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The High School Environment and the Gender Gap in Science and Engineering

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Abstract

Despite the striking reversal of the gender gap in education, women pursue science, technology, engineering, and mathematics (STEM) degrees at much lower rates than those of their male peers. This study extends existing explanations for these gender differences and examines the role of the high school context for plans to major in STEM fields. Building on recent gender theories, we argue that widely shared and hegemonic gender beliefs manifest differently across schools so that the gender-specific formation of study plans is shaped by the local environment of high schools. Using the National Education Longitudinal Study, we first show large variations between high schools in the ability to attract students to STEM fields conditional on a large set of pre–high school measures. Schools that are successful in attracting students to these fields reduce the gender gap by 25 percent or more. As a first step toward understanding what matters about schools, we then estimate the effect of two concrete high school characteristics on plans to major in STEM fields in college—a high school's curriculum in STEM and gender segregation of extracurricular activities. These factors have a substantial effect on the gender gap in plans to major in STEM: a finding that is reaffirmed in a number of sensitivity analyses. Our focus on the high school context opens concrete avenues for policy intervention and is of central theoretical importance to understand the gender gap in orientations toward STEM fields.

Keywords

STEM fields, gender gap, high school context, school curriculum, extracurricular activities

INTRODUCTION

Despite the striking reversal of the gender gap in educational attainment (Buchmann and DiPrete 2006; Legewie and DiPrete 2009) and near gender parity in math performance (Hyde et al. 2008), women still pursue science, technology, engineering, and mathematics (STEM) degrees at much lower rates than those of their male peers. Figure 1 illustrates these trends. It shows, on the one hand, how women have made impressive gains in college attainment compared to men; in recent decades, women clearly outnumber men among college graduates. On the other hand, women continue to lag behind in terms of bachelor's degrees awarded in the physical sciences, mathematics, and engineering (illustrated in the graph for different STEM subfields).[1] This gender gap in STEM degrees has negative implications for

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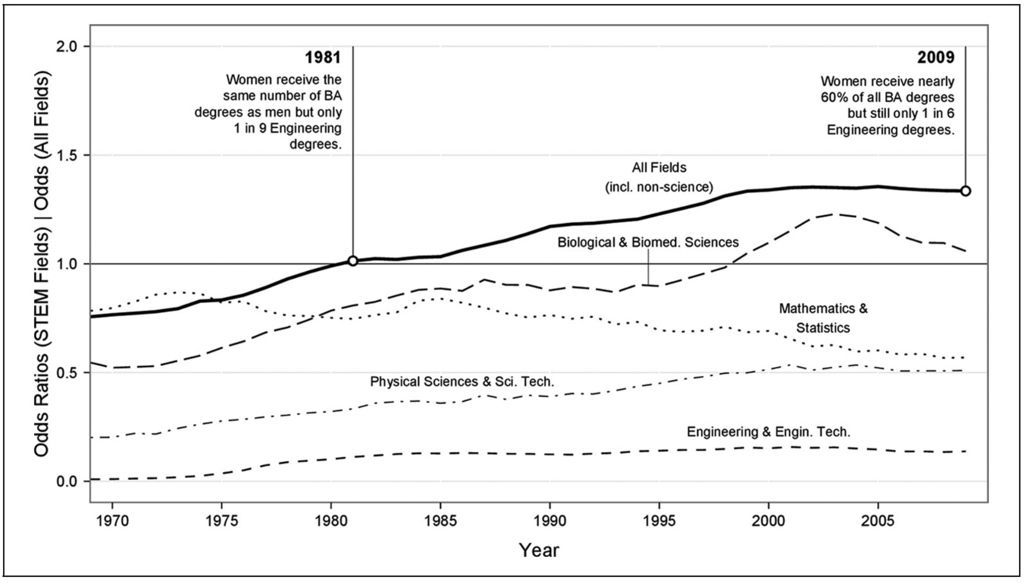

Figure 1. Gender gap in bachelor's degrees awarded by field of study, 1969–2009.
Source: Digest of Educational Statistics (2009:Tables 268, 299, 303, 305, 312, and 313).
Note: The trend line for all fields shows the odds that a BA degree is awarded to a woman, and the lines for the different subfields show the female/male odds ratio for the respective STEM field.

the supply of qualified labor in science and engineering and for closing the gender gap in earnings.

Now that women and men graduate from high school with equal preparation for science careers (Buchmann and DiPrete 2006; Buchmann, DiPrete, and McDaniel 2008), many researchers have shifted to concentrate on college as the decisive life-course period for explaining the gender gap in STEM degrees. Yet research finds that boys and girls develop different occupational orientations during early childhood, which are highly consequential for later career choices (Tai et al. 2006). Along the same lines, a recent study shows that the high school years are actually more important than the college years in determining the size of the gender gap in STEM degrees (Legewie and DiPrete 2014). In this article, we focus on the role of the high school context for gender differences in orientations toward STEM fields that begin to emerge in early childhood. In particular, we build on recent gender theories to argue that the gender-specific formation of study plans is shaped by the local environment of the high school. The literature underappreciates that widely shared gender beliefs manifest inside the high school context to varying degrees through the influence of peers and teachers, the level of exposure to information about STEM fields and occupations, and other factors. Based on this argument, we hypothesize that the gender gap in plans to study STEM fields at the end of high school varies across schools conditional on pre–high school performance, math and science interest, and aspirations for a STEM career.

To evaluate this argument, we first estimate the overall effect of high schools on students' development of intentions to study science and engineering at the end of high school, based on the National Education Longitudinal Study (NELS) (Curtin et al. 2002). While data limitations prevent a definitive analysis of the sources of variation in the local environment effect, we take a productive, even if preliminary, step in this direction by estimating the effect of two concrete high school characteristics on plans to major in STEM fields in college: a school's curriculum in STEM and gender segregation of extracurricular activities. The findings are reaffirmed in a number of sensitivity analyses based on a pretreatment measure of the outcome variable and as a simulation of unobserved confounders. Our results on the importance of the local high school environment not only open concrete avenues for policy intervention but also are of central theoretical importance to our understanding of the gender gaps in orientations toward STEM fields and graduating with STEM degrees from college.

EXPLANATIONS FOR THE PERSISTING GENDER GAP IN STEM DEGREES

The persisting gender gap in STEM degrees has motivated a growing literature on the causes and consequences of this gap. Recent research on gender differences in math ability shows that the gap in math performance (Hyde et al. 2008) and course taking (Xie and Shauman 2005) has largely closed: Girls' performance on math tests is very similar to that of boys, girls take at least as many math classes in high school as do boys, and their classes are at a similar level of rigor (Lee, Grigg, and Dion 2007). Debate persists around findings that boys are more likely to fall on the extremes of the performance distribution in standardized mathematics tests (Ellison and Swanson 2010; Hedges and Nowell 1995; Lohman and Lakin 2009), but extreme performance involves too few people to plausibly explain the entire gender gap in STEM degrees.

Sociological and social psychological research on the gender gap focuses on explanations based in widely shared gender beliefs and stereotypes that have implications for housework and child-rearing, math and science ability, occupational selection, and career trajectories (Charles and Bradley 2002). The family plans and life-goal explanation suggests that gender differences in values and attitudes are associated with the division of labor in families. Along these lines, a number of studies show that women are more interested in jobs involving people and social interactions, and women emphasize intrinsic, altruistic, and social rewards associated with an occupation. Men, in contrast, are more interested in jobs involving physical objects and abstract concepts, and they place a higher value on extrinsic rewards such as money, prestige, and power (Beutel and Marini 1995; Davies and Guppy 1996; Eccles 2007; Johnson 2002; Konrad et al. 2000). Previous research also finds that a strong desire for a future family life or for family-flexible professions negatively influences the selection of science and engineering majors (Frome et al. 2006; Ware and Lee 1988). Gender gaps in work and family values, however, are not sufficient to explain the gender gap in STEM fields (Mann and DiPrete 2013).

