The Impact of School and Classroom Gender Composition on Educational Achievement*

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Abstract

We estimate the impact of peer gender composition on student achievement, exploiting the random assignment of Korean middle school students to single-sex schools, coeducational schools with single-sex classes, and coeducational schools with mixed-gender classes. Boys attending coeducational schools with single-sex classes perform worse than boys in mixed-gender classes, while those assigned to single-sex schools outperform all other boys. We provide suggestive evidence of teacher specialization in response to school gender composition: teachers in all-male schools adopt stricter discipline and teaching methods, while students increase in-school effort and time devoted to academic activities. Peer gender does not affect female students' outcomes.

JEL codes: I20, I21, J24

Keywords: student achievement, gender, peer effects, single-sex schooling

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1 Introduction

There is great interest in both academic and policy discussions about ways to improve the educational performance of students. Although most inputs in the education production function have not been shown to increase student achievement (e.g., Hanushek 2006), in the presence of nonlinear peer effects, the assignment of students to classrooms and schools provides an additional policy tool. However, identifying the optimal allocation of students across educational settings involves two key challenges. First, in the absence of random assignment, endogenous sorting of students may lead to differences in unobservable characteristics of both students and schools that are correlated with group composition and achievement (e.g., Evans et al. 1992; Manski 1993; Moffitt 2001; Angrist 2014). Second, even when students are randomly assigned to schools and classrooms, within-group interactions may adjust endogenously to group composition (e.g., Carrell et al. 2013) and thus, out-of-sample predictions may deviate from the effect of a given "assignment regime" (Garlick 2014).

In this paper, we focus the role of school and classroom gender composition in the education production function in a setting that allows us to overcome the challenge of endogenous group formation and identify the channels through which peer gender affects achievement. We examine middle school students in the Seoul, South Korea metropolitan area. Within a given school district in Seoul, students are randomly assigned to single-sex schools, coed schools with only single-sex classes, and coed schools with mixed-gender classes. Furthermore, most inputs that would be considered endogenous in other settings, such as curriculum and school funding, are orthogonal to peer gender composition.

Peer gender has significant impacts on male students' achievement. Male students attending coed schools that segregate students into single-sex classes perform the worst, scoring 0.10 of a standard deviation below male students in balanced-gender classrooms. Conversely, assignment to a single-sex school maximizes male students' achievement, with students in all male schools scoring 0.15 of a standard deviation higher than their counterparts in coed classes. The gains male students receive from single-sex schooling do not operate solely through differences in classmates' behavior. Male students randomly assigned to single-sex schools exert more effort in school and substitute leisure time in favor of increasing time spent on academic activities. We provide suggestive evidence that endogenous responses of *teachers* to school gender composition might contribute to male students achievement gains in single-sex schools, with teachers in all-male schools employing stricter teaching and discipline methods.

Our finding that single-sex schools are able to raise male students' achievement is important given the growing gender gap in educational attainment. While female students' test scores, college attendance, and degree receipt have increased in recent decades, young men's academic outcomes have stagnated or even

declined (e.g., Goldin et al. 2006; Fortin et al. 2015).[1] Several papers provide evidence that differences in noncognitive skills can explain a large portion of gender gaps in attainment (Jacob 2002; Becker et al. 2010; Cornwell et al. 2013; Fortin et al. 2015) and that male students' development of noncognitive skills may be more sensitive to parental investments (Bertrand and Pan 2013; Autor et al. 2015).

