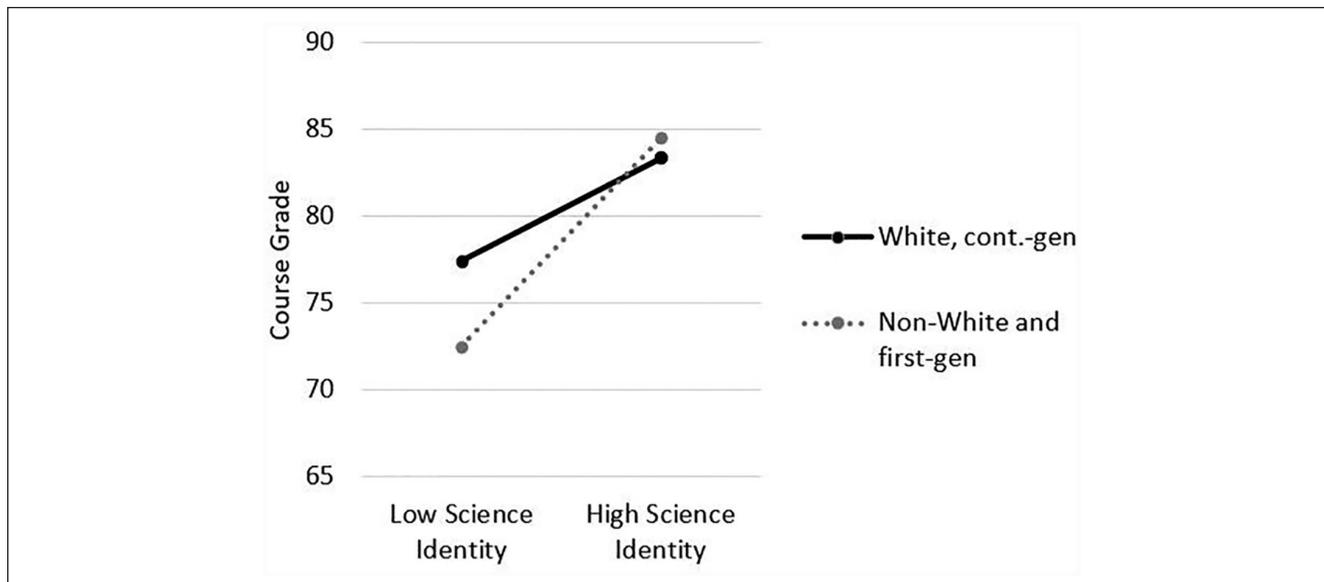


Figure 1. Study 1: Effect of science ID (± 1 SD) and minority status on course grade.
 Note. Error bars represent standard error of the mean.

between low and high science ID students were larger among minority students than among majority students. However, results did not illuminate *why* this happened. As reported, analyses of the affirmation intervention revealed the intervention did not have a main effect nor interact with science ID on course performance. This was an interesting finding, given that past research has noted that affirmation interventions can elicit sense of belonging (e.g., Shnabel et al., 2013; Tibbetts et al., 2016). It is possible that not enough students affirmed values that prompted belonging, and that perhaps a stronger belonging manipulation—as seen in Study 2—would produce the sense of belonging needed to buttress against the threat of low science ID in minority students.

Although speculative, another possibility for these null findings is that science ID, affirmation, and the various time-courses of performance in the course did not align in a way that allowed for their interaction. Past research has indicated that in regards to timing, interventions that occur in newly formed contexts are generally more effective than when the same intervention is delivered in more established contexts (Cohen et al., 2009; Yeager & Walton, 2011). We delivered the affirmation intervention prior to the second and fourth exam in each classroom, approximately 6 and 12 weeks into the term, respectively. If science ID does indeed protect students from stereotypes and belonging uncertainty, it may have already done so by the time the affirmation was administered.

Thus, in Study 1, we found evidence in support of our hypothesis that science ID was more predictive of subsequent academic success for minority students than for majority students. However, the study did not address our second research question (RQ2), which asks about mechanisms

involved; Study 2 attempted to address this question by investigating whether belonging served as the mechanism driving the effect of science ID on academic performance.

Study 2

In Study 2, we sought to replicate and bolster the Study 1 findings for RQ1 that science ID predicts performance, and that it does so more strongly for minority than for majority students. We also aimed to address RQ2 by investigating whether belonging mediated this relationship. We theorized that science ID should foster a sense of belonging in science classes and thus the university more generally. Since science is a core mission of most research universities (like the one under study), science belonging is likely central to general university belonging. We operationalized belonging in two ways: first, by manipulating belonging with a classroom-based belonging procedure conducted in student groups (i.e., manipulate-the-mediator approach; MacKinnon & Pirlott, 2015) and second, by measuring self-reported belonging at the university more generally (i.e., measure-the-mediator approach; Baron & Kenny, 1986).

Manipulating Social Belonging

By employing a belonging manipulation, we *manipulate the mediator* to test belonging as a psychological process explaining the effect of science ID on performance. We hypothesized that if science ID operates through fostering a sense of belonging, then increasing belonging via an experimental manipulation carried out inside the science course may serve to mimic the positive effects of having a strong

science ID, rendering science ID less predictive. The effect of science ID would be reduced analogously to the reduction in the C path in the Baron and Kenny (1986) measurement-based approach to mediation.