A second prominent explanation focuses on gender-biased self-assessment of career-relevant tasks. According to expectation states theory, gender stereotypes include status beliefs that attach greater competence in valued skills to the advantaged status (Correll 2001; Ridgeway 2001). As a consequence, women have lower self-assessment of the tasks and skills relevant for a profession, such as mathematics in the case of engineering, conditional on their actual performance. This lower self-assessment makes it less likely women will choose and persist in male-dominated professions. More recently, Cech and colleagues (2011:642) shift the focus from self-evaluation of career-relevant skills to professional role confidence, which they define as "individuals' confidence in their ability to fulfill the expected roles, competencies, and identity features of a successful member of their profession." This literature identifies social psychological factors that contribute significantly to the gender gap in fields of study and degree completion, and thereby highlights the need to understand how these factors are stimulated, strengthened, or challenged by the sociocultural environment.

High School Context and the Formation of Educational and Occupational Plans

Some existing research has implications for the role of the high school context, but most of the literature builds on the explicit or implicit assumption that gender beliefs and stereotypes in the sociocultural environment are widely shared. Accordingly, previous research does not explicate whether and how the local context, in addition to widely shared gender beliefs, shapes the gender gap. Here, we argue that school environments can influence the salience of gender in career-relevant decisions and thereby widen or narrow the gender gap in STEM orientations. Students enter high school with gendered presumptions of competence, appropriate jobs, and self-conceptions such as "emotional" or "people-oriented." From a decision-making perspective, these factors all influence the choice of college majors, such as a girl's determination of whether she is interested in math and science as a field of study (Cech 2013; Charles and Bradley 2009). But these prior conceptions are not fixed. They "change over the life course in reaction to individuals' structural and cultural circumstances" (Cech 2013:753) so that career-relevant decisions arise from a combination of these prior beliefs about the suitability of math and science for girls and the experience girls obtain in high school. These high school experiences differ in terms of the salience of widely shared gender beliefs. This argument is based on recent gender research that emphasizes how widely shared gender beliefs, such as stereotypes about appropriate occupations or status expectations, are enacted in local interactions and manifest differently in everyday interactions (Deutsch 2007). Ridgeway and Correll (2004:510) argue that the core aspects of gender, or the gender system, are "widely shared, hegemonic cultural beliefs about gender" and local interactions (or what the authors call *social relational contexts*) in which these gender beliefs are evoked, enacted, and ultimately reproduced in a self-fulfilling manner. While this perspective highlights that many gender beliefs are widely shared, it simultaneously points at the importance of the local context. As an example, Ridgeway and Correll (2004) refer to the sex composition of student-teacher interactions, which can implicitly evoke gender beliefs and influence role enactment and performance evaluation. From this perspective, the high school context matters as a social situational context in which widely shared beliefs about gender are challenged or reinforced.

Based on this argument, we contend that schools—as a context that structures many relevant interactions with peers, teachers, and others—can influence the salience of gender in career-relevant decisions and thereby narrow the gender gap in STEM orientations. A number of recent studies highlight the potential importance of the high school context for the gender gap in other educational outcomes. Legewie and DiPrete (2012a), for example, argue that peers in school foster or inhibit the development of antischool attitudes and behavior among boys. They document large variations in the gender gap in test scores across schools and show that peer socioeconomic status, as an important school resource, has a markedly different effect on boys than on girls (see also Legewie and DiPrete 2011). Recent research found evidence that all-boys high schools in South Korea increase the level of boys' interest in STEM fields but all-girls schools do not have a corresponding effect on the proportion of girls who major in STEM fields in college (Park, Behrman, and Choi 2013). Riegle-Crumb and Humphries (2012) find evidence of variation across course-level contexts in regard to high school teachers' bias in the assessment of boys' and girls' math ability.

This research supports the argument that schools can influence the role of gender in educational outcomes. Gender always plays an important role in adolescents' lives, but some environments foreground gender and magnify its influence, while others put gender further in the background and diminish its influence. This process can occur through peers' or teachers' actions, use of certain instruction methods, or a school's organizational characteristics, such as gender segregation of extracurricular activities. As a consequence, the high school experiences that influence career-relevant decisions either corroborate or challenge gendered presumptions of competence, appropriate jobs, and self-conceptions. Accordingly, factors at the center of previous explanations—life goals, family plans, and self-assessment—play out differently across contexts because widely shared cultural beliefs about gender are more salient in some schools than in others. Based on this argument, we expect to find differences across high schools in the extent to which young men and women differ in their formation of plans to major in STEM fields when in college, conditional on their pre–high school preferences.

Stated in this form, our hypothesis emphasizes the importance of the school context for the gender gap in the formation of study plans. Similar to the literature on school and teacher effects, however, it does not explicate the concrete characteristics that are behind this influence. As a productive, even if preliminary, step to elaborate this argument, we connect the influence of the high school context to two concrete high school characteristics: a high school's curriculum in math and science and gender segregation of extracurricular activities. As argued earlier, decisions about college majors arise from a combination of prior beliefs about the suitability of math and science and experiences in classes and other academic activities. When girls (and boys) have more opportunities to evaluate their math and science interest and competence in advanced math and science courses, these actual experiences will offset prior beliefs about gender differences and reduce the gender gap in interest and plans to study STEM fields in college. A strong *high school curriculum* *in math and science* provides more opportunities for concrete experiences of interest and competence and thus provides a partial antidote to gender stereotyping and the discouragement of girls' interest in STEM fields. Accordingly, the professional orientation of such high schools and the experiential knowledge inherent in a strong STEM curriculum should lead to a reduced gender gap in STEM orientation during high school.

Along the same lines, *gender segregation of extracurricular activities* has the potential to reinforce gendered preconceptions about appropriate jobs and raise the salience of gender in estimates of one's own competence and interest in STEM fields. Strong gender segregation of extracurricular activities, with girls' participation organized around female-typed activities (e.g., cheerleading) and boys' participation organized around male-typed activities (e.g., American football), foregrounds gender and magnifies a local cultural emphasis on gender difference, gender relevance, and gender homogeneity. This emphasis may influence the salience of gender in a variety of ways, including affecting students' aspirations for occupational careers. Accordingly, in such contexts gender typing of STEM fields is stronger because gender typing of activity in general is stronger. Gender-integrated extracurricular activities, in contrast, mitigate established stereotypes about gender differences. A de-emphasis on gender as a basis for making choices about interests and activities may push gender to the background and diminish its influence on the formation of aspirations for occupational careers. This argument does not focus on individual components of the extracurricular environment, such as baseball teams or cheerleading, but rather on the overall level of segregation. Similar to early arguments by Coleman (1960) about the role of interscholastic athletics for the learning orientation in student culture, our argument emphasizes how broader extracurricular activities can shape the relevance of gender in student culture. Eder and Parker's (1987) study on the reproduction of gender supports this argument: Focusing on a working-class middle school, the authors show how athletic-related activities influence the gendered culture of boys and girls.

Overall, our argument is based on the idea that gender beliefs or stereotypes can be intensified or mitigated through experiences in high school so that factors at the core of previous explanations—life goals, family plans, and gender-biased self-assessment—play out differently across schools. A strong high school curriculum in math and science and gender segregation of extracurricular activities are two factors that influence this process. Accordingly, we expect that these two concrete characteristics of high schools affect the gender gap in plans to major in STEM fields.