One explanation for why single-sex instruction benefits male students in single-sex schools while harming them in coed schools is that teachers and schools are able to specialize when they teach only male students. In Korean middle schools, while students remain with their assigned classroom, they are instructed by multiple teachers. Thus, teachers in coed schools with single-sex classes instruct both all-male and all-female classes, limiting their ability to adopt techniques, such as teaching styles and disciplinary methods, that may best serve students of a given gender.[2] We present suggestive evidence in support of teacher specialization: compared to teachers in coed settings, teachers in all male schools are significantly more likely to report using "strict" teaching methods and assign more difficult homework tasks. Male students who likely have the largest deficits in noncognitive skills - sons of single mothers - appear to benefit the most from assignment to a single-sex school. Although a handful of empirical papers provide evidence of general equilibrium effects of changes in the composition of student groups (e.g., Carrell et al. 2013; Garlick 2014; Conley et al. 2015), ours is the first to focus on student gender composition and resulting impacts on teacher behavior. Our findings suggest that, in our setting, teacher specialization can raise achievement by inducing male students to exert more effort towards academic tasks and that the gains from altering classroom gender composition are not zero-sum if single-sex schooling is an option.

Our paper contributes to the extensive literature on within-school gender peer effects.[3] In general, these studies find that both male and female students benefit from more female peers (e.g., Hoxby 2000; Whitmore 2005; Lavy and Schlosser 2011; Lu and Anderson forthcoming).[4] Likewise, our findings contribute to the

[1] Across OECD countries, more women than men graduate high school graduation and enroll in college (OECD 2014). In Korea, 98 percent of men and women between the ages of 25 and 34 in 2012 had graduated from secondary education. In this same group, 62 percent of men and 69 percent of women had attained a postsecondary degree. Among middle school students in our sample, female students earn significantly higher test scores in every subject.

[2] Our results are consistent with those of Ost (2014) and Cook and Mansfield (2014), who provide evidence that gains from teacher specialization exceed the gains from additional general teaching experience.

[3] Sacerdote (2011), Epple and Romano (2011), and Sacerdote (2014) summarize research on peer effects in education.

[4] In the first paper to take advantage of quasi-experimental variation in classroom gender composition, Hoxby (2000) uses within-school, across-cohort idiosyncratic variation in the share of female elementary and middle school students and estimates that students of both genders have lower performance when they have fewer female classmates. Lavy and Schlosser (2011) use both cross-cohort and within-student variation in cohort gender composition and find similar negative impacts of a decrease in the share of classmates that are female. Furthermore, by examining impacts of classroom gender composition on students' own behavior and the behavior of classmates, the authors provide evidence that the positive impact of female-heavy classes stems from a reduction in the probability of disruptive behavior in classes with fewer male students, rather than changes in students' own behavior due to peer gender. Using the random assignment of elementary students to classrooms in the Project STAR experiment, Whitmore (2005) finds that an increase in the share of classmates that are female raises achievement of male and female students, but only in lower grades. Lu and Anderson (forthcoming) examine within-class peer effects in China and find that female middle school students who are randomly assigned to sit near more female students earn higher test scores. The one exception to these findings is Black et al. (2013) , who focus on long-run outcomes and find that female students' adult outcomes benefit from more female classmates in 9th grade, while male students are harmed.

literature examining the impacts of single-sex schooling.[5] A number of recent studies estimate the impact of random assignment to coed and single-sex high schools in Seoul on college entrance exam performance and find positive impacts of single-sex schooling on male students' achievement (Lee and Park 2013, Park et al. 2013, Sohn 2013, Choi et al. 2014, and Ku and Kwak 2015).[6] In contrast, we provide evidence of the mechanisms through which single-sex schools improve male students achievement, by examining impacts on student effort and time use, teacher inputs, and peer effort. We also highlight important differences in the impact of classroom versus school gender segregation by compare students in single-sex schools to those in single-sex classrooms within coed schools. Finally, our focus on middle school students allows for cleaner identification, since high school students must choose a track at the end of their first year - a choice that might be affected by peer gender - and the scoring of college entrance exams is not comparable across tracks.

To our knowledge, ours is the first paper to identify the causal impact of assignment to a single-sex class relative to a single-sex school in a general setting.[7] We show that class- and school-based gender segregation yield significantly different outcomes for male students. In our setting, estimates using variation in the gender composition of coed classes provides an accurate prediction of the negative impact of assignment to a single-sex classroom within a coed school, suggesting that it may be appropriate to use results from existing studies, such as Hoxby (2000), to approximate the impact of single-sex classes. However, our results suggest that estimates from research examining the impacts of single-sex schools will not accurately predict the effect of single-sex classrooms within a mixed-gender school.

