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Abstract

Why are some youth more likely to think of themselves as a science kind of person than others? In this paper, we use a cognitive social-theoretical framework to assess disparities in science identity among middle school–age youth in the United States. We investigate how discovery orientation is associated with science interest, perceived ability, importance, and reflected appraisal, and how they are related to whether youth see themselves, and perceive that others see them, as a science kind of person. We surveyed 441 students in an ethnically diverse, low-income middle school. Gender and race/ethnicity are associated with science identity but not with discovery orientation. Structural equation model results show that the positive association between discovery orientation and science identity is mediated by science interest, importance, and reflected appraisal. These findings advance understanding of how science attitudes and recognition may contribute to the underrepresentation of girls and/or minorities in science.

Keywords

science; inequality; identity; youth; gender; ethnicity

Introduction

Decline in youth interest in science from elementary to high school has been a concern to many U.S. educators and policy makers for decades (Simpson and Oliver 1990; Sorge 2007). Economists, policy makers, private industry, and even the U.S. White House have placed great emphasis on developing a workforce with a strong background and mastery in science. The general goal of a larger U.S. science workforce is to increase innovation and to solve global economic and health challenges (Bianchini 2011; White House 2010). Gender, racial/ethnic, and social class disparities exist in many science degrees and fields in the United States; girls, youth who are black, Latino, rural, and who come from lower socioeconomic

status (SES) backgrounds are less likely to pursue science classes, degrees, and careers (Alegria and Branch 2015; National Science Board 2016; Penner 2015). These disparities represent both an opportunity cost and an underinvestment in human capital (Morgan et al. 2013). These inequalities also perpetuate historic social and economic disparities for women and people of color in the United States because science careers, on average, have higher pay and better working conditions (Langdon et al. 2011). Therefore, broadening participation in science is important to both increase innovation and reduce social inequality (Beede et al. 2011; Holdren 2011). To this end, it is critical that we better understand how youth engage and disengage with science throughout educational and career trajectories starting at a young age, when science career aspirations are forming (Lee, Miller, and Januszyk 2014; National Science and Technology Council 2013).

Prior studies suggest several reasons for differential persistence in science classes and careers among gender and race/ethnicity subgroups (Hill, Corbett, and St. Rose 2010; Ilumoka 2012; Xie, Fang, and Shauman 2015). Explanations include structural and institutional barriers in schools and the workplace, hostile gender and race/ethnicity educational and work environments, discrimination, institutionalized or interpersonal implicit biases that accumulate throughout the life course, and social-psychological and cognitive schemas that constrain individuals' choices.

One simplistic and pervasive explanation of race/ethnic and gender gaps in science persistence is the idea that members of historically underrepresented groups are simply not as interested in science and/or lack science proclivities (Barres 2006; Rosenbloom et al. 2008). Emphasizing the "supply side" of the science workforce does not require change in business as usual. In contrast, implicit framing of science as white and male is a demand-side explanation for race/ethnicity and gender gaps in science persistence (Ridgeway 2009; Ridgeway and Kricheli-Katz 2013). If youth perceive their social identities as inconsistent with the social framing of science, then they are more likely to self-select away from science, thus, reproducing historical inequalities and reinforcing stereotypes (Leonard 2008).

Youth develop interests and attitudes about science within larger social contexts that are stratified by race/ethnicity and gender (Ridgeway and Kricheli-Katz 2013). Youth are aware from young ages that their status characteristics (race/ethnicity/gender) fit better with some jobs than others; therefore, they are more likely to select extracurricular activities and classes consistent with jobs that align with their self-image (Correll 2004; Riegle-Crumb, Farkas, and Muller 2006). Over time, choices based upon these assumptions about what is and what is not possible lead some youth toward and some away from science. Even youth with high science interest and high science achievement may choose to not pursue science careers (DeWitt, Archer, and Osborne 2014).

Although interest in science is generally high in young children, there is some evidence that gaps in science interest may diverge during the middle school years (Barmby, Kind, and Jones 2008; Blue and Gann 2008). Thus, in countries where inequalities in science participation remain pervasive, many researchers have begun to focus on early science experiences in classrooms, in informal settings, and at home, to better understand how science identities are formed (Archer et al. 2010; Barton et al. 2013; Brickhouse, Lowery,

and Schultz 2000; Carlone, Scott, and Lowder 2014; DeWitt, Archer, and Osborne 2013; Tan et al. 2013; Wong 2016). Science identities are shaped by social processes that include science interest, perceived science ability/performance/competence, science recognition, and science reflected appraisal (Blanchard Kyte and Riegle-Crumb 2017; Brickhouse et al. 2000; Carlone and Johnson 2007; Cribbs et al. 2015; Hazari, Sadler, and Sonnert 2013). In addition, youth who see science as important to their lives, their future career prospects, and to society as a whole have higher science identities than youth who do not (Archer et al. 2015; Bennett and Hogarth 2009). Consistent with prior research, we measure science identity by asking youth if they see themselves and if they perceive that others see them as a "science kind of person" (Carlone et al. 2008; Cribbs et al. 2015; Gee 2000; Hazari et al. 2010).

In addition to our contribution to research exploring the role of identities in persistence in science in a U.S. middle school, we contribute a new theoretical construct, discovery orientation. Our goal is to capture science interests and proclivities in a way that does not activate implicit associations of science with gender and race/ethnicity categories (Cai et al. 2016; Nosek et al. 2009). The discovery orientation survey items capture interests and activities that reflect science propensity without mentioning "science." We ask youth how much they enjoy learning new discoveries, their curiosity about the world, and how much they like exploring nature. Separating discovery orientation from science identity provides a way to assess if differences in science identities reflect actual differences in discovery orientation or differences in implicit associations of science with gender and race/ethnicity (Bigler and Wright 2014; Cohen et al. 2006; Master, Cheryan, and Meltzoff 2016). We use the phrases "discovery orientation" and "science propensity" interchangeably in this paper.

In this study, we focus on science identity in a sample of 441 middle school–age youth looking closely at the intersection of race/ethnicity and gender in a predominantly low-income school in the United States. Using social-cognitive theories about how social schemas and status characteristics support or inhibit science identities (Correll 2004; Ridgeway and Kricheli-Katz 2013), we investigate how the intersection of race/ethnicity and gender are associated with discovery orientation, science interest, importance, perceived science ability, and science reflected appraisal (Bennett and Hogarth 2009; Carlone and Johnson 2007; Hazari et al. 2013). We then look at how these attitudes and beliefs about science influence youth science identity, namely, their science self-identification as a "science kind of person," as well as their perception of whether others see them as a "science kind of person." We use structural equation models (SEMs) to assess how discovery orientation might be mediated by explicit science attitudes and perceptions to impact science identity.

Theoretical Framework

Our work is guided by social and cognitive theories of identities. Identity development in early childhood occurs through social interactions and through play, leading to an understanding of "self" as separate from "other" (Mead 1934; Stryker 2008). The process of identity development eventually involves awareness of multiple others, captured by the concept "generalized other" (Mead 1934). The generalized other is an abstract

understanding of the self in relation to others in a society; through the generalized other, individuals imagine how society in general might view themselves and their actions (Holdsworth and Morgan 2007). Thus, identities are formed through interactions with others, and within the context of society as a whole.