DATA AND METHODS

Our analyses are based on two special samples from NELS and use plans to major in STEM fields at the end of high school as the principal outcome variable. The National Center for Educational Statistics (NCES) has fielded more recent longitudinal education surveys, but NELS has the unique advantage of beginning with eighth-grade students and thereby containing a rich set of pretreatment (i.e., pre–high school) control variables. These pre–high school control variables allow us to address selection issues more directly than would be possible with a more recent dataset, such as the NCES Education Longitudinal Study. This advantage is especially important in analysis of school effects because weaker designs are vulnerable to finding apparent evidence of school effects that is actually a consequence of the confounding effects of nonrandom assignment of students to schools (Legewie 2012).

The original NELS respondents (NELS 88-2000) were first interviewed in 1988. Many of these respondents were followed until 2000, when they graduated from high school and entered the labor force or pursued postsecondary degrees. In addition to this main sample, NCES created two restricted-use special samples that offer important advantages for our analytic goals. NELS 88-92 includes the full eighth-grade sample of NELS, which is a much larger sample than NELS 88-2000.[2] The NELS 88-92 sample does not, however, generally include a large number of students per high school because eighth-grade students in the same school typically transition to more than one high school. The NELS High School Effectiveness Study (HSES) addresses this problem. As an independent component of NELS, HSES extends the sample of students in a subset of 250 high schools in the first follow-up in 1990 so that these schools have a sufficiently large number of students per school to support our analytic strategy. In contrast to NELS 88-92, however, HSES does not include pre–high school information.

Table 1. Sample Characteristics

	NELS		Full HSES Sample		Combined HSES Sample	
Variable	Female	Male	Female	Male	Female	Male
High school variables (12th grade)						
Plans to major in STEM fields	0.07	0.17	0.06	0.15	0.07	0.15
Math test score	52.18	53.28	51.01	52.24	51.26	52.74
Reading test score	53.12	51.04	52.67	51.08	52.36	50.88
Middle school variables (8th grade)						
Occupational aspirations	0.04	0.1			0.03	0.11
Math test score	52.84	53.42			51.96	53.61
Reading test score	53.52	51.53			52.57	51.22
Observations	5,760	5,510	4,700	4,420	1,150	1.200
Schools	930		230		200	
Average students per school	12.12		40.18		11.91	
Observations	11,270		9,120		2,350	

Source: Data are from NELS, HSES, and HSES combined with pre–high school information from NELS.
Note: NELS = National Education Longitudinal Study; HSES = High School Effectiveness Study; STEM = science, technology, engineering, and mathematics. These samples use multiple imputation for missing data and exclude dropout students and students who did not participate in all survey waves (base year and first and second follow-up). The difference between female and male students is statistically significant for all of the reported variables across the three samples.

Combining the benefits of the full NELS 88-92 and HSES sample, we construct a third dataset that includes the subset of students in HSES high schools who were part of the base-year NELS interview in 1988. This third sample—the *combined HSES sample*—includes only about a third of the full HSES sample, but it contains a large set of pre–high school control variables and allows us to use aggregated high school–level characteristics from the full HSES sample (most importantly, gender segregation of extracurricular activities).

In all three samples, we restrict our analysis to cases that participated in all survey waves (base year and first and second follow-up), exclude dropout students, and use the appropriate weights provided by NELS. We exclude dropouts because our argument focuses on the role of school context for the gender gap in orientations toward STEM fields. These restrictions reduce the overall sample size to 11,270 for NELS 88-92; 9,120 for the full HSES sample; and 2,350 for the combined HSES sample. Out of these cases, about 30 percent had missing information on at least one variable. We use multiple imputation based on the chained-equations approach to recover missing values. We use auxiliary variables, such as 10th-grade test scores, to improve the imputation. Use of multiple imputation strengthens our confidence in the final results, but we obtained essentially the same results using casewise deletion.

Table 1 presents key characteristics for the three samples with imputed missing values, including gender differences in plans to major in STEM fields, occupational aspirations, and test scores.[3] Across the three samples, we observe pronounced gender differences in preferences for STEM fields and occupations but similar levels of math performance.

Estimating School Effects

Our argument suggests that school context plays an important role for the gender gap in orientations toward STEM fields. Our analyses evaluate this argument in two parts. First, we adopt recently developed methods from the value-added literature and estimate the overall impact of high schools on the development of intentions to study science and engineering at the end of high school. Focusing on the overall effect of high schools allows us to study variations in the extent to which schools attract students to STEM fields and the consequences for the gender gap. Second, we estimate the causal effect of gender segregation of extracurricular activities and schools' STEM curriculum as two concrete high school characteristics.

In both analyses, an unbiased estimation of school effects relies on the conditional independence assumption. This assumption implies that students do not select into schools based on unobservable factors related to major choice; that is, the observed control variables are sufficiently rich so that any remaining unobserved heterogeneity is balanced across schools. Accordingly (and as in all studies based on observational data), a causal interpretation of the estimates hinges on the quality of the control variables (Legewie 2012; Shadish, Clark, and Steiner 2008), which are represented by X_i in the equations here. In contrast to otherwise comparable panel studies, the NELS 88-92 sample includes a comprehensive set of pretreatment variables from eighth grade, including not only standard demographic measures but also eighth-grade orientation toward math and science, the extent to which students report they like math and science, and seven grade point average and test score performance measures for reading, math, and science (for a detailed description of the variables, see Table 2). These variables are high-quality control variables because they are directly related to the selection of students into high schools with strong math and science curricula. A number of recent studies that compare experimental with observational estimates show that such a comprehensive set of pretreatment variables is essential to reduce bias in estimates based on regression or matching methods (Shadish et al. 2008).

To address the possibility that our analyses might still be affected by confounding unobservable variables, even with the pretreatment control variables, we perform two sensitivity analyses based on a pretreatment measure of the outcome variable and a simulation of unobserved confounders. As we will show in greater detail, these sensitivity analyses support the conclusion that our results are accurate causal estimates of the effects of schools and school characteristics on the formation of STEM orientations.

Estimating the Impact of High Schools on Plans to Major in STEM. Let y_i^a and y_i^b be the potential outcomes reflecting student *i*'s major plans for schools *a* and *b* so that the causal effect of placing student *i* in school *a* versus *b* can be described as $y_i^a - y_i^b$. This individual-level causal effect is undefined, so we focus on the average causal effect $y^a - y^b = \mu_a - \mu_b$. To estimate μ_a, we fit the following empirical model:

$$y_{is} = \alpha + X_i\beta + \mu_s + \varepsilon_{is}.$$

This model decomposes the error structure into one component for school effect μ_s and one for the remaining error term ε_{is} that captures unobserved student-level heterogeneity. First, we estimate μ_s with a sufficiently large number of observations per school but a limited set of control variables using the HSES dataset. Then we confirm our findings with the NELS 88-92 dataset that includes the comprehensive set of pretreatment variables from 8th grade but only a relatively small number of students for many of the schools. To address the problem that some schools in NELS 88-92 have a small number of students, we estimate μ_s using empirical Bayes estimates from multilevel models (Gelman and Hill 2007; Raudenbush and Bryk 2002). This approach is similar to the most common method used to estimate value-added models for teacher effects (Kane and Staiger 2008; McCaffrey et al. 2004) and minimizes the mean squared prediction error, particularly for schools with a small number of students. To estimate the size of the gender gap, we extend the model with an additional term for gender and a random slope that captures variations in the gender gap across schools. Formally, the logistic hierarchical regression model used to estimate the overall impact of schools and the gender gap is specified as

$$P(y_{is} = 1) = logit^{-1}(\alpha_s + X_i\beta + \theta_s Female_i + \varepsilon_i),$$

where *i* and *s* are the indices for students and schools. The random slope and random intercept are modeled as $\alpha_s \sim N(\gamma_\alpha, \sigma_\alpha^2)$ and $\theta_s \sim N(\gamma_\theta, \sigma_\theta^2)$, respectively. Here, the school effect μ_s and the gender gap in this effect are the empirical Bayes predictions from this hierarchical model.