We manipulated belonging by delivering a social belonging intervention, which has been shown to mitigate negative academic outcomes for students subject to negative academic stereotypes (Walton & Brady, in press; Walton & Cohen, 2011; Wilson & Linville, 1982). This intervention focuses on teaching students to view adversity and setbacks in college as normal and temporary, not due to internal characteristics suggested by common stereotypes. That is, it seeks to shape the meaning students make about adversity in ways to establish and insulate sense of belonging. We theorize that having a strong science ID produces similar psychological outcomes. Students with high science ID may already feel increased sense of belonging in science, as their high identification confers a sense of competence in the domain, enabling them to engage in social connectedness with science peers, teachers, and activities. Those with low science ID, however, do not have this resource to insulate belonging. Thus, we posit that a classroom-based social belonging intervention during the first week of the semester, focused on general sense of belonging, may help such students stay engaged in the face of adversities and challenges in pursuing a science education.

Measuring Social Belonging

Following the more typical mediation approach (Baron & Kenny, 1986), we also measured students' sense of belonging in college. We theorized that, particularly in the control condition, this measure of belonging should mediate the effect of science ID on performance. Although we measured general college belonging, we posit that this belonging could also potentially affect domain-specific science belonging (e.g., Freeman et al., 2007). That is, science ID should bolster general university belonging and in turn predict higher performance within the science classroom.

Method

Participants. The social belonging intervention and control materials were given to 639 students in an Introductory Biology course with the same instructor over two different semesters. Students were evenly split among four recitation sections each semester, with the course instructor teaching each recitation. The final sample included 572 participants who completed the survey distributed at the end of the course. Participants were 18 years and older and largely identified as White ($N = 432$) and women ($N = 429$). See Table 1 for student demographics.

Procedure. In each semester, we randomly assigned recitation sections to the control or belonging intervention condition (two control and two social intervention sections each

semester—a total four sections per condition). In the first recitation meeting of the semester, the instructor asked students to form groups of three to five people based on a superficial similarity (e.g., living in the same dorm). Group members introduced themselves to each other and created a team name; students remained with this team throughout the semester. Students then completed either the belonging intervention or control condition exercise. At the end of the semester, students completed a Qualtrics survey that measured the dependent variables and demographic information. Course grades were also collected then. The timing of the science ID measure, however, differed by term. In the first semester, it was collected at the beginning of the semester via a Qualtrics survey distributed by the instructor. In the second semester, it was collected with the belonging and demographic measures at the end of the semester.¹⁰ Students received extra credit in the course for participating.

Social belonging intervention. The social belonging intervention was modeled after the intervention conducted by Walton and Cohen (2007, 2011), with several modifications. Most notably, random assignment was conducted at the section rather than the individual level, and the intervention was delivered within collaborative learning groups (e.g., students' science peers) inside the classroom rather than in a lab setting (see Binning et al., in press).

The intervention focused on belonging in the university following the transition to college. To start, the instructor introduced the idea that the college transition is particularly tough, and students might be experiencing some difficulties. Students then wrote for 10 min about difficulties they were experiencing in their first week. After collecting and scanning the writing samples, the instructor presented three quotes from junior and senior students that addressed common concerns (similar to Walton & Cohen, 2011), many of which appeared in students' writing. These quotes reinforced a general message: difficulties in the college transition are common across students rather than indicative of a personal deficit, often temporary, and not a permanent impediment to success and belonging at the university.

This was followed by a team discussion where students discussed similarities and differences between their experiences and the situations presented in the quotes. This portion of the intervention was intended to help establish the belonging message as a shared reality or "common ground" so that students would not only adopt the message, but they would know others had adopted the message as well (Binning et al., in press; Binning & Sherman, 2011). Finally, students were invited by the instructor to share topics brought up in group discussion with the class.

Control condition. Students in the control condition completed business-as-usual activities, which included "ice-breaker" activities of choosing a biology-themed team name, drawing a mascot, and presenting their name and mascot to the class.

Table 3. Correlations Between Variables of Interest for Study 2.

Study 2 Variables	1.	2.	3.	4.	5.	6.
1. Semester	1					
2. Minority status	-.01	1				
3. Condition	.02	-.04	1			
4. Belonging	-.04	-.09	-.01	1		
5. Science ID	-.14*	.06	-.02	.15*	1	
6. Class grade	.00	-.08	.04	.22*	.19	1

* $p < .05$.

Measures

Dependent and demographic measures were similar to those in Study 1, with a similar science ID measure and additional belonging measure.

Science identity. Science ID was measured with four items (e.g., “I am a science person”),¹¹ and students indicated agreement from 1 = *strongly disagree* to 4 = *strongly agree*. Scores were aggregated to create a single science ID variable ($\alpha = .94$, $M = 2.98$, $SD = 0.76$).

