



High school students' math and science gender stereotypes: relations with their STEM outcomes and socializers' stereotypes

Christine R. Starr¹ · Sandra D. Simpkins¹

Received: 17 June 2020 / Accepted: 22 January 2021 / Published online: 7 February 2021
© The Author(s), under exclusive licence to Springer Nature B.V. part of Springer Nature 2021

Abstract

This longitudinal study explores three research questions. First, what is the prevalence of math and science gender stereotypes among high school students, their parents, and teachers? Second, are parents' and teachers' gender stereotypes related to adolescents' stereotypes? And third, are adolescents' gender stereotypes associated with their math and science identity and outcomes? We used a nationally representative U.S. sample ($N=22,190$, 50% girls, 53% White, 22% Latinx, 13% Black) of adolescents surveyed at 9th and 11th grade, their parents, and teachers. Adolescents' transcripts were also collected at the end of high school. Adolescent gender stereotypes became significantly more traditional from 9 to 11th grade. Parents were three times more likely to believe that males are better at math/science (compared to believing females are better), and we found significant positive relations between parents' and adolescents' stereotypes. Finally, adolescents' math/science gender stereotypes were significantly related to their math/science identity, which in turn was related to their STEM outcomes over the course of high school. Our findings give insight to the development of academic gender stereotypes in adolescence, their potential precursors, and their relations to academic outcomes.

Keywords STEM · Gender stereotypes · Stereotype development · Parent stereotypes · Identity · Math · Science

1 Introduction

Women are underrepresented in many STEM fields (NSF 2017), and girls frequently report lower competence beliefs in math and science when compared to boys (Eccles and Wang 2016). Researchers and policy makers frequently pinpoint gender

✉ Christine R. Starr
cstarr1@uci.edu

¹ School of Education, University of California, 401 E. Peltason Drive, Irvine, CA 92617, USA

stereotypes as one of the primary explanations for gender gaps in STEM fields (e.g., Régner et al. 2014). Endorsing the gender ability stereotype that boys and men are better at math and science may shape students' subsequent STEM outcomes, such as enrollment in advanced courses, because of the stereotype's impact on their math and science identity (Cheryan et al. 2015). However, prior research has not yet longitudinally examined the changes in adolescents' math and science gender ability stereotypes, their subsequent correlates, and their predictors.

Using the High School Longitudinal Study (HSLs) dataset, we examined U.S. adolescent explicit gender ability stereotypes about math and science in 9th and 11th grade. HSLs is a nationally representative dataset of over 23,000 adolescents and includes information from adolescents, parents, teachers, and students' school records (NCES 2019). Using these rich multi-informant longitudinal data, we addressed three primary goals. Our first goal was to examine the prevalence of math and science gender stereotypes among adolescents, their parents, and their math and science teachers, as well as changes over time in adolescents' stereotypes. Our second goal was to investigate the extent to which parents' and teachers' stereotypes were associated with adolescents' stereotypes. Our third goal was to test the extent to which adolescents' math and science identities are potential mechanisms by which gender stereotypes might predict their STEM coursework and career goals.

1.1 Balanced identity theory and expectancy-value theory

Balanced identity theory helps researchers understand how stereotypes and identities may lead individuals to approach some domains while avoiding others (Greenwald et al. 2002). According to this theory, people seek a congruence between their stereotypes about a domain (such as math), their own identity, and the domains they seek out or belong to. Thus, if a girl stereotypes math and science as something males are better at, balanced identity theory predicts that she will disidentify with math and science domains and avoid advanced courses and careers in those domains (e.g., Greenwald et al. 2002; Cheryan et al. 2017).

Prior studies have explored implicit gender stereotypes in relation to individuals' math identities (e.g., Cvencek et al. 2011) and have explored STEM identity's positive relation to outcomes such as persistence and career goals (e.g., Chemers et al. 2011). However, few studies have investigated explicit gender ability stereotypes among adolescents in relation to their math and science identities, and in turn, outcomes such as advanced coursework. Explicit stereotypes are conscious stereotyped beliefs that a person holds (e.g., believing that men are better at math than women). Conversely, implicit stereotypes are automatic and often unconscious associations that people quickly make (e.g., more quickly matching a picture of math equations to a man when compared to a woman). It is valuable to explore the relation between explicit stereotypes and identity because they are conceptually different than implicit stereotypes and may relate to different outcomes (e.g., Passolunghi et al. 2014; Smyth and Nosek 2015).

Another complementary theory which has frequently been used to explore social factors related to gender differences in science and math is situated expectancy-value

theory (Eccles and Wigfield 2020). According to this theory, identifying with a domain (e.g., seeing oneself as a math person) is an important contributor to individuals' academic and career outcomes (Eccles 2009). These self-perceived social identities are influenced by individuals own beliefs (e.g., an adolescents' gender stereotypes) as well as their socializers' beliefs (e.g., parent's gender stereotypes). Two central socializers of adolescents' academic-related beliefs, including gender stereotypes, are their parents and teachers (Eccles 2009). Thus, parent and teacher gender stereotypes should predict adolescents' gender stereotypes, and in turn, predict their science and math identities.

1.2 The prevalence and changes in adolescents' math and science gender stereotypes

Existing research on the development of youth's gender stereotypes has relied on cross-sectional data to describe age differences. The prevalent pattern of age differences in individuals' math and science gender stereotypes is one where younger children tend to favor their own gender. However, during adolescence egalitarian and then traditional gender stereotypes favoring males are more prevalent. In math, research suggests that 3rd–8th grade children in the U.S. and Europe on average either view their own gender as better at math during this period (Kurtz-Costes et al. 2014, 2008; Plante et al. 2013; Passolunghi et al. 2014) or hold more gender egalitarian beliefs in early adolescence (Kurtz-Costes et al. 2014; Passolunghi et al. 2014). Traditional gender stereotype beliefs that males are better than females at math have been found among U.S. middle school students (Hargreaves et al. 2008) and German high school and university students (Steffens and Jelenec 2011). Similar patterns have emerged in science. One large meta-analysis covering five decades of draw-a-scientist studies in the U.S. from grades kindergarten through high school found that traditional stereotypes were more prevalent in studies conducted among older children and adolescents compared to studies conducted among younger children (Miller et al. 2018). However, one recent study about STEM gender stereotypes among families at informal science centers in the U.S. and U.K. found adolescents were more egalitarian than children (McGuire et al. 2020).

To date, no study to our knowledge has longitudinally investigated the prevalence and outcomes of math and science gender stereotypes among high school students. Adolescence, particularly the high school period, is an important developmental period for individuals' math/science stereotypes and identity for multiple reasons. First, adolescence is a period of intense identity development, when individuals explore their identities (Erikson 1968). Adolescents use cues from society and important people in their lives, like parents and teachers, to help them decide who they are and what they should pursue (Lauermann et al. 2017). Second, stereotypes may contribute to these identities particularly during adolescence, because adolescents have the cognitive skills needed to relate stereotypes to themselves and their identities (Cross and Cross 2008; Marcia 1994; Patterson and Bigler 2018; Umaña-Taylor et al. 2014). Adolescents are also more likely to be aware of stereotypes about science (and potentially math) when compared to younger children (Steinke

et al. 2007). Finally, high school is a time when STEM beliefs change and students have more consequential STEM related choices (e.g., course enrollment; Hsieh et al. 2019; Jacobs et al. 2002; National Science Board 2018).

This combination of identity development, heightened awareness of stereotypes, and the cognitive ability to match stereotypes to the self may result in increases in academic gender stereotypes and a greater impact of these stereotypes on identity development. Increases in traditional stereotype endorsement during adolescence may help explain why adults tend to have higher traditional academic gender stereotypes when compared to children (e.g., Bleeker and Jacobs 2004). Additionally, the freedom to choose advanced coursework may result in stereotypes having an impact on adolescents' academic outcomes.

The majority of the cross-sectional studies about math and science gender stereotypes are smaller scale studies with fewer than 200 participants that were collected using convenience samples. We sought to extend prior research by investigating gender stereotypes longitudinally in a large, nationally representative sample. We expected that adolescents' gender stereotypes would become significantly more traditional from 9 to 11th grade (i.e., towards stereotyping males as better at math and science).

1.3 Parents and teachers as contributors to adolescent gender stereotypes

Expectancy-value theory predicts that adolescents' gender stereotypes and other academic beliefs are shaped by parents' and teachers' gender stereotypes (Eccles 2015). Specially, parents' and teachers' gender stereotypes shape adolescents' beliefs through the messages adults give and the extent to which adults support adolescents in these domains. The research on age differences reviewed in the prior section and research on parents (e.g., Bleeker and Jacobs 2004) suggests that adults tend to hold traditional gender stereotyped beliefs in math and science. However, some research suggests that parents' endorsement of traditional gender roles differs depending on race and class. For example, one study found that Black mothers in the U.S. believed girls and boys are equally good at math and science (Rouland et al. 2013). Regarding teachers, one study among Swiss middle school teachers found that teachers were significantly more likely to stereotype math as a male domain (defined broadly) as opposed to a female domain (Keller 2001). Another study among German teachers asked them to evaluate the math performance of a girl and boy in a vignette and found that teachers evaluated the performance of the girl more poorly (Holder and Kessels 2017). Given past findings, we expected that parents and teachers would be significantly more likely to believe males are better than females at math and science.