From a social-psychological perspective (Howard 2000), the process of identity development also includes the formation of social schemas that are cognitive shortcuts used to categorize people, objects, and situations into similar or dissimilar groups (Master, Markman, and Dweck 2012; Oakes, Turner, and Haslam 1991; Turner et al. 1987). The groups that emerge as relevant are primarily framed by larger social structures, at the micro-, meso-, and macro level, to reinforce prevailing power structures and social inequalities along social strata such as race, class, and gender (Ridgeway 2009; Ridgeway and Kricheli-Katz 2013). Self-schemas are how individuals organize and categorize their behaviors, preferences, and goals into or out of social schemas (Oyserman et al. 2003; Tajfel and Turner 2004). Characteristics that people often use to group themselves and others include skin color, language, gender, and age. The specific subgroup characteristics used to group vary across cultures and historical time periods. Thus, identities, including science identities, are developmental, interactional, and embedded in macro- and micro-level social structures (Hogg and Ridgeway 2003; Nosek et al. 2009)

Self-identifying as a science kind of person is a social process that occurs through interaction with others (Lewis 2003). As Heidi B. Carlone and Angela Johnson (2007:1190) explain, "One cannot pull off being a particular kind of person (enacting a particular identity) unless one makes visible to (performs for) others one's competence in relevant practices, and, in response, others recognize one's performance as credible." Self-identifying as a science kind of person is likely to depend on how much others acknowledge and recognize science aptitude or interest and how much adolescents reflect those appraisals back onto themselves (Bouchey and Harter 2005). Because recognition is filtered through others and understood by individuals, gender and race/ ethnicity schemas about science can influence both the self and other; how one might perform science and how others recognize science performances (DeWitt et al. 2014).

The influence of gender and race/ethnicity schemas on science identities occurs through several mechanisms: reduced performance through stereotype threat; biased assessments by teachers, parents, or significant others; and biased self-assessments. Stereotype threat occurs when cultural stereotypes about the abilities of a group negatively influence the performance of members of a group (Steele and Aronson 1995). Stereotype threat lowers science identities by lowering science performances and thus creating a self-fulfilling prophecy or lack of fit with a science identity (Régner et al. 2015; Shapiro and Williams 2012; G. M. Walton and Spencer 2009). Even if stereotype threat is not activated, implicit biases can reduce science identities among girls and racial/ethnic minorities because of the mismatch between own and perceived scientist social characteristics. In addition, implicit biases can shape how parents and teachers perceive and rate the performances of girls, boys, and racial/ ethnic minority/majority group members. There is evidence that some teachers lower their expectations for science performance for girls and racial/ ethnic minorities because of implicit biases (Dee 2005; Gershenson, Holt, and Papageorge 2016). Similarly, there is

evidence that parents have lower expectations of their daughters than their sons (Lindberg, Hyde, and Hirsch 2008). Theories of identity development suggest that performances and subsequent evaluations by significant social others will lead to biased self-assessments that encourage more white boys and fewer members of other gender and race/ethnicity groups to pursue science paths (Correll 2001; Goetz et al. 2013; Orenstein 2013).

Several recent studies have explored youth science identity. There is a rich literature in education on how youth develop identities more generally, and how those identities shape achievement and educational attainment (Barber et al. 2005; Case and Light 2011; Christian and Bloome 2004; Cobb, Gresalfi, and Hodge 2009; Flum and Kaplan 2012). Studies within the field of social psychology have used Identity Theory (Burke and Stets 2009; Stets and Burke 2014) to study science identities, focusing on youth in high school (Lee 1998, 2002, 2005) or college (Brenner, Serpe, and Stryker 2014; Merolla et al. 2012). A team of researchers in the United Kingdom (Archer et al. 2013) build on prior work in a large, longitudinal, mixed-methods study, ASPIRES. They focus on gender as performance (Butler 1993) and cultural capital (Archer et al. 2015; Bourdieu and Passeron 1990) frameworks to explore science identity and career aspirations during early adolescence (age 10–14; Archer et al. 2013; DeWitt et al. 2014).

James Paul Gee's (2000) framework of identity within education research has been widely influential in assessing science identity through qualitative studies on college students (Carlone and Johnson 2007) and for elementary and middle school–age youth (Archer et al. 2010; Barton et al. 2013; Brickhouse and Potter 2001; Tan et al. 2013). Gee's framework has also contributed to quantitative research on science identity, math identity, and physics identity in college samples that focus on understanding how science interest, competence, and recognition are associated with science self-identification and science other-identification (Cribbs et al. 2015; Hazari et al. 2013; Hazari et al. 2010). We combine insights from prior empirical research and theories of science identity rooted in a social-cognitive framework to develop a model of adolescent science identity and inequality (Bachrach and Morgan 2013).

Literature Review

Research on Gender Race/Ethnicity Bias in Science

Girls have made gains in academic achievement compared with boys, but there have not been similar increases in desire for science careers, creating what Tan and colleagues call a "*science identity gap*" (Tan and Barton 2008; Tan et al. 2013). Angela Calabrese Barton et al. (2013) describe the "identity work" of adolescence as dynamic as well as cumulative. Youth who "do science" have more of a chance to think of themselves as science kinds of people (Archer et al. 2010). In addition, youth with more exposure to scientists who look like them can more easily imagine themselves as science kinds of people (Degenhart et al. 2007; DeWitt et al. 2014). Prior research finds that science and math competence may be necessary, but are not sufficient, for youth to claim science or math identities (Cribbs et al. 2015; Pajares and Urdan 2006). Similarly, simply enjoying doing science in or outside of school may not be sufficient to develop a higher science identity (Archer et al. 2010, 2012; Diamond et al. 1987). Considering science as important and relevant to their lives and

aspirations is also associated with higher science identities, but might not result in high science identities if youth do not feel competent in their ability to do science (Bennett and Hogarth 2009; Carlone et al. 2014; Siegel and Ranney 2003). Therefore, it likely takes a combination of social and psychological factors to turn science interest, perceived competence, and importance into a science identity.

In recent years, there have been declines in gender gaps in math and science achievement (Organisation for Economic Co-operation and Development [OECD] 2015; Provasnik et al. 2012). There have not been commensurate declines in science identity gaps, suggesting that science identities reflect more than ability or performance. Science identity development also reflects interest, recognition, and the belief that science is important and relevant to the lives of students (Afterschool Alliance 2013). A small gap in science interest between boys and girls grows into large inequalities in science career aspirations for women through adolescence and early adulthood (Beede et al. 2011; Hill et al. 2010; National Science Board 2014). In some fields (e.g., engineering and computer science), the proportion of women has actually declined in recent years (Gürer and Camp 2002; Misa 2011; J. P. Walton 2012). In other science disciplines, women in the United States have achieved parity at the undergraduate level and among new faculty (e.g., biology), but there are few women full professors or senior scientists (National Science Board 2014; Valian 1999).

In addition, racial/ethnic minorities, particularly African American and Latino youth, are underrepresented in science careers (Baysu, Phalet, and Brown 2011; Brown 2004). Economic and social-structural factors still contribute to lower science achievement scores among racial/ ethnic minority compared with white youth (Altschul, Oyserman, and Bybee 2008; Green 2014; Provasnik et al. 2012). No science fields have proportional representation by race/ethnicity (National Science Board 2016). Gender and racial/ethnic identities are constantly being negotiated during adolescence and in school settings in particular (Altschul, Oyserman, and Bybee 2006; French et al. 2006; Rogers, Scott, and Way 2014). Alignment of student, racial/ethnic, and gender identity depends on school context; marginalized identities make membership in school science communities undesirable or even impossible (Altschul et al. 2008; Brown 2004; Riegle-Crumb, Moore, and Ramos-Wada 2011; Simpson and Oliver 1990). For African Americans, in particular, identifying with science or scientists may be difficult due to historical racism in science (Green 2014). Scientific studies that try to link intelligence to race contribute to stereotype threat that limits academic achievement for African Americans (Cohen et al. 2006). The research on gender and race/ethnicity science identity gaps suggests that minority girls have to navigate the highest barriers to achieving and maintaining a science identity (Carlone et al. 2014; Polman and Miller 2010; Tan and Barton 2008).

