Received: 19 March 2018 | Accepted: 30 November 2018

DOI: 10.1002/sce.21492

LEARNING

WILEY

How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers

Hosun Kang[1] | Angela Calabrese Barton[2] | Edna Tan[3] | Sandra D. Simpkins[4] | Hyang-yon Rhee[5] | Chandler Turner[6]

[1]School of Education, University of California —Irvine, 3200 Education, Irvine, California

[2]Department of Teacher Education, Michigan State University, East Lansing, Michigan

[3]Department of Teacher Education and Higher Education, University of North Carolina at Greensboro, Greensboro, North Carolina

[4]School of Education, University of California —Irvine, 3200 Education, Irvine, California

[5]College of Education, Ewha Womans University, Seoul, South Korea

[6]University of Notre Dame, Notre Dame, Indiana

Correspondence
Hosun Kang, School of Education, University of California, Irvine, 3200 Education, Irvine, CA 92697-5500.
Email: Hosunk@uci.edu

Funding information
National Science Foundation, Grant/Award Number: HRD #0936692

Abstract

This study explores ways to support girls of color in forming their senses of selves in science, technology, engineering, and math (STEM) during the middle school years. Guided by social practice theory, we analyzed a large data set of survey responses (n = 1,821) collected at five middle schools in low-income communities across four states in the United States. Analyses focus on the extent to which key constructs that inform girls' development of senses of self and relations among those indicators of STEM identities varied by their race/ethnicity. Though the means of indicators sometimes varied across racial/ethnic groups, multigroup structural equation modeling analyses indicate no significant racial/ethnic differences in the relations of STEM identities, suggesting that similar supports would be equally effective for all girls during the middle school years. 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. This study argues for strategically expanding girls' experiences with science across *multiple* settings during middle school in a way that increases their positive self-perception in and with STEM.

KEYWORDS
equity, identities, quantitative, social practice theory, STEM-career aspirations

1 | INTRODUCTION

Despite decreasing achievement gaps, the underrepresentation of women, African Americans, Latinx, and Native Americans in physical sciences, engineering, and computer science persist (National Science Board, 2016). There is growing evidence that the underrepresentation of females and individuals from ethnic and racial minority groups in the sciences is closely associated with students' personal goals, self-conceptions, and the compatibility of identities, rather than a result of differential achievement (Archer, Osborne, DeWitt, Dillon, & Wong, 2013; Downey et al., 2005; Riegle-Crumb, King, Grodsky, & Muller, 2012). Underrepresentation of women and people from nondominant communities in science, technology, engineering, and math (STEM) persists and is especially pronounced among women from African American and Latina backgrounds (National Science Board, 2016).

In our inquiry into this persistent underrepresentation, we attend to Ladson-Billings' (2006) argument that the achievement gap between students of color and white students, while real, is misplaced attention. She argues that the field ought to be concerned with addressing the education debt—the outcome of accumulated historical, sociopolitical, economic, and moral policies and decisions that are owed to communities of color who have long been marginalized and inadequately served in education. Without considering the ways in which institutional and social structures have inhibited pathways to success, the science education community cannot fully work toward more equitable opportunities to learn, succeed, and develop in STEM. For example, many students of color in the United States who succeed in school science classes still choose not to pursue a future in STEM. Students may not see themselves as a part of that community, they may not feel fully welcomed, or they may not be recognized for the assets that they bring to STEM.

Aligning ourselves with critical equity scholars, grounded in social practice theory, we argue that the ongoing underrepresentation in STEM might be better understood through the lens of *identity*. In particular, we suggest that an identity gap is one manifestation of the education debt, which has created the conditions for many youths, but in particular women of color, to not feel welcomed for who they are and what they bring to STEM in spite of their high test scores. Even when students are successful in STEM-based learning, many still do not identify with STEM fields, nor are they recognized for their contributions (Archer et al., 2013; Hill, Corbett, & St. Rose, 2010; Osborne, Simon, & Collins, 2003). Likewise, when students do not identify with science, their engagement and academic achievement can be affected (Krapp & Prenzel, 2011; Osborne et al., 2003; Singh, Granville, & Dika, 2002). This gap in opportunities to construct powerful identities is an urgent problem that needs to be better understood and addressed to achieve equity in STEM.

Despite the increasing attention to the role of identities in academic engagement, studying identities from a social practice perspective is difficult, in particular at scale with a large number of participants across multiple research sites. The ever-changing nature of one's identity through social encounters, across time and setting, raises the question of how to best study one's developing identity in STEM. In our previous work, we suggested that attending to "identity work" instead of identities in STEM allows one to more closely examine both the nature of social encounters and girls' responses at critical events as a part of identity development (Calabrese Barton & Tan, 2010; Calabrese Barton et al., 2013). By tracing the identity work that 36 girls do as they engage in science-related activities at home, in afterschool science clubs, and in their science classrooms over time, we illustrated how science-related activities in home, school, and afterschool settings facilitated or failed to facilitate middle school girls of color and youth from economically disadvantaged communities to see their current and possible future selves in STEM (see Calabrese Barton et al., 2013).

Building upon our prior qualitative research, this study explores the process of becoming a STEM-minded person during middle school, using a large-scale survey data set (n = 1,821). The overarching question that guides this study is, “How do girls of color develop STEM identities during their middle school years?” By developing STEM identities, we mean a young person coming to see both her current *and* possible future selves in STEM. We view these STEM identities as manifested through youth’s positive relationship with, positioning and expressed interest toward STEM and STEM-related careers. Using our theoretical STEM-identities model, we analyzed whether and how the constructs and relations varied by girls’ race/ethnicity. The ultimate goal is to provide theoretically well-grounded, and empirically supported insights for supporting girls of color to form their sense of selves in STEM during the middle school years.

2 | MIDDLE SCHOOL YEARS AND THE DEVELOPMENT OF STEM IDENTITIES

Researchers point to the middle school years as a critical time in determining later career aspirations (Blackhurst & Auger, 2008; Gibbons & Borders, 2010; Jackson et al., 2011). Adolescents form their career aspirations long before the point at which they make critical (and potentially life-changing) choices about subjects in which to specialize (Osborne et al., 2003; Tai, Qi Liu, Maltese, & Fan, 2006; The Royal Society, 2006). Middle school is also the period in which science and engineering interest and participation drop steeply even if grades remain high (Christidou, 2011; Lindahl, 2007). Understanding how or why girls of color, between the ages of 10 and 14, come to identify as the STEM-minded person is critical to better support those girls during middle school.

There is a considerable body of literature that explores middle school students’ engagement and identification with STEM and STEM-related careers. Overall, five themes emerged from prior large-scale studies that examine middle school students’ engagement, interest, and identification with STEM and STEM-related careers. First, the majority of large-scale studies analyzed middle school students’ interest, engagement, and identification with STEM using aggregated data sets. There are few studies that examined group differences with careful attention to girls of color, which is critical for addressing current inequities in STEM (see the exception of Aschbacher, Ing, & Tsai, 2014). Second, many studies found that middle school students tended to have a different attitude toward specific STEM disciplines, such as biological sciences versus the physical sciences (e.g., Baram-Tsabari & Yarden, 2005; Buccheri, Gurber, & Bruhwiler, 2011; Dawson, 2000; Jones, Howe, & Rua, 2000). Third, researchers found a strong relationship between students’ self-perception and career interest, suggesting the importance of developing and preserving youth’s feelings of self-efficacy in STEM during the middle school years (e.g., Aschbacher et al., 2014; Barmby, Kind, & Jones, 2008; Haussler & Hoffmann, 2002; Nugent et al., 2015). Fourth, multiple factors influenced middle school students’ science attitudes and early career interests. These factors spanned from gender and culture, family background, self-esteem, previous achievements, hobbies, or life experiences to negative perceptions about STEM or STEM-related careers (Archer et al., 2012; Aschbacher et al., 2014; Christidou, 2011; Hoffman, 2002; Ing, Aschbacher, & Tsai, 2014; Koul, Lerdpornkulrat, & Chantara, 2011). There are few studies, however, that examined how these multiple factors related to one another with respect to middle school students’ positioning and interest toward STEM-related careers, beyond studying the individual impact of any one of these factors. In general, researchers tended to report the overwhelmingly positive impact of their innovative curricular activities in one context (e.g., afterschool robotics club) on improving youths’ interest in and aspiration toward STEM.

This study builds upon and extends these prior large-scale studies by addressing some key limitations. We explored the relationship among multiple factors that influence the development of girls’ sense of current and future selves during the middle school years, considering the intersection of gender and racial/ethnic differences. Informed by prior studies, we categorized STEM-related careers into four subdomains: (a) basic biological sciences, (b) applied biological sciences (e.g., medicine), (c) basic physical sciences, and (d) applied physical sciences (including engineering and computer sciences). We attended to science-related experiences across *multiple* contexts (i.e., home, out-of-school settings, and school science classrooms) in the process of girls of color developing STEM identities.