Several studies have investigated the relations between adult and child stereotypes, either via measuring children's perception of adult stereotypes or by directly measuring adults' stereotypes, with conflicting results (Kurtz-Costes et al. 2014, 2008; Galdi et al. 2017). Two studies among U.S. grade school students found that when children perceive adults (defined as "most grownups") have more traditional

gender stereotypes, they tend to hold the corresponding belief that girls are less capable than boys in math and science (Kurtz-Costes et al. 2014, 2008).

However, studies on parents specifically have mixed findings. One of the few studies that directly measured parent and child academic stereotypes found parents' report of their gender stereotypes were not associated with their child's gender stereotypes (Galdi et al. 2017). The non-significant finding may in part be due to combining language and math gender stereotypes into one measure. Conversely, one meta-analysis of parent and child gender-related beliefs (broadly defined) found a significant positive relation between parent and child beliefs about gender (Tenenbaum and Leaper 2002). Additionally, one large longitudinal study (Bleeker and Jacobs 2004) found that mothers' math and science gender stereotype endorsement when their child was in 6th or 7th grade was related to mothers' perceptions of their child's ability in 6th or 7th grade, and that these perceptions were in turn related to children's math and science self-efficacy two years after high school. Although this study did not investigate children's own gender stereotypes, it is possible that children internalized their mothers' views, affecting their self-efficacy. Based on these studies, we expected parents' gender stereotypes to be significantly positively related to adolescents' gender stereotypes at both 9th and 11th grade.

Even less research exists on the relations between teachers' beliefs and student indicators. One correlational study among Swiss middle school students found that teachers' stereotyping of math as a male domain (broadly defined) was significantly related to their students' stereotyping of math as a male domain (Keller 2001). Additionally, one study found that elementary school teachers' gender stereotypes are related to their likelihood of recommending male versus female students for a math/science focused secondary school (Nürnberg et al. 2016), indicating that teacher gender stereotypes can affect their behavior towards students. Additionally, developmental theories (e.g., situated expectancy-value theory) posit that teachers are important academic socializers for students (Gunderson et al. 2012). They may impact their students via direct statements about ability and interests, by differential treatment, or by demonstrating their own math anxieties (Gunderson et al. 2012; Leaper 2015). Teachers may be especially impactful regarding stereotypes about the subject domain that they teach (Leaper 2015; Leaper and Brown 2008). It is thus plausible that teacher stereotypes regarding which gender is better at math may significantly relate to adolescent stereotypes.

1.4 Adolescents' gender stereotypes and their identity, coursework, and goals

Several studies have investigated whether adolescent gender stereotypes about math and science are related to their subsequent outcomes. Findings in math suggest that students' traditional math gender stereotypes were significantly related to math GPA and self-efficacy in middle school (Casad et al. 2017), math self-concepts and motivational beliefs in grade school and middle school (Passolunghi et al. 2014; Plante et al. 2013), and self-reported math grades in high school (Chatard et al. 2007). In all cases, traditional gender stereotypes in math was associated with negative outcomes for girls and positive outcomes for boys. Moreover, children's math expectancy and

value beliefs mediated the relation between gender stereotypes and academic outcomes, such as grades and career intentions, even after controlling for prior grades (Plante et al. 2013). There is less research regarding the correlates of students' science gender stereotypes, such processes in high school, and the relations between gender stereotypes students' identities. One study found that traditional gender stereotypes about science positively related to 4th to 8th grade boys' competence beliefs but were unrelated for girls (Kurtz-Costes et al. 2008).

Based on balanced identity theory (Greenwald et al. 2002; Tobin et al. 2010), those who feel they do not match the stereotypes of a group may feel less like a member of that group (e.g., not view themselves as a science person). This discordance may decrease their identity with that domain, which in turn may lead to avoiding STEM courses and careers (Cheryan et al. 2015). Thus, math and science identity may be an important mediator between stereotypes and math/science outcomes such as taking advanced courses. Boys who view math or science as a male domain may identify more with math or science and take more advanced courses in it. Meanwhile, girls who view these domains as masculine may be less likely to take advanced courses. Indeed, prior studies have found STEM identity mediates relations between implicit gender stereotypes and STEM career goals among undergraduates (e.g., Cundiff et al. 2013; Starr 2018). Other studies have found significant positive relations between STEM identity and outcomes such as persistence in advanced coursework (Aschbacher et al. 2010; Carlone and Johnson 2007; Chang et al. 2014; Chemers et al. 2011). We expected to find similar patterns in the present study. Additionally, based on this prior research, we expected gender to moderate the relation between gender stereotypes and math and science identity.

1.5 Present study

In a nationally-representative, longitudinal sample of high school students, their parents, and their teachers, we investigated the prevalence of math and science gender stereotypes among high school students, their parents, and teachers, and changes in gender stereotypes among adolescents from 9 to 11th grade. Additionally, we investigated the relation between (1) adolescents' gender stereotyped beliefs about math and science and their parents' and teachers' gender stereotyped beliefs, (2) adolescents' gender stereotyped beliefs and their math and science identity, and (3) science identity and outcomes such as number of math and science courses taken throughout high school. Based on prior literature, we hypothesized that:

1. Significantly more adolescents, parents, and teachers would endorse the belief that males are better in math and science when compared to endorsing the belief that females are better than males. Additionally, we hypothesized that both boys and girls would become significantly more biased towards the traditional gender stereotype that males are better in math and science from 9 to 11th grade.
2. Parent and teacher gender stereotyped beliefs would be positively related to adolescent gender stereotyped beliefs.

3. Adolescent gender stereotyped beliefs about math and science would be significantly related to their identity in the same domain. However, this relation would be moderated based on gender. Believing males are better at math and science would be associated with a stronger math/science identity among boys, but a weaker math and science identity among girls.
4. Finally, we hypothesized that stereotypes would have an indirect effect via math and science identity on outcomes such as number of courses in math and science taken throughout high school, the most advanced math and science course taken, and future STEM career goals.

2 Method

2.1 Participants

Data were drawn from the High School Longitudinal Study (HSLs) dataset. Use of the data was approved by the University of California, Irvine Institutional Review Board under the project name “Family Support of Math and Science: Examining an Untapped Source of Resilience for Diverse High School Students” (protocol HS# 2018-4349). HSLs is a nationally representative longitudinal study of over 23,000 adolescents from 944 schools in the United States. High School Students Data were collected by the National Center for Education Statistics (NCES; see <https://nces.ed.gov/surveys/hsls09/>). A stratified random sample design was used to determine eligible schools and students, resulting in a nationally representative sample (see NCES survey documentation for more detail, NCES 2019). Adolescents were excluded from our sample if they (a) did not report their gender ($n=50$) or (b) did not have data from any of the following socializers: their parent, math teacher, and science teacher ($n=2970$). Overall, less than 1% (.88%) of participants were dropped because they either were missing data for one of these two reasons.

The analytic sample included 22,190 adolescents. Of these adolescents, 50% identified as a boy and 50% as a girl. About half of participants identified as White (52.9%), and almost a quarter of the sample (22.2%) identified as Latinx or Hispanic. Furthermore, 12.8% of the sample identified as Black and 3.4% as Asian. Finally, 7.6% identified as multiracial, and 1.2% of people in the sample identified as another race/ethnicity (e.g., American Indian). Additionally, 62.9% of the sample were potential first-generation college students as neither parent graduated from a 4-year college.

Of the adolescents included, 72.1% ($n=16,000$) had math teacher survey data and 62.3% ($n=13,830$) had science teacher survey data. Additionally, 76.6% ($n=16,990$) of adolescents had parent surveys that were filled out. In the paragraphs below, we report valid percentages (i.e., include only participants' who had a parent survey filled out). Majority of the parent surveys were completed by the adolescents' mother or stepmother (75.6%). Fathers or stepfathers comprised 21% of caregivers who completed the parent survey, and 3.4% of surveys were completed by a caregiver with another relationship to the adolescent (e.g., grandmother). The highest education attained for either parental figure was less than high school for 8.2% of the

sample, high school or GED for 38.6%, and associate degree for 16.1%. Additionally, 22% of adolescents had at least one parental figure with a bachelor's degree and 15.1% of adolescents had a parental figure with an advanced degree (e.g., M.D.). In terms of household income, 50.1% of the sample had a total household income of \$55,000 or below. An additional 24.7% of families in the sample had an income between \$55,000 and \$95,000. Finally, 25.2% of the families had a household income of over \$95,000.