Belonging. Sense of belonging was assessed with a four-item measure (e.g., “I feel like I belong at [school]”); adapted from Walton & Cohen, 2007). Students rated their agreement with the items from 1 = *strongly disagree* to 6 = *strongly agree*. Items were averaged to create a composite measure of belonging ($\alpha = .87$, $M = 4.94$, $SD = 0.85$).

Results

As in Study 1, all analyses controlled for semester, gender, and previous academic performance. Because similar patterns emerged between the two semesters, we collapsed data across semesters; all analyses were conducted based off all available data.¹² Table 3 presents correlations between all variables of interest.

RQ1: Is science ID differentially predictive of performance for minority and majority group students? We found a significant Condition \times Science ID \times Minority Status three-way interaction on course grade, $B = -6.53$, $SE = 2.68$, $t(549) = -2.44$, $p = .015$, 95% CI = $[-11.79, -1.27]$ (Figure 2). Because we found an effect of the belonging intervention, we first isolated the control group to determine science ID’s effect on performance between minority and majority students to address RQ1.

Replicating Study 1 findings, control condition results indicate science ID was more predictive of course performance for minority than for majority students. For control group students, there was a marginal Science ID \times Minority Status interaction, $B = 3.81$, $SE = 1.94$, $t(549) = 1.96$, $p = .051$, 95% CI = $[-0.01, 7.63]$ (Figure 2). Science ID was

more predictive of minority students’ performance, $B = 6.02$, $SE = 1.52$, $t(549) = 3.95$, $p = .001$, 95% CI = $[3.03, 9.02]$, than of majority students’ performance, $B = 2.22$, $SE = 1.23$, $t(549) = 1.80$, $p = .072$, 95% CI = $[-0.20, 4.63]$. For every 1-unit increase in science ID, minority students scored 6% higher in the course, whereas majority students scored 2% higher.

RQ2: Is the differential effect of science ID on performance due to science ID conferring an increased sense of belonging? Analyses were consistent with the hypothesis that belonging is an active component that makes science ID particularly important for minority students. The following results support this theory: (a) science ID predicted belonging for minority, not majority, students; (b) the belonging intervention improved belonging for minority, not majority, students; and (c) the belonging intervention’s effect mediated the relationship between science ID and course performance.

First, science ID was a significant predictor of belonging for minority but not majority students, $B = 0.30$, $SE = 0.10$, $t(461) = 2.99$, $p = .003$, 95% CI = $[0.10, 0.50]$. Majority students reported similar belonging regardless of their science ID, $B = 0.03$, $SE = 0.06$, $t(461) = 0.46$, $p = .645$, 95% CI = $[-0.10, 0.15]$. However, sense of belonging for minority students differed by science ID, $B = 0.33$, $SE = 0.08$, $t(461) = 4.19$, $p < .0001$, 95% CI = $[0.18, 0.49]$ (Figure 3), such that students who reported higher science ID also reported higher belonging.

Second, the social belonging intervention boosted self-reported belonging for minority but not majority students, $B = 0.39$, $SE = 0.15$, $t(461) = 2.51$, $p = .012$, 95% CI = $[0.08, 0.69]$. Among minority students, receiving the intervention improved sense of belonging, $B = 0.33$, $SE = 0.08$, $t(461) = 4.19$, $p < .001$, 95% CI = $[0.18, 0.49]$, whereas for majority students, the manipulation did not affect belonging, $B = 0.03$, $SE = 0.06$, $t(461) = 0.46$, $p = .645$, 95% CI = $[-0.10, 0.15]$.

As a final step, we put these patterns of results together to explore how the measure of social belonging operated across conditions and subgroups. We conducted a moderated mediation analysis to determine if, and for whom, the measure of social belonging mediated the effect of science ID on grade. In other words, is belonging to the mechanism through which science ID affects performance? If so, does the effect differ between minority and majority students?

Using the Hayes (2012) PROCESS macro V3.0 to explore patterns of moderated mediation (Model 70), we found that the measure of belonging only mediated the effect of science ID on performance among minority students in the control condition (indirect effect: $B = 0.92$, 95% CI = $[0.14, 2.10]$; Figure 4A). For these students, science ID was positively associated with belonging, $B = 0.44$, $SE = 0.12$, $t(460) = 3.67$, $p < .001$, 95% CI = $[0.21, 0.68]$, and belonging was positively associated with performance, $B = 2.79$, $SE = 1.13$, $t(460) = 2.46$, $p = .014$, 95% CI = $[0.56, 5.02]$.