3 | THEORETICAL PERSPECTIVES

3.1 | Social practice theory, identities, and STEM-career aspirations

In this study, we draw upon social practice theory to examine middle school students' experiences in and with science and how their experiences relate to their identifications with STEM-related careers (see Calabrese Barton et al., 2013; Tan, Calabrese Barton, Kang, & O'Neill, 2013). A girl's interest in and aspirations toward STEM careers is, in part, a reflection of her identities—who she is and who she wants to be. Distinct from the stance that identity is a reflection of one's internal characteristics, social practice theory situates *identities* in the web of relationships and interactions among people in structured activities (e.g., science clubs; Holland, Lachicotte, Skinner, & Cain, 1998). As an adolescent experiences science across time and different spaces, she continuously comes to recognize, be recognized, identify, be identified, position, and be positioned as someone in relation to science (Barton, Tan, & Rivet, 2008; Carlone, 2004; Polman & Miller, 2010). We view such identity work as ongoing, cumulative, and contentious because it always takes place under the power dynamics sanctioned by cultural and historical narratives of "what it means to be a science person" and "who can do science" (Barton et al., 2013). Identity work involves girls' continuing responses to others and taking action for and against the receptions, recognitions, and positioning "under conditions of political-economic and cultural-historical conjuncture" (Holland & Lave, 2009, p. 3). Within this framework, we view who one is—their *current self* —and who one thinks they can be in the future—their *possible future self* —as informed by and shaped through the encounters one has across time and setting.

How might one study "identities" from a social practice perspective using a survey? From an analytical perspective, the event of "responding to Science Identity survey" is *one moment* of identity work. A girl's particular personal and family backgrounds and her specific experiences with science all interact to produce an identity artifact (i.e., her survey responses). During this event, she positions herself with respect to science and science-related careers as she responds to each survey item, such as "I am NOT at all good at science." It is important to note that survey-based identity research in and of itself is inherently limited in understanding the complex social interactions that shape the identities of girls of color over time. However, capturing moments of identity work is important. Such moments provide insight into an individual's personal and family backgrounds, positioning, and access to science-related experiences and identification with STEM careers *in the moment*. This provides insight into how an individual asserts their current and future identities, and the relationship between the two.

3.2 | A theoretical STEM identities model: Current and future selves

Recent theoretical progress in identity studies provides a strong conceptual foundation for large-scale empirical investigations into the mechanism of developing STEM identities. Our in-depth qualitative studies led us to build a theory that explains the process of developing STEM identities. From a social practice perspective, we view the *current self* and *possible future self* as informed by and shaped through the encounters one has across time and setting. Therefore, in our framework, various features that influence identity work are categorized into two groups: A set of constructs that explain *current selves in and with science* and the other set explaining *future selves in relation to science*. A set of constructs for current selves are recategorized as personal and familial background, opportunities, and experiences with/in sciences in different settings, and perceptions about self, science, and scientists' work (see Table 1 and Figure 1). We view this set of constructs as *identity negotiators* that dynamically shape one's identity work, instead of static factors that determine one's identity.

The first construct for current selves emerging from our qualitative studies is the role of *youth's personal and family backgrounds* in shaping social encounters and responses to events (e.g., gender, ethnicity, parents' interest in and support to science and science career, and parents' occupations). Family related variables, including parental involvement, are widely recognized as critical factors that influences students' choices, engagement, and identification with science (see Archer et al., 2012; Aschbacher et al., 2014; Jodl, Michael, Malanchuk, Eccles, &

TABLE 1 Identity negotiators and our theoretical model

	STEM Identifying processes (Who one is, who one wants to be, and who one thinks can be in the future)			
	Current self(s)			Future self(s)
Identity constructs	Personal and family backgrounds	Participation in science-related activities	Perceptions	Possible future selves (PFS) in STEM
Variables	• Gender • Ethnicity • Parents' college attendance (ParCol) • Parents having a science-related job (ParJob) • Family science orientation (i.e., parents' interest in science and support to science career; FSO)	Experiences in and with sciences • At home (HP) • At out-of-school settings (OSP) • In school science (ISP)	Perception about • Self in and with science (PS) • Science and scientists' work (PSS)	Biological sciences • Basic • Applied (medical) physical sciences • Basic • Applied (engineering/ computer sciences)

Note. STEM: science, technology, engineering, and math.

Sameroff, 2001; Nugent et al., 2015; Oyserman, Brickman, & Rhodes, 2007; Simpkins, Fredricks, & Eccles, 2015; Simpkins, Price, & Garcia, 2015; Zarrett & Eccles, 2009). From a social practice theory perspective, the repertoires of practice and ways of being that are learned over time at home are important because they position a youth in particular ways when he or she engages in identity work (Calabrese Barton et al., 2008; Polman & Miller, 2010; Tan

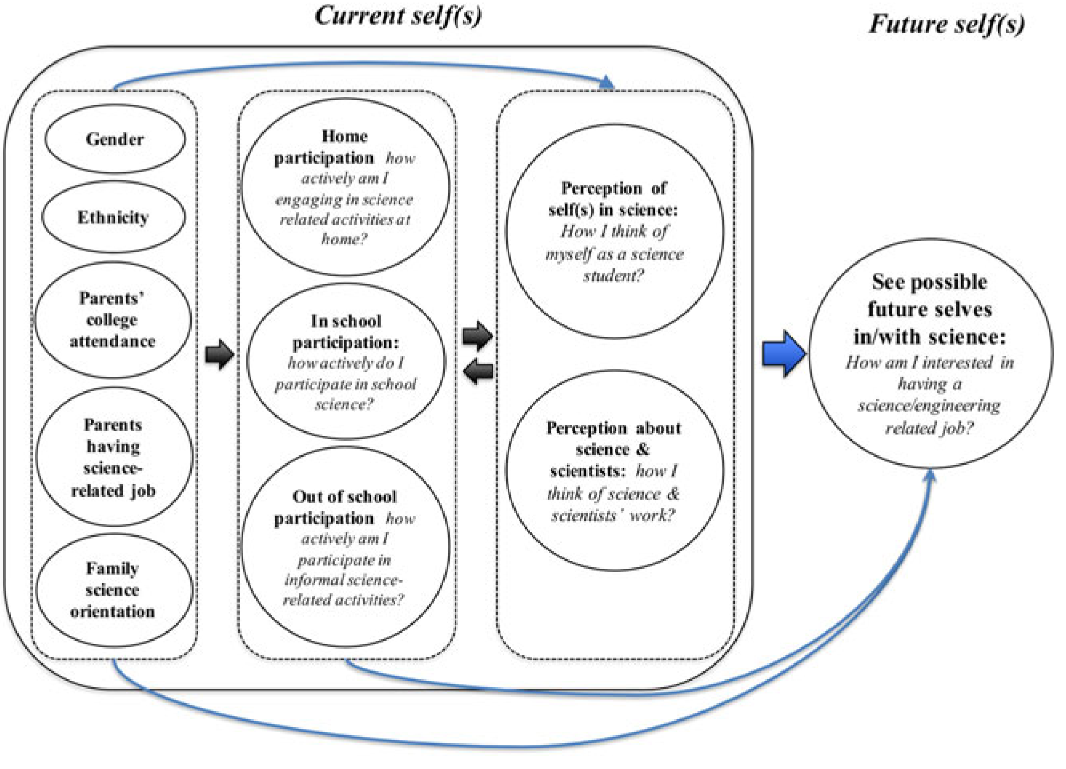

FIGURE 1 Identity negotiators and our theoretical model [Color figure can be viewed at wileyonlinelibrary.com]

& Calabrese Barton, 2010). These repertoires also affect the resources (and associated capital) one can access and activate toward STEM-related identity work.

The second construct for current selves is *opportunities and experiences with/in science in different settings* (e.g., at home, in school, and out-of-school). Different settings are governed by specific discourses (e.g., ways of knowing, doing, talking, and being) that serve to delineate membership. Prior work points to five aspects that shape these settings: the *discourse* of the figured world (e.g., legitimized ways of knowing, doing, and talking); the *activities* that transpire (e.g., lab and small group work); the science *artifacts* that are produced (e.g., lab reports, public representations, and responses to the science identity survey); the *roles* individuals play (e.g., facilitator and follower) and how those roles are shaped by *rules and expectations* (e.g., testing mandate or a classroom policy on group work); and the learning *outcome* (e.g., achievement, interest, and aspirations). Because each setting is operationalized with different norms, rules, and expectations, each setting offers different affordances and constraints for the youth's identity work (Nasir & Cooks, 2009). Whether or not youth have access to experiences with the sciences beyond school, the nature of those experiences, and if/how actively they participate in these science-related activities (and with whom and for what purpose) across settings are all important because they reflect the kinds of social encounters that can affect identity work.