In the second step of our analysis, we estimate the effect of the strength of schools' math and science curriculum and gender segregation in extracurricular activities. For this purpose, we reformulate the models so that our estimation strategy focuses on a treatment indicator D_S. Specifically, estimates for the effect of school characteristics are based on logistic regressions with clustered standard errors on the school level and use the same comprehensive set of pretreatment control variables described earlier.

Table 2. Description of Variables

Variable	Description
Outcome variable	
Plans to major in STEM fields	Our coding first uses the filter question, "Do you plan to continue your education past high school at some time in the future?" to determine the people who do not plan to go to college. We then use the intended field of study question to distinguish between STEM and non-STEM fields.
High school treatment indicators	
Math and science curriculum	Index based on advanced placement–level course offering in math and science
Gender segregation	Gender segregation of extracurricular activities measured in terms of the index of dissimilarity for membership in 18 sport and other clubs
Pre–high school control variables	
Gender	0 = female; 1 = male.
Race	Categorical (reference category is white): Asian, Hispanic, black (not Hispanic), white (not Hispanic), Native American
Region-urban	Categorical variable with 12 groups defined by all possible combinations of four large U.S. regions (Northeast, North Central, South, West) and urbanicity of the area (urban, suburban, and rural)
Occupational aspirations	Binary indicator based on occupational aspiration in 8th grade ("What kind of work do you expect to be doing when you are 30 years old?"): 0 = not science or engineering (12 categories such as craftsperson, housewife, business owner, and others); 1 = "science or engineering professional, such as engineer or scientist"
Performance (test scores)	8th-grade reading, math, and science test scores (separate, continuous variables)
Performance (grade point average)	Self-reported English, math, science, and social studies grades from 6th to 8th grade (separate, continuous variables).
Math/science interest	"I usually look forward to mathematics class." "I usually look forward to science class" (four-point Likert-type scale, 8th grade).
Math/science usefulness	"Math will be useful in my future." "Science will be useful in my future" (four-point Likert-type scale, 8th grade).
Math/science extracurricular activities	Three dichotomous indicators (8th grade) for participation in math club, science club, and science fair
Middle school variables	School size, socioeconomic status composition, average STEM orientation, presence of gifted programs for math and science, student-teacher ratio, and school type

Note: STEM = science, technology, engineering, and mathematics. All continuous variables have been standardized for the analysis.

DESCRIPTION OF VARIABLES

Our main dependent variable is expressed intention to study a STEM field in college at the end of high school (12th grade). Previous research shows that one's intended field of study at the end of high school is highly consequential for obtaining a STEM BA degree and particularly for the gender gap in STEM degrees (Legewie and DiPrete 2014; Morgan, Gelbgiser, and Weeden 2013). As such, the intention to major in STEM at the end of high school is an excellent measure to determine the role of the high school context for attracting students to these fields.

Coding of this 12th-grade variable is based on two questions from the NELS 1994 second follow-up survey: the filter question, "Do you plan to continue your education past high school at some time in the future?" and the intended field of study question, "Indicate the field that comes closest to what you would most like to study if you go to school." For the main analysis, we categorize responses into two groups: (1) no college or college without STEM major and (2) college with plans to major in a STEM field. STEM is defined as any science, technology, engineering, or mathematics field, excluding social and behavioral sciences and health work. Online Appendix A (at soe.sagepub.com) contains a detailed list of the different STEM fields. This dependent variable captures the main outcomes—whether students major in STEM—but subsumes two distinct groups that might reflect different underlying processes: selection into college plans and selection into STEM plans (conditional on plans to attend college). To address this issue, we also present results for the subset of students who plan to attend college. Supplementary analyses also distinguish different STEM subfields because there are important differences in their historical trends.

Our focal treatment variables are high schools' curricula in math and science and gender segregation of extracurricular activities. To measure *high school STEM curriculum*, we created an index based on the advanced placement (AP), college- or university-level courses offered at a school. We selected the specific courses based on the eight currently defined STEM AP classes in the United States: biology, calculus (AB and BC), chemistry, computer science, environmental science, different physics classes, and statistics. This definition is based on standards set by the College Board, which sponsors AP classes in the United States.[4] Our focal treatment indicator is the standardized sum index with a mean of 0 and a standard deviation of 1 from the questions that most closely match these eight STEM AP classes offered by the College Board. It reflects the degree to which schools offer a strong STEM curriculum. This curriculum measure is based on the school administrator questionnaire and does not rely on aggregation of student data. To estimate the effect, we can thus use the full NELS 88-92 sample, which includes the comprehensive set of pretreatment variables described earlier.

Gender segregation is measured in terms of the index of dissimilarity. It uses student-reported membership in 18 sport and other clubs, including baseball, basketball, football, soccer, swimming, cheerleading, pom-pom drill team, school orchestra, school play or musical, student government, and yearbook. The main analysis focuses on an index constructed from all clubs, but we also report results from a supplementary analysis based on an index from clubs that are not sport related, such as school orchestra, school play, and student government. The index of dissimilarity is a measure of evenness that captures the extent to which two groups are segregated across clubs. It can be interpreted as the percentage of one group that would have to change club membership to produce an even distribution across the two groups. A value of 1 indicates complete segregation (e.g., all boys participate in baseball, basketball, and football; all girls are in swimming, school play, and academic clubs); a value of 0 indicates an even distribution that corresponds to the distribution of the two groups in the whole population. We calculate the index for all of the 230 HSES schools, with an average sample size of about 40 students per school. The dissimilarity index for school j is defined as

$$D_j = \frac{1}{2}\sum_{k=1}^{K}\left|\frac{n_{jk}^{girls}}{N_j^{girls}} - \frac{n_{jk}^{boys}}{N_j^{boys}}\right|,$$

where j and k are indices for schools and clubs, respectively. n_{jk}^{girls} and n_{jk}^{boys} refer to the number of girls and boys in club k and school j, and $N_j^{\bullet}$ refers to the corresponding overall club membership. To account for uncertainty, we bootstrap the dissimilarity index and use the shrinkage estimator defined in Gelman and Hill (2007:253) for the final statistic. This shrinkage estimator improves the mean squared prediction, particularly for schools with a small number of students, insofar as the index for a particular school is a weighted average of the overall dissimilarity and the estimate for that particular school. Based on this index calculated for all HSES schools, we estimate the effect of gender segregation for the combined HSES sample with students who were also part of NELS 88-92.[5]

Key independent variables are gender, the comprehensive set of pretreatment control variables described earlier, and a number of high school characteristics. Table 2 includes a full list and short descriptions of these variables.

RESULTS

The Overall Contribution of High Schools

We begin with a model estimated on the full HSES sample, with about 9,120 students in 230 schools. The model includes female, a number of standard demographic control variables and categorical indicators for region and urban as independent variables, a random intercept, and a random slope for female at the school level, which allows the effect of gender to vary across schools. The first column in Table 3 presents these results. We see substantial variation in the proportion of students who plan to major in STEM fields across schools. In the average school, about 13 percent of boys report an interest in majoring in STEM fields at the end of high school. In some schools, however, the predicted probability of planning to major in STEM is as high as 20 percent or as low as 9 percent (see *x*-axis in Figure 2A). Second, the estimated coefficients show a substantial gender effect; girls' odds of reporting an intention to study a STEM field in college at the end of high school are about 60 percent (HSES) lower than the odds for boys (the female/male odds ratio is .4, calculated from the coefficients on the log-odds scale reported in Table 3). This gender gap varies substantially across high schools. Specifically, the estimated standard deviation of the random effect on the school level implies a range from 18 to 80 percent in the gap in female/male odds ratios across the middle 95 percent of schools. This variation is illustrated in Figures 2A and 2B, which show the empirical Bayes estimates for the 230 high schools in HSES. The predicted probabilities are clearly related to the size of the gender gap, indicating that schools effective in attracting students to STEM fields are also able to reduce the gender gap.[6]

To purge our estimate of high school effects on the gender gap in STEM orientations from confounding due to nonrandom sorting of students into schools, we next use the NELS 88-92 sample to condition on a large number of eighth-grade orientation and performance measures (the variables are described in Table 2). Similar to value-added models in educational research on the effect of schools and teachers on performance (e.g., Kane and Staiger 2008), the empirical Bayes estimates from these models show the extent to which schools are particularly supportive or unsupportive of a science orientation for girls, net of the school's support for a science orientation for boys.