Who Can Become a Scientist?

Youth are aware of social stereotypes about who can become a scientist from a young age, and vary to the degree in which they explicitly endorse or defy them (DeWitt, Archer, and Osborne 2013; Hill et al. 2017; Wong 2016). The classic "Draw-a-scientist" studies were the first to illuminate these biases in the United States and abroad (Chambers 1983; Miller, Eagly, and Linn 2015). Implicit biases that favor boys in science are ubiquitous, however,

and are apparent in adults and youth (Cvencek, Meltzoff, and Greenwald 2011; Greenwald, McGhee, and Schwartz 1998; Nosek, Banaji, and Greenwald 2002). These biases lead others to underestimate the science abilities of some youth based on status characteristics (race, gender, and class) and also lead to biased self-assessments in science by the marginalized youth themselves (Correll 2001; Glick and Fiske 1999). Social interactions and social settings (e.g., classrooms) often reaffirm stereotypes and create conditions in which science recogntion, and therefore reflected appraisal, is unequally distributed, reinforcing biased self-assessments and perpetuating inequality.

Implicit biases among parents, teachers, and peers have subtle and cumulative effects on ideas about who can be a scientist (Banchefsky et al. 2016; Grunspan et al. 2016; Hazari et al. 2013; Master et al. 2016; G. M. Walton and Spencer 2009). Although these micro interactions might go unnoticed or seem minor or inconsequential to individuals who experience them, evidence suggests they have cumulative and long-lasting consequences for the science career aspirations of girls, minorities, and other youth from disadvantaged populations (Correll 2004).

Efforts and interventions to help youth persist in science paths implicitly assume that all youth have a propensity toward science and to engage in science learning (Quinn et al. 2012). The Next Generation Science Standards (NGSS) explicitly state, "All Standards, All Students," and focus on engaging historically underrepresented minorities in science through science practices, cross-cutting concepts, and core ideas (Lee et al. 2014). The idea that everyone has the potential to practice science, or to be a scientist, is counter to the popular stereotype that only some (usually men) are born with "genius" abilities to excel in particular fields (e.g., math and physics) (Leslie et al. 2015).

Brett Moulding, Rodger Bybee, and Nicole Paulson (2015) argue that cultivating curiosity is an essential foundation for helping all youth succeed with NGSS. The core idea is that youth are born with curiosity; their brains are built to learn. Curiosity is not something science teachers must work to create, instead, it is their task to tap into what already exists. We conceptualize this as discovery orientation, and we define it as separate from other more explicit science attitudes and beliefs, and we measure it differently than other researchers studying the relationship between curiosity and science (Weible and Zimmerman 2016). Discovery orientation is a measure of affect or feeling—the spark of curiosity, enjoyment, and interest that is key to all types of learning but is particularly crucial for science (Farrington et al. 2012; Trujillo and Tanner 2014; Watt et al. 2012). We created this measure in a way that would not trigger cognitive schemas or implicit attitudes that may inhibit self-selection into science pathways for some youth in order to assess if discovery orientation is distributed similarly among all social categories (Green 2014; Hill 2017; Hughes 2001; Ridgeway and Kricheli-Katz 2013). With the discovery orientation concept, we evaluate the idea that, in the absence of implicit gender and race/ethnicity associations, anyone with high discovery orientation could be a science kind of person.

Why Middle School?

Although implicit biases and gaps in science identity emerge in elementary school (Andre et al. 1999; Archer et al. 2010; Cvencek et al. 2011; Régner et al. 2015; Sorge 2007; Wong

2016), there is evidence that middle school is the time when gaps in science interest may widen in the United States, particularly between boys and girls (Blue and Gann 2008; Sorge 2007). Early adolescence is a time of significant physical, emotional, and social growth where developmental and cognitive changes lead to heightened awareness of social processes and social hierarchies, where students' categorization of themselves and others becomes more complex (Barber et al. 2005; Bigler and Liben 1993; Eccles et al. 1997; Eder and others 1995; Kinney 1993; Levy and Dweck 1999; Master et al. 2012).

Suburban and urban middle schools often differ from elementary schools in the United States in ways that can influence science identity development. Middle schools tend to be larger and more diverse than elementary schools because elementary schools usually consist of neighbors in close proximity who have similar socioeconomic and racial/ethnic statuses (Mickelson 2015). Middle schools usually receive students from four to five elementary schools that differ from each other on several social and geographical dimensions (Eccles et al. 1997; Serbin, Stack, and Kingdon 2013). Elementary schools usually focus more on reading, writing, and math than science. While elementary students usually have only one to two teachers in a year and a core group of classmates in most of their classes, middle school science is a clearly defined subject with designated subject teachers and classrooms. While most elementary school teachers are women, there are more male teachers as students move through K–12, and math and science teachers are more likely to be male (Banilower et al. 2013). Fewer than 10 percent of science teachers are racial/ethnic minorities in the United States (Banilower et al. 2013).

Middle school is also a time when parents become less influential and friends become more important for social support, well-being, belonging, and self-esteem (Barber, Eccles, and Stone 2001; Kinney 1993). Friendship groups have more influence over norms of behavior and standards for what qualities are desirable in middle school compared with elementary school, including topics such as clothes, music, appearance, sports, extracurricular activities, and achievement (Barber et al. 2005; Bishop et al. 2003).

Lastly, we focus on middle school age youth because this is a time when career aspirations begin to take shape and are predictive of future academic attainment and careers, particularly for students who are interested in science (DeWitt, Osborne, et al. 2013; Tai et al. 2006). Career aspirations are closely linked with identity, and vary by race, gender, and social class (DeWitt, Osborne, et al. 2013).

Research Expectations

In this paper, we investigate a social-cognitive approach to science identity that explores paths from discovery orientation to science identity through science interest, importance, perceived ability, and reflected appraisal at the intersection of race/ethnicity and gender. We determine whether our measure of discovery orientation is distinct from other theoretical and empirical measures of explicit science attitudes. We expect that because discovery orientation does not use the term "science," it should not trigger schemas that bind social status characteristics with science identity. Therefore, we expect no differences in the level

of discovery orientation by the four gender race/ethnicity groups (white boy, minority boy, white girl, and minority girl).

We also assess attitudes toward science (science interest, perceived science ability, science importance, and science reflected appraisal) across these four gender race/ethnicity groups. Prior research indicates that we should expect differences in science attitudes and experiences by race/ ethnicity and gender at the middle school level in some areas (e.g., reflected appraisal) but not others (e.g., interest) (Archer et al. 2013). In addition, we ask youth to assess the extent to which others see them as a science kind of person, and whether they see themselves as a science kind of person (i.e., science identity, self-ID and other-ID). We expect that white boys will be more likely to self-label as a science kind of person and to perceive others as seeing them as a science kind of person, and minority girls will be less likely to do so (Tan et al. 2013).

