Exploring Leveraging Points to Increase High School Students' Identification with STEM: Differences Across Race/Ethnicities

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Abstract

This study intends to identify leverage points to increase Latinx high school students' identification with STEM careers. We used multi-group structural equation modeling to analyze science identity survey data (N=1295) focusing on differences across race/ethnicity. Although Latinx students on average reported lower science activities participation and perception of science than their White and Asian American peers, the indirect effects from participation in science activities at home, school, and out-of-school consistently held for all racial/ethnic groups. Our findings suggest: (a) the importance of increasing Latinx students' participation in science activities at home, science classrooms, and out-of-school programs, and (b) the need to strategically design the activities, including school science curricula, in ways that increase Latinx students' self-perception in and with science.

Purposes

The purpose of this study is to identify leverage points to increase Latinx high school students' identification with STEM careers. Despite the urgent call for addressing racial injustice in students' opportunities to learn and participate in STEM, the under-representation of Latinx in STEM continues (National Science Board, 2016). Research increasingly shows that this ongoing under-representation has to do with the gap in opportunities for students to construct powerful

identities in/with science (Archer et al., 2013; Author et al., 2013). In this project, researchers and high school science teachers worked together to expand students' opportunities to learn in science classrooms. At the onset of the project, the team administered a science identity survey (Author et al., 2019; Aschbacher et al., 2012) to understand high school students' current and future self(s) in relation to STEM. Building upon and extending prior studies that explored the process of middle school girls of color becoming science-minded persons (Author et al., 2019), in this project, we examine the relations among 'identity negotiators' expressed by high school students in Southern California. Additionally, we advance the prior work by further examining the extent to which these constructs and their relations were similar for Latinx students compared to White and Asian American students. The following questions guide the analysis:

1. As depicted in the theoretical STEM identities model (Figure 1), did high school students' participation in science-related activities in different settings (home, school, out-of-school) predict their identification with four STEM-related careers directly and indirectly through their perceptions about self and science?

2. Are there any differences in the constructs (i.e., mean-level differences) or the relations (i.e., process-level differences) of the STEM identities model by for Latinx compared to White and Asian American students?

Theoretical framework

We draw upon social practice theory (Holland, Lachicotte, Skinner, & Cain, 1998) to examine Latinx students' STEM engagement and identification. From a social practice theory perspective, one's interest in and aspirations toward STEM careers are, in part, a reflection of one's identities--who s/he is and who s/he wants to be (Author et al., 2019). Social practice theory draws our attention to social encounters and a web of relationships to recognize one's identities (e.g., Author & others, 2013; Holland et al., 1998). This perspective calls for shifting the focus from identities into the work of identity--one's continuing responses to others and taking action for and against the receptions, recognitions, and positioning (Author & others, 2013). One's identity work is ongoing, cumulative, and contentious because it always takes place "under conditions of political-economic and cultural-historical conjuncture" (Holland & Lave, 2009, p. 3).

The conception of identity grounded in this framework provides a foundation for building a STEM identity model shown in Figure 1 (Author & others, 2013; 2019). This model assumes that the current and possible future selves are informed by and shaped through the encounters one has across time and settings. This model identifies key constructs, what is called 'identity negotiators.' They are personal and family backgrounds, participation in science-related activities, perceptions, and possible future selves in STEM. The model also shows the relationship among the STEM identity negotiators that influence the development of one's sense of current and future selves, with particular attention to science-related experiences across

multiple settings (i.e., home, out-of-school, and school science classrooms). In the prior study using data collected at five middle schools across four states in the US, the researchers found that girls' self-perception in relation to science was the strongest predictor of their identification with STEM-related careers, and this self-perception was positively and distinctively associated with their experiences with science at home, outside of school, and in school science classes. The study concluded, "expanding girls' experiences with science across *multiple* settings during middle school in a way that increases their positive self-perception in and with STEM" (p. 418).