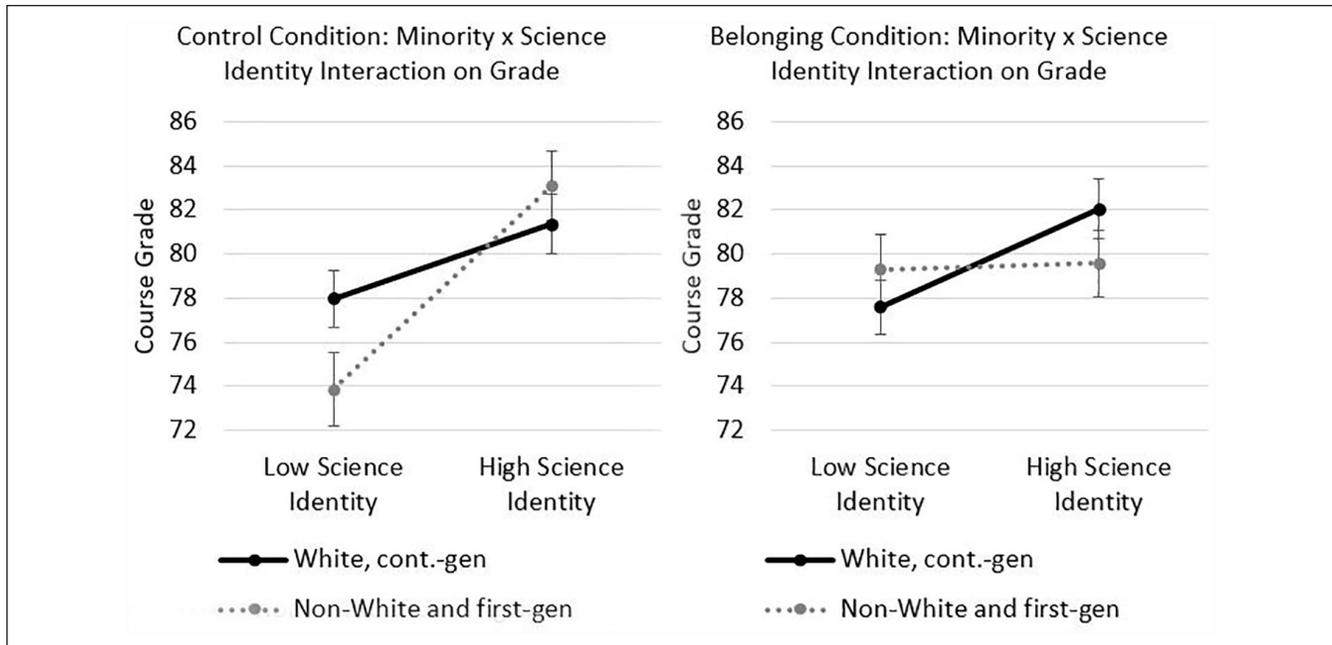


Figure 2. Study 2: Effect of science ID (± 1 SD) and minority status on course grade for control and belonging condition participants. Note. Error bars represent standard error of the mean.

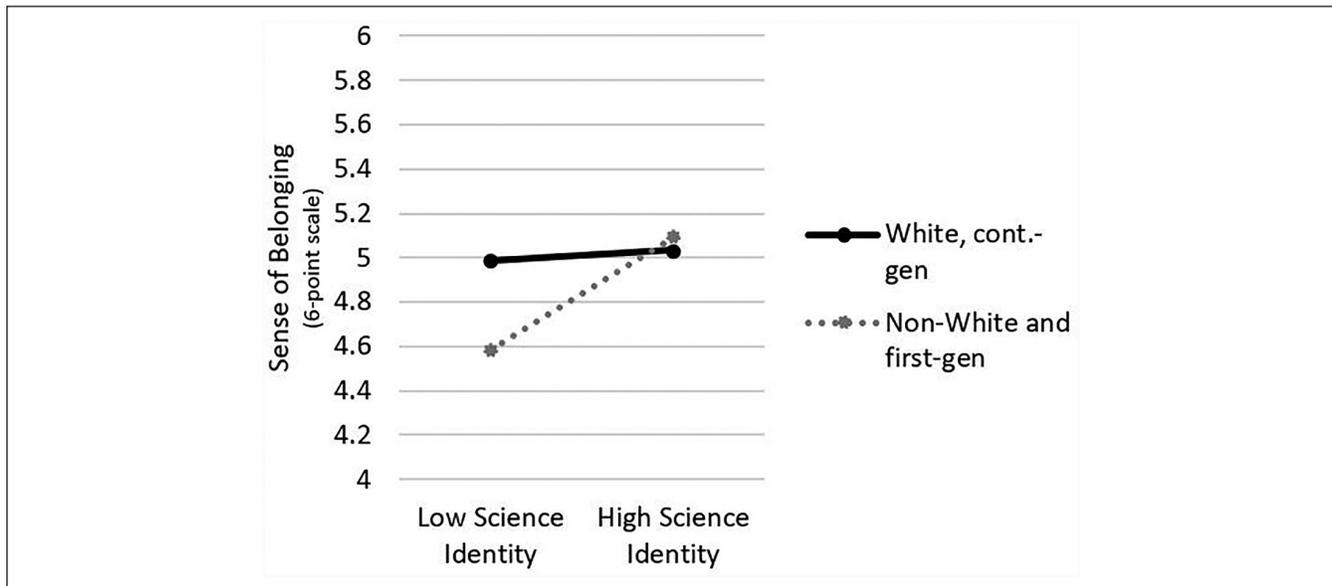


Figure 3. Study 2: Effect of science ID (± 1 SD) and minority status on reported belonging. Note. Error bars represent standard error of the mean.