Finally, previous studies on identities suggest that *youth' perceptions about self, science, and scientists' work* need to be attended to understand the mechanisms of developing STEM identities (Aschbacher, Li, & Roth, 2009; Downey et al., 2005). Drawing from social practice theory, positioning has been referred to as "one particular aspect of identity work" having to do with "the manner participants perceive their sense of social place and entitlement in an activity. It translates into a focus on how youth position themselves in relation to the activity—the world of science and education that constitutes the activity studied" (Rahm, 2008, p. 101). We are interested specifically in how girls' *expressed* interest in and perception of science serve as observable and measurable proxies for positioning. For example, when a student marks "strongly disagree" in response to the survey item, "I am good at science," this student positions herself in light of her perceived notion of "being good at science" in the moment. This perceived notion projects the *rules and expectations* about "being good at science" experienced by the student through her social encounters over time. Likewise, when a student indicates that I am "Not at all" interested in having a job like engineering, this student positions herself with respect to a career option based on: (a) what she knows about this career and (b) whether/how she relates herself to a STEM career. From a social practice theory perspective, things that the student knows about the career and whether or how she relates herself to science are cumulatively shaped by social encounters and interactions as well as access information. Furthermore, girls' perceptions of science also shape how and why they participate in STEM. For example, Eisenhart and Finkel (1998) pointed out two decades ago that science in general, as a cultural practice, has been shaped by the ideas, experiences, and biases of white middle-class males, and that many (but certainly not all) women tend toward those domains of science that reflect the values to which they have been enculturated, such as caring about the living environment, bodies, and health. It is no surprise that the number of women in the biological and health sciences quadruples the number of women in engineering (National Science Board, 2016). Thus, why a girl pursues particular forms of science or expresses interest in science is related to how one positions oneself in relation to a culturally imbued science (Blickenstaff, 2005; Brickhouse, Lowery, & Schultz, 2000).

In terms of future selves, we denote the construct of youth's identification with careers in four STEM subdomains (i.e., basic and applied biological and physical sciences). From the perspective of social practice theory, we are interested in understanding whether STEM-related careers are "(un)thinkable" (Archer et al., 2010) to girls of color, assuming that this reflects historical struggles and the encounters that the girls have in various contexts. We consider youth's expressed interest toward STEM-related careers as a window into whether and to what degree youth see their possible future selves[1] in STEM (see Calabrese Barton et al., 2013).

[1]The constructs of future time perspective and possible selves are increasingly used by researchers in other research traditions who seek to understand students' present actions (e.g., course work) in light of their long-term goals and motivations (e.g., Husman & Lens, 1999; Kirn, Faber, & Benson, 2014;

Thus, the ways in which a girl thinks of herself and science at any moment, such as responding to our Science Identity survey, is a reflection of current self/selves that is/are dialectically shaped through cumulative identity work. In theory, being a STEM-minded person—seeing a possible future self in STEM—is shaped by the current self. As illustrated in Figure 1, we theorize that how youth see their possible future selves in STEM can be explained by the relationships among the key identity negotiators involved in their identity work (see the constructs and variables in Table 1 and Figure 1).

4 | RESEARCH QUESTIONS

With the goal of better understanding how middle school girls of color develop STEM identities, we first test a theoretical STEM identities model employing structural equation modeling (SEM) using the whole data set. In this analysis, we examine relations among the identity negotiators as depicted in Figure 1. Next, we examine whether the difference in the constructs and relations is based on race/ethnicity across the four subdomains of STEM *within* girls. The following questions guide our analyses:

1. How do middle school students' current selves relate to possible future selves (i.e., identification with STEM-related careers) in the four subdomains of STEM?
   - **a.** As depicted in the theoretical STEM identities model (Figure 1), does students' participation in science-related activities in different settings predict their perceptions about self and science; and do their perceptions predict their identification with STEM-related careers?
   - **b.** Does students' participation in science-related activities indirectly predict their identification with STEM-related careers through their perceptions?
2. Is there any difference in the STEM identities model by race/ethnicity within girls?
   - **a.** Do the constructs vary by race/ethnicity within girls (i.e., mean-level group differences)?
   - **b.** Do the relations in the STEM identities model differ by race/ethnicity within girls (i.e., moderation)?

5 | RESEARCH DESIGN AND ACTIVITIES

5.1 | Study context and participants

This study is part of a large project that examines middle school girls' engagement in afterschool science programs and their identity development. The research sites are five middle schools located in five different cities in four states of the United States (MI = 797, NC = 275, NY = 273, and HI = 476; see additional details in Supporting Information Table S1). These schools were deliberately selected based on historical relationships, due to our goal of understanding underrepresented youth's science identity development as situated in historical, social, and cultural context. The research team had established long-term relationships with teachers and family members, allowing for depth of knowledge regarding schooling and science institutional and cultural narratives. All participating schools were public, located in urban communities, served a diverse population of students (with a majority of students from nondominant communities in all but one school), and provided youth with consistent informal science learning opportunities outside of the school day. The informal science learning opportunities, such as afterschool science clubs, are year-long programs that are free, readily accessible, and run by either a teacher or the researchers throughout the school year. Free and reduced lunch rates were 70–97% at four schools across MI, NC, and NY, and

Simons, Vansteenkiste, Lens, & Lacante, 2004). Drawing upon social practice theory, in this study, the construct of "possible future selves" is conceptualized as *one* manifestation of one's STEM identities which are shaped through social encounters situated in the larger historical, sociopolitical, and cultural context

55% at the school at HI. We conducted longitudinal ethnographic qualitative case studies with 36 girls who participated in afterschool science clubs at these schools over 3 years, from sixth to eighth grade. During this study period, we administered a survey to all students each year, once a year between April and June. In this study, we report the findings from the survey data collected from a total of 1,821 middle school students (6th to 8th grades) in one academic year (see the demographic information of participants in Supporting Information Table S4).

5.2 | Measures

5.2.1 | Instrument: *Is Science and Me? (ISME)* survey

Data were collected using a modified version of the survey, *ISME*. *ISME* is an empirically validated survey developed to measure secondary school students' identities grounded in social practice theory (Aschbacher et al., 2009, 2014; Gilmartin, Li, Aschbacher, & McPhee, 2006). We selected this survey because of its theoretical orientation, empirical validity, and potential for measuring important constructs of science identities. The *ISME* survey was developed from a social practice theory perspective of identity development and drew from existing scales and questions on related surveys (e.g. Phinney, 1992), as well as from the science education and STEM pipeline literature (e.g., Hanson, 1996; Seymour & Hewitt, 1997). *ISME* was designed to be completed in a single class period. In the original survey, identity was operationalized along four lines: perceptions of self, perceptions of science, interest, and participation in science-related activities, and majors/career aspirations.

We modified the *ISME* survey iteratively over 2 years as we conducted qualitative longitudinal case studies in partner schools and developed our theories on identities, identity work, and identity trajectories (see Calabrese Barton et al., 2013; Tan et al., 2013). Overall, the four constructs on science identities—personal/family backgrounds, perception, participation, and possible future selves (PFS)—that emerged from the qualitative studies guided the revision of survey items. Complete details of the changes to the scales are provided in Supporting Information Table S2 with the final version of the items in Supporting Information Table S3. In short, two scales (home participation [HP] and outside of school [OSP]) were unchanged, and two constructs (ISP, PFS) were slightly modified. One scale, perception of self (PS), which is a key construct in our theoretical model, was expanded from two to five items. Lastly, the perception of science and scientists' work (PSS), items for which were largely stated negatively in the original survey, was revised and expanded to include positive statements. We have several pieces of evidence concerning the validity of the scores on all of our measures. The qualitative data provide substantive evidence of validity (Messick, 1995). With the quantitative data included in this study, we conducted confirmatory factor analysis and tested measurement invariance on all indicators. These analyses are described in Section 6 and provide evidence of structural and generalizability aspects of validity (Hubley & Zumbo, 2013).

5.2.2 | STEM identities model constructs

In what follows, we describe our constructs with respect to each of the four identity constructs in Figure 1. The first construct, *personal and family backgrounds* included five variables: (a) gender, (b) race/ethnicity, (c) parents' college attendance, (d) parents' science-related occupation, (e) parents' interest in science and support of science-related careers (i.e., family science orientation [FSO]), and (f) grade level. In the final version of the modified *ISME* survey, the race/ethnicity item included six categories (e.g., African American/Black African; White/Caucasian/European/European American) as well as an "others" category. The survey prompted students to "check all that apply." A total of seven racial/ethnic groups emerged from students' responses, yielding two groups with small sample sizes: White ($n = 357$), African American ($n = 306$), Latinx ($n = 378$), Asian American ($n = 322$), Multiracial ($n = 366$), Hawaiian ($n = 34$), American Indian ($n = 9$), and Other ($n = 56$). We dropped adolescents who only identified as Hawaiian, American Indian, and Other due to the small sample size for the SEM. The final five race/ethnicity groupings allowed us to conduct robust statistical analyses, in particular focusing on the group differences by gender and by race/ethnicity.