This current study builds upon and expands prior studies by examining the extent to which the process of Latinx high school students becoming STEM-minded persons are similar or different compared to White and Asian American students. Understanding racial/ethnic similarities and differences provides insight into interventions in terms of what might need to be bolstered for which group and whether an intervention might have similar benefits across groups.

Method

Data were collected in 2017 and 2019 in three socioeconomically under-resourced high schools in Southern California. Participants were 745 Latinx, 228 multiracial with Latinx descent (hereafter referred to as Latinx-Plus), 215 White, and 107 Asian American students (see Table 1 for descriptive statistics).

Measures

We used a modified version of the survey *Is Science Me?* (ISME), an empirically validated survey developed to measure secondary school students' identities grounded in social practice theory (Aschbacher et al., 2010; Gilmartin, Li, Aschbacher, & McPhee, 2006).

Identification with STEM-related careers. Our outcome, identification with STEM-related careers, was measured by the youth's responses to "How interested are you in having a

job like these someday?" (1=*disagree strongly*, 4=*agree strongly*). The four domains included basic biological sciences (2 items, α=.74); (b) applied biological sciences (3 items, α=.69); (c) basic physical sciences (1 item), and (d) applied physical sciences (4 items, α=.82)

Participation in science-related activities. Our predictors include measures of participation in science-related activities in three contexts. Home participation (HP) was the average of 14 binary items (α=.83; e.g., "do you read books about science or science fiction at home"). Participation in science-related activities outside of the classroom (OSP) was the average of 6 binary items (α=.81; e.g., "have you attended a science camp or special program in the summer"). Lastly, participation in school sciences (ISP) was the average of 6 items each on a 4-point Likert scale (α=.76; e.g., "for our science class this year, how often did you participate in class discussion")

Perception of STEM. Two predictors pertained to students' perceptions of STEM. Both on a 4-point Likert scale (1= *disagree strongly*, 4=*agree strongly*), perception about self in and with science (PS) was the average of 5 items (α=.86; e.g., "I think like a scientist") while perception about science and scientists' work (PSS) was the average of 8 items (α=.81; "science helps people").

Covariates. We included a list of STEM-related and demographic indicators as covariates. Pertaining to the families, parents' education, parents' STEM-related job, and family science orientation (4 items; α=.76; e.g., "my family thinks it is important for me to learn science"; 1=*disagree strongly*, 4=*agree strongly*) were controlled. In terms of youth's demographic, we controlled for grade level (grade 9, 10, 11, or 12), gender, college interest, and the year of data collection (2017 or 2019).

Analytical Approach

Analyses of mean-level differences were conducted in Stata v.15.1, whereas multi-group path analyses were estimated with Mplus v7.11 (Muthén &Muthén, 2016). Model fit was judged based on multiple indices (Hu & Bentler, 1999; Table 2). Missing data were imputed with full information maximum likelihood (Enders, 2010).

Results and Discussion

How does high school students' participation in science activities relate to their current and future selves?

Overall, our data fitted the theoretical STEM identity model well (see Table 2 for model fit indices). Science activities participation in all three contexts, namely home, school, and out-of-school, positively predicted perception of self in/with science (PS) (β=.07-25; p<.01). PS, then, positively predicted identification with STEM-related careers in all four STEM domains (β=.07-37; p<.05). As shown in Table 3, the indirect effects from participation in science activities to identification with STEM-related careers via PS were mostly positive and statistically significant.

In contrast, students' perception of science and scientists (PSS), was only positively predicted by participation in science activities at school (ISP) and did not predict identification with STEM-related careers in any of the four domains. As shown in Table 3, the indirect effects from participation in science activities to identification with STEM-related careers via PSS were mostly non-significant.