In addition, we explore if discovery orientation is simply directly associated with science identity or if it is mediated by interest, importance, perceived ability, and/or reflected appraisal. It is important to identify mechanisms that inhibit or facilitate science identities, particularly those that parents, teachers, and programs can influence. Finally, if there are race/ethnicity and gender differences in interest, importance, perceived ability, and/or reflected appraisal, then there is evidence for where to put efforts to attract more youth to science (e.g., making science more interesting to a broader range of youth, demonstrating more ways that science is important, creating more ways to develop competence, or being more intentional about recognizing success in science practices for all youth).

Method

All sixth-, seventh-, and eighth-grade students enrolled in science classes at a middle school in a midsized Midwestern city were asked to participate in our survey during winter 2013–2014. Overall, 78 percent of youth in this school participate in the free/reduced lunch program, indicating that this is a high-poverty school. Of the 663 students at the school, 92.7 percent (615) were enrolled in a science class. Those who were not were either suspended or were placed in the lower proficiency English Language Learner class instead of science class. Students had to return informed consent forms with a parental consent marked and signed to participate in the survey. Seventy-two percent (444) returned permission forms and participated in the online survey during science class. Three youth did not provide information on race/ethnicity and, therefore, could not be included in the final analytic sample, resulting in a sample size of 441.

All parents or guardians of potential participants were notified of the survey with an automated phone call and e-mail; the consent forms were attached to the e-mails and were available in four languages (English, Spanish, Vietnamese, and Arabic). Consent forms were also distributed by teachers in science class directly to students to take home. For students who returned consent forms, the self-report survey was administered during a science class period online, via computer, with a series of questions about their attitudes and beliefs about science. Students not present on survey administration days were asked to complete the survey at a later time after school. There were at least two data-collection staff in each room

to assist the students if necessary. On average, students were able to complete the survey in 25 minutes. In addition to the focal questions described in this study, there was an additional social network component of the survey instrument that asked youth about their friends and shared interest in science (Gauthier et al., 2017). The network data are not included in this analysis.

Measures

Social Location Indicated by Race/Ethnic Minority Status and Gender

In the survey, students were asked, "What is your race/ethnicity? You can mark more than one answer." Response categories were "black/African American," "Latino/Hispanic," "white," "Asian," "Native American," "Pacific Islander," "Mixed," and "other," with space to write in any other race/ethnic group. Seventy-six percent of those who responded to this question marked only a single race/ethnicity category ($n = 337$). Overall, 36 percent identified as only "white" ($n = 158$), and 64 percent ($n = 283$) identified as either a single or a combination of race/ethnic minority statuses. Sixteen percent identified as African American ($n = 71$), 20 percent as Latino ($n = 90$), 8.3 percent as Asian ($n = 37$), 4.5 percent were Native American ($n = 20$), and 14 percent identified as "other" or "mixed" ($n = 61$), with later waves of data revealing many were of Arabic or Persian descent.[1]

We chose to include students who marked any nonwhite minority status into a single "minority status" category for the purposes of this analysis. We are aware of recent empirical research that indicates some students of Asian descent may be more likely to aspire to science careers than white students (Archer, DeWitt, and Wong 2014; DeWitt et al. 2011). We chose to include students who marked that they were Asian into the minority category, however, primarily due to the low SES status of this particular school within the larger community, and our awareness of Vietnamese being the third most prevalent language in this school. This school is located within a city that has been designated as Department of Health and Human Services preferred for refugee resettlement, and most of the students of Asian descent are not likely to have high "science capital" or parents who are working in STEM (science, technology, engineering, and mathematics) on H-1B visas (Salzman, Kuehn, and Lowell 2013). Finally, gender was provided by the school register and verified by the online survey. Among the nonminority students, 49 percent were girls ($n = 81$), and 51 percent were boys ($n = 80$). For the race/ethnic minority students, 53 percent were girls ($n = 150$) and 47 percent were boys ($n = 130$).

Discovery Orientation

At the beginning of the survey, prior to any questions specifically using the word "science", students were asked three questions about their discovery orientation: (1) "How much do you like learning about new discoveries?" (2) "How curious are you about the world?" (3) "How much do you like exploring nature?" Response categories were unique to each question and had a range from 1 to 4, with 1 indicating lower discovery orientation and 4

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[1]Students could mark any racial/ethnic category that applied; categories are not mutually exclusive. The vast majority of students who identify as Asian in this school are first or second generation immigrants from Vietnam. Vietnamese is the third most frequently spoken language at this school after English and Spanish.

indicating higher discovery orientation. Cronbach's alpha for the three measures is .55; the mean was 3.24 (SD = .57). Although Cronbach's alpha of .55 is lower than we hoped, factor analysis in Statistical Package for the Social Sciences (SPSS) shows that all three items load on a single construct and explain 52.9 percent of the total variance. Using exploratory factor analysis, all loadings were above .65. Table 1 shows the results of the standardized factor loadings for discovery orientation and all other latent constructs in the final SEM.

Science Interest

Students were asked two questions related to how much they enjoy science. The questions were (1) "How much do you like science?" (2) How boring are science classes for you?" (reverse coded item 2) Cronbach's alpha for the two measures is .72; Pearson's r correlation for these two variables is .57 the mean was 3.04 (SD = .76).

Perceived Science Ability

Students were asked three questions related to how good they are at science. The questions were (1) "How good are you at science?" (2) "How well do you do in science classes?" (3) "What grades do you usually get in science classes?" Response categories were unique to each question, and had a range from 1 to 4, with 1 indicating a negative response and 4 a positive response. Cronbach's alpha for the three measures is .72; the mean was 3.12 (SD = . 64).

Science Importance

Students were asked four questions related to how relevant/important science is to their lives. The questions were (1) "How much, if any, do you think studying science will help you in the future?" (2) "How often do you use science to solve daily problems?" (3) "How much, if at all, does science help people?" (4) "How much does science help you make decisions that affect your body?" Response categories had a range from 1 to 4, where 4 = *a lot*, 3 = *some*, 2 = *a little*, and 1 = *not at all*, or they could choose *I don't know*. Only 13 percent of the sample responded "I don't know" to any one of these four items. Data exploration revealed no pattern to marking "I don't know"; thus, the "I don't know" responses were coded as missing at random. Missing data were handled using the mean of available items in bivariate descriptive analysis, and full information maximum likelihood (FIML) in the SEM models (Enders 2006). Cronbach's alpha for the four measures is .82; the mean was 2.88 (SD = .65).

Science Reflected appraisal

Students were asked two items about science reflected appraisal from their parent/guardian and teacher: (1) "How much does your parent or guardian tell you that you are good at science?" and (2) "How much does your teacher make you feel like you are good at science?" Response categories had a range from 1 to 4, where 4 = *a lot*, 3 = *some*, 2 = *a little*, and 1 = *not at all*. Cronbach's alpha for the two item measure is .71; Pearson's *r* correlation for these two variables is .58, the mean was 2.88 (SD = .89).

Science Identity - Self-ID

To measures Science Idenntity Self-ID, students were asked, "How much do you think you are a science kind of a person?" The response categories had a range from 1 to 4, where 1 = "I am not a science kind of person at all," 2 = "I am a little bit of a science kind of person," 3 = "I am somewhat of a science kind of person," and 4 = "I am totally a science kind of person." The mean was 2.43 (SD = .86).