Table 3 and Figure 2C present results from these models. The estimated standard deviation for school variation is almost identical after pre–high school variables are controlled. Moreover, the remaining variation in effect of the local environment is still substantial and statistically significant. In particular, the estimated random slope from the multilevel model suggests that the gender gap ranges from .22 to .75 for the female/male odds ratio in 95 percent of schools. Figure 2C shows the distribution of the empirical Bayes estimates in the NELS 88-92 sample. Even though the estimated random slope for the variation of the gender effect across schools is similar between NELS 88-92 and HSES, the empirical Bayes estimates do not vary as strongly because of the greater "shrinkage" stemming from the smaller average number of students per school in NELS 88-92. Even with this greater shrinkage, the empirical Bayes estimates from the NELS 88-92 data reveal substantial variation (from .3 to .45 for the female/male odds ratio) in the gender slope across schools. As a comparison, Table 3 also shows results for our third sample, the combined HSES dataset.

Is the High School Effect Lasting, and How Big Is the Effect?

A common argument in the debate over teachers' effect on students' learning is that potential gains in performance abate during the following years (Jacob, Lefgren, and Sims 2010; Rothstein 2010). A similar concern should apply to high schools' effect on boys' and girls' science and engineering orientation. If girls who were enrolled in high schools that were especially good recruiters of girls into STEM orientations were to leak from the science pipeline at higher rates, the school effect would not be an important determinant of the gender gap in STEM bachelor's degrees. In a recent review of interventions to increase girls' interest in science and technology, Hill, Corbett, and St. Rose (2010) note the uncertainty about the long-term effects of these interventions that arise simply from the lack of long-term follow-up data. In this respect, NELS data are attractive because they allow a direct assessment of the durability of high school effects on STEM orientations.

To conduct this assessment, we use the NELS 88-2000 sample and group high schools by the

Table 3. Gender Effect in Science, Technology, Engineering, and Mathematics Orientation across Schools

	HSES (full)		NELS 88-92		Combined HSES	
	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)
Intercept	–1.991***	(0.14)	–1.722***	(0.10)	–2.667***	(0.32)
Female	–0.985***	(0.09)	–1.163***	(0.09)	–0.895***	(0.19)
Control variable						
Standard demographic	yes		yes		yes	
Region-urban	yes		yes		yes	
Pre–high school			yes			
Random effects						
Standard deviation for intercept	0.393		0.403		0.234	
Standard deviation for female	0.424		0.450		0.430	
Log-likelihood ratio chi-square	109.2***		301.9***		35.7***	
p value		0		0		0
Schools	230		1,280		200	
Average students per school	40.18		10.2		11.91	
Students	9,120		11,270		2,350	

Note: HSES = High School Effectiveness Study; NELS = National Education Longitudinal Study. Clustered standard errors are in parentheses. Estimates are based on three samples from NELS and HSES. All three samples use multiple imputation for missing data and exclude dropout students and students who did not participate in all survey waves (base year and first and second follow-up). A detailed description of the control variables is in Table 2. The likelihood ratio test compares the model reported here with a model that omits the random effect for gender and therefore tests whether the effect of female varies across high schools.
***$p < .001$.

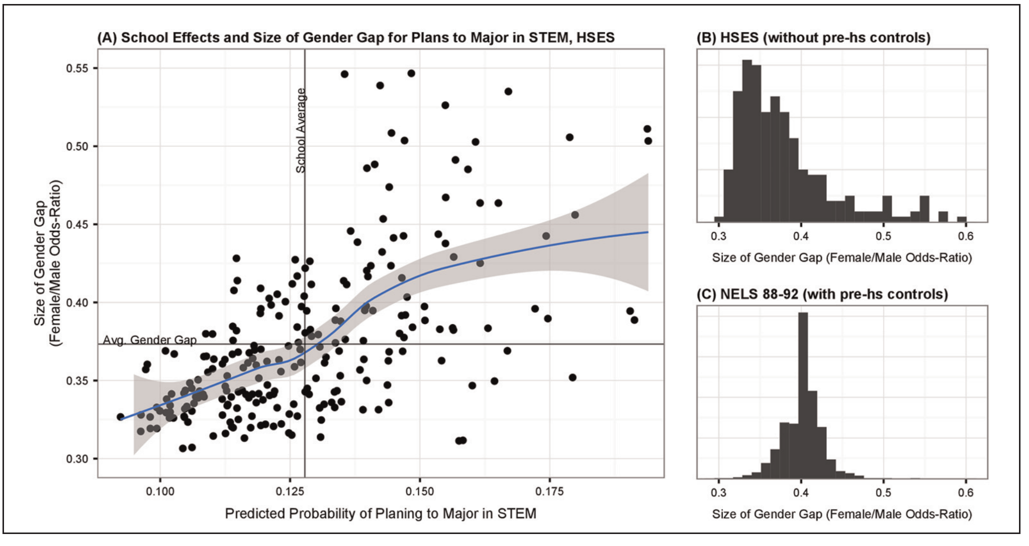

Figure 2. School effects and variation of gender gap in plans to major in science, technology, engineering, and mathematics fields, High School Effectiveness Study and National Education Longitudinal Study 1988-92.
Note: The *y*-axis reports female/male odds ratios so that a value of 1 indicates gender equality and values closer to 1—that is, higher values in this graph—a smaller gender gap.

size of the gender gap in science and engineering orientation. For each group of high schools, we examine the rate at which students change their orientation to a different field (leakage rate), persist in pursuing their STEM major plans (persistence rate), and enter a STEM major without having developed such plans in high school (late entry rate). These results, reported in Online Appendix B, show that post–high school transition rates are remarkably constant across the three samples. In particular, students from high schools that encourage a science and engineering orientation among women do not have higher leakage rates from the science pipeline than do their peers from schools with big gender gaps. This finding suggests that high schools' effect on women's science and engineering orientation is not temporary but endures after high school and ultimately reduces the gender gap in the attainment of STEM BAs.

Building on this finding, we ask how much the gender gap in STEM BAs would be reduced if all schools would encourage women to study science and engineering at the same rate as schools in the bottom tercile of the gender gap. As reported in Online Appendix B, the findings show that the gender gap in STEM BAs would be reduced by about 25 percent if all schools encouraged girls to study science and engineering at the same rates as the top third of schools (from 1.7 male/female odds ratio in the entire sample to 1.3 odds ratio in the subsample of students who attend high schools with a small gender gap). The reduction would presumably be even larger if all schools could achieve the same results as the most gender-egalitarian schools in our sample.

The Effect of High School Characteristics on the Gender Gap in Plans to Major in STEM Fields

The results so far show that, net of science and math orientation in eighth grade, high schools play an important role in shaping students' plans to study in STEM fields. This high school effect is large and durable. It remains unclear, however, which particular high school characteristics explain the considerable variation in the effect across schools. As a first step toward understanding what matters about schools, we estimate the effect of two concrete high school characteristics that on theoretical grounds should affect the gender gap in STEM orientations.