Difference in the STEM identities model by race/ethnicity

There were some mean-level differences in the constructs across racial/ethnic groups. Latinx students reported the lowest level of participation in science activities in all three settings, as well as the lowest level of self and science perceptions (i.e., PS and PSS) compared to other

racial/ethnic groups (Table 1). Notably, this pattern was different from the patterns using the middle school data set collected in different places in the prior study, where there were no significant mean-level differences between Latinx and White students. In addition, Latinx reported higher identification with applied biology career (i.e., medical-related) than all three other racial groups, but lower identification with applied physical careers compared to Asian American students. Latinx-Plus (L+) students were similar to Latinx students on home and in-school participation and were lower than their White and Asian American peers. However, Latinx-Plus students did not vary from the other groups on out-of-school participation or PSS. In sum, Latinx students were lower than White and Asian American students on science participation and perceptions of self and scientists; however, the patterns were not as consistent for Latinx-Plus students.

In terms of process-level differences, model fit indices suggested that the direct paths from science participation to identification with STEM-related careers varied by race/ethnicity (see the dashed lines in Figure 2). Overall, more paths from science participation to identification with STEM-related careers are significant for Latinx, Latinx-Plus, and White students than Asian American students. Among the Latinx, Latinx-Plus, and White students, home science participation positively predicted identification with STEM-related careers in three or four domains (b=.35-54; $p<.05$) whereas out-of-school science participation positively predicted identification with one of the four STEM career domains. School science participation did not predict identification with STEM careers among the Latinx participants but did so in one domain among the Latinx-Plus and White students. In contrast, for Asian American participants, only 2 out of the 12 possible paths from participation in science activities to identification with STEM-related careers were significant (Figure 2d).

Scholarly Significance

The findings of this study provide both practical and theoretical implications for addressing racial/ethnic disparities in STEM. For the practitioners, our results point out two 'leveraging points' to increase Latinx high school students' identification with STEM. One is increasing Latinx students' participation in science activities at home, science classrooms, and out-of-school programs. The Latinx and Latinx-Plus, who were the multiracial population with Latinx descent, on average reported lower participation in science activities and perception of science than their White and Asian American peers, but the *relations* between science activities participation and identification with STEM-related careers via the perception of self in and with science held for all four racial/ethnic groups. In other words, although the Latinx students on averaged reported lower science activities participation and perception of science, their identification with STEM careers would equally increase as other race/ethnic groups if an intervention were to promote their science activities participation. Second, the activities, including school science curricula, need to be strategically designed in a way to increase Latinx students' self-perception. Similar to the findings using middle school data set, perception of self in and with science is shown to consistently predict identification with STEM-related careers, highlighting the criticalness of STEM *identity*.

This study further extends the prior study by providing empirical evidence to support the theoretical STEM identity model using a high school data set collected in a different place. The methodology (i.e., multi-group analysis of path models) enables us to explore racial differences in STEM identification, which has yet to be explored in the existing body of literature.