The distinction between single-sex schools and single-sex classrooms within coed schools is policy relevant: since the United States Department of Education relaxed restrictions on single-sex education in 2006, public schools have been allowed to separate male and female students into single-sex classrooms and schools. While most of the expansion in single-sex schooling in the U.S. has taken the form of single-sex *classes* within coed

[5]Most similar to our paper's setting, Link (2012) compares the achievement of Korean middle school students enrolled in single-sex and coed schools. The conclusions that can be drawn from such comparisons are limited by the fact that random assignment occurs within school districts, which are not observed in her data.

[6]Park et al. (2013) estimate random and fixed effects models while Choi et al. (2014) estimate school production functions that allow for heterogeneous impacts of single-sex schooling across districts; both studies find a positive impact of single-sex schooling on male students' achievement. Using a fixed effects model, Sohn (2013) finds positive impacts of single-sex schooling for male and female students. Lee and Park (2013) use variation driven by policy changes that led seven single-sex high schools in Seoul to admit female students between 1998 and 2003 and find that transitioning to a coed population led to a reduction in male students' performance. Ku and Kwak (2015) use both cross-sectional and time-series variation in school gender composition for identification. Outside of Korea, Jackson (2012) uses variation in assignment to single-sex secondary schools in Trinidad and Tobago (conditional on demand for single-sex schooling) in a instrumental variables framework. His results suggest that, while the marginal male student does not benefit from attending an all-male school, the marginal female student with strong preferences for single-sex schooling earns higher test scores but takes fewer science courses.

[7]Strain (2013) examines impact of single-sex classrooms in the context of a coed school using variation in the availability of single-sex math and reading classes in North Carolina elementary and middle schools in a differences in differences framework. Although the author estimates significant negative impacts of single-sex classes on achievement for students of both genders, placebo tests indicate a correlation between period t test scores and period $t+1$ treatment, suggesting that the implementation of single-sex classrooms is correlated with unobservable factors that are not fully captured by school, year, and grade fixed effects. Eisenkopfa et al. (2015) examine the outcomes of Swiss students enrolled in a high school specializing in teacher training where female students are randomly assigned to coed and single-sex math classes. The authors find that single-sex math schooling increases female students' achievement when the teacher is male.

schools, almost all studies on single-sex education involve comparisons between single-sex and coed *schools*.[8] In reference to the 2006 policy change, Halpern et al. (2011) assert that "there is no well-designed research showing that single-sex (SS) education improves students' academic performance..." We believe our study fills this gap by providing a nuanced view of the potential benefits of single-sex schooling. Our results suggest that in the context of primary and secondary education, changes in group assignment schemes will not only lead to changes in social interactions between students, but potentially changes in the decisions of teachers and administrators.

The remainder of our paper proceeds as follows: in Section 2, we describe middle schools and students in Korea. Section 3 discusses our data and sample and in Section 4, we describe our empirical approach. We present estimates of the impact of school and classroom gender composition on the achievement of male and female students in Section 5, while in Section 6, we discuss how evidence from survey data on student time use and student, peer, and teacher effort can inform our understanding of the mechanisms through which school and classroom gender composition affects achievement. Section 7 concludes.

2 Setting

We focus on middle school students in the Seoul, South Korea metropolitan area, which provides an ideal setting for identifying the causal effect of peer gender on student outcomes for several reasons. First, due to South Korea's "Equalization Policy", elementary and middle school students in Seoul are randomly assigned to a school in their district.[9] Seoul has 11 school districts, which contain approximately 370 middle schools within its 605 km^2 (234 mi^2) boundaries. Roughly 30 percent of these schools are single-sex, around 7 percent are coed schools that separate all male and female students into single-sex classes, and the remainder of schools are coed with only mixed gender classes.[10] All students in coed schools with single-sex classes are grouped with peers of the same gender. Within coed schools that place students in mixed-

[8] According to the National Association for Single Sex Public Education, an advocacy program for single-sex schooling, as of 2012, over 500 U.S. public schools contained single-sex programs, and close to 400 of these involved single-sex classrooms within coed schools. See http://www.singlesexschools.org/schools-schools.htm for details.