2.2 Procedures and measures

Data for this study were collected by NCES starting in 2009 when adolescents were in 9th grade, with a follow-up in 2012 when most adolescents were in 11th grade. Additionally, high school transcript data were collected in 2013. The student survey took students about 90 min. Approximately 98% of students were surveyed in school, and 2% outside of school. When adolescents were in 9th grade, parents and teachers took the survey in their own time and were given the option to either have web-based self-administration or computerized interviewer-administration. The measures used in this study are described below.

2.2.1 Adolescents', parents', and teachers' math and science gender stereotypes

Adolescents, parents, and teachers were each asked the same question to separately assess math and science stereotypes (Eccles et al. 1990): "In general, how would you compare males and females in each of the following subjects? [Math][Science]" (1=females are much better, 2=females are somewhat better, 3=females and males are the same, 4=males are somewhat better, and 5=males are much better). This single item has been used to measure math gender stereotypes relation to motivational beliefs in other studies (e.g., Eccles et al. 1990; Kurtz-Costes et al. 2008, 2014) and is a core item for other scales measuring academic gender stereotype measurement (e.g., Bleeker and Jacobs 2004; Passolunghi et al. 2014). Theoretically, the item is useful in that it allows individuals to endorse the non-traditional stereotype that females are better or that males and females are equal, in addition to traditional stereotype endorsement. Adolescents were asked at 9th and 11th grade. Parents were asked when their child was in 9th grade. Math and science teachers were asked when the adolescent was in 9th grade. Adolescents' math teachers' data were used for the math model, whereas adolescents' science teachers' data were used for the science model.

2.2.2 Adolescents' math and science identity

Adolescents were asked two questions for math and science identity (Shanahan 2009): "You see yourself as a [math] [science] person" and "Others see you as a [math] [science] person" (1=strongly disagree to 4=strongly agree). These scales evidenced excellent internal reliability (9th grade: math $\alpha = .84$, science $\alpha = .84$; 11th grade: math $\alpha = .88$, science $\alpha = .89$).

2.2.3 Adolescents' math and science courses

Data were obtained from student transcripts during the year following high school graduation regarding (a) the number of math and science courses the adolescent had taken during high school and (b) the highest level of math or science the adolescent had achieved. The latter was coded by NCES (see coding documentation for more detail; NCES 2019) based on difficulty of the final math course the adolescent had taken in high school, with 1 = *Basic Math* to 13 = *AP/IB Calculus*. For science, this was coded similarly, with 1 = *General Science* to 5 = *AP/IB Science*. If the adolescent had not taken a math or science course throughout high school, this variable was coded as "0" (1% of the sample had not taken a math course in high school, and 2% had not taken a science course).

2.2.4 Adolescents' STEM career goals

Adolescents were asked in 11th grade: "As things stand now, what is the job or occupation that you expect or plan to have at age 30?" Answers were coded dichotomously for STEM content (0 = *no STEM content*, 1 = *STEM content*) by NCES based on O*NET occupational categories.

2.2.5 Background and control variables

Adolescents were asked to report their gender, ethnic/racial background, and 8th grade math grade (A to below D). Additionally, in 9th grade adolescents were given a math assessment for the present study, which was standardized by NCES and included as a control variable along with their 8th grade math grade. The math assessment was designed to assess adolescent algebraic reasoning in content domains (e.g., nonlinear equations) and algebraic processes (e.g., solving algebraic problems). Parents reported their education level, occupation (which was coded by NCES for prestige), and income. These data along with location were used by NCES to create a socioeconomic status variable that was used as a control variable. More detail about background and control variables (including the math assessment and socioeconomic status variable) can be found on the NCES website in their base year data file documentation (NCES 2019).

2.3 Data analytic plan

2.3.1 Sample weights and descriptive statistics

Analyses in this study were adjusted to be representative of the study population by using analytic weights, clusters, and strata. These account for nonresponse rates in the nationally representative sampling process, including data collection at multiple time points and with multiple reporters. *T*-tests were used to investigate gender differences in gender stereotypes and other variables. We compared boys and girls

in their math and science gender stereotypes, math/science identity, math/science coursework, and STEM career goals. We also compared 8th grade math grade and standardized math test scores (both used as control variables) to determine whether there were performance differences between boys and girls in our sample. Additionally, we investigated potential gender stereotype differences among parents and teachers of boys and girls. Finally, correlations were run between all major variables for math and science.

2.3.2 Prevalence and changes in stereotypes (Hypotheses 1)

One sample *t*-tests were used to test whether group stereotype means differed from “3=females and males are equal;” we hypothesized that these means would significantly differ towards the traditional stereotype that males are better at math/science. Repeated measures ANOVAS were used to look at changes in stereotype endorsement from 9 to 11th grade. We hypothesized that gender stereotypes would significantly increase from 9 to 11th grade, and that boys would have significantly more traditional gender stereotypes at 9th grade.

2.3.3 Relations between indicators (Hypotheses 2–4)

To investigate the hypotheses testing the relations between parent and teacher gender stereotypes, adolescent gender stereotypes, and adolescent math/science identity and outcomes, the R structural equation modeling (SEM) package *lavaan* was employed. We hypothesized that parent and teacher gender stereotypes would positively relate to adolescent gender stereotypes at 9th grade, and adolescent gender stereotypes would relate to math/science identity at 9th grade. We hypothesized that these factors would significantly relate to adolescent gender stereotypes and math/science identity at 11th grade. Finally, we hypothesized that 11th grade math and science identity would positively relate to the outcome variables: STEM career goals at 11th grade, math/science total number of courses taken in high school, and highest course level taken by end of high school (see Fig. 1). Both math and science identity at 9th and 11th grade were latent indicators and all other variables were manifest indicators. A two-step modeling process was followed (e.g., Tabachnick and Fidell 2013). First, the theoretical model was tested for each stereotype, using the model described above plus controls (8th grade math grade, standardized math test score, race/ethnicity, and the SES variable which also considered parental education levels). Control variables were removed when not significant. Additionally, the path between math/science teacher gender stereotypes and adolescents' math/science identity was tested but removed due to not being significant.

Gender was tested as a moderator, given our hypothesis that some paths might differ based on gender. Specifically, we hypothesized that believing males are better at math and science will be associated with a stronger math/science identity among boys, but a weaker math/science identity among girls. Multigroup analysis tested for significant pathways. After testing for significant differences, all non-significant paths were set to be equal. We additionally hypothesized that gender stereotypes would have an indirect effect via 11th grade math and

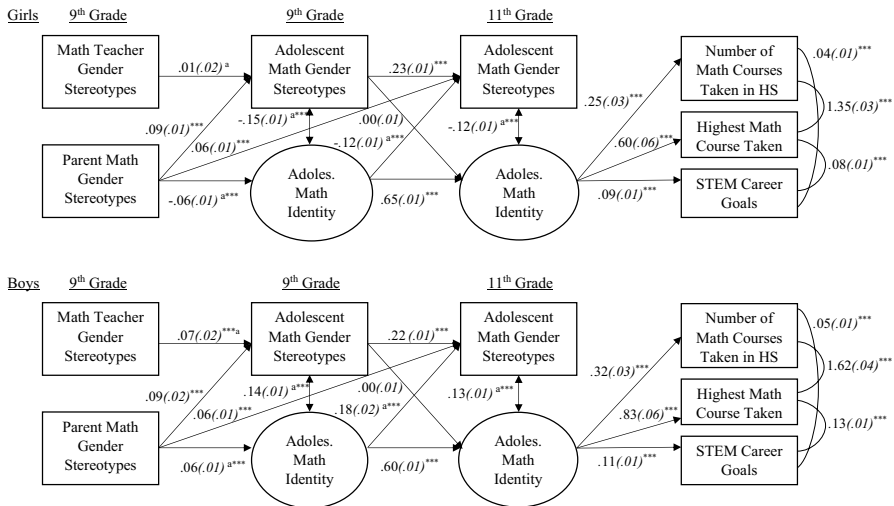


Fig. 1 Math Model. Note ^aSignificant path difference between girls and boys. *** $p < .001$. Adoles. = Adolescent. Paths unstandardized. Controlling for: 8th grade math grade, standardized math test score, socioeconomic status, and underrepresented minority status throughout the model. Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSL:09), Base Year, First Year Follow-Up, and High School Transcripts

science identity on career goals, total math/science courses taken, and highest math/science course taken. To determine if gender stereotypes had an indirect effect via math and science identity on academic outcomes, direct, indirect, and total effects for math and science identity were investigated.