However, in line with our hypothesis, the social belonging intervention rendered individual differences in belonging irrelevant in predicting grades, as belonging did not mediate the effect of science ID among minority students who received the intervention (indirect effect: $B = -0.56$, 95% CI = $[-2.07, 0.32]$). Among these students, belonging did not predict class grade, $B = -1.70$, $SE = 1.36$, $t(460) = -1.25$, $p = .212$, 95% CI = $[-4.36, 0.97]$ (Figure 4B). Rather, the

manipulation boosted social belonging across the sample; thus, individual differences in reported belonging had less predictive power.

These results were supported by the three-way interaction reported previously. Although science ID differentially predicted course performance for majority and minority students in the control condition, no Science ID \times Minority Status interaction appeared among students who received the

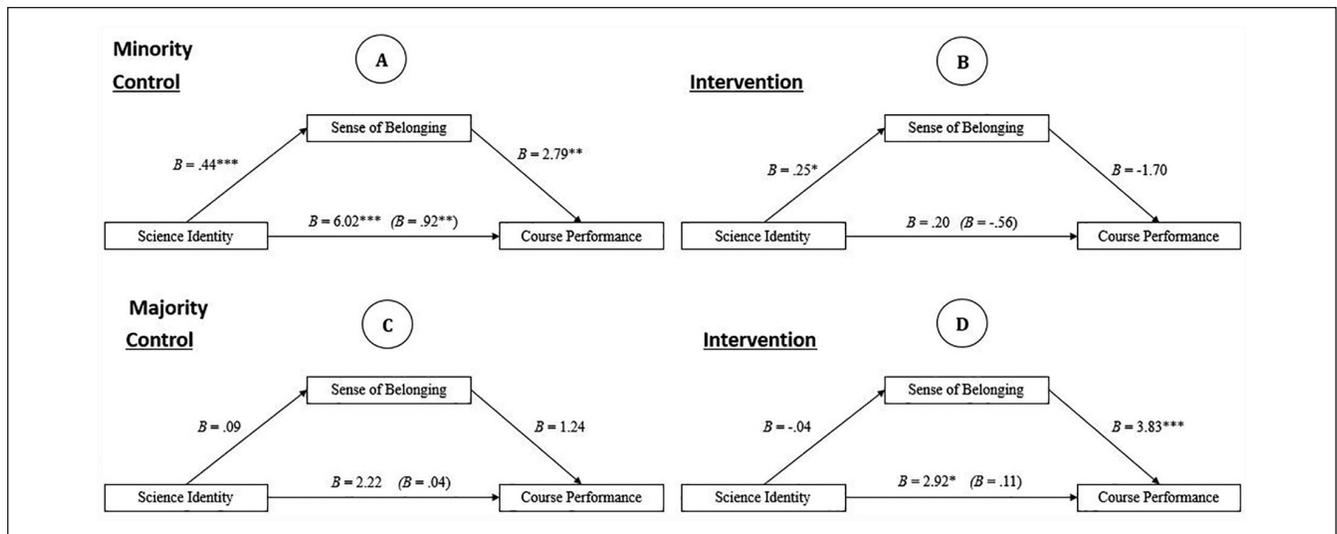


Figure 4. Study 2: Moderated mediation model. (A) Minority and control. (B) Minority and belonging. (C) Majority and control. (D) Majority and belonging.

Notes. Reported sense of belonging mediating the relationship between science ID and course performance, moderated by minority status and intervention condition. Indirect effects of science ID on course performance, controlling for reported sense of belonging, in parentheses.

* $p < .05$. ** $p < .01$. *** $p < .00$

belonging intervention, $B = -2.72$, $SE = 1.86$, $t(549) = -1.47$, $p = .143$, 95% CI = $[-6.38, 0.92]$. Similar to previous findings, majority students in the intervention condition performed better in the course as science ID increased, $B = 2.92$, $SE = 1.19$, $t(549) = 2.46$, $p = .014$, 95% CI = $[0.59, 5.25]$ (Figure 4D). For every 1-unit increase in science ID, majority students experienced a 3% boost in grade, similar in magnitude to control condition majority students. However, for minority students who received the intervention, science ID no longer predicted grade, $B = 0.20$, $SE = 1.44$, $t(549) = 0.14$, $p = .892$, 95% CI = $[-2.63, 3.02]$ (Figure 4B). This suggests that for minority students, whose belonging are more likely to be threatened, a belonging intervention appears to mimic the effect of having high science ID.

In line with this, simple slopes analysis revealed the belonging intervention differentially affected course performance for minority students with low and high science ID. Those with low science ID significantly benefited from the belonging intervention, $B = 5.25$, $SE = 2.28$, $t(549) = 2.31$, $p = .021$, 95% CI = $[0.78, 9.72]$, whereas those with high science ID were not affected, $B = -3.50$, $SE = 2.17$, $t(549) = -1.61$, $p = .108$, 95% CI = $[-7.77, 0.78]$.

Supplemental analyses of course passage. We also analyzed whether the three-way interaction significantly predicted passing the course, an important outcome because the course is the first in a series of STEM courses required for science majors or those pursuing a health career.