[9] This policy, implemented in the 1970s, was designed to provide a homogeneous educational environment to all South Korean students, and prohibits schools from selecting students, segregating students based on their performance, and deviating from the national curriculum (Kim et al. 2008).

[10] The existence of single-sex schools and coed schools with single-sex classrooms is largely due to historical decisions. Specifically, when universal access to middle school was enacted in 1969, the demand dramatically exceeded the supply of middle schools. Regulations over private middle and high schools were weakened leading to a large expansion in the private provision of middle school education (Bae et al. 2011). Private schools were more likely to be single-sex. As discussed below, during the period we examine, private and public schools are quite similar. It is quite rare for single-sex schools to switch to being coed or vice versa. The only notable exception is the period between 1998 and 2003 when the Seoul superintendent In Jong Yoo promoted coed schooling (Lee and Park 2013). During the period we focus on, one all female school started admitting male students and one all-male school started admitting female students. Additionally, two coed schools with single-sex classes switched to offering coed classes while three coed schools with coed classes switched to offering single-sex classes. We do not find any systematic differences in achievement in the years prior to switching for any schools in these four groups and all of our results are robust to excluding these schools from our sample (available upon request).

gender classes, the random assignment of students to schools and idiosyncratic variation in cohort gender composition generates additional variation in the share of students that are female in a given class. Students are not allowed to submit preferences over schools during the assignment process. Within a school district, distance between a student's residence and a given school does not affect the random assignment process.[11] Compliance with random assignment is high, because the only way to avoid assignment to a specific school is through a student's entire family moving to a different district. Even if a student's family moves to another school district, he or she is still subject to random assignment. The central government's education policies, including the random assignment rule, apply to almost all schools except for a small number of specialized institutions (mostly for arts and athletics) supervised by the government with separate regulations, which represent less than 2 percent of middle schools and contain less than 1 percent of middle school students in Seoul. Therefore, we observe the vast majority of middle school students and their outcomes.

Second, within schools, students have no choice over the peer group with whom they are required to spend the majority of their time at school. Students are divided into classes, called "Bahns", of approximately 34 students. Students are allocated to classes such that prior achievement is equalized across Bahns (Kang 2007). For example, if school has three classes in a given grade, students are ranked by their prior year test scores, and the student with the highest score is assigned to the first classroom, the student with the second highest score is assigned to the second classroom, the student with the third highest score is assigned to the third classroom, the student with the fourth highest score is assigned to the first classroom, and so on. Each Bahn has a homeroom teacher, who is in charge of keeping track of students' performance, while subject teachers visit the classroom throughout the day.[12]

[11] Beginning in 2012, the Seoul Metropolitan education office adopted a policy that took into account distance when assigning disabled students to schools. The law governing nondisabled student assignment states that, within a school district, the Seoul Metropolitan education office must randomly assign students to schools but can consider "Kyotongpyun", or the possibility that students cannot get access to an assigned school with public transportation (e.g., bus or metro). Although accessibility to a given school can be correlated with distance from the school, the assignment rule does not consider "distance to school" *per se*. Seoul has a well-developed public transportation system with over 300 subway stations that are, on average, only 1 kilometer apart, with travel time between stops of approximately one minute. Since the average size of school's school district is small (approximately 7 km^2) , the consideration of "Kyotongpyun" is unlikely to be binding. To show this, we simulate the distance between students and a given school in their district by randomly drawing the location of 10,813 students (the average number of students in a Seoul district) in a 7 km^2 square district with one school located in its center. This mean simulated distance a student would have to travel was 2.7 km - less than 3 metro stops in Seoul. The maximum distance is less than 5 metro stops. Furthermore, this exercise likely provides upwardly-biased estimates, because students are not uniformly distributed within a school district and schools are located in the areas with dense population. Over 40 percent of households in Seoul reside in high-rise buildings that are typically concentrated near the center of school districts (the outside of a school district is often non-residential due to zoning laws). Unfortunately, we do not observe student addresses and thus, cannot directly examine our expectation that access to public transportation does not interfere with within-district random assignment. However, we show that our findings are robust to replacing our assumption of within-district random assignment with the assumption of random assignment within smaller administrative units inside districts (available upon request).