Model fit was tested using multiple indicators. First, the chi-square test of model fit was examined. Additionally, the following indices were examined: TLI, CFI, and RMSEA. For both the TLI and CFI, a value $\geq .95$ indicates a good model fit (Hu and Bentler 1999). For RMSEA, values $\leq .06$ indicate a good model fit (McDonald and Ho 2002). As a robustness check, the same SEM analysis was estimated separately for White, Latinx, and Black sample participants given some of the earlier findings on race differences (e.g., Rouland et al. 2013).

2.3.4 Missing data and non-response

Missing data are common in large-scale longitudinal studies (e.g., Ibrahim and Molenberghs 2009). The proportion of missing values varied between 0 and 16% for demographic variables, between 28 and 38% for teacher and parent gender stereotypes, 9–26% for adolescent-reported variables in 9th grade, 17% for adolescent variables in 11th grade, and 10–35% for transcript variables. Missing data were handled by Full-Information-Maximum-Likelihood (FIML) (Enders 2010).

3 Results

3.1 Preliminary analyses

Bivariate correlations were run across key variables for math (Table S1) and science (Table S2). Additionally, independent samples *t*-tests were estimated to assess potential gender differences (Table 1). Regarding stereotypes, parents of boys were significantly more likely to hold traditional stereotypes compared to parents of girls, and boys at both grades were significantly more likely to hold the traditional stereotype that males are better at math and science than girls. Additionally, there were several significant differences regarding math and science identity and academic outcome variables. Girls had significantly lower math and science identity beliefs in both 9th and 11th grade. However, girls enrolled in significantly more math and science courses than boys and their highest course taken in high school was significantly more advanced for both subjects. Additionally, girls' STEM career goals were significantly higher than boys' goals. Regarding control variables, there was no significant gender difference in students' performance on the standardized math test. Girls received significantly higher math grades than boys in 8th grade. Regarding effect sizes, all the above gender differences were negligible (i.e., $< .20$).

3.2 Prevalence and changes of math and science gender stereotypes

For hypothesis 1, we hypothesized that significantly more adolescents, parents, and teachers would endorse the traditional belief that males are better in math and science when compared to endorsing the belief that females are better than males. Additionally, we hypothesized that both boys and girls would become significantly more biased towards the traditional gender stereotype that males are better in math and science from 9 to 11th grade. Overall, when looking at raw frequencies over half of parents (61% math, 72% science), teachers (73% math, 77% science), and adolescents (9th grade: 60% math, 65% science; 11th grade: 57% math, 65% science) viewed females and males as equally good at math and science. However, parents, boys at 9th grade, and both boys and girls in 11th grade were significantly more likely to believe males are better at math and science than endorse the belief that females are better (one sample *t*-test, Cohen's $d = .05-.28$, all p 's $< .001$, see Table 2). Parents were about three times as likely to believe that males are better at math (28%) and science (21%) than believe that females are better in math (11%) and science (7%). Contrary to our hypothesis, teachers were significantly more likely to view females as better at math and science ($d = .12$ and $.14$, $p < .001$). See Table 2 for means and one sample *t*-tests investigating whether the mean significantly differed from viewing both genders as equal.

We had data regarding adolescent stereotypes at both 9th and 11th grade. In 9th grade, a comparable percentage of adolescents believed females are better at math and science as believed males are better at math and science. Boys had significantly more traditional stereotypes when compared to girls, in both math and

Table 1 Descriptive statistics and gender group comparisons for major variables

	Scale Range	Math					Science				
		All M (SD)	Boys M (SD)	Girls M (SD)	t	d	All M (SD)	Boys M (SD)	Girls M (SD)	t	d
Parent GS	1–5	3.19 (.83)	3.27 (.82)	3.12 (.84)	6.58***	.18	3.15 (.68)	3.21 (.66)	3.09 (.69)	6.56***	.18
Teacher GS	1–5	2.90 (.65)	2.90 (.63)	2.90 (.66)	.04	.00	2.91 (.57)	2.92 (.56)	2.90 (.57)	1.16	.04
9th grade GS	1–5	2.94 (.92)	3.03 (.99)	2.85 (.84)	7.63***	.20	3.03 (.86)	3.11 (.93)	2.96 (.79)	7.35***	.17
11th grade GS	1–5	3.10 (.92)	3.13 (.97)	3.07 (.87)	2.62**	.07	3.13 (.82)	3.21 (.87)	3.04 (.75)	8.86***	.21
9th grade identity	1–4	2.51 (.86)	2.55 (.86)	2.46 (.86)	3.97***	.11	2.29 (.80)	2.32 (.82)	2.25 (.79)	3.47***	.09
11th grade identity	1–4	2.38 (.90)	2.46 (.89)	2.30 (.90)	7.09***	.18	2.46 (.84)	2.50 (.83)	2.43 (.85)	3.68***	.08
Number of courses	0–13	3.61 (1.18)	3.54 (1.22)	3.68 (1.14)	–3.98***	–.12	3.28 (1.24)	3.19 (1.24)	3.37 (1.23)	–5.96***	–.15
Highest lvl. course	0–13 ^b	8.01 (3.06)	7.79 (3.14)	8.24 (2.97)	–5.72***	–.15	1.99 (1.36)	1.88 (1.32)	2.09 (1.40)	–6.07***	–.15
STEM career goals	0–1	.35 (.48)	.27 (.44)	.43 (.49)	238.53*** ^a	.11	–	–	–	–	–
8th math grade	1–5	3.95 (1.00)	3.87 (1.02)	4.03 (.97)	–7.09***	–.16	–	–	–	–	–
Std. math score	1–5	3.03 (1.40)	3.01 (1.42)	3.05 (1.39)	–.85	.00	–	–	–	–	–

GS gender stereotypes

** $p < .01$, *** $p < .001$; Cohen's d effect size standards: .2 = small, .5 = medium^aBecause STEM career goals is a binary variable (yes/no), a chi-square is reported rather than a t -test. For effect size, a ϕ is reported; standards are .1 = small, .3 = medium^bHighest lvl. course for science ranged from 1 to 5 Parent and Teacher GS are separated by gender of the youth. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSL:09), Base Year, First Year Follow-Up, and High School Transcripts

Table 2 Results of one-sample t-test and descriptive statistics for gender stereotype endorsement: testing if group mean significantly differs from “females and males are equal”

Math gender stereotypes	M	SD	<i>t</i>	<i>d</i>	Science ender Stereotypes	M	SD	<i>t</i>	<i>d</i>
Parents	3.19	(.83)	29.78***	.28	Parents	3.15	(.68)	29.78***	.24
Math teachers	2.90	(.65)	-14.59***	-.12	Science teachers	2.91	(.57)	-15.91***	-.14
Girls 9th grade	2.85	(.84)	-15.22***	-.16	Girls 9th grade	2.96	(.79)	-4.53***	-.05
Boys 9th grade	3.05	(.98)	5.48***	.05	Boys 9th grade	3.11	(.92)	12.33***	.12
Girls 11th grade	3.07	(.87)	10.92***	.12	Girls 11th grade	3.04	(.75)	7.97***	.08
Boys 11th grade	3.17	(.96)	17.27***	.18	Boys 11th grade	3.23	(.86)	26.60***	.28

*** $p < .001$. Cohen's *d* effect size standards: .2 = small, .5 = medium, .8 = large. Comparison value = 3, females and males are the same. Response scale: 1 = females are much better, 2 = females are somewhat better, 3 = females and males are the same, 4 = males are somewhat better, 5 = males are much better. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSL:09), Base Year, First Year Follow-Up, and High School Transcripts

science (see Table 1). Boys in 9th grade were significantly more likely to view males as better at math and science compared to viewing males and females as equally good ($d=.05-.12$, $p<.001$), whereas girls at 9th grade were significantly more likely to view females as better at math and science ($d=.05-.16$, $p<.001$; see Table 2).

However, from 9 to 11th grade, gender stereotypes significantly increased towards the traditional stereotype that males are better in math [$F(1)=404.49$, $p<.001$, $\eta^2=.02$]; and science [$F(1)=163.55$, $p<.001$, $\eta^2=.01$]. Girls' beliefs switched to being significantly more likely to believe males are better at math ($d=.12$) and science ($d=.08$) in 11th grade, and the effect size for boys' same gender bias increased ($d=.18-.28$; Table 2). The percentage of students who endorsed the stereotype that males are better than females increased in both math (9th grade: 18.8%, 11th grade: 25.8%) and science (9th grade: 20.0%, 11th grade: 22.9%). In comparison, by 11th grade the number of adolescents who believed females are better decreased for both math (9th grade: 21.5%, 11th grade: 17.4%) and science (9th grade: 15.5%, 11th grade: 12%). Thus, by 11th grade, about 25% or more adolescents believed males are better in math and science (similar to parent stereotypes). Boys still had significantly higher traditional stereotypes than girls (see Table 1); however, the increases did not significantly differ by gender for science $F(1)=3.97$, $p=.046$, $\eta^2=.00$]. For math the gender interaction was significant, however the effect size was negligible [$F(1)=49.61$, $p<.001$, $\eta^2=.00$]. This indicates that increases towards the traditional stereotype occurred at similar rates regardless of gender.