Similar to the grade findings, a binary logistic regression analysis revealed a significant three-way interaction on passing (odds ratio [OR] = -1.49 , $SE = 0.59$, $p = .012$, 95% CI = $[-2.65, -0.34]$). In the control condition, there was a

significant Science ID \times Minority Status interaction (OR = 1.01 , $SE = 0.43$, $p = .019$, 95% CI = $[0.17, 1.86]$; Figure 5). For majority students, science ID did not influence the likelihood of passing the course (OR = 0.002 , $SE = 0.27$, $p = .993$, 95% CI = $[-0.53, 0.54]$); 84% of both low and high science ID majority students passed. However, science ID had the predicted effect on passing for minority students (OR = 1.02 , $SE = 0.34$, $p = .003$, 95% CI = $[0.36, 1.68]$); 87% of high science ID minority students passed, whereas only 60% of low science ID minority students passed.

In the belonging condition, however, the Science ID \times Minority Status interaction disappeared (OR = -0.48 , $SE = 0.40$, $p = .240$, 95% CI = $[-1.26, 0.31]$; Figure 5), illustrating how the belonging intervention negated science ID's effect. In the belonging condition, science ID did not affect course passage for either majority students (OR = 0.42 , $SE = 0.26$, $p = .111$, 95% CI = $[-0.10, 0.94]$; Figure 5) or minority students (OR = -0.06 , $SE = 0.30$, $p = .852$, 95% CI = $[-0.64, 0.54]$; Figure 5). For majority students, 79% of low science ID and 88% of high science ID students passed; for minority students, 79% of low science ID and 77% of high science ID students passed.

Discussion

Consistent with Study 1 findings, results from the Study 2 control group found science ID was more predictive of outcomes for minority students than for majority students. This effect, however, was dampened among minority students who received a social belonging intervention, providing support for RQ2, which asked whether belonging served as a psychological mechanism of science ID. After receiving the

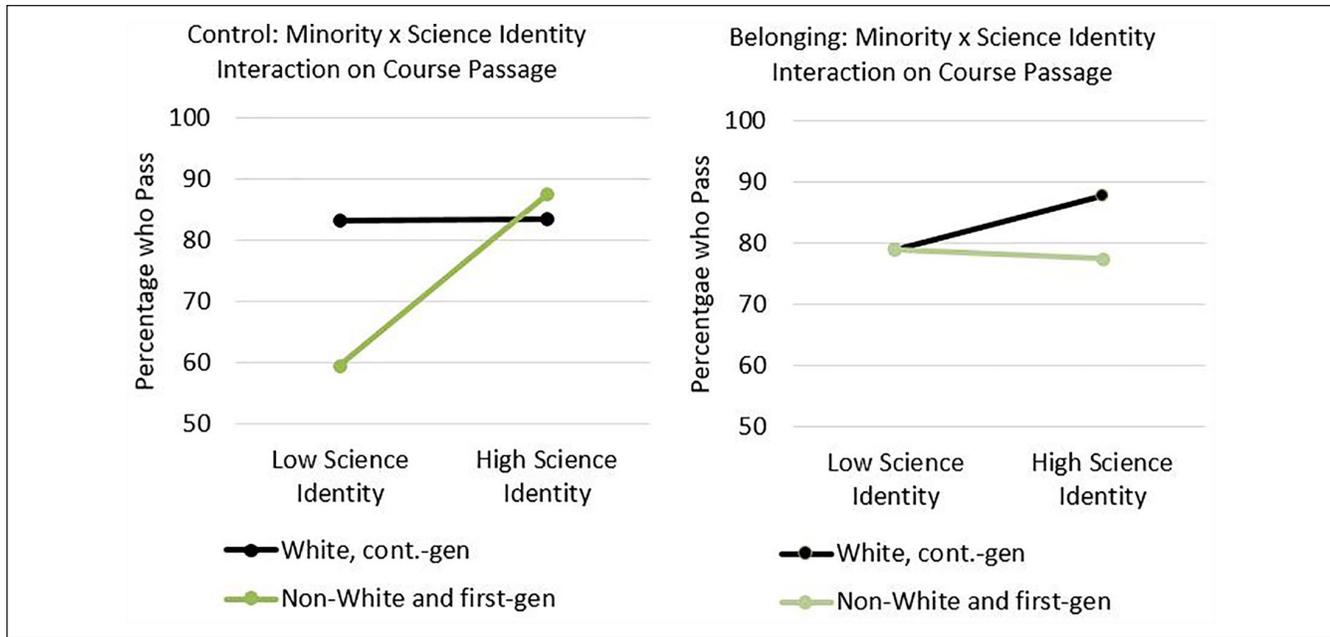


Figure 5. Study 2: Effect of science ID (1 SD) and minority status on course passage.
Note. Passing the course denoted as earning a C or higher.

belonging intervention, minority students, regardless of science ID level, performed similarly to majority students. Importantly, this effect was seen for both course grade and likelihood of passing the course.