[12] During our sample period, schools were allowed to track students based on their baseline math and English test scores. In general, students from two separate classrooms were divided into two groups - a high performing group and low performing group. Students were only divided this way for math and/or English instruction and returned to their original classroom for the remainder of the day. Given the class time allocated to math and English based on the national curriculum for middle schools, students in a school using tracking systems for both math and English, are exposed to other classroom students for about 20 percent of their school day. About 51 percent of middle schools in our data tracked students in both math and English in 2009, and 67 percent did in 2010. School and class gender composition do not significantly interact with tracking and students in schools that use tracking do not perform any better on math and English tests (results available upon request).

Finally, many factors that would be considered endogenous in other settings, such as curriculum and school funding, are held constant across districts, schools, and classes. All Seoul elementary schools are coed with coed classrooms; middle school is the first opportunity for students to be exposed to single-sex instruction. All Korean middle schools use the national curriculum and the length of academic year does not vary. Schools are centrally financed, resulting in equal funding across schools. Nationwide, teachers are subject to the same qualification requirements and salary schedule.

The one dimension along which schools may differ is whether a school was historically established by a public or private entity. However, "private" schools participate in the random assignment process, are publicly funded, use the national curriculum, and are not allowed to charge tuition.[13] Private schools have more discretion over teacher hiring and firing, conditional on the national qualification requirements, but no discretion over teacher pay or benefits. Public school teachers are randomly assigned to schools for approximately five year periods and restricted from teaching in the same school more than twice.[14] Due to the fact that schools that were established by a private entity are more likely to be single-sex, we will control for this characteristic, as well teacher characteristics, to show that our estimated impacts of single-sex education are not driven by differences between public and private schools.

The Korean Ministry of Education administers the National Assessment of Educational Achievement (NAEA) each June to measure students' academic performance. All South Korean students at grades 6, 9, and 11, take NAEA tests in five subjects: reading, math, English, social studies, and science. The NAEA tests we will focus on - those given to ninth graders - are not as high stakes as the national college entrance exam. However, these tests still represent a useful proxy for students' educational attainment as the tests' content is well aligned with the middle school curriculum and a student's middle school performance determines whether he or she is admitted to a magnet high school.[15] Since Korean middle schools include grades 7 through 9, the NAEA test we focus on measures student achievement at the end of students third year of middle school.

Our focus on middle school students provides several advantages over previous research examining the impact of single-sex schooling at the high school level in Korea (e.g., Lee and Park 2013; Park et al. 2013;

[13]Prior to receiving public funding via South Korea's Equalization Policy, Private schools were viewed as less prestigious than public schools (Link 2012).

[14]Since the 1970s, public school teachers in Korea were not allowed to stay in a given school for more than 5 years except in very exceptional circumstances, under which teachers could stay for 10 years. During the period we study, a teacher who exhausts her 5 year stay can list up to three schools among the schools who have an opening in the teacher's area of specialization (e.g., reading, math, English). New assignments are made by the Seoul Metropolitan Office of Education rather than individual schools. Importantly, most teachers submit preferences for the same set of schools that are known to have high performing students (Hong 2007). Given teachers' homogenous preferences over their assignments, it is not surprising that teachers report that their preferences are not represented in the assignment process (Hong 2007), suggesting that endogenous sorting of teachers in public schools is not likely to be a concern for our identification strategy.