As argued earlier, the strength of high schools' math and science curricula and gender segregation of extracurricular activities should affect the gender gap through separate mechanisms. With a correlation of .351, the two characteristics are modestly related and represent different dimensions of the high school environment. Tables 4 and 5 and Figure 3 present the findings from our analyses (additional sensitivity analyses are discussed in the next section). Note that the models for the two high school variables are based on different datasets. Estimates for math and science curriculum use the full 88-92 sample because the crucial independent variable (STEM curriculum) is from the NELS school questionnaire. Its precision is therefore not affected by the number of student respondents per high school. Estimates for gender segregation, however, use the combined HSES sample because the gender segregation measure is aggregated from student-level data. Its precision is therefore improved by using the sample that contains the largest possible number of student respondents for each school. The combined HSES sample allows us to use the aggregated measure from the full HSES sample together with the comprehensive set of pre–high school control variables that are part of NELS, which is important for minimizing selection bias.

First, we estimate the effect of the strength of high schools' math and science curricula. Table 4 shows a significant positive effect of the curriculum index on intentions to major in STEM fields for girls but not for boys. In particular, the estimated effect (in units of odds ratios) is 1.16 (model II), which implies that a 1 standard deviation change in the curriculum index leads to a 16 percent increase in the odds that a girl develops intentions to major in STEM fields. As a consequence of the gender difference in the effect, the gender gap in STEM orientation narrows in high schools with strong math and science curricula, net of pretreatment controls. Figure 3a illustrates this finding graphically and shows how the predicted probability of plans to major in STEM depends on a high school's math and science curriculum (the graph covers the range between the 1st and 99th percentile). Because schools that have a strong science curriculum plausibly have greater resources and are of higher quality in other regards, one might ask whether our measures are functioning as a proxy for other high school characteristics. Evidence for our interpretation is the fact that the positive effect persists after

Table 4. Logistic Regression Estimates for the Effect of High Schools' Math and Science Curricula

	Model I		Model II		Model III		Conditional on College Plans		Sensitivity Analysis	
	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)
Intercept	–2.650***	(0.054)	–3.243***	(0.232)	–3.356***	(0.737)	–2.991***	(0.243)	–3.745***	(0.285)
Male	1.085***	(0.066)	0.961***	(0.073)	0.977***	(0.074)	0.993***	(0.073)	0.786***	(0.090)
Curriculum index	0.258***	(0.052)	0.145*	(0.057)	0.137*	(0.059)	0.151**	(0.057)	0.056	(0.073)
Curriculum Index × Male	–0.223**	(0.063)	–0.247***	(0.067)	–0.249**	(0.069)	–0.288***	(0.068)	–0.060	(0.084)
Pre–high school control variables										
Standard demographic variables			yes		yes		yes		yes	
Urban/region variables			yes		yes		yes		yes	
8th-grade variables			yes		yes		yes		yes	
High school control variables					yes					
Students	11,270		11,270		11,270		9,010		11,270	

Note: Continuous variables are standardized. Clustered standard errors are in parentheses. Data are from the National Education Longitudinal Study. The sample uses multiple imputation for missing data. It excludes dropout students and students who did not participate in all survey waves (base year and first and second follow-up). Control variables are described in Table 2. The sensitivity analysis replaces the dependent variable with a proxy pretreatment measure of the outcome variable, namely, the eighth-grade occupational aspirations for science and engineering (Imbens 2004).
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 5. Logistic Regression Estimates for the Effect of Gender Segregation of Extracurricular Activities

	Model I		Model II		Model III		Conditional on College Plans		Sensitivity Analysis	
	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)	Coefficient	(Standard Error)
Intercept	–2.957***	(0.162)	–3.050***	(0.450)	–4.030	(2.372)	–2.828***	(0.456)	–3.942***	(2.290)
Male	0.971***	(0.159)	0.540**	(0.182)	0.572**	(0.187)	0.575**	(0.183)	0.869***	(0.230)
Gender Segregation	–0.381**	(0.125)	–0.302*	(0.140)	–0.333*	(0.151)	–0.311*	(0.140)	–0.151	(0.190)
Gender Segregation × Male	0.369*	(0.148)	0.311*	(0.158)	0.303	(0.162)	0.307	(0.160)	0.119	(0.208)
Pre–high school control variables										
Standard demographic variables			yes		yes		yes		yes	
Urban/region variables			yes		yes		yes		yes	
8th-grade variables			yes		yes		yes		yes	
High School Club Membership	yes		yes		yes		yes		yes	
High school control variables					yes					
Students	2,350		2,350		2,350		2,070		2,350	

Note: Continuous variables are standardized. Clustered standard errors are in parentheses. Data are from the High School Effectiveness Study combined with pre–high school information from the National Education Longitudinal Study (combined High School Effectiveness Study sample). The sample uses multiple imputation for missing data. It excludes dropout students and students who did not participate in all survey waves (base year and first and second follow-up). Control variables are described in Table 2. All continuous variables are standardized. The sensitivity analysis replaces the dependent variable with a proxy pretreatment measure of the outcome variable, namely, the eighth-grade occupational aspirations for science and engineering (Imbens 2004).
$*p < .05$. $**p < .01$. $***p < .001$.