To measure *students' experiences of participating in science-related activities*, three continuous variables were included: (a) home participation (HP, 14 items: $\alpha = 0.84$), measured by the degree of having science-related experiences at home; (b) participation in science-related activities outside of the classroom (OSP, six items: $\alpha = 0.71$), measured by the degree of participation; (c) participation in school sciences (ISP, six items: $\alpha = 0.77$), measured by the frequency of engaging in class activities.

Two variables represented the measures of *students' perceptions*: (a) perception about self in and with science (PS, five items: $\alpha = 0.82$), and (b) perception about science and scientists' work (PSS, eight items: $\alpha = 0.81$).

Finally, *identification with STEM-related careers* was measured by the youth's expressed interest with STEM careers (e.g., "How interested are YOU in having a job like these some day?"). The four domains included (a) basic biological sciences (two items, $\alpha = 0.80$); (b) applied biological sciences (three items, $\alpha = 0.75$); (c) basic physical sciences (one item), and (d) applied physical sciences (four items, $\alpha = 0.82$).

5.3 | Analytical approach

All analyses, except for tests of mean-level differences, were estimated with SEM in MPlus v7.11 (Muthén & Muthén, 2016). We used several indicators of model fit, including the χ^2, comparative fit index (CFI), root mean squared error of approximation (RMSEA), and standardized root mean square residual (SRMR). Specific guidelines have been put forward for CFI, RMSEA, and SRMR (e.g., Hu & Bentler, 1999) to help identify models that fit the data well (CFI ≥ 0.95, RMSEA ≤ 0.05, and SRMR ≤ 0.05), and models that provide adequate fit (CFI > 0.90, RMSEA < 0.08, and SRMR < 0.08). All models were estimated with full information maximum likelihood to incorporate cases with missing data (Enders, 2010).

5.4 | Measurement models and invariance

To test RQ1 and RQ2, a critical first step is to test for measurement invariance in the indicators. Given that RQ2 focuses on variations across race/ethnicity within each gender, we examined measurement invariance across race/ethnicity within girls. Following the two-step modeling approach (Anderson & Gerbing, 1988; Kline, 2010), we estimated a measurement model including the nine constructs in Figure 2, as they are focal constructs in the STEM identities model, as well as FSO, as it has multiple indicators and can be specified as a latent variable. Thus, the 10 constructs included in the measurement model were family science orientation (FSO), participation in science-related activities at home (HP), in school (ISP), outside of school (OSP), perception of self (PS) and of science and scientists (PSS), and identification with STEM-related careers in four domains (basic biology, applied biology, basic physical, and applied physical). All constructs were specified as latent variables except STEM-career identification in the domain of basic physical science, which was a single item. The scale of each latent variable was identified by fixing one loading of the item with the highest loading and theoretical centrality of the construct to 1.0. There was one exception to this rule—the two-item scale for basic biology. STEM identification in the domain of basic biology was calculated by constraining the two loadings to be equal and fixing the latent variance to 1.0. Five of the constructs (i.e., HP, OSP, ISP, PS, and PSS) had five or more indicators. For each of these five constructs, we created three parcels with the balancing approach and used those as indicators in the measurement model (Little, Rhemtulla, Gibson, & Schoemann, 2013). Parcels have several statistical and modeling advantages when the number of items per latent variable is large (Little et al., 2013). The covariances between all 10 constructs were estimated.

We tested measurement invariance of this model to assess whether the 10 constructs included in this model functioned similarly across racial/ethnic groups within girls (i.e., configural and weak; Little, 2013; Millsap, 2011). We examined model differences through the overall model fit and the change in CFI between two nested models (Little, 2013). A change in CFI, that is, <0.01 suggests the models are similar or invariant across groups (Cheung & Rensvold, 2002). These analyses tested whether all measures included in the model have robust psychometric properties and function similarly across groups. In the testing of the STEM identities model, however, we decided to

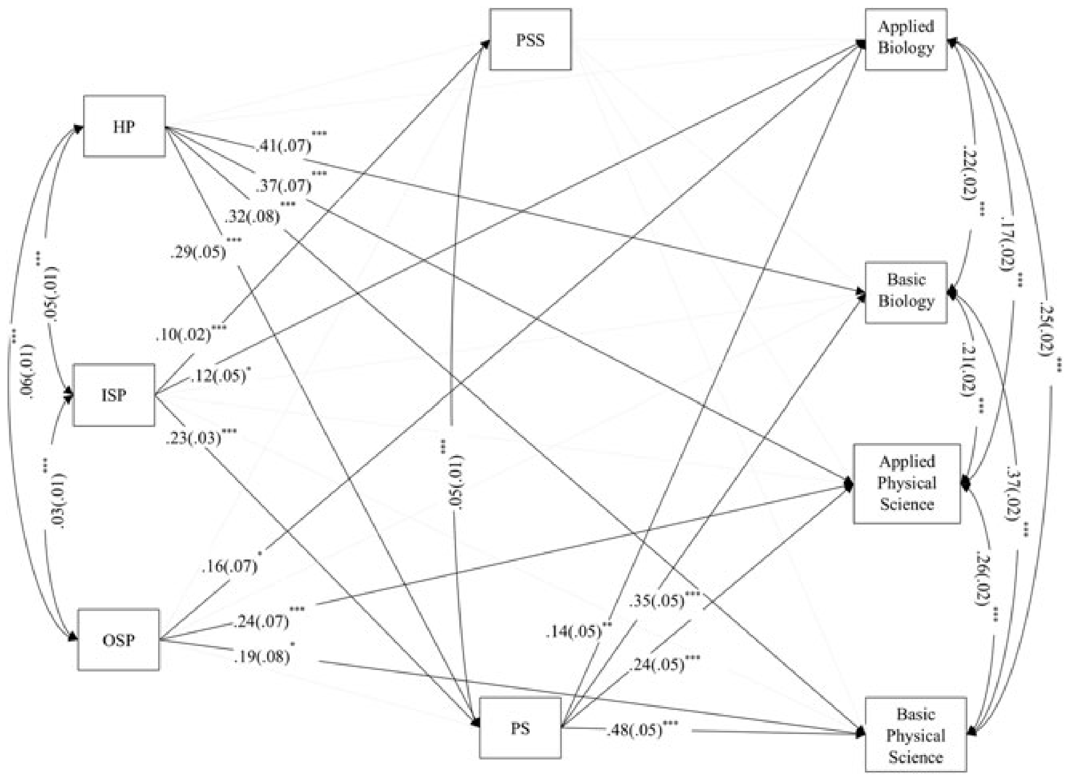

FIGURE 2 Path analysis of the STEM identities model (girls-only data). HP: home participation; ISP: participation in school sciences; OSP: participation in science-related activities outside of the classroom; PFS: possible future selves; PS: perception of self; PSS: perception of science and scientists' work; STEM: science, technology, engineering, and math. **p* < .05, ***p* < .01, ****p* < .001

use observed variables instead of latent variables because a path model was more conservative given our sample size for the multigroup comparisons.

5.5 | RQ1: How do middle school students' current selves relate to possible future selves? testing the STEM identities model

5.5.1 | Path models

We used path models to test our theoretical STEM identities model for the four STEM domains (RQ1). The model included all of the paths and covariances showen in Figure 2 as well as paths estimating the predictive relations between personal and family background constructs (i.e., student grade level, FSO, parent job, and parent education) and the constructs shown in Figure 2. Initially, we included all background constructs and then dropped any predictive paths from a background construct if the path was not statistically significant at $p < 0.05$ for any one of the five racial/ethnic groups to achieve a more parsimonious model. We refer to this model as the STEM identities model throughout the paper.

5.5.2 | Indirect effects

We tested the direct and indirect effects of participation in science at home (HP), outside of school (OSP), and in-school (ISP) on students' four PFSs through their perceptions of self (i.e., PS and PSS) with indirect effects in MPlus.

5.6 | RQ2: Do the constructs vary by race/ethnicity (i.e., mean-level group differences), and do the relations in the STEM identities model differ by gender and by race/ethnicity (i.e., moderation)?

First, we examined differences in students' experiences, perceptions, and possible future selves (PFS) by race/ethnicity within each gender using analysis of variance. We also tested mean-level differences across other personal and family background characteristics which are available in the supplementary materials (see Supporting Information Tables S4 and S5 for descriptive statistics).

Second, we tested whether the relations in the STEM identities model (i.e., the path model described under RQ1) varied by race/ethnicity within girls. We tested gender and race/ethnicity moderation through multigroup SEMs (Little, 2013). Specifically, we examined the change in χ^2 ($\Delta\chi^2$) across two nested models—a model that freely estimate the predictive paths and covariances for each group separately and a model that constrained all or some of the predictive paths and covariances to be equal across groups. A statistically significant change in χ^2 at $p < 0.001$ across two models indicates the presence of moderation—namely, that the relations are significantly different across groups. A nonsignificant change in χ^2 indicates that the two models fit the data equally, which in this case means that the relations are similar across groups.