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Figures

Figure 1. Conceptual model

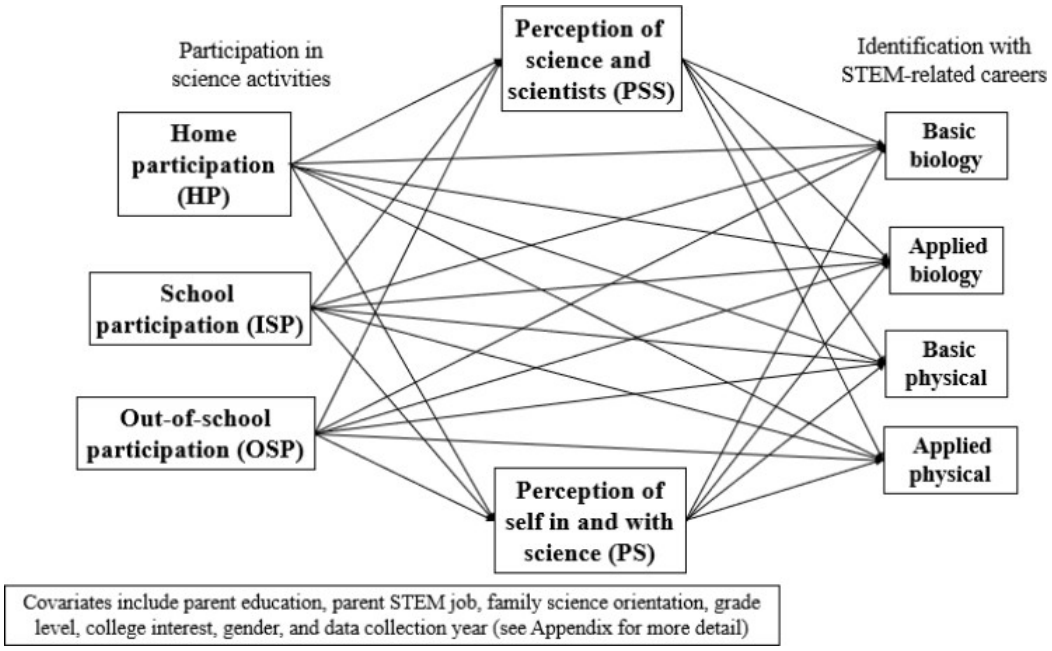
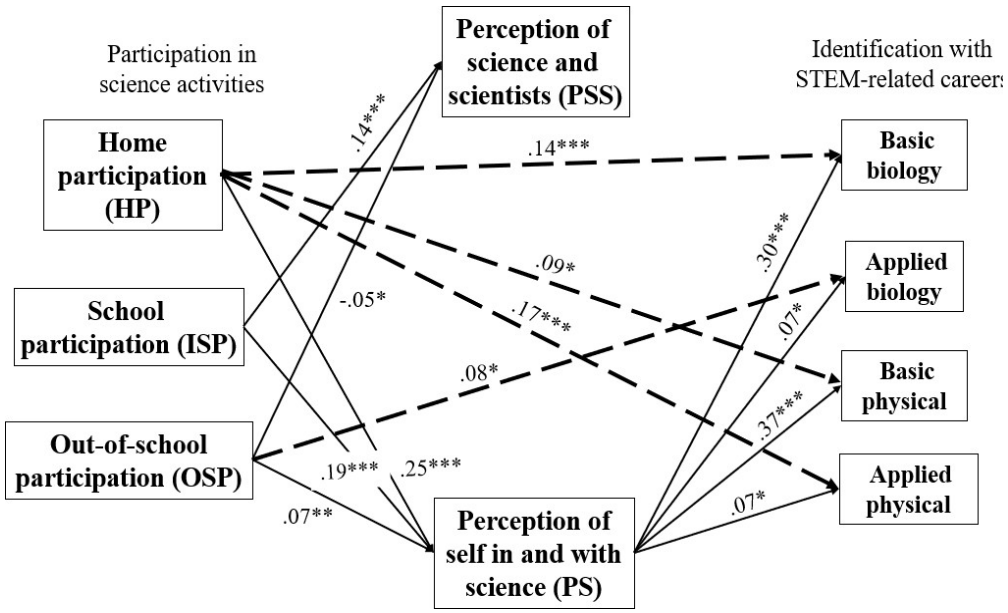
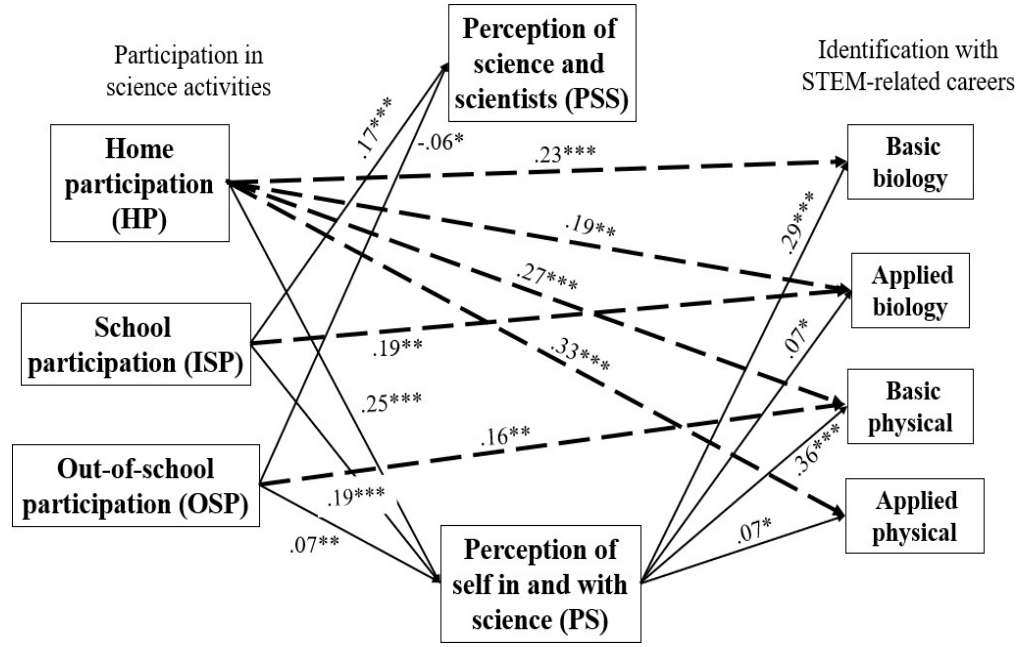