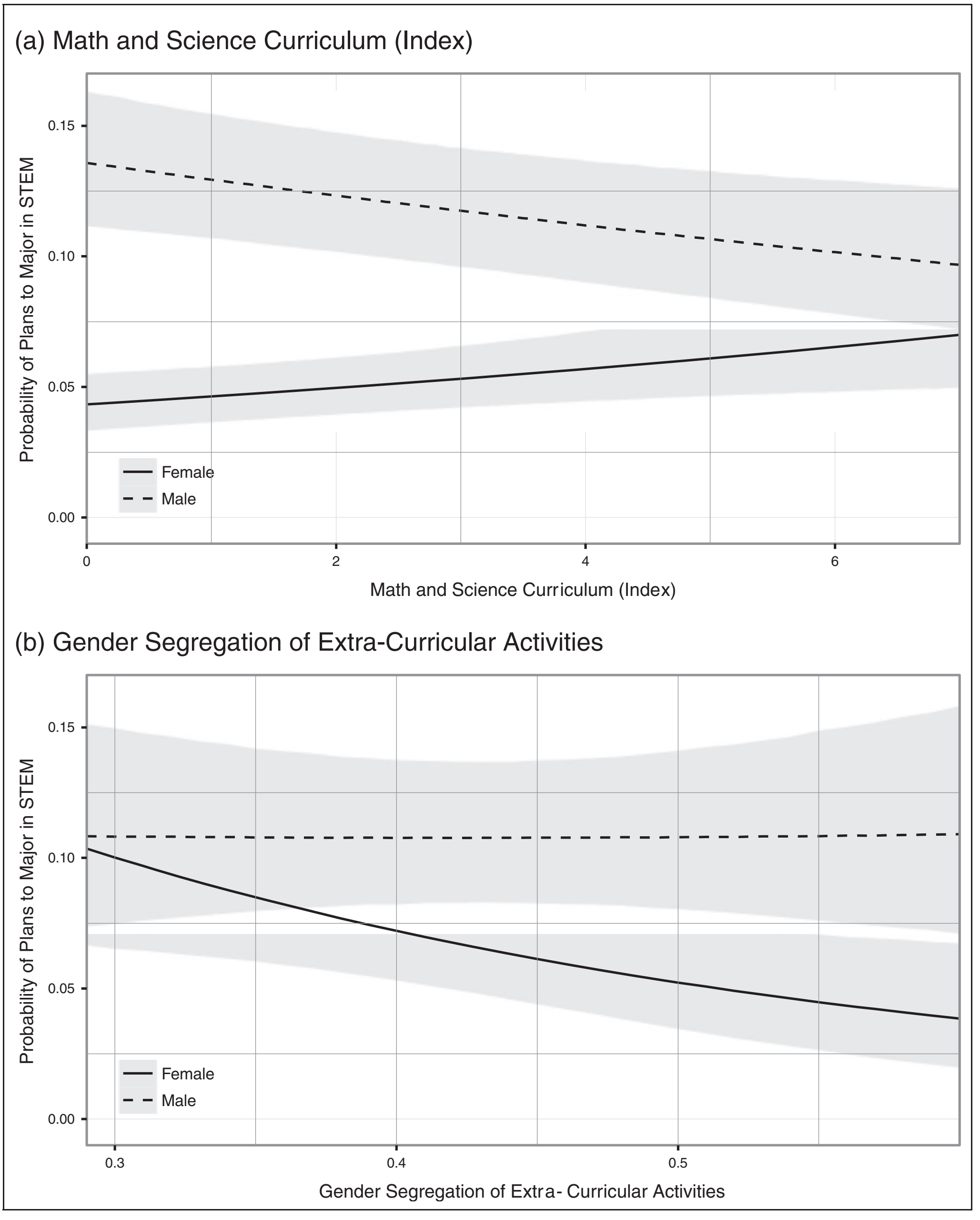

Figure 3. Probability of planning to major in science, technology, engineering, and mathematics by high school characteristics and gender.

controlling for additional high school variables that measure school resources (model III in Table 3).[7] These additional variables include the dropout rate, the proportion of students from different racial backgrounds, the proportion of students who go to college, the attendance rate, the number of college representatives who visit the school, and a number of variables related to teacher salary and teacher-student ratio (a full list is in Table 2).

While the large and statistically significant positive effect of the high school curriculum for girls confirms our hypothesis, we did not expect to find a negative point estimate of the curriculum on boys' behavior (main effect plus interaction) after controlling for the large set of pretreatment control variables. Although the effect for boys is only marginally significant in a regression just for boys, and generally smaller for other definitions of the treatment indicator, it might still be substantively meaningful. One possible interpretation is that boys who overevaluate their own performance in middle school are suddenly confronted with higher-performing peers in STEM-oriented schools, which in the end inhibits them from switching to a STEM orientation. This interpretation is plausible because boys are known to overevaluate their skills compared to girls, but more research is needed to determine whether the negative effect will be reproduced in future studies with data that allow the same quality analysis as the NELS data.

Our dependent variable separates high school students who plan to major in STEM fields in college from all other students, both with and without college plans. This dependent variable captures the main outcome—whether students major in STEM—but subsumes two distinct groups that might reflect different underlying processes: selection into college plans and selection into STEM plans (conditional on plans to attend college). To address this issue, we reestimate model II conditional on plans to attend college, so the sample includes only students who plan to go to college. These findings are presented in Table 4 and closely resemble the previous results, indicating they are not driven by the selection of students into college plans. Instead, the point estimates are slightly larger, suggesting that the strength of high schools' math and science curricula has a significant positive effect on intentions to major in STEM fields *for girls who intend to go to college but not for boys.*

Second, Table 5 presents estimates of the effect of *gender segregation in extracurricular activities* on intentions to major in STEM fields. Consistent with our hypothesis, results show that gender segregation of extracurricular activities has a substantial negative effect on intentions to major in STEM for girls but not for boys. The estimated effect (in units of odds ratios) is .72 (model III), which implies that a 1 standard deviation change on the gender segregation scale leads to a 28 percent decrease in the odds that girls develop intentions to major in STEM fields. Boys, however, are unaffected by this gender segregation (the corresponding effect for boys is 1.008 in terms of odds ratios). Figure 3b illustrates the consequence of this gender-specific effect for the predicted probability of plans to major in STEM, covering the observed range of the segregation index (99 percent of schools fall in the range of values represented on the *x*-axis). In an average school with a gender segregation index of .43, the size of the gender gap is substantial and increases as gender segregation in extracurricular activities becomes larger. The gender difference in the predicted probability of STEM intentions for schools with little gender segregation in extracurricular activities, however, disappears. This result was obtained after controlling for a comprehensive set of pretreatment control variables for STEM orientation, academic performance, and other variables and is stable across different model specifications. As in the last analysis, model III in Table 5 adds a large number of high school characteristics to rule out the possibility that the observed effect is driven by other high school characteristics (a full list is in Table 2). Even after controlling for this large number of high school characteristics, the same pattern persists. We find a similar pattern in a supplementary analysis based on a gender segregation index that excludes sport-related clubs. In particular, the point estimates show a negative and significant effect for girls (the main effect for gender segregation is –.322) and a positive point estimate for the interaction that is marginally significant at the .1 level (.241 with a *p* value of .089). This finding indicates these results are not driven just by sport-related clubs, such as baseball and cheerleading, that are typically fully or nearly fully segregated by gender. Overall, the robustness of our results supports the hypothesis that gender segregation in extracurricular activities plays an important role in shaping girls' interest in STEM fields. As in the analysis for the curriculum index, the dependent variable separates high school students who plan to major in STEM fields in college from all other students. However, Table 5 also includes model II conditional on plans to attend college. These findings are in line with the previous models indicating the results are driven mainly by the selection of college-bound students into STEM fields.

Online Appendix C presents similar models for different STEM subfields. Overall, these results resemble those reported here, although some of the estimated coefficients are not statistically significant. Importantly, the same pattern remains: Gender segregation of extracurricular activities and high schools' math and science curricula play important roles in influencing the size of the gender gap in intentions to major in these different STEM subfields.

Sensitivity Analysis. Although we control for a large set of highly relevant pretreatment control variables, the results of our analyses might still be affected by unobservable variables related to the treatment and the outcome conditional on these variables. We perform two sensitivity analyses to evaluate this problem. First, we estimate the effect of our two treatment indicators on a pretreatment measure of the outcome variable, STEM orientation in eighth grade. This pretreatment measure of the outcome variable *cannot* be causally affected by the treatment and provides a way to indirectly assess the plausibility of the unconfoundedness assumption. If the effect is indeed close to 0 and statistically insignificant, the conditional independence assumption is more plausible (Imbens 2004). A positive effect, on the other hand, indicates that a selection process is at work that invalidates the conditional independence assumption. Results of these regressions are presented in the last columns of Tables 4 and 5. We find that effects are substantially smaller and statistically insignificant in both cases. Accordingly, this sensitivity analysis increases the plausibility of the core assumption, even though we are unable to test it directly. Second, we examine how robust our estimates are to additional unobserved confounders using a method that is an extension of Ichino, Mealli, and Nannicini (2008) for the case of logistic regression. Our findings show that any unobserved confounder has to be relatively large, compared to any of the observed covariates (including such key variables as eighth-grade STEM orientation or eighth-grade math test score), to invalidate our findings. Online Appendix D contains a detailed description of this sensitivity analysis.

CONCLUSION

Despite the striking reversal of the gender gap in educational attainment and the near gender parity in math performance, women still pursue STEM degrees at much lower rates than those of their male peers. Existing explanations of this persisting pattern of gender differences focus on mathematical abilities, beliefs related to gendered expectations about appropriate jobs, considerations about work-family balance, and self-assessment of career-relevant tasks. In this article, we extended these theories and examined the role of high school context for plans to major in science and engineering. In particular, we found considerable empirical support for our argument that high school context plays an important role in the process by which gender differences in plans to major in STEM fields emerge.