These results suggest that science ID is important for minority students because it confers a sense of belonging in science that might otherwise be negatively targeted due to their marginalized group status. This enhanced belonging then bolsters performance in a difficult, evaluative course. For control students, having a strong science ID led to higher performance, whereas having a weak science ID led to lower performance. This relationship was mediated by science ID's effect on sense of belonging. However, a social belonging exercise eliminated this relationship between science ID and performance, highlighting how an active component of the positive effect of science ID may stem from it communicating belonging. This is especially evident in the finding that the social belonging intervention had larger effects on minority students with low science ID, who may doubt their belonging in science.

These results show that enhancing belonging is one-way to counteract the threat experienced by stereotyped students with low domain-belonging. It is not that enhancing belonging diminishes the role of science ID; rather, higher belonging serves as a protective barrier against the consequence of having low science ID. This evidence suggests that the social belonging manipulation enhanced belonging similar to having a strong science ID.

General Discussion

Despite the increasing emphasis on promoting science identification (Falk & Needham, 2011), few empirical studies

have investigated how science ID impacts college students' outcomes. The present research builds on prior literature by demonstrating that (a) science ID differentially impacts majority and minority students, and (b) social belonging serves as a psychological mechanism through which science ID impacts academic performance.

In support of the first claim, results from both studies showed science ID was differentially predictive of course performance, such that the same increase in science ID was related to a greater increase in grade for minority than for majority students. While previous work had shown the importance of science ID for minority students (Chang et al., 2011; Hazari et al., 2013), research had not directly compared whether science ID had *differential* benefits for them. Data from both studies show that while students with high science ID performed better in the course compared with those with low science ID, the magnitude of this difference was greater within minority students. For minority students, the confluence of having low science ID and being subject to stereotypes undermining sense of belonging (Steele et al., 2002) was particularly harmful. Those with high science ID were relatively protected against these stereotypes (Woodcock et al., 2012).

After showing science ID differentially impacted majority and minority students, we examined whether this effect operated through the mechanism of bolstering students' sense of belonging. We obtained evidence by both measuring students' sense of belonging and experimentally manipulating it. For the latter, we found evidence that science ID uniquely influenced self-reported belonging among minority and majority students. While majority students across all science ID levels reported similar belonging, minority students with high science ID reported higher belonging than those with low science ID.

Experimentally manipulated belonging also supported the argument that social belonging is the active ingredient explaining science ID's effect on performance. This effect was reduced to non-significance among minority students who received a belonging intervention, whereas for control condition minority students, belonging still significantly mediated the effect of science ID on course performance. That is, when belonging was established through an intervention, science ID was no longer needed to bolster performance. Although the belonging intervention did not specifically target science belonging, we believe it was able to protect against science-specific threat because the intervention was conducted within students' science environment. This, coupled with the fact that the interaction was completed with science peers, may have contributed to the belonging intervention enhancing science belonging.

These findings are particularly important in light of research showing that children early on start developing stereotypes about who can and cannot excel in STEM-oriented fields (Cvencek et al., 2011). Increasing children's science ID may be beneficial for halting the development of these stereotypes, as the current study suggests that minority individuals who develop a strong science ID may be buffered from effects of stereotypes and belonging uncertainty. Indeed, some conceptualizations of "identity" stipulate that it derives from group memberships or contexts (Tajfel & Turner, 1979; Turner, 1975), analogous to *belonging* to that group or domain. Together with our current findings, this suggests that increasing science identification may be one means of increasing belonging in STEM, and ultimately a step toward equity in science.

Limitations and Future Directions

One significant limitation is that the present work did not address issues of intersectionality. Indeed, identities are multifaceted, and individuals are simultaneously members of many groups (e.g., gender, racial, socio-economic). The role of each of these identities—and certainly their intersection—is incredibly important and necessitates further research. In the current studies, the primary reason for omission of intersectionality related to a lack of statistical power to make responsible comparisons between intersectional categories (e.g., only 16 students and 21 students in Studies 1 and 2, respectively, were doubly stigmatized [first-generation and non-White]). Thus, an important unanswered question is whether science ID differentially impacts such students or, more generally, whether science ID's effect varies as a function of intersectional identities.

Given that this is one of the first studies to empirically examine the psychological mechanisms driving science ID's effect on performance, future work should aim to replicate the findings in other contexts. The present studies were implemented only in Introductory Biology which, at the current university, is comprised of majority Whites and women. Would the same results appear if the intervention

was delivered in other science domains with different demographic profiles (see Binning & Unzueta, 2013; Murphy et al., 2007; Walton et al., 2015)? Substantial evidence reveals the presence of gender stereotypes in math (Nosek et al., 2002; Riegle-Crumb & King, 2010), where women may be at greater risk for stereotype threat than in the life-sciences. Here, science identity among women may be more important (Vincent-Ruz & Schunn, 2017).