6 | RESULTS

Before we tested the research questions, we first tested for measurement invariance. The results suggest that all of the constructs included in the measurement model, which includes FSO and all of the nine focal constructs in Figure 2 (i.e., HP, ISP, OSP, PS, PSS, and identification in four subdomains), functioned similarly across racial/ethnic groups within each gender. This result provides confidence that group differences are less likely to be a function of differential bias in the measures. Specifically, according to model fit indices and the change in CFI (ΔCFI < 0.01), the measurement model evidenced full configural and weak invariance across race/ethnicity within each gender. Within girls, the configural model fit the data well, $\chi^2(1{,}659) = 2{,}322.596$, $p < 0.001$, CFI = 0.934, RMSEA = 0.048, SRMR = 0.057, and the model evidenced full weak invariance ΔCFI = 0.000. Within boys, the configural model fit the data well, $\chi^2(1{,}659) = 2{,}368.998$, $p < 0.001$, CFI = 0.937, RMSEA = 0.050, SRMR = 0.056, and the model evidenced full weak invariance ΔCFI = 0.003. The results of the standardized factor loadings were all above 0.4 (with most above 0.60) and significant at $p < 0.001$, suggesting good convergent validity (Acock, 2013; Costello & Osborne, 2005). Given the purpose of this paper, we present the results from the girls' data in the following sections. The results from the boys' data are provided in Supporting Information (see Table S8 and Figure S1).

6.1 | RQ1: How do middle school students' current selves relate to their identification with STEM-related careers?—testing the theoretical STEM identities model

The STEM identities path model fit the data well for girls (see model G3 in Table 2). Figure 2 includes the statistically significant coefficients from the multigroup models testing differences across racial/ethnic groups. We discuss the multigroup models at length under RQ2 in the Section 6.2. It is important to note here that we used unstandardized coefficients in Figure 2 because all of the relations in the figures were constrained to be equal across racial/ethnic groups. By using the unstandardized coefficients, we only need to show one coefficient per path for girls as the coefficients are exactly the same for all racial/ethnic groups for girls. We include all of the standardized coefficients in Supporting Information Tables S6 and S7 for those interested.

Figure 2 includes statistically significant unstandardized coefficients among the focal variables of the STEM identities model for girls. The gray lines in the figures were included in the model but were not statistically significant. They are presented in gray without their coefficients for ease of presentation. A complete list of all

TABLE 2 Model fit statistics and change in χ^2 testing racial/ethnic differences within girls (Gs) in the STEM identities model

	Model fit					Comparison to the unconstrained model		
Models	**(df) χ^2**	**p-Value**	**CFI**	**SRMR**	**RMSEA**	**(Δdf) $\Delta\chi^2$**	**p-Value**	**Are there differences across groups (i.e., $p < 0.001$)?**
Invariance across racial/ethnic groups within girls								
G1. Unconstrained	(90) 97.974	0.265	0.997	0.023	0.028			
G2. All constrained	(382) 495.391	<0.0001	0.960	0.041	0.080	(292) 397.417	<0.0001	Yes
G3. Constrained relations among focal constructs	(234) 289.082	0.008	0.980	0.037	0.053	(144) 191.108	0.005	No
G4. Constrained paths with background variables	(238) 305.263	0.002	0.976	0.040	0.064	(148) 207.289	0.0009	Yes

Note. CFI: comparative fit index; RMSEA: root mean squared error of approximation; SRMR: standardized root mean square residual; STEM: science, technology, engineering, and math.

standardized coefficients included in the STEM identities model for each of the five racial/ethnic groups is presented in Supporting Information Tables S6 and S7. Our discussion concentrates on the relations depicted in Figure 2 as they are the focus of RQ1.

Overall, the findings confirmed the hypothesized relations for the STEM identities model. There were three consistent common predictors of students' identification with four STEM-related careers: PS, HP, and OSP. Students' perception of self (PS) predicted higher identification with STEM careers in all domains (Figure 2). In addition, girls' participation in science-related activities at home (HP) predicted higher identification with all four STEM careers with one exception. Home participation did not predict identification in applied biology (Figure 2). Participation outside of school (OSP) predicted higher identification with STEM careers in three domains. OSP did not predict basic biology.

Students' perception of science and scientists' work (PSS) and in-school experiences (ISP) did not predict their identification with STEM-related careers. The one exception to this pattern was that ISP predicted higher identification in the domain of applied biology (e.g., medicine). Notably, students' participation in science-related activities in all three contexts (HP, OSP, and ISP) predicted higher perceptions of self (PS), but only participation in school (ISP) predicted higher perceptions of science and scientists' work (PSS).

6.1.1 | Indirect effects

Table 3 shows the total effect for each context as well as the one direct effect and two indirect effects that comprise the total effect. These indirect effects are drawn from the multigroup analyses. The tables only include one set of estimates from each multigroup model because the paths that comprise these effects are constrained to be equal across racial/ethnic groups and therefore these tests are equal across racial/ethnic groups. For example, there is one set of coefficients for the relation of HP to girls' identification with basic biology rather than one for each of the five racial/ethnic multigroups because all of these paths (and therefore these indirect effect tests) are constrained to be equal across groups.

The indirect effects analyses suggest that there were indirect effects of science participation in all three contexts on students' possible future selves (PFS); however, this occurred through perceptions of self (PS), and not through perceptions of science and scientists' work (PSS), which never accounted for any indirect effects.

Participating in science activities at home (HP) had both direct and indirect effects for girls' identification with STEM-related careers across domains, with one exception. Participating in science activities at home (HP) indirectly predicted girls' identification with STEM-related careers in all domains (i.e., HP → PS → STEM identifications). HP also directly predicted girls' identification with STEM-related careers in three domains: basic biological, basic physical, and applied physical sciences.

The findings for girls' science experiences outside of school (OSP) differed from HP. Whereas OSP had direct effects on identification with STEM careers in all areas except basic biology, OSP did not show indirect effects. OSP was neither a strong predictor of students' perceptions of self (PS) nor their perceptions of science and scientists' work (PSS) for both girls and boys in this study.

Similar to HP, girls' participation in science classrooms (ISP) indirectly predicted their identification with STEM careers in all four areas. Parallel to HP, all indirect effect was channeled through PS (i.e., ISP → PS → STEM identifications) and never indirectly predicted students' identification through their perception of science and scientists' work (PSS). Girls' ISP had one additional direct effect—applied biology. In contrast to HP, ISP rarely directly predicted students' identification with STEM-related careers.

In sum, students' participation in science-related activities in contexts, directly and indirectly, predicted their identification with STEM-related careers. The indirect effects only emerged through students' perceptions of self (PS) and not their perceptions of science and scientists' work (PSS). The indirect effects emerged in predicting students' identification with STEM careers in all areas. HP had additional direct effects predicting identification with STEM-related careers above and beyond the indirect effects.

TABLE 3 Unstandardized coefficients (and standard errors) for the total, direct, and indirect effects (girls-only data)

	Applied bio	Basic bio	Applied physical	Basic physical
HP				
Total HP effect	0.06 (0.08)	0.52 (0.07)***	0.44 (0.07)***	0.46 (0.08)***
HP → PFS	0.02 (0.08)	0.41 (0.07)***	0.37 (0.07)***	0.32 (0.08)***
HP → PS → PFS	0.04 (0.02)*	0.10 (0.02)***	0.07 (0.02)***	0.14 (0.03)***
HP → PSS → PFS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
OSP				
Total OSP effect	0.17 (0.07)*	0.09 (0.07)	0.25 (0.07)***	0.21 (0.08)*
OSP → PFS	0.16 (0.07)*	0.08 (0.07)	0.24 (0.07)***	0.19 (0.08)*
OSP → PS → PFS	0.01 (0.01)	0.02 (0.02)	0.01 (0.01)	0.02 (0.02)
OSP → PSS → PFS	0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
ISP				
Total ISP effect	0.15 (0.05)**	0.08 (0.05)	0.04 (0.04)	0.04 (0.05)
ISP → PFS	0.12 (0.05)*	0.00 (0.05)	−0.02 (0.05)	−0.08 (0.05)
ISP → PS → PFS	0.03 (0.01)*	0.08 (0.02)***	0.06 (0.01)***	0.11 (0.02)***
ISP → PSS → PFS	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)

Note. Only one set is reported because the paths in these effects were constrained to be equal across racial/ethnic groups, therefore these tests are equal across racial/ethnic groups.

HP: home participation; ISP: participation in school sciences; OSP: participation in science-related activities outside of the classroom; PFS: possible future selves; PS: perception of self; PSS: perception of science and scientists' work.

***$p < 0.001$.

**$p < 0.01$.

*$p < 0.05$.

6.2 | RQ2: Do the constructs and relations in the STEM identities model differ by race/ethnicity within girls?