Based on data from NELS, our analyses show large variations in the ability of high schools to attract students to STEM fields. Going to a school that supports girls' STEM orientations reduces the gender gap by 25 percent or more, and the school's impact is durable. Despite this sizable reduction, a substantial gender gap remains, even for students who attend schools that are supportive of girls' STEM orientations. This remaining gap, which is net of individual as well as school characteristics, is presumably a consequence of broad gender beliefs about and preferences for majoring in science and engineering that emerge from the widely shared cultural environment. We also found that high schools' curricula in science and math and gender segregation of extracurricular activities have large effects on the gender gap in plans to study STEM fields, and these effects are robust to the subfields we use to define a STEM orientation. While these estimated effects are large, we find, not surprisingly, that these two factors explain only part of the total estimated variations in school effects. These findings provide important, even if preliminary, evidence about the influence of two concrete high school characteristics, suggesting that these and other factors should be the focus of future research with better data on various high school characteristics.

Our findings contribute to a growing body of research that highlights the importance of school context for gender differences in educational outcomes (Legewie and DiPrete 2012a; Park et al. 2013; Riegle-Crumb and Humphries 2012). In contrast to previous work, we focused on the continuing gender segregation by field of study, which extends the theoretical argument and introduces new empirical evidence. Our findings provide an important new interpretation of results in

Legewie and DiPrete (2012a). Legewie and DiPrete (2012a) argue that strong academic cultures have greater effects on the educational attainment of boys than of girls, whereas this article argues that strong math and science curricula have greater effects on the STEM orientation of girls than of boys. A broader theoretical argument reconciles these different results: Supportive peers, or more generally a supportive school environment, are particularly beneficial for the disadvantaged group—boys in the case of work habits and educational performance and girls in the case of STEM interests.

While our focus has been on STEM fields, our results potentially have implications for the broader distribution of majors for both boys and girls, for gender occupational segregation, and even for the gendered character of household work. Simply put, our results suggest that the local environment in which adolescents spend their high school years plays an important role in the strengthening or weakening of gender stereotypes. Similar processes could be at work with respect to gender stereotypes concerning elementary or secondary school teaching or interest in the humanities and the performing arts. Just as some local environments pull adolescent girls away from an orientation consistent with gender stereotypes and toward an interest in STEM fields, the same or other local environments might pull adolescent boys toward an interest in humanities, performing arts, or elementary school teaching. However, gender integration of occupations has occurred more through women's moving into formerly male-dominated occupations than through men's moving into female-dominated occupations, and the trend with respect to college majors has the same qualitative profile. This pattern reinforces other research suggesting that boys are more concerned than girls about violating gender stereotypes. Boys may thus be more resistant than girls to local environments that challenge gender stereotypes. Nonetheless, similar research could be applied to a broader set of life course outcomes, and the results should be highly informative about how variation in the coding of gender in local environments affects the distribution of gender roles and identities in adulthood.

From a policy perspective, our findings point to important directions for research about concrete interventions. Examination of variations across contexts shows that the local context in high school plays an important role for the gender gap in orientations toward STEM fields. As such, our findings not only point at the life course period that should be targeted by policy interventions but also provide evidence that high school interventions might be effective. In light of recent research asserting only a temporary effect from exposure to Head Start programs or to individual above-average teachers (Jacob et al. 2010), it is of considerable importance that the effects of the high school environment on the formation of STEM orientations appear to be durable. Some existing interventions have indeed targeted high school students and shown success in promoting a STEM orientation among girls. Eisenhart (2008), for example, discusses a seemingly effective outreach project that educates high-achieving minority girls in high school about science and engineering jobs. While such policy interventions have to withstand the serious scrutiny of experimental field trials, the evidence presented in this article encourages researchers and policy makers alike to take seriously the potential impact of high school interventions on girls' STEM orientations. Our finding that more intense math and science curricula and less gender segregation in extracurriculars reduce the gender gap in science orientation strongly supports this conclusion.

Our results also have implications for the future trend of gender segregation in STEM fields. Figure 1 shows the increase between the early 1980s and 2005 in biological and biomedical sciences bachelor's degrees obtained by women, as well as women's less dramatic but still notable progress in the physical sciences and science technology bachelor's degrees. During this period, high schools were strengthening their mathematics and science curricula, as measured by the fraction of students who took precalculus or calculus or by the percentage of high school graduates who completed chemistry, physics, or advanced biology (Dalton et al. 2007). The fact that these trends move in the same direction suggests that the expansion of high schools' science curricula may have been one factor increasing the fraction of STEM degrees awarded to women over these years. Our results suggest that the propagation of more supportive local environments would further increase the proportion of women interested in STEM fields.

An important advantage of our study is the comprehensive set of pretreatment control variables together with the sensitivity analysis that allow us to make a strong case for causal inference within the limitations of observational data. This benefit is unique to NELS compared to otherwise similar panel studies because the first survey was conducted in eighth grade, before students entered high school. The downside of NELS is that the dataset is relatively old and the gender gap in educational outcomes has changed over the past two decades. There is good reason to believe, however, that the main empirical point is still valid. In particular, a simple cross-sectional analysis based on the Educational Longitudinal Study (ELS) of 2002 without pretreatment variables (which are not available in ELS) revealed similar variations in the gender gap of plans to study in STEM fields across high schools (a replication of other aspects was not possible because ELS does not include the same set of variables). High schools continue to play an important role in the gendering of educational outcomes.

The present study obviously cannot address all the characteristics of high schools that influence the gender gap. Similar to the state of knowledge about teacher quality, our findings suggest that high schools have the potential to shape the orientation toward STEM fields and suggest that the gender segregation of extracurricular activities and math and science curricula play an important role, but we still know relatively little about other high school characteristics or programs that influence the formation of STEM orientations. Our argument suggests that commonly held stereotypes are strengthened by the lack of adequate information about science and engineering careers in the local environment; conversely, the power of these stereotypes over behavior can be reduced through greater exposure to knowledge about science and engineering through the academic curriculum. Recently, Frank and colleagues (2008) argued that social dynamics play an important role in girls' and boys' propensity to take math courses. Greater efforts to directly measure the strength of gender stereotypes concerning science and other careers might provide particularly valuable information about how the high school environment shapes male and female students' gender identities and career orientations. Future research should investigate these issues in greater depth.

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NOTES

1. Exceptions to this trend are the biological, biomedical, and life sciences, in which women today outnumber men.
2. Only a randomly selected subset of students was followed after high school.
3. In Table 1 and subsequent tables, sample sizes are rounded to the nearest 10 as a requirement of the data license with the National Center for Education Statistics.
4. These advanced placement (AP) classes are nationally standardized with a clear curriculum and exam-based evaluation. The National Education Longitudinal Study school questionnaire in the first follow-up, however, allows school administrators to designate classes in the broader math and science area as "Advanced Placement (AP) Courses" that most probably are not College Board–certified AP courses or university-level math and science courses. Our results are somewhat sensitive to the actual selection of classes for the definition of the treatment indicator. Estimates from separate regressions where each of the 34 courses was used as a dichotomous treatment indicator range from –0.171 to 0.608 (with an outlier at 1.77) for girls (the estimate for the AP course–based index presented in this article is 0.14). Most of these estimates are positive. The single-course dichotomous effects are particularly strong for math classes (including many that are not part of our AP course–based index) and for most but not all of the College Board AP classes.
5. One concern is that gender segregation in activities is fairly standard across schools and largely reflects school size. The correlation between school size and our gender segregation index, however, is modest

at .27. In addition, we reestimated our models with an additional interaction term between gender segregation and school size to examine whether the effect of gender segregation depends on the size of schools. The findings indicate that the effect of gender segregation does not depend on the size of schools (the interaction term is small and statistically insignificant).

6. To facilitate the interpretation, we transformed the commonly reported value-added estimates to predicted probabilities of majoring in science, technology, engineering, and mathematics fields for each school and highlighted the school average with the vertical line in Figure 2A.
7. These additional variables are not pretreatment measures and as such might actually remove part of the high school curriculum effect from our estimate.

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