[15]In Seoul, about 10 percent of high schools fall into this category. These school are widely regarded as providing their students with an advantage on the national college admissions exam. For example, over 46 percent of the new enrollees in Seoul National University, considered the best college in Korea, graduated from special high schools (Ministry of Education, Press Release, June 26th, 2014).

Sohn 2013; Choi et al. 2014; Ku and Kwak 2015). First, assignment to high school is not completely random. Nationwide, approximately half of all Korean high schools select their students based on academic performance (Kim et al. 2008). In Seoul, dozens of magnet high schools are exempt from the random assignment rule, and about half of school districts in our sample period allow for students to submit preference rankings over their high school assignment. Therefore, the students subject to random assignment are not representative sample of the population in Korea or Seoul, making the estimated impact of single-sex schooling more difficult to interpret, especially given the limited available information on students' background characteristics. Furthermore, high school students endogenously select into one of two tracks (math/science or humanities/social science) at the end of their freshman year, and scores from the available performance measure (the College Scholastic Ability Test or CSAT) are not comparable across tracks, but can only be used to measure relative performance of students conditional on track choice. As the fraction of students who choose the math/science track varies across single-sex and coed high schools, selection bias complicates identification of gender peer effects at the high school level.[16]

Finally, developmental psychology research suggests middle school may be an especially relevant period for examining the impacts of single-sex schooling, since differences in learning and brain development by gender are particularly pronounced. This research suggests that girls complete more of their brain development at earlier ages, and that boys and girls experience differences in the development of areas related to language versus spatial reasoning during this period (Lenroot et al. 2007; Hanlon et al. 1999). However, differences in brain development do not necessarily imply differences in learning (Halpern et al. 2011; Eliot 2013). The onset of puberty results in differences in hormone levels and behavior. Even in the absence of meaningful physiological differences, adolescence is a period when differences in socialization and norms experienced by boys and girls may reinforce pressure to conform to gender-specific stereotypes, resulting in differences in performance (e.g., Steele et al. 2002). For example, Lee et al. (2014) and Booth and Nolen (2012) find significant gender differences in middle school students' willingness to compete in South Korea and U.K, respectively, which has been shown to have long-run implications for gender gaps in labor market outcomes (e.g., Gneezy et al. 2003; Niederle and Vesterlund 2007; Flory et al. forthcoming). However, it is important to note that test scores represent a short-term outcome and there may be longer-term impacts of single-sex education on career choices or labor market outcomes (e.g., Schneeweis and Zweimüller 2012).

[16]The math test for the math/science track is more difficult than the humanities/social sciences math test. Although CSAT English and reading tests were standardized across tracks in 2004, students' performance on these tests will not be comparable across tracks if track choice alters the distribution of effort devoted to studying math versus verbal subjects. Furthermore, Korea's college admission system and CSAT content and scoring have changed over time (Avery et al. 2014). Starting in 2002, the Ministry of Education allowed colleges to admit students without CSAT scores when students could demonstrate "special talents". The share of high school seniors taking the CSAT has decreased over time, from 84 percent in 1999 and 2000, to 78 percent in 2001, 73 percent in 2002, and 72 percent in 2003. Since the selection into taking CSAT is non random and may be correlated with changes in school gender composition, studies that use time-series variation in school gender composition (e.g., Lee and Park 2013; Ku and Kwak 2015) may yield biased estimates of the impact of peer gender on achievement.