6.2.1 | Mean-level differences

There were several significant differences across the racial/ethnic groups within each gender group. All findings are presented in Supporting Information Tables S4 and S5; here we highlight a few notable differences among the race/ethnic groups within girls. For the girls' identification with STEM-related careers, Asian American girls showed the strongest identifications in all four domains and African American girls showed weak identifications in all domains except applied biological sciences. This pattern is parallel with the one of self-perception (PS). Asian American girls showed the strongest self-perception followed by Latina, White, Multiracial, and African American girls. The difference between Asian American and African American girls' self-perception was significant ($p < 0.05$). There were *no* differences in the perception of science and scientists' work (PSS) across the girls. There were some notable differences in girls' participation in science-related activities at home (HP), outside of school (OSP), and in school (ISP). Specifically, Asian American girls reported the most experiences with science at home (HP) and African American girls reported the least experiences. This difference was significant ($p < 0.05$). With respect to girls' participation in out-of-school (OSP), Asian American girls had the most experiences with science outside of school (OSP) followed by Latinx, African American, Multiracial, and White girls. Asian American girls' science-related experiences at out-of-school contexts was higher than all the other girls (p's < 0.01 to 0.001). White girls reported significantly fewer experiences with science at out-of-school context than Asian American girls and Latinx (p's < 0.05–0.001). The pattern was slightly different in the girls' participation in school sciences (ISP). Asian American girls reported the most active participation followed by African American, Multiracial, White, and Latinx girls. Latinx girls' in-school participation was significantly lower than Asian American girls ($p < 0.05$), but their self-perception was as high as that of Asian American girls. In contrast, African American girls reported that they actively participated in school science as much as Asian girls did, but their self-perception in relation to science (PS) was the lowest.

6.2.2 | Moderation analyses

Our second question concerning group differences focused on the extent to which the relations in the STEM identities model described under RQ1 varied by race/ethnicity within girls. The multigroup SEM findings suggest that the central relations of the STEM identities model shown in Figure 2 did not vary by race/ethnicity, though some of the relations with the background variables did vary significantly. Table 2 displays the model fit statistics and change in chi-square across the nested multigroup models.

The same series of models were estimated within girls as shown in Table 2. The findings concerning moderation across race/ethnicity suggest that some of the relations differed across racial/ethnic groups because a significant $\Delta\chi^2$ was significant when comparing model G2 to G1 for girls. We estimated two follow-up models to pinpoint which type of paths and covariances might vary across groups. Model G3 suggests that the relations among the focal constructs in Figure 2 were similar across racial/ethnic groups for girls. In contrast, the relations including the background variables (i.e., FSO, parent job, education, and grade levels) differed across racial/ethnic groups for girls as noted by the significant $\Delta\chi^2$ of model G4. We allowed the relations including background variables to be freely estimated across racial/ethnic groups, which included 29 paths where a background variable predicted the nine focal constructs in Figure 2 and their covariances. All other paths (i.e., the paths are shown in Figure 2) were constrained to be equal across groups.

7 | DISCUSSION: HOW CAN WE BETTER SUPPORT GIRLS OF COLOR TO DEVELOP STEM IDENTITIES DURING THE MIDDLE SCHOOL YEARS?

Middle school is a pivotal time in shaping youth's sense of selves in relation to STEM, which can have a life-long impact on their engagement with STEM (Blackhurst & Auger, 2008; Gibbons & Borders, 2010; Tai et al., 2006). This study advances our understanding of middle school girls' development of STEM identities by exploring the relations among multiple factors that influence the development of the girls' identity development while considering the intersection of gender and racial/ethnic differences. Our analyses point to significant and distinctive roles that *multiple* contexts (i.e., home, school, and activities outside of school) play in shaping girls' identification with STEM and STEM-related careers during their middle school years. Notably, this pattern was consistent across girls from different racial/ethnic backgrounds. Based on these results, we argue for strategically expanding girls' experiences with science across *multiple* settings, and not just in one setting, as a means of increasing girls' sense of being people who value and can do science. Below, we unpack this idea by discussing the key patterns in our findings.

7.1 | The significant and distinctive role of experiences with science in *multiple* contexts for girls of color forming their senses of self in STEM

Overall, the results show a good model-to-data fit, suggesting that mathematical correlations in survey data can be explained by our social practice theory guided STEM identities model—whether and how youth see their possible future selves (PFS) in STEM is explained by the key identity negotiators involved in youth's identity work (personal, family backgrounds, experiences in and with sciences across time and spaces, and their perception of self (PS), science, and scientists' work). The multigroup analysis provides evidence that the relations in the model are similar across race/ethnicity within each gender group. Whereas the majority of prior studies focused on identifying key predictors of middle school students' career aspirations (e.g., self-efficacy and family support), our STEM identities model, which emerged from prior qualitative work and was empirically tested with quantitative data, enables us to shed light on a complex, relational, and dynamic process of girls of color developing STEM identities.

Consistent with other researchers' findings (e.g., Aschbacher et al., 2014; Nugent et al., 2015), one strong predictor of the girls' identification with STEM-related careers in this study was their perception of self (PS) in relation to science (PS). Mirroring dominant discourses in American society, Asian American girls reported the highest self-perception and African American girls reported the lowest self-perception. Notably, girls' self-perceptions were significantly and positively associated with their experiences with science-related activities at home and in their school science classrooms. From the perspective of social practice theory, these patterns can be interpreted thus: A girl's expressed self-perception, which is one observable proxy for her positioning toward science as indicated by social practice theory, is socially mediated and distilled from relational interactions as that girl engages in science-related activities across settings. Alternatively, it is possible that youths' self-perception drives their selection of and increasing participation in science-related activities, as indicated by the bidirectional relations in our theoretical STEM identities model (see Table 1 and Figure 1).

The findings of this study suggest that girls' experiences with sciences in *all three* contexts play significant and distinctive roles in forming their senses of self in STEM. Girls' experiences with science-related activities *at home* was the most consistent predictor in terms of both direct and indirect effects. In this data set, girls' experiences at home (HP) were both significantly and positively associated with their identification with STEM-related careers in all domains, except applied biology. The indirect effect was channeled through the perception of self (PS). Again, this pattern was consistent across all of the girls regardless of their racial/ethnic backgrounds. Notably, there was a statistically significant difference between Asian American and African American girls. Mean-level differences suggest that Asian American girls have more experiences at home that they deem science-related than do African American girls. However, the lack of moderation suggests that science-related experiences at home were equally predictive for all girls regardless of race or ethnicity. These findings suggest that increasing science-related experiences at home likely has benefits for all girls.

In addition, the analyses suggest that girls' increasing experiences with science outside of school settings may increase their identification with STEM-related careers. In this data set, girls' experiences with science outside of school (OSP) were directly associated with their identification with STEM-related careers in three domains, including basic and applied physical sciences. This finding supports the argument made by numerous researchers that increasing girls' participation in science-related activities outside of school (e.g., afterschool programs, summer programs, and field trip) is a promising approach for increasing girls' interest, aspiration, and identities with STEM (National Research Council, 2015; Tan et al., 2013). Recently, there is an increasing call for attending to the form of the activity rather than just its content to better understand the relationship between girls' science learning experiences outside of school settings and their interest in STEM-related careers (Potvin & Hasni, 2014; Swarat, Ortony, & Revelle, 2012). Prior qualitative studies show that activities outside of school can offer qualitatively different science learning experiences for girls from nondominant communities by delineating nontraditional norms and the discourse of what it means to do science and be good at it (Calabrese Barton et al., 2013; Tan et al., 2013).

Patterns regarding science experiences in schools (ISP) were more complex than the others (HP, OSP). Unlike girls' experiences at home and outside of school, their experiences with science in the classroom did not directly predict identification with STEM-related careers, except for the domain of applied biology. Girls' experiences with school sciences, however, did have a significant indirect effect through self-perception (ISP → PS → Identification with STEM-related careers; see Table 3). In other words, the results suggest that enhancing middle school girls' active participation in school science lessons likely increases their self-perception (PS) of identifying with science. This may, in turn, increase their identification with STEM-related careers. One possible explanation about the lack of direct effect of school sciences on girls' identification with STEM-related careers is that girls' experiences with science in this formal school setting are qualitatively different from their experiences in an informal setting. Prior studies suggest that inquiry-based, problem-solving activities about relevant and important issues that matter to girls of color positively affect their identification with STEM (Calabrese Barton, 1998; Brickhouse & Potter, 2001; Mouza, Marzocchi, Pan,

& Pollock, 2016). Prior qualitative studies show that girls engage in school science lessons in different ways when they are able to incorporate community and familial funds of knowledge into science learning (Calabrese Barton et al., 2013; Birmingham et al., 2017). It is possible that the girls in this particular data set had low access to such high-quality science learning experiences at schools that increase positive self-perception in and with science. Alternatively, the lack of direct effect of school science experiences observed in our data set may have to do with the nature of our survey instrument itself. The six items used for measuring school science experiences mostly focused on whether and to what extent middle school students actively participated in their science lessons (e.g., "how often do you participate in class discussions, work on assignments with other students"). This makes it difficult to gauge the extent to which these girls had high-quality science learning experiences at school, as suggested by the literature. Regardless of, we believe our findings support the idea that how girls identify with STEM in school settings is crucial. This study advances the existing argument that girls of color need more opportunities, and higher quality opportunities, in school by beginning to unveil the mechanisms by which this may work. The findings of this study point to the association among girls' school science experiences, their perceptions of self in/with science, and their identification with STEM-related careers.