Science Identity - Other-ID

To measure Science Identity - Other-ID, students were asked, "How much do you think other people see you as a science kind of person?" Response categories had a range from 1 to 4, where 4 = "Others think I am totally a science kind of person," and 1 = "Others don't think I'm a science kind of person at all." In addition, a substantial proportion of respondents (34.5 percent) selected "I don't know." We conducted a series of analyses to examine whether we should treat the "I don 't know responses" as missing at random, as well as sensitivity analyses for two methods of imputation,[2] based upon the results, we retained a model imputing 1.5 for those who selected "I don 't know" for the ordinal variable. The mean was 1.99 (SD = .87).

Analytic Strategy

We conducted bivariate analyses in SPSS Version 21 and in Mplus Version 6. First we investigated bivariate relationships between the race/gender groups (white boys, minority boys, white girls, and minority girls) and all other variables in the model. We used expectation maximization (EM) imputation for missing data in the bivariate analysis using analysis of variance (ANOVA) of the four race/ethnicity by gender groups. In this analysis, we assess group differences for four groups: white boys, minority boys, white girls, and minority girls, on discovery orientation, science interest, perceived science ability, science importance, science reflected appraisal, and the two science identity dependent variables. We also examined Pearson's r correlations among the continuous and ordinal variables in Mplus using FIML to handle missing data. The correlation matrix is available in the appendix.

For multivariate analysis, we chose to use structural equation modeling to assess direct and indirect paths from discovery orientation and gender/status characteristics to science self-ID and science other-ID. Because we are interested in better understanding the pathways from discovery orientation to the two science identity dependent variables, SEM was the most

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[2]Although some researchers might eliminate "I don 't know" responses as missing (similar to a skipped item) our investigation of the associations of "I don 't know" with other variables showed a systematic pattern, not a missing at random pattern (Enders 2006; Francis and Busch 1975; Little and Rubin 2002). Specifically, we compared mean values for science identity - self-ID, science interest, perceived science ability, and science importance by the response categories for science other-ID (−9 "I don 't know", 1 "not at all" to 4 "others thik I am totally a science kind of person"). The comparisons showed that the means for those who selected "I don 't know" were consistently between the means for "1" and "2" values on all other items, and that the means followed a linear progression across all other response categories. The pattern is consistent with the idea that youth who marked "I don't know" were providing a substantive response - ambivalent attitudes and perceptions of how others see them rather than committing to reporting that "Others *don't* think I am a science kind of person at all" or "Others think I am *a little* bit of a science kind of person." We also conducted a sensitivity analysis and ran the SEM model with Science Identity-Other-ID imputed two ways; using FIML imputation for the "I don't know" category, and placing those who marked "I don't know" as a 1.5. The models were very similar and both had good model fit; however, the model fit where the imputed value was 1.5 was slightly better.

appropriate method. The models were fitted in two stages: First, we fit a measurement model using maximum likelihood estimation with robust standard errors (MLR) yielding four latent variables, the first exogenous (discovery orientation) and the others endogenous mediators (science interest, science importance, perceived science ability, and science reflected appraisal). Chi-square was 1,606.322 with 91 degrees of freedom (*df; p* < .001), comparative fit index (CFI) = .99, Tucker– Lewis index (TLI) = .98, root mean square error of approximation (RMSEA) = .03, indicating good model fit (Hu and Bentler 1999). Table 1 shows the standardized factor loadings for all latent constructs from the measurement model. Most of the loadings are strong (over .50).

Next, we estimated a structural model to assess relationships between latent constructs and observed variables. For the structural model including gender by race/ethnicity indicator variables, we first estimated models using WLSMV (mean- and variance-adjusted weighted least squares) to obtain robust estimators that do not assume normally distributed variables and appropriately model categorical data for the ordinal dependent variables, which are on a 4-point Likert-type scale. We also estimated models with MLR (maximum likelihood with robust standard errors) to adjust for nonnormality and nonindependence of errors. We report this latter model because the estimates were nearly identical and the model fit indices were better (Finney and DiStefano 2006; Muthén and Muthén 1998). In addition, we used group invariance to see if the relationship between the variables in the model were different for each of the four groups. We do not report group-specific models because subgroup sample sizes are too small, and estimates were unstable.

In the final SEM, all predictor variables are mean-centered except for science identity self-ID. Thus, the constant/intercept for the focal dependent variable, science self-label, is the value on that variable for white boys (2.75), the omitted category when all other variables are the mean.

Results

We compared mean scores for all of the variables by gender and race/ethnicity. As we expected, based upon a cognitive schema understanding of perceptions of science, there were only small and nonsignificant differences in mean discovery orientation scores, and there were substantial and significant differences in science identity (Table 2). The mean scores for discovery orientation were high (all groups over 3.0 on a scale from 1 = *low* to 4 = *high*). In addition, the standard deviations were smallest for discovery orientation (from .54 to .62) compared with the other measures, thus indicating that youth cluster around higher discovery orientation scores. The opposite is true for science identity. Scores are lower (from 2.25 for minority girls to 2.80 for white boys), and the standard deviations are larger (between .76 and .89).

There are statistically significant differences in science interest between groups. Science interest is higher among white boys than for minority girls. Generally, science interest means are higher (from 2.95 to 3.29) than for science self-ID, but slightly lower than for discovery orientation; they are all above the middle of the scale (2.5). Overall, science importance, perceived science ability, and science reflected appraisal means are also fairly high (ranging

from 2.71 to 3.36), particularly compared with science other-ID (ranging from 1.83 to 2.33) and science self-ID (ranging from 2.25 to 2.80).

Science importance is higher among white and minority boys than for white and minority girls. Perceived science ability is higher among white than minority students. White boys and girls have higher scores than minority boys and girls on the questions about parents and teachers, giving them positive messages about their science performance (reflected appraisal). These gender and race/ethnicity mean patterns give a fairly complex picture of the possible explanations for race/ethnicity gender intersection differences in science identity constructs. It is interesting that the differences by gender and race/ethnicity on science-related measures were not consistent; some measures differed mostly by gender (e.g., science importance), some differed mostly by race/ethnicity (e.g., perceived science ability), and some by both gender and race/ethnicity. For science self-ID and science other-ID, for example, we see specific group differences at the intersection of gender and race/ethnicity. White boys have significantly higher science other-ID than all other groups, while only white boys and minority girls differ significantly on science self-ID. Bivariate associations among discovery orientation, science attitudes, perceptions, and science identity are available in the appendix. All had moderate to strong and positive associations that were significant.

Based upon prior research and theories, we assessed these possible mediating variables (science interest, importance, perceived ability) that could explain why youth with no differences in levels of discovery orientation could have differences in levels of science identity, and why there are no differences by gender and race/ethnicity in discovery orientation but there are gender and race/ethnicity gaps in both science identity dependent variables. The patterns of mean differences at the intersection of race/ethnicity and gender described above suggest that the mediating variables could contribute to the patterns that we identify. To assess the two dependent variables that make up science identity (self-ID and other-ID), we used an SEM to simultaneously estimate associations among all of the variables, including direct, indirect, and total effects.

The unstandardized direct effects in Table 3 are also illustrated in Figure 1. Because all of the variables in the model have a range from 1 to 4, we show unstandardized estimates, thus providing values in the original metrics. In the full model, the intercept for science identity is the mean science identity score for white boys when all other variables have a score of 0 (because the measures are mean-centered). The unstandardized covariances among the latent endogenous (mediating) variables are provided in Table 4 but omitted from Figure 1 to simplify the presentation.