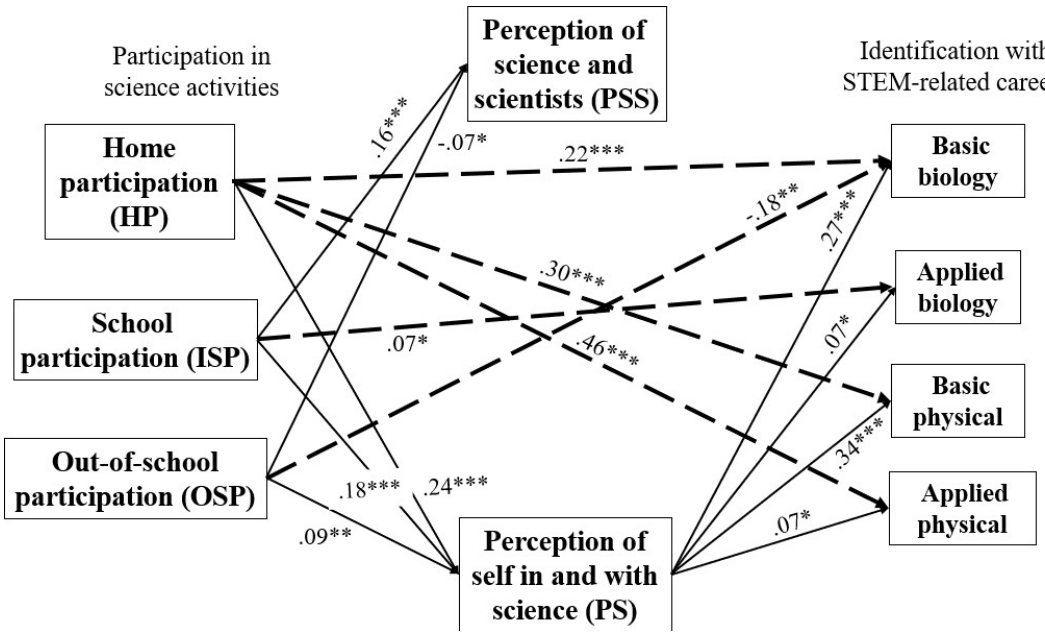
Figure 2. Path model for (a) Latinx, (b) Latinx-plus, (c) White, (d) Asian Americans.
Note. Only statistically significant paths are shown. Solid paths are constrained across racial groups, whereas dashed paths were allowed to vary across racial groups. Covariates include parent education, parent STEM job, family science orientation, grade level, college interest, gender, and data collection year (see Appendix for more detail). Coefficients were standardized, standard errors in parenthesis.