Taken together, the results provide evidence that girls' experiences with science-related activities in each of three different contexts (home, school, and outside of school) have distinctive effects on their identification with STEM-related careers, either directly or indirectly. Social practice theory underscores the critical role of girls' social encounters in shaping their identities as they engage in science-related activities across settings and over time (Holland et al., 1998). Researchers have documented the *cumulative* nature of girls' identity work as they travel across multiple settings (see Calabrese Barton et al., 2013; Polman & Miller, 2010). Girls' experiences with science in one setting, such as at home, can have a synergic effect on forming their identities when experiences in this one setting are leveraged and capitalized in another setting. Attending to girls' experiences with science across multiple settings, not just in one, is necessary to support their forming senses of self in STEM.

Our analyses support the argument that the current underrepresentation of women of color has to do with "missing opportunities" for girls of color to form their senses of self in science (Ladson-Billings, 2006). Providing these currently absent opportunities for girls of color at home and via programs outside of school may be one promising approach to support those girls in seeing their possible future selves (PFS) in STEM. However, we posit that the familiar, generic recommendation of more "family" or "afterschool" exposure is not useful. Rather, attention ought to be paid to the *kinds* of family and support that leverage the assets of the girls, their families, and their communities. This may be the most important form of experience outside of school, given that these experiences may be the most likely to support girls' self-perception. Furthermore, we reject the argument that parents of those girls simply need to do more. As reported in other studies (see Calabrese Barton et al., 2013 for example), it may be that African American girls' opportunities to engage in science outside of school are limited because experiences that appear to be culturally sustaining are simply not available. Or it may be that the ones that are available are not designed in ways that support the identity work of girls of color. Researchers note that, currently, the participation of youth of color in organized activities outside of school settings have been understudied (Fredricks & Simpkins, 2012). One important question raised from these analyses is: *How can we create structures and activities that mutually enhance girls' experiences with science at home, in school, and outside of school during their middle school years?* If young women do not see their experiences as scientific—even if they are—then this will impact their senses of self in science. Do schools or programs outside of school formally recognize home-based experiences that are related to science in ways that help girls see the value of these experiences in science? If so, in what ways? A future study that provides insight into the kinds of family, school, and out-of-school science experiences that might attract the families of girls of color and best support girls' self-perceptions in science, would be fruitful.

7.2 | Limitations and directions for future research

The findings of this study should be interpreted with consideration of its limitations. First, the results are based on limited observation using a survey with selected middle schools. As discussed above, regarding identities from a social practice theory perspective, survey-based identity studies are limited to capturing an interactive part of identity work. A survey of multiple people who directly interact with the girls who participated, such as parents, teachers, and peers, will allow identity researchers to produce more a robust understanding of how girls develop STEM identities during their middle school years.

Second, the patterns reported in this study are bounded in the sample, which may not reflect the patterns of the overall population in the United States regarding underrepresentation in STEM. Future research with representative samples of students from various geographical, cultural, or socioeconomic backgrounds may provide more comprehensive insights into the processes of middle school students' formation of identities in science.

Third, the mechanisms of developing STEM identities suggested by the theoretical model need to be further explored with longitudinal data. As discussed above, the current data were generated from one-time survey administration and prevent us from testing our hypothesis about dialectical relationships among identity negotiators. As asserted in the model, we speculate that youths' self-perception also drives youth's selection and increasing participation in science-related activities. Moreover, we expect that the strongest direction of influence may differ across development and depends on contextual factors. Youth's increasing autonomy and maturity in adolescence might strengthen the role of their perceptions in selecting science activities across contexts (Simpkins et al., 2015). A robust set of data collected at multiple time points of youth's identity trajectories will enable us to test the dialectical relationship, identify the direction of influences at different points, and explore various alternative models through cross-lag and growth curve analyses.

Fourth, the STEM identities model needs to be further examined with the consideration of unmeasured variables. For example, the significant, persistent direct effects of science experiences at home (HP) and outside of school contexts (OSP) on girls' identification with STEM careers suggest there may be additional mediators. One potential variable which emerged from prior qualitative research but was not measured in this study was "recognition"—whether and to what extent youth's identity work is recognized, legitimized, and validated by others (see Calabrese Barton et al., 2013). Future research including a measure of this construct will further strengthen the explanatory power of the STEM identities model.

Finally, results about racial/ethnic groups should be interpreted carefully, with consideration of the inherent limitations of racial/ethnic grouping. On one hand, the current data and the selected methodology limit us in making any interpretation about certain racial/ethnic groups, including Hawaiian and American Indian groups. On the other hand, the characterization of a particular racial/ethnic group based on statistical patterns leads the researchers to run the risk of reinforcing prevalent problematic racial discourses in the American society, such as the Asian model minority stereotype. Understanding the affordances and limitations of the methodology as well as the consequences of the research findings to the people from racially minoritized groups will be essential for generating the knowledge that serves people.

8 | CONCLUSION

We, as a field, have just begun to recognize and understand the complexity of studying youth forming senses of self in STEM during middle school. The STEM identities model tested in this study sheds light on the processes involved by specifying key constructs and how they relate to one another. More important, this study provides evidence of current unequal opportunities of experiencing science for girls of color, suggesting that this has a potential effect in their developing senses of self in/with STEM during their middle school years.

There are two implications for policy and research to support girls of color in developing identities in STEM during middle school. As noted by other scholars, we believe that providing expanded opportunities to participate in science-related activities beyond classroom instruction has a potential for supporting youth's developing senses of self in STEM. The present study further extends this argument in two ways. First, experiences with science outside of school settings should be strategically designed as a way of increasing positive self-perception in and with science. Second, it is important to attend to girls' experiences across multiple contexts, not just in one setting. This study shows significant and distinctive contributions of girls' experiences at home, in school, and outside of school settings.

This study reveals both the challenges and possibilities of building upon qualitative work with quantitative data to study complex educational phenomena. We found it challenging to articulate and interpret the meanings of these measures while holding a consistent theoretical perspective of learning and identities. It is even more difficult to communicate the findings with an audience who is likely familiar with one methodology or the other, but not both. Support for interdisciplinary collaboration will advance the knowledge base on critical topics in education sciences through robust research.

ACKNOWLEDGMENTS

We thank Jacquelynne S. Eccles and Pamela Aschbacher who provided insightful comments and critiques on an earlier draft of this manuscript. We are also thankful to the editors and reviewers for critical comments and support. This study would not be possible without Tara O'Neill, who helped us collecting data at Hawaii and all the teachers and students who participated in this project and allowed us to document their journeys. This material is based upon work supported by the National Science Foundation under Grant No. HRD #0936692. Any opinions, findings, and conclusions or recommendations expressed in this material are our own and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

Acock, A. C. (2013). *Discovering structural equation modeling using Stata: Revised edition*. College Station, TX: A Stata Press Publication.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*, 411–423.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education*, *94*(4), 617–639.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal*, *49*(5), 881–908.

Archer, L., Osborne, J. F., DeWitt, J., Dillon, J., Wong, B. (2013). Aspires report: Young people's science and career aspirations, age 10-14. London, UK: King's College London. Retrieved from http://www.kcl.ac.uk/sspp/departments

Aschbacher, P. R., Ing, M., & Tsai, S. M. (2014). Is science me? Exploring middle school students' STE-M career aspirations. *Journal of Science Education and Technology*, *23*(6), 735–743. https://doi.org/10.1007/s10956-014-9504-x

Aschbacher, P. R., Li, E., & Roth, E. J. (2009). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, *47*(5), 564–582.

Baram-tsabari, A., & Yarden, A. (2005). Characterizing children's spontaneous interests in science and technology. *International Journal of Science Education*, *27*(7), 803–826.

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education*, *30*, 1075–1093.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American educational research journal*, *50*(1), 37–75.

Calabrese Barton, A. (1998). Teaching science with homeless children: Pedagogy, representation and identity. *Journal of Research in Science Teaching*, *35*(4), 379–394.

Calabrese Barton, A., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences*, *19*(2), 187–229.

Calabrese Barton, A., Tan, E., & Rivet, A. (2008). Creating hybrid spaces for engaging school science among urban middle school girls. *American Education Research Journal*, *45*, 68–103.