The model has a significant chi-square, $\chi^2 = 2{,}197$, $df = 68$ ($p < .001$), which is common with moderately large samples. The model fit measures that are less sensitive to sample size indicated good model fit: CFI = .98, TLI = .96, RMSEA = .03. We ran the model in Table 3 and Figure 1 four times, each time making a different group the reference group to compare across all four groups. We show the model with white boys as the reference group because this is the cultural default category for "scientist" in the United States (Hughes 2001; Miller et al. 2015). Comparisons between the omitted category and other indicators represent

differences in intercepts, not differences in slopes. In the adjusted model, there are several mean differences at the intersection of race/ethnicity and gender.

After adjusting for the other measures in the model, minority boys: –.21 (0.10), $p < .05$; and minority girls: –.23 (0.09), $p < .05$, have significantly lower science identity self-ID than white boys. This difference is about one third of a standard deviation unit difference. It is interesting that when we adjust for the other variables in the model, the estimated mean science identity for white boys is lower than the unadjusted mean in the bivariate results (from unadjusted 2.80 to adjusted 2.75) and higher for minority girls (from unadjusted 2.25 to adjusted 2.52) and minority boys (from unadjusted 2.43 to adjusted 2.54). In addition, in the full model, there are no longer any significant differences for white girls and white boys on science self-ID. Gaps for science other-ID were similarly attenuated in the adjusted model, but significant differences remained between all groups. Compared with white boys, minority boys: –.25 (0.13), $p < .05$; and girls: –.28 (0.11), $p < .05$, were significantly less likely to say "others see them as a science kind of person," and the difference was the widest between white boys and white girls: –.41 (0.13), $p < .01$. The reduction and elimination of science identity gaps from the unadjusted to adjusted model suggest that some of the gaps in science identity can be explained by the differences on other measures included in the model (e.g., science importance, perceived science ability, science reflected appraisal), but gendered and race/ethnic inequalities remain.

In the full model, minority boys: –.29 (0.09), $p < .10$; and minority girls: –.28 (0.09), $p < .10$, have significantly lower science interest than white boys; this difference was only significant for minority girls in the bivariate analyses, thus indicating a suppression effect for minority youth (Table 2). Other differences persisted but were attenuated in the full model; all of the effect sizes are about a third of a standard deviation: Compared with white boys, minority boys and minority girls had lower perceived science ability, both –.29 (0.09), $p < .01$, and minority girls had lower science reflected appraisal from parents and teachers, –.25 (–0.13), $p < .05$. There were no differences between gender and race/ethnic group on science importance in the adjusted model..

The biggest differences are for minority girls, who have lower science identity, perceived science ability, science reflected appraisal, and science other-ID than white boys. Therefore, the gender and race/ethnicity gaps in science identities are not fully explained by science interest, enjoyment, perceived ability, and reflected appraisal.

We next examine the total, direct, and indirect effects summarized in Tables 3, 4, and 5. All of the mediating variables have positive and significant covariances (Table 4). As expected, the two science identity dependent variables, self-ID and other-ID, covary: .10 (0.03), $p < .001$. The standardized effect size has reduced considerably from the unadjusted ($r = .46$, $p < .001$) to the adjusted model (Beta = .23, $p < .001$).[3] Higher discovery orientation is associated with higher science interest: .80 (0.10), $p < .001$, importance: .48 (0.09), $p < .001$, perceived ability: $B = .38$ (0.08), $p < .001$, and reflected appraisal: .48 (0.08), $p < .001$, but is

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[3]Pearson's r correlations are available in the appendix, but only standardized coefficients are shown in figures and tables; the standardized coefficient is shared here for comparison.

only associated with science self-ID indirectly through science interest and science importance. Similarly, there is no direct association between discovery orientation and science other-ID; instead, it is fully mediated through science reflected appraisal (Table 5). In the adjusted model, only science interest: .42 (0.14), $p < .05$, and importance: .70 (0.13), $p < .05$, are associated with science self-ID, and science reflected appraisal is associated only with science other-ID: .29 (0.09), $p < .01$. Perceived science ability is not directly associated with either science identity measure, yet perceived science ability covaries with the other mediating variables.

Discussion

Our study makes several important contributions to the current scientific literature on science identity. First, we introduce the concept "discovery orientation" to separate science propensity from measures that activate schemas associated with the word "science." Our results provide evidence to support the proposal that "science" activates race/ethnicity and gender schemas (Hughes 2001). As expected, most youth have high levels of discovery orientation, higher than any other construct, with the least amount of variability (smallest standard deviations), and levels are similar by race/ethnicity and gender. This pattern suggests that the discovery orientation construct effectively assesses propensity toward science and avoids the implicit biases associated with the word *science*. Contrary to the idea that some groups of people have more proclivity toward math and science fields (Barres 2006), our findings demonstrate that science propensity is similar among race/ethnicity and gender subgroups. The NGSS are based on the premise that teachers do not need to develop curiosity, but, instead, need to leverage the sense of discovery that all children have, to fully engage all students in science practice (Moulding et al. 2015). Our findings support these principles.

Although there was a strong bivariate correlation between discovery orientation and science identity, this association was fully mediated by science interest, science importance, and science reflected appraisal in the SEM. Therefore, efforts to illuminate the pleasures of discovery and fun aspects of science appear likely to foster higher science identities. Finding that minority boys and girls have lower science interest than white boys in the adjusted model suggests that it is especially important to pay attention to the diversity of ways that youth can enjoy science. Efforts to observe what is enjoyable for a broader array of youth, and bringing enjoyable elements into engagement with science, should help foster higher ID with science among minority boys. Efforts to increase science identity by only focusing on perceived science ability (as indicated by questions about being good at science, getting good grades in science, and doing well in science classes) will miss other important avenues to engaging middle school youth with science. We find that youth who find science enjoyable, relevant, and who perceive others as seeing them as a science kind of person, adjusted for all of the other measures, have higher science identity.

Second, we extend survey research on science identity from college- and high school-based samples (Cribbs et al. 2015; Hazari et al. 2013) to early adolescents in a U.S. middle school, to enhance the rich qualitative empirical research in this field (Barton et al. 2013; Brickhouse et al. 2000; Brickhouse and Potter 2001; Carlone et al. 2014; Tan and Barton

2008). Our research supports findings from other quantitative research on 10- to 14-year-olds in the United Kingdom that overall interest in science is high among youth at this age across gender and race/ethnic groups (DeWitt et al. 2014). Similar to findings in other studies of science identity, we find that science ability does not lead directly to science self-ID or science other-ID (Hazari et al. 2013), although perceived science ability is an important construct for science identity through strong associations with other science attitudes (science interest, science reflected appraisal, and science importance). Our results indicate that efforts aimed at improving youth academic science achievement or proficiency will not lead directly to higher science identities for youth, including girls or students of color. Instead, programs that put science into practice in ways that are enjoyable and relevant to youth from diverse backgrounds will likely increase science literacy and participation in the science workforce overall (Zimmerman 2012). Indeed, there is a real risk that focusing too much on science achievement at young ages, and too little on science practice and inquiry, may actually distance even high-achieving youth from science identities and, consequently, later careers in science.

In our study, we found evidence to support that recognition from parents and teachers, as measured through reflected appraisals, has a positive association with science other-ID. This is a finding widely reported in studies of college and high school–age youth (Hazari et al. 2013; Hazari et al. 2010). In fact, in other studies of middle school–age youth, perceived parental recognition has a stronger association with science career aspirations for secondary school students than even gender and race, and we know career aspirations are strongly related to student identity (DeWitt et al. 2014). Our findings suggest that teachers can help recognize science propensity in youth and facilitate (Harrell-Levy and Kerpelman 2010) or inhibit youth persistence in science (Lavy and Sand 2015).