3.3 Investigating the relations between socializer stereotypes and adolescent stereotypes, identity, and academic outcomes

To test hypotheses 2–5 about the relations between parent and teacher stereotypes, adolescent stereotypes, math/science identity, and other outcome variables, SEM models were used. The hypothesized math model (see Fig. 1) was a good fit to the observed data, as indicated with fit indices which met the standard for a good fit, $\chi^2(104, N=22,190)=1590.42$, $p<.001$, TLI=.959, CFI=.979, SRMR=.017, RMSEA=.036, 95% CI[.034, .037]. Factor loadings indicated that latent variables significantly loaded on to 9th grade math identity ($\geq .91$; p 's $>.001$) and 11th grade math identity ($\geq .90$; p 's $>.001$). Additionally, the hypothesized science model was a good fit (see Fig. 2), as indicated with fit indices which met the standard for a good fit, $\chi^2(112, N=22,190)=1547.06$, $p<.001$, TLI=.957, CFI=.975, SRMR=.019, RMSEA=.034, 95% CI[.033, .036]. Factor loadings indicated that latent variables significantly loaded on to 9th grade science identity ($\geq .92$; p 's $>.001$) and 11th grade science identity ($\geq .94$; p 's $>.001$). For both the math and science models, multigroup analysis were used to explore gender as a moderator. For full output from the SEM analyses, please see Supplementary Materials, Table S3. Additionally, as a robustness check the same SEM analysis was conducted separately for White, Latinx, and Black participants (see Supplementary Tables S4–S6).

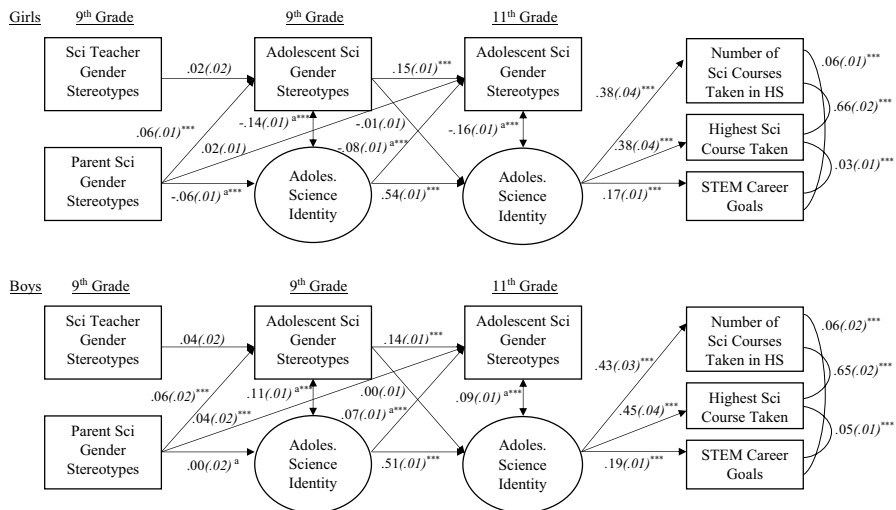


Fig. 2 Science Model. Note ^aSignificant path difference between girls and boys. *** $p < .001$. Sci = Science, Adoles. = Adolescent. Paths unstandardized. Controlling for: 8th grade math grade, standardized math test score, SES, and underrepresented minority status throughout the model. Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSL:09), Base Year, First Year Follow-Up, and High School Transcripts

3.3.1 Hypothesis 2: relations between parent and teacher stereotypes and adolescent stereotypes

As expected, we found that parent math gender stereotypes positively predicted 9th graders' math gender stereotypes. Parent math stereotypes predicted 11th grade gender stereotypes for both genders. Additionally, math teacher gender stereotypes significantly predicted boys, but not girls, math gender stereotypes (paths for boys and girls were significantly different from each other; $z = .06, p = .018$). As expected, we found that parent science gender stereotypes positively predicted 9th graders' science gender stereotypes. Unlike math, science teacher gender stereotypes did not predict adolescents' 9th grade science gender stereotypes for either gender. Finally, parent science stereotypes predicted adolescents' 11th grade gender stereotypes for boys (but not girls).

3.3.2 Hypothesis 3: relations between parent and adolescent gender stereotypes and identity

Parent and adolescent math gender stereotypes significantly related to 9th grade math identity. Both pathways differed significantly by gender (parent stereotypes: $z = .12, p \leq .001$; 9th grade adolescent stereotypes: $z = .26, p \leq .001$). Girls were likely to have lower math identities relative to their peers when they and their parents stereotyped males as better math. In contrast, boys were likely to have higher math identities when they and their parents stereotyped males as better at math.

Math identity in 9th grade significantly predicted relative changes in math gender stereotypes from 9 to 11th grade; girls with higher math identity in 9th grade were less likely to stereotype males as better at math in 11th grade, whereas boys with higher math identity in 9th grade were more likely to stereotype males as better at math in 11th grade (these paths were significantly different from each other, $z = .30$, $p \leq .001$). In turn, math gender stereotypes at 11th grade significantly was related to math identity in 11th grade, even after controlling for 9th grade math identity. This significantly differed by gender; boys who viewed males as better were likely to have higher math identities, whereas girls who stereotyped males as better were likely to have lower math identities ($z = .24$, $p \leq .001$).

Adolescent science gender stereotypes were significantly related to 9th grade science identity, and parent science stereotypes predicted girls' science identity. Both pathways differed significantly by boys and girls (parent stereotypes: $z = .06$, $p = .004$; 9th grade adolescent stereotypes: $z = .25$, $p \leq .001$). Girls' science identity was lower whereas boys' science identity was higher when parents and adolescents stereotyped males as better at science. Adolescents' science identity in 9th grade significantly predicted their science gender stereotypes in 11th grade. Girls with higher science identities in 9th grade were less likely to stereotype males as better at science in 11th grade; the opposite relation emerged for boys where a higher 9th grade science identity strengthened their traditional science gender stereotype (creating a significant difference between these paths; $z = .15$, $p \leq .001$). In turn, science gender stereotypes at 11th grade were related to science identity in 11th grade, even after considering 9th grade science identity. This significantly differed for girls and boys ($z = .27$, $p \leq .001$); like before, the relation between gender stereotypes and identity was negative for girls and positive for boys.

3.3.3 Hypothesis 4: math and science identity and indirect effects from gender stereotypes to academic outcomes

For both genders, math identity in 11th grade significantly predicted adolescents' overall number of courses taken in high school, highest math course taken, and 11th grade STEM career goals. Finally, there were significant indirect effects from gender stereotypes in 11th grade to academic outcomes via 11th grade math identity for math courses taken ($z = .02$, $p \leq .001$), highest level of math course taken ($z = .04$, $p \leq .001$), and future STEM career goals ($z = .03$, $p = .002$). However, after controlling for 11th grade gender stereotypes, 9th grade gender stereotypes did not significantly predict 11th grade math identity or other outcomes.

Parallel to the math findings, science identity in 11th grade significantly predicted adolescents' overall number of courses taken in high school, highest science course taken, and 11th grade STEM career goals. Finally, there were significant indirect effects from 11th grade gender stereotypes to academic outcomes via math identity in 11th grade for total number of science courses taken ($z = .02$, $p = .03$), highest level of math course taken ($z = .02$, $p = .03$), and future STEM career goals ($z = .02$, $p = .046$). However similar to math, after controlling for 11th grade gender stereotypes, 9th grade gender stereotypes did not significantly predict 11th grade science identity.

4 Discussion

Stereotyping one gender as better than the other at math or science may affect adolescents' identity in that subject. Girls especially may be negatively affected due to cultural stereotypes that males are superior to females in math and science. This study had three primary research questions: (1) What is the prevalence of math and science gender stereotypes among high school adolescents and their parents and teachers, and do adolescent stereotypes become more traditional from 9 to 11th grade? (2) Do parents' and teachers' math and science gender stereotypes positively relate to adolescents' stereotypes? (3) What is the relationship between adolescent gender stereotypes, identity, and academic outcomes over the course of high school?

We found that adolescents' gender stereotypes became more traditional from 9 to 11th grade, but that a majority of students endorsed the belief that girls and boys are equally good at math at both grades. Additionally, parents' math and science gender stereotypes (but for the most part, not teachers' stereotypes) significantly and positively related to adolescents' gender stereotypes about math and science, and in some cases adolescents' math and science identity. As expected, adolescents' math and science gender stereotypes had a bi-directional relation with their math and science identity and had indirect effects on overall high school outcomes such as total number of math and science courses taken and STEM career goals. However, after accounting for 11th grade gender stereotypes, 9th grade gender stereotypes did not have a significant relationship with 11th grade math and science identity.