Birmingham, D., Calabrese Barton, A., McDaniel, A., Jones, J., Turner, C., & Rogers, A. (2017). "But the science we do here matters": Youth-authored cases of consequential learning. *Science Education*, *101*(5), 818–844.

Blackhurst, A., & Auger, R. (2008). Precursors to the gender gap in college enrollment: Children's aspirations and expectations for their futures. *Professional School Counseling*, *11*(3), 149–158.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and education*, *17*(4), 369–386.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*(5), 441–458.

Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching*, *38*(8), 965–980.

Buccheri, G., Gürber, N. A., & Brühwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education*, *33*(1), 159–178.

Carlone, H. B. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching*, *41*(4), 392–414.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*, *9*(2), 233–255.

Christidou, V. (2011). Interest, attitudes and images related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental and Science Education*, *6*, 141–159.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for setting the most from your analysis. *Practical Assessment, Research & Evaluation*, *10*, 173–178.

Dawson, C. (2000). Upper primary boys' and girls' interests in science: Have they changed since 1980? *International Journal of Science Education*, *22*(6), 557–570.

Downey, G., Chatman, C. M., London, B., Cross Jr., W. E., Hughes, D., Moje, E., & Eccles, J. S. (2005). Introduction In G. Downey, J. S. Eccles, & C. M. Chatman (Eds.), *Navigating the future: Social identity, coping, and life tasks* (pp. 1-20). New York, NY: Russell Sage Foundation

Eisenhart, M. A., & Finkel, E. (1998). *Women's science: Learning and succeeding from the margins*. Chicago, IL: University of Chicago Press.

Enders, C. K. (2010). *Applied missing data analysis*. New York, NY: Guilford Press.

Fredricks, J. A., & Simpkins, S. D. (2012). Promoting positive youth development through organized after-school activities: Taking a closer look at participation of ethnic minority youth. *Child Development Perspectives*, *6*(3), 280–287.

Gibbons, M., & Borders, L. (2010). A measure of college-going self-efficacy for middle school students. *Professional School Counseling*, *13*(4), 234–243.

Gilmartin, S. K., Li, E., Aschbacher, P. A., & McPhee, C. (2006). The relationship between interest in physical science/engineering, science class experiences, and family contexts: Variations by gender and race/ethnicity among secondary students. *Journal of Women and Minorities in Science and Engineering*, *12*, 179–207.

Hanson, S. L. (1996). *Lost talent: Women in the science*. Philadelphia, PA: Temple University Press.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: American Association of University Women.

Hoffmann, L. (2002). Promoting girls' interest and achievement in physics classes for beginners. *Learning and Instruction*, *12*(4), 447–465.

Holland, D., Lachicotte, W., Jr., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Holland, D., & Lave, J. (2009). Social practice theory and the historical production of persons. *An International Journal of Human Activity Theory*, *2*, 1-15.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55.

Hubley, A. M., & Zumbo, B. D. (2013). Psychometric characteristics of assessment procedures: An overview, In K. F. Geisinger, B. A. Bracken, J. F. Carlson, J. I. C. Hansen, N. R. Kuncel, S. P. Reise, & M. C. Rodriguez (Eds.), *APA handbook of testing and assessment in psychology*, (Vol. 1, pp. 3–19).

Husman, J., & Lens, W. (1999). The role of the future in student motivation. *Educational Psychologist*, *34*(2), 113–125.

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching*, *39*(9), 870–888.

Ing, M., Aschbacher, P. R., & Tsai, S. (2014). Gender differences in the consistency of middle school students' interest in engineering and science careers. *Journal of Pre-College Engineering Education Research*, *4*(2), 1–10.

Jackson, M. A., Perolini, C. M., Fietzer, A. W., Altschuler, E., Woerner, S., & Hashimoto, N. (2011). Career-related success-learning experiences of academically underachieving urban middle school students. *The Counseling Psychologist*, *39*(7), 1024–1069.

Jodl, K. M., Michael, A., Malanchuk, O., Eccles, J. S., & Sameroff, A. (2001). Parents' roles in shaping early adolescents' occupational aspirations. *Child Development*, *72*(4), 1247–1266.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education*, *84*(2), 180–192.

Kirn, A., Faber, C., & Benson, L. (2014, June). *Engineering students perception of the future: Implications for student performance*. Proceedings of the 2014 ASEE Annual Conference. Indianapolis, IN.

Kline, R. (2010). *Principles and practice of structural equation modeling* (3rd ed.). New York, NY: Guilford Press

Koul, R., Lerdpornkulrat, T., & Chantara, S. (2011). Relationship between career aspirations and measures of motivation toward biology and physics, and the influence of gender. *Journal of Science Education and Technology*, *20*(6), 761–770.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, *33*(1), 27–50.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in US schools. *Educational Researcher*, *35*(7), 3–12.

Lindahl, B. (2007). *A longitudinal study of students' attitudes towards science and choice of career*. Paper presented at the 80th NARST International Conference, New Orleans, LA.

Little, T. D. (2013). *Longitudinal structural equation modeling: Methodology in social sciences*. New York, NY: Guilford Press

Little, T. D., Rhemtulla, M., Gibson, K., & Schoemann, A. M. (2013). Why the items versus parcels controversy needn't be one. *Psychological Methods*, *18*(3), 285–300.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning. *American Psychologist*, *50*(9), 741–749.

Millsap, R. E. (2011). *Statistical approaches to measurement invariance*. New York, NY: Routledge.

Mouza, C., Marzocchi, A., Pan, Y. C., & Pollock, L. (2016). Development, implementation, and outcomes of an equitable computer science after-school program: Findings from middle-school students. *Journal of Research on Technology in Education*, *48*(2), 84–104.

Muthén, L. K., & Muthén, B. O. (2016). Mplus [computer software]. Los Angeles, CA: Muthén & Muthén.

Nasir, N. S., & Cooks, J. (2009). Becoming a hurdler: How learning settings afford identities. *Anthropology & Education Quarterly*, *40*, 41–61.

National Research Council (2015). *Identifying and supporting productive STEM programs in out-of-school settings*. National Academies Press.

National Science Board. (2016). *Science and engineering indicators 2016*. Arlington, VA: Author.

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education*, *37*(7), 1067–1088.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079.

Oyserman, D., Brickman, D., & Rhodes, M. (2007). School success, possible selves, and parent school involvement. *Family Relations*, *56*(December), 479–489.

Phinney, J. S. (1992). The multigroup ethnic identity measure: A new scale for use with diverse group. *Journal of Adolescent Research*, *7*, 156–176.

Polman, J. L., & Miller, D. (2010). Changing stories. *American Educational Research Journal*, *47*(4), 879–918.

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education*, *50*(1), 85–129.

Rahm, J. (2008). Urban youths' hybrid positioning in science practices at the margin: A look inside a school–museum–scientist partnership project and an after-school science program. *Cultural Studies of Science Education*, *3*(1), 97–121.

Riegle-Crumb, C., King, B., Grodsky, E., & Muller, C. (2012). The more things change, the more they stay the same? Prior achievement fails to explain gender inequality in entry into STEM college majors over time. *American Educational Research Journal*, *49*(6), 1048–1073.

Seymour, E., & Hewitt, N. (1997). *Talking about learning*. Boulder, CO: Westview Press.

Simons, J., Vansteenkiste, M., Lens, W., & Lacante, M. (2004). Placing motivation and future time perspective theory in a temporal perspective. *Educational Psychology Review*, *16*(2), 121–139.

Simpkins, S. D., Fredricks, J., & Eccles, J. S. (2015). The role of parents in the ontogeny of achievement-related motivation and behavioral choices. *Monographs of the Society for Research in Child Development*, *80*(2), 1–151.

Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls. *Journal of Research in Science Teaching*, *52*(10), 1386–1407.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *The Journal of Educational Research*, *95*(6), 323–332.

Swarat, S., Ortony, A., & Revelle, W. (2012). Activity matters: Understanding student interest in school science. *Journal of Research in Science Teaching*, *49*, 515–537.

Tai, R. H., Qi Liu, C., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science*, *312*, 1143–1145.

Tan, E., & Calabrese Barton, A. (2010). Transforming science learning and student participation in sixth grade science: A case study of a low-income, urban, racial minority classroom. *Equity & Excellence in Education*, *43*(1), 38–55.

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, *50*(10), 1143–1179.

The Royal Society (2006). *Taking a leading role*. London: Author.

Zarrett, N., & Eccles, J. (2009). The role of family and community in extracurricular activity participation: A developmental approach to promoting youth participation in positive activities during the high school years. In L. Shumow (Ed.), *Promising practices for family and community involvement during high school* (pp. 27–51). Charlotte, NC: Information Age Publishing Inc.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Kang H, Calabrese Barton A, Tan E, Simpkins S. D., Rhee H-y, Turner C. How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education*. 2018;1–22. https://doi.org/10.1002/sce.21492