The lower adjusted science interest scores for minority boys and girls compared with white boys and the lower perceptions of others' seeing them as a science kind of person scores for minority boys and girls and white girls compared with white boys indicate areas for future interventions. Future research should focus on finding out ways to make science more enjoyable to minority youth, because interest has a robust positive association with science self-labeling. In addition, we speculate that science other-ID measure is not simply the reflected appraisal of parents and teachers, but, instead, is what George Herbert Mead would call the "generalized other." If we are correct, then science other-ID captures not only recognition from parents and teachers but also from peers and more abstractly from society at large. The societal influences likely reflect the narrow media images of minority men and women, and white women scientists in textbooks, classrooms, comics, movies, and television (Destin and Oyserman 2010).

Clare Holdsworth and David Morgan (2007) argue that the concept of the "generalized other" (Mead 1934) is rarely explicitly assessed, perhaps because it is quite abstract. Many researchers often include science other-ID in a scale along with science self-labeling and other identity relevant measures (i.e., career intentions; Archer et al. 2015). We, however, provide a unique conception of self- and perceived other-labeling as dual outcomes of identity processes. First, although they have a moderate to strong correlation at the bivariate level, adjusting for social processes and gender and race/ethnicity accounts for half of that

correlation. In addition, minority girls seemed to face a double bind across a number of science attitudes and self-appraisals, likely due to their social location at the intersection of gender and race/ethnicity. The only difference between white girls and boys in the adjusted model is in perceived other science identity; white girls had substantially lower scores than white boys on this measure.

What is science "generalized other" really measuring? We believe that this may be a proxy for media and culture, where implicit and explicit messages about who is or is not a scientist are communicated through stories, music, and advertising. Images and messages about who creates science and who participates in science still mostly depict white boys and men, although there are efforts toward diversity. There were youth who did not know if others saw them as a science kind of person, suggesting that not all youth think about this topic. Because science "generalized other" differs by race/ethnicity and gender, and is associated with science self-ID, we hope that there will be future research to learn more about how youth perceive that others in general see or do not see them as science kinds of people.

As with all research, we have many remaining questions, in part generated by our findings and also stemming from the limitations of the current study. First, we have a sample of 441 diverse students from a single middle school. Because this is not a national sample, we must be careful to not generalize our findings to the broader population of youth aged 10 to 14 in the United States. The middle school surveyed for this study is primarily lower income, with a relatively mobile population, and located in a midsized Midwestern city. Therefore, some of the effects may be attenuated by the social class homogeneity. Although this school has more students of color than white students, this is not true of the broader community, despite the substantial refugee and immigrant populations in this particular city. Because most youth are lower income, they have lower cultural capital, and generally will have lower achievement scores, which have direct implications for both science capital and science identity, respectively. According to Louise Archer et al. (2015), science capital is defined as a student's scientific-related dispositions, preferences, and science-related behaviors and practices (i.e., consumption of science-related media, participation in out-of-school science), as well as science-related social capital (i.e., knowing someone who works in a science job, parental science qualifications, talking to others about science). Given our sample 's known social capital, very few youth in our study will likely have high science capital compared with a national sample of youth. Due to wide variations in the size, quality, context, and curriculum across schools in the United States, and in the Midwest, more research needs to be done to assess science identity in various school contexts.

Another limitation of our study is the self-report measures of reflected appraisal from parents and teachers. As discussed in the section "Literature Review," differences in perceived recognition and more informal interactions might be due to objective differences in parents and teachers behaviors toward youth, and/or to differences in youths' perceptions of those interactions, and, therefore, related to their own cognition and implicit biases. There is evidence in prior research to support both, but we cannot distinguish between these mechanisms in the current study. To better inform ideas for action, we would ideally have observational data on interactions between youth and their parents and teachers. We would also include information from the perspective of parents and teachers. If we could add more

"objective" measures of parent and teacher interaction with youth, like parent or teacher reports in addition to youth report, or observations of their interactions, we might find that they have more influence than we find in the current study.

The measure of discovery orientation is an important contribution to research on identity in general and science identity in particular, yet we want to refine this measure. The low reliability of the discovery orientation scale, which we discussed in the section "Method," suggests that we need to improve the items in the scale. Based on qualitative feedback from science teachers during the fielding of this study, we added additional items to the discovery orientation scale in subsequent waves.

We also do not know for certain the causal ordering of the theoretical constructs. Because science identity is, in part, future oriented, we argue the logic of having these two dependent variables as the outcome to capture social and cognitive processes. The exogenous, mediating, and endogenous variables were measured at the same time. It will be important to explore if changing interest, importance, and recognition are associated with changes in science identities. Following youth over time will help to provide more insights regarding how science identities change and the general influences on increases or decreases in science identity. It would also be valuable to have larger samples to conduct a multiple-groups analysis in which we could assess whether the associations differ between groups, whether specific race/ethnicity subgroups (e.g., youth from Mexico, Caribbean, Vietnam, African American youth, etc.) are unique, or whether they all share the experiences of implicit bias against nonwhites.

Among middle school youth in the current sample, there are no differences in discovery orientation by race/ethnicity and gender. There are differences, however, in explicit science self-ID. Therefore, race/ethnicity and gender differences in science identities are not simply a reflection of different levels of science propensities. The findings in this study provide tantalizing hints toward interventions to increase science identities, particularly among groups that are underrep-resented in science, and those with high propensity but low identity. We need to design interventions to see whether making science more enjoyable and relevant will actually increase science identities. In addition, interventions that involve illustrating minorities and women in science could help a more diverse array of students to think that others might see them as a science kind of person. Stereotypical images of science in the mainstream media may be more prolific in lower SES communities and schools making the identity of "athlete" seemingly more attainable (Destin and Oyserman 2010). These efforts should be a high priority for investments in science education that help youth to do science in ways that build knowledge and skills as well as science identities (Basu and Barton 2007; Carlone et al. 2008; Painter et al. 2006). Interventions in science education that focus on engaging youth with low science identities with science content and ideas are imperative (Spiegel et al. 2013).

Acknowledgments

Appendix

Bivariate Correlation Matrix (n = 441).

Variables	Science identity		Discovery orientation	Science interest	Science importance	Perceived science ability
	Self-ID	Other-ID				
Science identity self-ID	1					
Science Identity other-ID	.45	1				
Discovery orientation	.56	.36	1			
Science interest	.56	.35	.69	1		
Science importance	.68	.38	.56	.63	1	
Perceived science ability	.49	.32	.37	.61	.49	1
Science reflected appraisal	.43	.40	.40	.60	.49	.60

Note. All correlations are significant at the $p < .001$ level (two-tailed test). ID = identification.