4.1 Stereotype prevalence and change

Overall, parents had the most traditional stereotypes, with 28% endorsing the traditional stereotype that males are better than females at math and 21% endorsing that males are better in science. In comparison, 11% and 7% of parents said that females are better at math and science, respectively—this is especially interesting, given that girls on average had significantly higher math grades than boys in the sample in 8th grade. Teachers had the least traditional stereotypes, and adolescents were also fairly gender egalitarian in 9th grade. About half of adolescents at both 9th and 11th grade reported they believed both genders are equally good at math and science. In 9th grade, about one fifth of adolescents said males are better at math/science, and a fifth said females are better. Girls were more likely to say females are better and boys were more likely to say males are better. This self-serving bias is similar to what prior research has found among younger children (e.g., Kurtz-Costes et al. 2014; Plante et al. 2013). However, by 11th grade this stereotype had significantly shifted towards the traditional stereotype that males are better at math (26%) and science (23%). This increase was significant, although effect sizes were small and a majority of students endorsed the belief that both genders were equal.

Adolescent stereotype means by 11th grade were similar to parent means, indicating that late high school may be an important developmental period for starting to endorse traditional stereotypes that may persist into adulthood. Our prevalence findings were most similar to two other studies conducted with high school and college

age students (Hargreaves et al. 2008; Steffens and Jelenec 2011). However, we found slightly higher traditional stereotype endorsement than most previous work. This may be due to multiple reasons. First, we examined math/science gender stereotypes among adolescents, while most prior studies have been done with students in grade school or middle school (e.g., Kurtz-Costes et al. 2014). Children may increasingly endorse more traditional gender stereotypes over time as exemplified in our findings (discussed more below). Second, our study was a large, nationally representative U.S. sample. Prior studies have been smaller, and many have been conducted with predominately White U.S. or Western Europe samples.

Our study found that mean level adolescent gender stereotypes significantly increased from 9 to 11th grade (with small effect sizes). Gender stereotypes were relatively unstable from 9 to 11th grade. Changes in gender stereotypes may occur in adolescence given that adolescents have increased exposure to academic stereotypes in the media (e.g., Miller et al. 2019; Steinke et al. 2007) and may also experience more interpersonal bias and discrimination while taking advanced courses (e.g., Musto 2019). Additionally, adolescents have the cognitive skills needed to relate stereotypes to their own identities (Umaña-Taylor et al. 2014) and the desire to do so, given the primary goal of adolescence is identity development (Erikson 1968). The combination of having a heightened interest in personal identity, the cognitive ability to apply group stereotypes to the self, and increased media and interpersonal exposure to academic stereotypes, may result in increases in math and science gender stereotypes from 9 to 11th grade that persist into adulthood.

A final interpretation is that two prior studies among children have found an age by gender interaction when it comes to stereotyping which gender is better at math; when asked whether boys or girls are better, children are more likely on average to say girls, but when asked to compare men and women, children say men are better (Martinot et al. 2012; Steele 2003). This age by gender interaction may occur because girls tend to outperform boys in math classrooms, but men are overrepresented in STEM (Martinot et al. 2012). Our question compared females to males. Given adolescents may be thinking of their own age group when answering the question, it is possible that as adolescents age, they begin to think of themselves more as “men and women” and less as “boys and girls,” thus moving their beliefs towards the traditional gender stereotype that males are better at math and science.

4.2 Associations between adolescent gender stereotypes with teacher and parent stereotypes

Parents' gender stereotypes predicted their child's gender stereotypes whereas, for the most part, teacher stereotypes did not. Few studies have specifically looked at the relation between teachers' and adolescents' gender stereotypes. Two prior studies investigated children's own perceptions of adults' (defined broadly) gender stereotypes and found that they were significantly related to the child's own stereotypes (Kurtz-Costes et al. 2014, 2008). The present study implies that although adolescents' own perceptions of their teachers' gender stereotypes may matter in regard to the adolescents' gender stereotypes (e.g., Kurtz-Costes et al. 2014), 9th grade

teachers' self-reported gender stereotypes are not significantly related to adolescents' gender stereotypes. One limitation is that teachers and students were asked about their gender stereotypes early in the school year, when students may have had limited exposure to their math or science teacher. An exception was that boys' math gender stereotypes were significantly positively related to their math teachers' stereotypes in 9th grade. It is possible that teacher stereotypes were more likely to positively relate to boys' stereotypes (as opposed to girls) given that privileged groups are often more likely to endorse traditional stereotypes (Rowley et al. 2007). However, this does not explain why the same relation was only marginally significant for science gender stereotypes.

Conversely, parents' math and science gender stereotypes were significantly positively related to both boys' and girls' gender stereotypes in both 9th and 11th grade, even after controlling for demographic factors such as race and SES as well as performance factors such as standardized math test scores. Furthermore, parent gender stereotypes were significantly related to math identity for girls and boys and science identity for girls. This implies parents' stereotypes are important factors in the development of their child's math and science gender stereotypes and identity, even as late as 11th grade. These findings further support prior research that has highlighted the importance of parents for adolescents' academic-related beliefs and identities (e.g., Simpkins et al. 2015; Simpkins et al. 2012; Simpkins et al. 2020; Sota-Lara and Simpkins 2020).

4.3 Math/science gender stereotypes, identity, and academic outcomes

As expected, we found that adolescents' stereotypes predicted their math and science identity, and in turn, their math and science coursework and STEM career goals. This study was novel in that it longitudinally investigated math and science gender stereotypes and correlates at an older age (high school) when compared to most other studies with children. Findings were similar to other studies among Italian 6–8th graders (Passolunghi et al. 2014) and French 6th and 8th graders (Plante et al. 2013) which found that gender stereotypes were related to adolescent expectancy and value beliefs. Unlike Kurtz-Costes and colleagues' (2008) work among U.S. 4th–8th graders which only found a significant relationship between stereotypes and competence beliefs among boys, we found significant relations between stereotypes and identity among girls as well as boys. These differences may have occurred due to age differences or different outcome variables (competence beliefs vs. identity).

Unexpectedly, we did not find that 9th grade gender stereotypes predicted 11th grade math and science identity after controlling for 11th grade gender stereotypes. One reason for this may be that adolescent gender stereotypes changed quite a bit from 9 to 11th grade over large 2-year time span. Adolescents' concurrent beliefs about stereotypes in 11th grade may relate to their math and science identities more in 11th grade than past beliefs about which gender is better at math and science. In contrast, 9th grade math and science identity (which was relatively stable from 9 to 11th grade) had a significant relationship to 11th grade gender stereotypes. Rather

than gender stereotypes informing students' identity, adolescents may use their own identity and self-perceptions to inform their stereotypes about which gender is better at math and science. Thus, an alternative explanation may be that rather than math and science gender stereotypes influencing gender gaps in STEM identity, group differences between males and females in STEM identity (and other motivational beliefs) may contribute to stereotyping males as better at math and science (e.g., "I'm a girl, I'm not good at math, therefore girls are not good at math"). Both interpretations are not mutually exclusive, and due to cultural stereotypes girls may be more likely to fall back on traditional stereotypes if they feel they are not good at math.

4.4 Practical implications

Our findings have several practical implications for teachers and parents. First, parents own gender stereotypes relate to their children's gender stereotypes and math/science identity, even as late as 11th grade. Parents' gender stereotypes were significantly related to adolescent stereotypes at both 9th and 11th grade, as well as math and science identity (in comparison, teachers' stereotypes were only related to boys' math gender stereotypes in 9th grade). Parents and teachers should try to counteract increases in traditional stereotype endorsement across high school. Interventions, such as fostering growth mindset in the classroom (e.g., Romero et al. 2014), and conducting interventions aimed specifically at reducing gender stereotypes (e.g., Master et al. 2017) may help prevent adolescents from stereotyping males as better as they get older and are exposed to more academic gender stereotypes in the media and classrooms. However, it is also important to note that at least explicitly, a majority of teachers, parents, and adolescents viewed females and males as equally good at math. People may be less likely to endorse the stereotype that males are superior in math when compared to other subjects such as engineering and computer science (Cheryan et al. 2017).