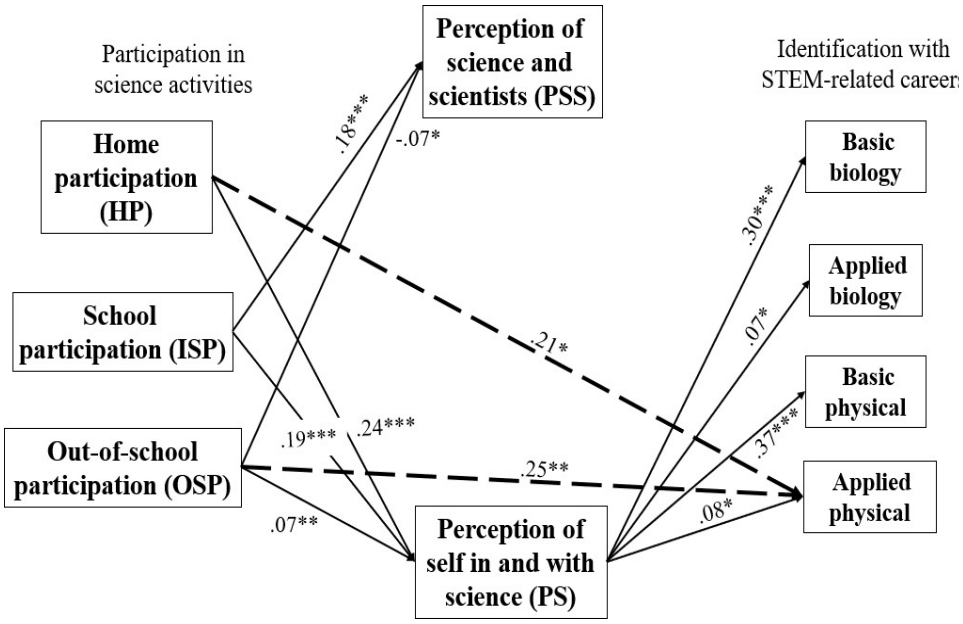
(a) Latinx



(b) Latinx-plus



(c) White



(d) Asian American

Table 1
Descriptive statistics by race

				Latinx (n=745)		Latinx-plus (n=228)		White (n=215)		AANHPI (n=107)		
		min	max	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*anova*
Outcomes												
	Identification with STEM-related careers: basic biology	1	4	2.22	.85	2.07	.89	2.2	.84	2.2	.85	no differences
	Identification with STEM-related careers: applied biology	1	4	2.5	.83	2.33	.87	2.29	.85	2.5	.82	* W, L+ < L
	Identification with STEM-related careers: basic physical	1	4	2.29	1.02	2.19	1.04	2.38	1.03	2.34	.99	no differences
	Identification with STEM-related careers: applied physical	1	4	2.1	.83	2.04	.88	2.11	.86	2.41	.80	* L+, L, W < A
Predictors												
	Perception of self (PS)	1	4	2.63	.65	2.7	.67	2.88	.63	2.88	.64	*** L < W, A; L+ < W
	Perceptions of science and scientists (PSS)	1	4	3.38	.47	3.42	.41	3.46	.38	3.5	.36	** L < A
	Home participation (HP)	0	1	.48	.26	.51	.27	.59	.25	.59	.25	*** L, L+ < W, A
	Out-of-school science participation (OSP)	0	1	.18	.25	.23	.27	.27	.31	.28	.26	*** L < W, A
	In school science participation (ISP)	1	4	2.48	.56	2.63	.62	2.8	.55	2.86	.58	*** L, L+ < W, A
Covariates												
	Parent BA	0	1	.24	.42	.58	.50	.80	.40	.79	.41	*** L < L+ < W, A
	Parent STEM job	0	1	.08	.26	.17	.38	.17	.38	.25	.44	*** L < L+, W, A
	Family science orientation	1	4	2.88	.62	2.96	.64	3.17	.61	3.08	.68	*** L, L+ < W; L < A
	Interest in college	1	5	4.45	.92	4.42	1.04	4.62	.75	4.61	.80	* L < W
	Grade level: 9	0	1	.07	.25	.08	.28	.04	.20	.05	.21	no differences
	Grade level: 10	0	1	.48	.50	.52	.50	.46	.50	.50	.50	no differences
	Grade level: 11	0	1	.37	.48	.32	.47	.40	.49	.36	.48	no differences
	Grade level: 12	0	1	.08	.27	.07	.26	.10	.30	.09	.29	no differences
	data collection: 2019	0	1	.48	.50	.54	.50	.74	.44	.53	.50	*** L, A, L+ < W
	Female	0	1	.55	.50	.53	.50	.45	.50	.49	.50	no differences