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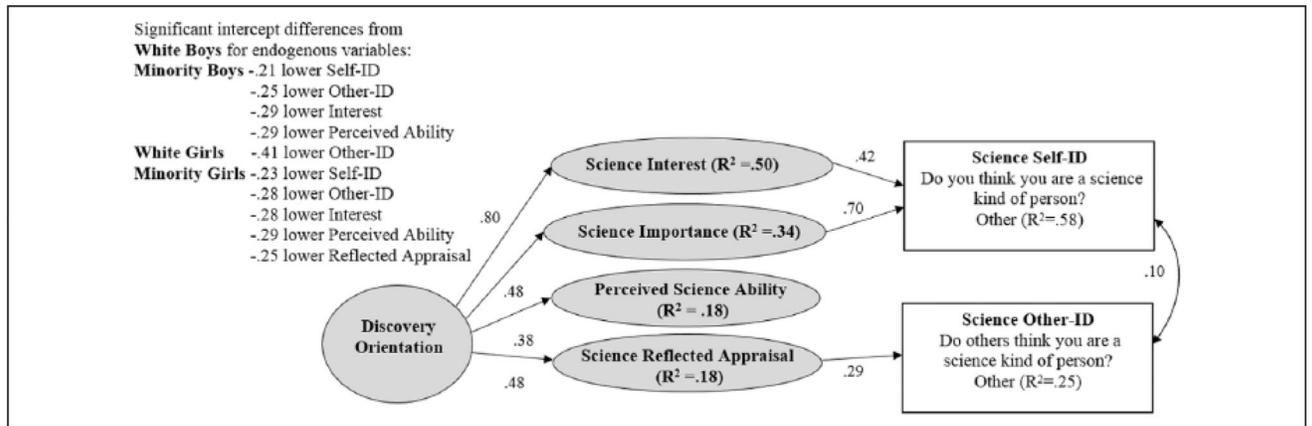
Figure 1.
Unstandardized significant direct effects from discovery orientation and social location (gender and race/ethnicity) to science identity

Note. See Tables 3 to 5 for full details. All mediating variables are positively correlated. The intercept for science identity is 2.75, which is the value on science identity self-ID for white boys adjusting for all other variables, when they are average on all other variables (variables are mean-centered). ID = identification.

Table 1

Standardized Factor Loadings for Latent Constructs.

Construct	Factor loading	*SE*
Discovery orientation		
How much do you like learning about new discoveries?	.75	.05
How curious are you about the world?	.48	.05
How much do you like exploring nature?	.42	.05
Science interest		
How much do you like science?	.83	.03
How boring are science classes for you?	.69	.04
Science importance		
How much, if any, do you think studying science will help you in the future?	.73	.04
How often do you use science to solve daily problems?	.65	.04
How much, if at all, does science help people?	.56	.05
How much does science help you make decisions that affect your body?	.53	.05
Perceived science ability		
How well do you usually do in science classes?	.87	.02
How good are you at science?	.81	.03
What grades do you usually get in science?	.67	.03
Science reflected appraisal		
How much do teachers at school make you feel like you are good at science?	.78	.04
How much do your parents or guardians make you feel like you are good at science?	.74	.04

Table 2

Bivariate Descriptive Statistics Gender and Race/Ethnic Social Identities and Science Constructs ($n = 441$).

| | Boys | | | | Girls | | | | |
| | White ($n = 81$) | | Minority ($n = 130$) | | White ($n = 80$) | | Minority ($n = 150$) | | |
Variables	MI proportion	SD	MI proportion	SD	MI proportion	SD	MI proportion	SD	Significance
Discovery orientation	3.31	.54	3.27	.62	3.22	.54	3.215	.56	ns
Science identity—Self-ID	2.80$_a$	.89	2.43$_b$	.88	2.43$_b$	.76	2.25$_b$	.86	***
Science identity—Other-ID	2.33$_a$	.91	2.02$_b$	.88	1.83$_b$	.80	1.88$_b$	.86	***
Science interest	3.29$_a$	.64	3.03$_{a,b}$	.79	3.01$_{a,b}$	.74	2.95$_b$	.82	*
Science importance	3.01$_a$	.55	2.97$_a$	.64	2.78$_b$	.72	2.78$_b$	.72	**
Perceived science ability	3.36$_a$	.63	3.03$_b$	.64	3.25$_a$	.54	3.04$_b$	.63	***
Science reflected appraisal	3.07$_a$	.88	2.87$_{a,b}$	.90	3.03$_{a,b}$	.90	2.74$_b$	.88	*

Note. All range from 1 (*low*) to 4 (*high*). Means with different subscripts are statistically significantly different using Tukey's Honestly Significantly Different Test; consequently, variables that share subscripts are not significantly different. ID = identification; *ns* = not significant.

*
$p < .05$.

**
$p < .01$.

***
$p < .001$ (two-tailed test).

Table 3

Unstandardized Direct Effects of Exogenous Predictors and Endogenous Mediators ($n = 441$).

Variables	Science identity		Science interest	Science importance	Perceived science ability	Science reflected appraisal
	Self-ID	Other-ID				
Exogenous predictors						
Discovery orientation	.15 (0.13)	**.31 (0.14)** *	**.80 (0.10)** ***	**.48 (0.09)** ***	**.38 (0.08)** ***	**.48 (0.09)** ***
Minority boy[a]	**−.21 (0.10)** *	**−.25 (0.13)** *	**−.29 (0.09)** **	.00 (0.07)	**−.29 (0.09)** **	−.15 (0.12)
White girl[a]	−.06 (0.10)	**−.41 (0.13)** **	−.15 (0.10)	−.09 (0.09)	−.07 (0.10)	.10 (0.14)
Minority girl[a]	**−.23 (0.09)** *	**−.28 (0.11)** *	**−.28 (0.09)** **	−.11 (0.08)	**−.29 (0.09)** **	**−.25 (0.13)** *
Endogenous mediators						
Science interest	**.42 (0.14)** *	−.146 (0.146)				
Science importance	**.70 (0.13)** ***	.26 (0.13)				
Perceived science ability	.11 (0.10)	.07 (0.11)				
Science reflected appraisal	−.07 (0.07)	**.29 (0.09)** **				

[a]Reference category is white boy. ID = identification.

*
 $p < .05$.

**
 $p < .01$.

***
 $p < .001$ (two-tailed test). Significant results are **bolded** for ease of reading the table.

Table 4

Unstandardized Covariances among Endogenous Mediators and Dependent Variables ($n = 441$).

Variables	Science interest	Science importance	Perceived science ability	Science identity other-ID
Science importance	.08 (0.02)**			
Perceived science ability	.13 (0.03)***	.06 (0.02)**		
Science reflected appraisal	.16 (0.03)***	.08 (0.02)**	.20 (0.03)***	
Science identity self-ID				.10 (0.03)***

Note. ID = identification.

*
$p < .05$.

**
$p < .01$.

***
$p < .001$ (two-tailed test).

Table 5

Unstandardized Total, Direct, Total Indirect, and Specific Indirect Paths from Discovery Orientation to Science Identity Self- and Other-ID ($n = 441$).

Variables	Total	Direct	Total indirect	Specific indirect
DO → self-ID	**.82 (0.11)** ***	−.15 (0.13)	**.67 (0.11)** ***	
DO → interest → self-ID				**.33 (0.12)** **
DO → importance → self-ID				**.34 (0.08)** ***
DO → perceived ability → self-ID				.04 (0.04)
DO → reflected-appraisal → self-ID				−.04 (0.04)
DO → other-ID	**.51 (0.09)** ***	.31 (0.4) *	.20 (0.10) *	
DO → interest → other-ID				−.27 (0.28)
DO → importance → other-ID				.134 (0.06) *
DO → perceived ability → other-ID				.04 (0.06)
DO → reflected-appraisal → other-ID				**.16 (0.05)** **

Note. DO = discovery orientation; ID = identification.

*
$p < .05$.

**
$p < .01$.

***
$p < .001$ (two-tailed test).