4.5 Future directions and limitations

This study has several limitations, which may give other researchers ideas for future directions. First, we investigated explicit, but not implicit, stereotypes. Implicit stereotypes (or associations) may be more strongly related to identity and outcomes than explicit stereotypes (e.g., Cvencek et al. 2011). Explicit stereotypes are more limited in that they are subject to reporting bias and social desirability; i.e., some adolescents, parents, or teachers may believe that males are better than females at math or science but not wish to admit so on a survey. Additionally, our stereotypes measure was limited to one question based on ability. Adolescents and socializers may believe that males and females have equal abilities but hold other stereotypes that are limiting to girls and women such as the stereotype that females are less suitable for careers in STEM (Cheryan et al. 2015), are less interested in STEM (Master and Meltzoff 2016), or that to be successful in STEM you have to be a genius (which is often viewed as incongruent with women and girls) (Cheryan et al. 2015; Starr

2018; Starr and Leaper 2019). Furthermore, our stereotype and identity questions asked generally about science and math. Math and science incorporate a variety of courses and domains. Some of these domains are male dominated (e.g., computer science) while others are more gender balanced (e.g., chemistry) (Cheryan et al. 2017). Future work might ask more specifically about gender imbalanced fields, which might be more gender stereotyped (Master et al. 2017).

Finally, effect sizes were often small, and we can only speculate based on prior work why stereotyping males as better at math and science increases across high school. Future studies might investigate this finding further, perhaps qualitatively or by looking at classroom practices. Additionally, future studies might investigate whether parental gender stereotypes relate to differential math and science support of girls when compared to boys, whether it has different effects based on age (e.g., greater encouragement of boys in advanced math classes), and whether this intersects with ethnicity (e.g., Simpkins et al. 2018).

5 Conclusions

In closing, this study makes important contributions in several areas. First, this study is the first to investigate math and science gender stereotypes among a large, nationally representative U.S. adolescent sample. We find that although most parents, teachers, and adolescents believe that females and males are equally good at math and science, roughly a quarter of parents and 11th graders believe that males are better than females. Furthermore, our study contributes to developmental insights regarding changes in gender stereotypes over time. The traditional stereotype that males are better at math and science increased among adolescents from 9 to 11th grade (although effect sizes favoring males are small). Additionally, we investigated the relations between child stereotypes and parent and teacher stereotypes. At both 9th and 11th grade, adolescent gender stereotypes related to parent gender stereotypes in math and science, but for the most part were unrelated to teacher stereotypes. Furthermore, adolescent gender stereotypes were significantly related to their concurrent math and science identity, and identity in turn related to outcomes like total number of math and science courses taken in high school and STEM career goals. In short, traditional gender stereotypes regarding math and science increase from 9 to 11th grade, and negatively relate to girls' math and science outcomes.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11218-021-09611-4>.

Funding The research was supported by National Science Foundation Grant DRL-1760757 to Simpkins, S. D. (Principal Investigator), & Eccles, J.

Availability of data Data is available via the National Center for Educational Statistics: <https://nces.ed.gov/surveys/hsls09/>.

Code availability R package *laavan* for SEM modeling.

Compliance with ethical standards

Conflict of interest All authors report there are no conflicts of interests.

Ethics approval Use of the data was approved by University of California, Irvine Institutional Review Board under the project name “Family Support of Math and Science: Examining an Untapped Source of Resilience for Diverse High School Students” (protocol HS# 2018-4349).

References

- Aschbacher, P. R., Li, E., & Roth, E. J. (2010). 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. <https://doi.org/10.1002/tea.20353>.
- Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology*, 96(1), 97–109. <https://doi.org/10.1037/0022-0663.96.1.97>.
- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218. <https://doi.org/10.1002/tea.2023>.
- Casad, B. J., Hale, P., & Wachs, F. L. (2017). Stereotype threat among girls: Differences by gender identity and math education context. *Psychology of Women Quarterly*, 41(4), 513–529. <https://doi.org/10.1177/0361684317711412>.
- Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching*, 51(5), 555–580. <https://doi.org/10.1002/tea.21146>.
- Chatard, A., Guimond, S., & Selimbegovic, L. (2007). “How good are you in math?” The effect of gender stereotypes on students' recollection of their school marks. *Journal of Experimental Social Psychology*, 43(6), 1017–1024. <https://doi.org/10.1016/j.jesp.2006.10.024>.
- Chemers, M. M., Zurbruggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, 67(3), 469–491. <https://doi.org/10.1111/j.1540-4560.2011.01710.x>.
- Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, 6, 49. <https://doi.org/10.3389/fpsyg.2015.00049>.
- Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, 143(1), 1–35. <https://doi.org/10.1037/bul0000052>.
- Cross, W. E., & Cross, T. B. (2008). Theory, research, and models. In S. M. Quintana & C. McKown (Eds.), *Handbook of race, racism, and the developing child* (pp. 154–181). Hoboken: Wiley.
- Cundiff, J. L., Vescio, T. K., Loken, E., & Lo, L. (2013). Do gender–science stereotypes predict science identification and science career aspirations among undergraduate science majors? *Social Psychology of Education*, 16(4), 541–554. <https://doi.org/10.1007/s11218-013-9232-8>.
- Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math–gender stereotypes in elementary school children. *Child Development*, 82(3), 766–779. <https://doi.org/10.1111/j.1467-8624.2010.01529.x>.
- Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, 44(2), 78–89. <https://doi.org/10.1080/00461520902832368>.
- Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues*, 46(2), 183–201.
- Eccles, J. S., & Wang, M. T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, 40(2), 100–106. <https://doi.org/10.1177/0165025415616201>.
- Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*. <https://doi.org/10.1016/j.cedpsych.2020.101859>.

- Enders, C. K. (2010). *Applied missing data analysis*. New York, NY: Guilford Press.
- Erikson, E. H. (1968). *Identity: Youth and crisis*. New York, NY: Norton.
- Galdi, S., Mirisola, A., & Tomasetto, C. (2017). On the relations between parents' and children's implicit and explicit academic gender stereotypes. *Psicologia Sociale*, 12(2), 215–238.
- Greenwald, A. G., Banaji, M. R., Rudman, L. A., Farnham, S. D., Nosek, B. A., & Mellott, D. S. (2002). A unified theory of implicit attitudes, stereotypes, self-esteem, and self-concept. *Psychological Review*, 109(1), 3–25. <https://doi.org/10.1037/0033-295X.109.1.3>.
- Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, 66(3–4), 153–166. <https://doi.org/10.1007/s11199-011-9996-2>.
- Hargreaves, M., Homer, M., & Swinnerton, B. (2008). A comparison of performance and attitudes in mathematics amongst the “gifted”. Are boys better at mathematics or do they just think they are? *Assessment in Education: Principles, Policy and Practice*, 15(1), 19–38.
- Holder, K., & Kessels, U. (2017). Gender and ethnic stereotypes in student teachers' judgments: A new look from a shifting standards perspective. *Social Psychology of Education*, 20(3), 471–490. <https://doi.org/10.1007/s11218-017-9384-z>.
- Hsieh, T., Liu, Y., & Simpkins, S. D. (2019). Changes in united states Latino/a high school students' science motivational beliefs: Within group differences across science subjects, gender, immigrant status, and perceived support. *Frontiers in Psychology*, 10, 12. <https://doi.org/10.3389/fpsyg.2019.00380>.
- 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), 1–55. <https://doi.org/10.1080/10705519909540118>.
- Ibrahim, J. G., & Molenberghs, G. (2009). Missing data methods in longitudinal studies: A review. *Test*, 18(1), 1–43. <https://doi.org/10.1007/s11749-009-0138-x>.
- Keller, C. (2001). Effect of teachers' stereotyping on students' stereotyping of mathematics as a male domain. *The Journal of Social Psychology*, 141(2), 165–173. <https://doi.org/10.1080/00224540109600544>.
- Kurtz-Costes, B., Copping, K. E., Rowley, S. J., & Kinlaw, C. R. (2014). Gender and age differences in awareness and endorsement of gender stereotypes about academic abilities. *European Journal of Psychology of Education*, 29(4), 603–618. <https://doi.org/10.1007/s10212-014-0216-7>.
- Kurtz-Costes, B., Rowley, S. J., Harris-Britt, A., & Woods, T. A. (2008). Gender stereotypes about mathematics and science and self-perceptions of ability in late childhood and early adolescence. *Merrill-Palmer Quarterly*, 54(3), 386–409. <https://doi.org/10.1353/mpq.0.0001>.
- Lauermann, F., Tsai, Y., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, 53(8), 1540–1559. <https://doi.org/10.1037/dev0000367>.
- Leaper, C. (2015). Gender and social-cognitive development. In R. M. Lerner, L. S. Liben, & U. Muller (Eds.), *Handbook of child psychology and developmental science*, vol. 2: *Cognitive processes* (7th ed., pp. 806–853). New York: Wiley.
- Leaper, C., & Brown, C. S. (2008). Perceived experiences with sexism among adolescent girls. *Child Development*, 79, 685–704. <https://doi.org/10.1111/j.1467-8624.2008.01151.x>.
- Marcia, J. E. (1994). The empirical study of ego identity. In H. A. Bosma, T. G. Graafsma, H. D. Grotevant, & D. J. de Levita (Eds.), *Identity and development: An interdisciplinary approach* (pp. 67–80). Thousand Oaks, CA: Sage.
- Martinot, D., Bagès, C., & Désert, M. (2012). French children's awareness of gender stereotypes about mathematics and reading: When girls improve their reputation in math. *Sex Roles*, 66(3–4), 210–219. <https://doi.org/10.1007/s11199-011-0032-3>.
- Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, 160, 92–106. <https://doi.org/10.1016/j.jecp.2017.03.013>.
- Master, A., & Meltzoff, A. N. (2016). Building bridges between psychological science and education: Cultural stereotypes, STEM, and equity. *Prospects*, 46, 215–234. <https://doi.org/10.1007/s11125-017-9391-z>.
- McDonald, R. P., & Ho, M. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, 7(1), 64–82. <https://doi.org/10.1037/1082-989X.7.1.64>.