Note. SD=standard deviation. L=Latinx, L+=multi-racial with Latinx descent ('Latinx-Plus'), W=White, A=Asian American.
***$p < 0.001$.**$p < 0.01$.*$p < 0.05$

Table 2. Model fit indices

	Model fit					Compare to the unconstrained model	
	(df) $\chi 2$	*p*	CFI	SRMR	RMSEA	Change (df) $\chi 2$	*p*
Unconstrained	(144) 163.106	.13	.994	.020	.024		
Constrained HP, ISP, OSP ➔ PS	(162) 183.316	.12	.994	.027	.020	(18) 20.210	.321
Constrained HP, ISP, OSP ➔ PSS	(162) 187.720	.08	.993	.028	.022	(18) 24.614	.146
Constrained PS ➔ STEM identifications	(174) 198.079	.10	.993	.026	.021	(30) 34.973	.244
Constrained PSS ➔ STEM identifications	(174) 203.400	.06	.991	.026	.023	(30) 40.294	.099
Constrained HP, ISP, OSP ➔ STEM identifications	(225) 312.658	.0001	.975	.036	.035	(81) 149.552	< .00001
Final model: all constrained *except* HP, ISP, OSP ➔ STEM identifications	(216) 253.003	.043	.989	.023	.032	(72) 89.897	.08

Note. df=degree of freedom. CFI=comparative fit index (conventional threshold is ≥ 0.95), RMSEA=root mean squared error of approximation (≤ 0.05), SRMR=standardized root mean square residual (≤ 0.05). HP=home participation in science activities, ISP=in school participation in science activities, OSP=out of school participation in science activities

Table 3. Unstandardized coefficients (and standard errors) for the indirect effects.

	Basic biological	Applied biological	Basic physical	Applied physical
HP				
HP➔PS➔STEM identification	.24 (.04) ***	.06 (.03) *	.35 (.05) ***	06 (.03) *
HP➔PSS➔ STEM identification	-.00 (.00)	-.00 (.00)	.00 (.00)	.00 (.00)
ISP				
ISP➔PS➔STEM identification	.08 (.01) ***	.02 (.01) *	.12 (.02) ***	.02 (.01) *
ISP➔ PSS➔STEM identification	-.00 (.01)	-.01 (.01)	.01 (.01)	.00 (.01)
OSP				
OSP➔PS➔STEM identification	.07 (.03) **	L: .02 (.01)	.10 (.04) **	02 (.01)
OSP➔ PSS➔STEM identification	.00 (.01)	L: .01 (.01)	-.01 (.01)	-.00 (.01)

Note. Only one set is reported because the paths were constrained to be equal across racial/ethnic groups. HP=home participation, ISP=participation in school sciences, OSP=participation in science-related activities outside of the classroom, PS=perception of self, PSS=perception of science and scientists' work.
***$p < 0.001$.**$p < 0.01$.*$p < 0.05$

Appendix: Paths from covariates

Paths from covariate	**to which outcomes**
Parent education	PS (perception of self in and with science), OSP (out-of-school participation in science)
Parent STEM job	Identification with STEM-related careers: apply biology, apply physical; PSS (perception of science and scientists)
FSO (family science orientation)	Identification with STEM-related careers: basic biology; HP (home participation in science); ISP (school participation in science)
Grade level	Identification with STEM-related careers: basic biology, basic physical; PSS; PS; HP; OSP
College interest	Identification with STEM-related careers: basic biology; PSS; PS; HP; OSP; ISP
Gender	Identification with STEM-related careers: apply biology, basic physical, apply physical; PS; HP; ISP
Data collection year	Identification with STEM-related careers: apply physical; OSP