Future extensions of this work should also examine whether the race and science ID relationship exists at other educational levels (e.g., elementary, middle school). Extensive work has demonstrated that racial/ethnic-minoritized students face barriers to STEM inclusion at every step in their education (Cooper & Burciaga, 2011), and experiences in science during middle and high school significantly influence whether individuals stay on the STEM pathway in college (H. S. Astin & Sax, 1996). In fact, Osborne and Walker (2006) found that ethnic-minority students in 9th grade with high levels of school identification were less likely to drop out after 2 years, compared with ethnic-minority students with low levels of school identification. Such findings shed light on when science identification or awareness of negative performance stereotypes become salient and affect academic outcomes. As with other social psychological interventions, it is important to recognize that these findings do not place the burden of change on the student. Rather, they should inform ways that institutions create situations and environments that consider and support all students. These findings suggest that institutional actions that consider students' psychological experiences can lead to meaningful improvements, and further reinforce the notion that institutions should shoulder the effort to create equitable academic environments.

One methodological limitation of the present studies was that science ID was measured at different times over the semester and seemed to not affect results. However, it is possible that science ID may fluctuate over time as students calibrate their initial identities with respect to their actual outcomes. Although previous research (Carlone & Johnson, 2007; Elmesky & Seiler, 2007) and the similarity of results between both studies suggest science ID is relatively stable, future work could aim to measure science ID repeatedly to understand its potential time course and relationship to success and adversity in science.

Finally, we note that Study 1 included a values affirmation manipulation that did not moderate the present findings. This is notable, given previously seen connections between affirmation and belonging (Shnabel et al., 2013). However, as is often true of null findings, it is difficult to know if features of the present methods limited the effects of affirmation. For example, the affirmation was delivered later in the term, before the 2nd or 4th exam but after students had already experienced several weeks in the course. Given the importance of timing and early delivery for affirmation effects (e.g., Cohen & Sherman, 2014), the timing of the affirmation in Study 1 may have simply been too late for a single, light-touch affirmation to have an effect.

Conclusion

Although the number of students entering science is generally increasing, disparities across major social categories persist. The present research suggests an optimistic note for promoting a specific identity to address these disparities. Science ID—a sense that one is a “science person”—consistently had positive associations with performance in a gateway science course. This was particularly true for minority students, in part because science ID bolstered sense of belonging in the course and college more generally. Helping students develop and maintain a stable sense of science identification may be a promising and effective way to help them contend with the threat of being stereotyped and marginalized in STEM.

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ORCID iD

Susie Chen  <https://orcid.org/0000-0003-2446-6190>

Supplemental Material

Supplemental material is available online with this article.

Notes

- In many STEM domains (e.g., engineering), women also contend with stereotype threat and belonging uncertainty (Cheryan et al., 2017). However, this tends to be less prevalent in Biology, where women tend to be more equitably represented (Leslie et al., 2015). Exploratory analyses in our studies found no significant effects of gender ($ps > .10$). As such, gender was not the focus of the present research.
- Although Biology differs from other STEM courses (e.g., women are often overrepresented in Biology, compared with other fields; Meyer et al., 2015), it is still encompassed within the general science domain and therefore an appropriate venue for studying science ID.
- This encompassing definition of minority also increased statistical power. There were not enough first-generation students ($N_{\text{Study 1}} = 47$ and $N_{\text{Study 2}} = 81$) to adequately analyze racial-ethnic identities and first-generation identities separately or in interaction.
- Previous work by another research team at the same university found similar underperformance for Asian/Asian American students in Introductory Psychology (Betancur et al., 2019).
- All participants were presented with a list of 11 values (e.g., Being with Friends or Family). Affirmation condition students were instructed to identify their most important value from the list, reflect on it, and then write a brief paragraph about a time that value was important to them. Control condition students were instructed to identify their least important value and write about why it might be important to someone else. The manipulation was patterned after those used in previous affirmation field studies (Binning et al., 2019; Sherman et al., 2013).
- When demographic information from university records and student surveys conflicted ($N < 30$), we used university record information. However, using the survey data instead did not affect the findings.
- Students who selected “Other” and indicated White as one of their race components were categorized as majority students.
- In the spirit of transparency and completeness, we analyzed the effect of the affirmation on grade, as well as its interaction with science ID. The affirmation neither impacted grade, $B = -0.05$, $SE = 0.90$, $t(354) = -0.06$, $p = .624$, 95% CI = $[-1.82, 1.72]$ nor interacted with science ID, $B = -0.38$, $SE = 0.78$, $t(354) = -0.49$, $p = .624$, 95% CI = $[-1.92, 1.15]$. Thus, we collapsed across the experimental manipulation for Study 1 analyses.
- Similar to the analytic procedure used by Hulleman and colleagues (2017) to control for course exam scores delivered prior to a utility-values intervention.
- Since science ID was measured at different times, we first ran separate analyses for each semester. Results indicated that neither term nor minority group status significantly moderated the effect of science ID on course grade ($ts < 2.00$, $ps > .50$).
- Although the Studies 1 and 2 science ID measures differed in scales used, they contained the same four items. Study 1 analyses were conducted after launching Study 2; as such, we were unable to use the same scale.
- Although 572 students completed the end-of-semester survey, not all completed belonging and science ID measures; thus, degrees of freedom vary in the analyses. A total of 549 students completed the science ID measure, 461 students completed the belonging measure, and 460 students had all complete demographic, science ID, belonging, and grade measures.

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