- McGuire, L., Mulvey, K. L., Goff, E., Irvin, M. J., Winterbottom, M., Fields, G. E., et al. (2020). STEM gender stereotypes from early childhood through adolescence at informal science centers. *Journal of Applied Developmental Psychology*. <https://doi.org/10.1016/j.appdev.2020.101109>.
- Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of U.S. draw-a-scientist studies. *Child Development*, 89(6), 1943–1955. <https://doi.org/10.1111/cdev.13039>.
- Musto, M. (2019). Brilliant or bad: The gendered social construction of exceptionalism in early adolescence. *American Sociological Review*, 84(3), 369–393. <https://doi.org/10.1177/0003122419837567>.
- National Center for Education Statistics (NCES). (2019). *High school longitudinal study of 2009 user manuals*. Washington, DC: Institute of Education Sciences. Retrieved from <https://nces.ed.gov/surveys/hsls09/usermanuals.asp>
- National Science Foundation (NSF). (2017). *Women, minorities, and persons with disabilities in science and engineering*. Washington, DC: National Science Foundation. Retrieved from www.nsf.gov/statistics/wmpd/
- Nürnberg, M., Nerb, J., Schmitz, F., Keller, J., & Sütterlin, S. (2016). Implicit gender stereotypes and essentialist beliefs predict preservice teachers' tracking recommendations. *Journal of Experimental Education*, 84(1), 152–174. <https://doi.org/10.1080/00220973.2015.1027807>.
- Passolunghi, M. C., Rueda Ferreira, T. I., & Tomasello, C. (2014). Math–gender stereotypes and math-related beliefs in childhood and early adolescence. *Learning and Individual Differences*, 34, 70–76. <https://doi.org/10.1016/j.lindif.2014.05.005>.
- Patterson, M. M., & Bigler, R. S. (2018). Effects of consistency between self and in-group on children's views of self, groups, and abilities. *Social Development*, 27, 154–171. <https://doi.org/10.1111/sode.12255>.
- Plante, I., de la Sablonnière, R., Aronson, J. M., & Théorêt, M. (2013). Gender stereotype endorsement and achievement-related outcomes: The role of competence beliefs and task values. *Contemporary Educational Psychology*, 38(3), 225–235. <https://doi.org/10.1016/j.cedpsych.2013.03.004>.
- Régner, I., Steele, J. R., Ambady, N., Thinus-Blanc, C., & Huguet, P. (2014). Our future scientists: A review of stereotype threat in girls from early elementary school to middle school. *Revue Internationale De Psychologie Sociale*, 27(3–4), 13–51.
- Romero, C., Master, A., Paunesku, D., Dweck, C. S., & Gross, J. J. (2014). Academic and emotional functioning in middle school: The role of implicit theories. *Emotion*, 14, 227–234. <https://doi.org/10.1037/a0035490>.
- Roulant, K. K., Rowley, S. J., & Kurtz-Costes, B. (2013). Self-views of African-American youth are related to the gender stereotypes and ability attributions of their parents. *Self and Identity*, 12(4), 382–399. <https://doi.org/10.1080/15298868.2012.682360>.
- Rowley, S. J., Kurtz-Costes, B., Mistry, R., & Feagans, L. (2007). Social status as a predictor of race and gender stereotypes in late childhood and early adolescence. *Social Development*, 16(1), 150–168. <https://doi.org/10.1111/j.1467-9507.2007.00376.x>.
- Shanahan, M.-C. (2009). Identity in science learning: Exploring the attention given to agency and structure in studies of identity. *Studies in Science Education*, 45, 43–64.
- Simpkins, S., Estrella, G., Gaskin, E., & Klobardanz, E. (2018). Latino parents' science beliefs and support of high school students' motivational beliefs: Do the relations vary across gender and familism values? *Social Psychology of Education*, 21(5), 1203–1224. <https://doi.org/10.1007/s11218-018-9459-5>.
- Simpkins, S. D., Fredricks, J. A., & Eccles, J. S. (2012). Charting the Eccles' expectancy-value model from mothers' beliefs in childhood to youths' activities in adolescence. *Developmental Psychology*, 48(4), 1019–1032. <https://doi.org/10.1037/a0027468>.
- Simpkins, S. D., Fredricks, J. A., & Eccles, J. S. (2015). Families, schools, and developing achievement-related motivations and engagement. In J. E. Grusec & P. H. Hasting (Eds.), *Handbook of socialization: Theory and research* (2nd ed., pp. 614–636). New York: Guilford Press.
- Simpkins, S. D., Liu, Y., Hsieh, T., & Estrella, G. (2020). Supporting Latino high school students' science motivational beliefs and engagement: Examining the unique and collective contributions of family, teachers, and friends. *Educational Psychology*, 40(4), 409–429. <https://doi.org/10.1080/01443410.2019.1661974>.
- Smyth, F. L., & Nosek, B. A. (2015). On the gender–science stereotypes held by scientists: Explicit accord with gender-ratios, implicit accord with scientific identity. *Frontiers in Psychology*, 6, 19. <https://doi.org/10.3389/fpsyg.2015.00415>.

- Soto-Lara, S., & Simpkins, S. D. (2020). Parent support of Mexican-descent high school adolescents' science education: A culturally grounded framework. *Journal of Adolescent Research*. <https://doi.org/10.1177/0743558420942478>.
- Starr, C. R. (2018). "I'm not a science nerd!": STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly*, 42(4), 489–503. <https://doi.org/10.1177/0361684318793848>.
- Starr, C. R., & Leaper, C. (2019). Do adolescents' self-concepts moderate the relationship between STEM stereotypes and motivation? *Social Psychology of Education*. <https://doi.org/10.1007/s11218-019-09515-4>.
- Steele, J. (2003). Children's gender stereotypes about math: The role of stereotype stratification. *Journal of Applied Social Psychology*, 33(12), 2587–2606. <https://doi.org/10.1111/j.1559-1816.2003.tb02782.x>.
- Steffens, M. C., & Jelenec, P. (2011). Separating implicit gender stereotypes regarding math and language: Implicit ability stereotypes are self-serving for boys and men, but not for girls and women. *Sex Roles*, 64(5–6), 324–335. <https://doi.org/10.1007/s11199-010-9924-x>.
- Steinke, J., Lapinski, M. K., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S. H., & Kuchibhotla, S. (2007). Assessing media influences on middle school aged children's perceptions of women in science using the draw-a-scientist test (DAST). *Science Communication*. <https://doi.org/10.1177/1075547007306508>.
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson.
- Tenenbaum, H. R., & Leaper, C. (2002). Are parents' gender schemas related to their children's gender-related cognitions?, A meta-analysis. *Developmental Psychology*, 38(4), 615–630. <https://doi.org/10.1037/0012-1649.38.4.615>.
- Tobin, D. D., Menon, M., Menon, M., Spatta, B. C., Hodges, E. V. E., & Perry, D. G. (2010). The intrapsychics of gender: A model of self-socialization. *Psychological Review*, 117(2), 601–622. <https://doi.org/10.1037/a0018936>.
- Umaña-Taylor, A. J., Quintana, S. M., Lee, R. M., Cross, W. E., Rivas-Drake, D., Schwartz, S. J., & Seaton, E. (2014). Ethnic and racial identity during adolescence and into young adulthood: An integrated conceptualization. *Child Development*, 85(1), 21–39. <https://doi.org/10.1111/cdev.12196>.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Christine R. Starr PhD in developmental psychology, is a postdoctoral scholar at the University of California, Irvine School of Education. She attained her doctorate at the University of California, Santa Cruz. Her research focuses on STEM motivation and identity among girls/women and other underrepresented students, as well as sexual objectification, stereotyping, prejudice, and discrimination.

Sandra D. Simpkins PhD in developmental psychology, is a Professor at the University of California, Irvine School of Education. Her research addresses positive youth developmental processes, the influence of families and organized activities on those processes, and how these processes vary by social position factors (such as, ethnicity and gender). Her current projects focus on how youth's organized after-school activities support their positive adjustment into adulthood and how families help support adolescents' STEM motivation, activities, and choices.