3 Data and Sample

Our primary data set contains student-level administrative records from 2009 and 2010. We observe 9th grade students' NAEA performance in each of the five tested subjects (math, reading, English, science, and social studies). We standardize test scores to have a mean of zero and standard deviation equal to one across all students in a given year. We also construct a measure of overall achievement by standardizing the sum of a student's performance in all subjects.[17] In addition to the test scores, we observe each student's gender, school district, class and school gender composition, and responses to survey questions measuring family background, effort, time-use, and evaluations of teachers and peers.[18] Unfortunately, we do not observe test scores before 9th grade. Additionally, the survey data offer only limited information on family background. Specifically, we only observe a student's living arrangements, which provides a rough proxy for socioeconomic status (SES) in that students living with both biological parents are more likely to come from an advantaged family (Park 2014). We supplement our data two additional data sets. The Korea Education & Research Information Service (KERIS) data, maintained by the Korean Ministry of Education, provide information on school-level characteristics, such as student-teacher ratios, whether a school was established by a private entity, teacher characteristics, number of bullying incidents and student transfers. Second, we use data from the Korean Education Longitudinal Study (KELS), a nationally representative panel of students who were in middle school in 2005. The KELS includes survey data from student panel members as well as their parents and teachers. We use the KELS teacher survey data to examine impacts on teaching methods and school discipline. Online Appendix A contains additional information on our data sources.

3.1 Characteristics of schools and students

We limit our sample to students enrolled in a Seoul metropolitan area school. Students in Seoul are not allowed to express their preference rankings over schools within their school districts, while in some other regions, students' preference rankings are used in middle school assignment. We further restrict our sample to students in districts that contain all four types of middle schools (e.g., single-sex male and female schools, coed schools with mixed-gender classes, and coed schools with single-sex classes). Eight of the 11 Seoul-area school districts contain all four types of schools: coed schools with coed classes, coed schools with single-sex classes, all male schools, all female schools.[19] These eight districts contain 280 schools representing 76

[17] We also construct an alternative measure of overall achievement equal to the average of standardized subject test scores. Using this alternative measure yields similar results in all analyses.

[18] A small number of students who take the NAEA tests do not respond to a given survey item. All of our results are robust to restricting the sample to students that completed every survey item (available upon request).

[19] Two districts do not contain either single-sex male or single-sex female schools and one district that does not contain coed schools with single-sex classes.

percent of all schools and 77 percent of students in Seoul.[20]

Table 1 displays the characteristics of students and schools in our sample. As shown in Panel A, the average class size, share of teachers with experience, and student to teacher ratios are quite similar across the four types of schools. However, single-sex schools have fewer classes and schools with mixed-gender classes are less likely to be classified as private schools.[21] Single-sex schools also have a smaller share of teachers that belong to a professional teachers' organization.[22] A higher share of all-male schools received support from a government program targeting low-performing schools in 2010.[23] Finally, single-sex male schools have fewer female teachers - on average, 41 percent of teachers in such schools are female, compared to 65 percent of teachers in single-sex female schools, 61 percent in coed schools with single-sex classrooms, and 73 percent in coed schools.

Female students earn higher test scores than males in every subject and in each type of school. Across all school types, female students' combined achievement is 0.16 standard deviations higher than the achievement of male students. Female students score significantly higher than male students in reading, English, and science, while differences in math and social studies scores are not statistically significant. Regardless of gender, students assigned to coed schools with single-sex classrooms have the lowest average achievement. Male students in single-sex schools outperform male students in all other settings, whereas female students in single-sex schools and those in coed classrooms have similar performance. An F-test rejects the hypothesis that test scores are equal across school types with $p < 0.001$ for both genders.[24]

4 The Role of Student Gender Composition in the Education Production Function

School and class gender composition may affect a given student's achievement through several channels. First, peer gender composition may induce students and their parents to alter their inputs (Epple and Romano

[20] Our estimates are robust to using the full set of Seoul schools and students (available upon request).

[21] Around 30 percent of privately founded schools were established by a religious entity. The national curriculum does not include religious instruction, but schools can offer extracurricular activities related to religion (e.g., meditation before classes start, events related to Christmas). Schools may also use up to four hours per week to offer religious instruction as an elective but are required to offer alternative courses to protect students' religious beliefs. We show that privately founded religious schools have no effect on students assigned to single-sex schools or coed schools with single-sex classes in a robustness test.

[22] These organizations were primarily established for political purposes, such as lobbying for changes in the national curriculum but do not have collective bargaining rights.

[23] Schools with more than 20 percent of their students receiving NAEA scores below the threshold for "basic understanding" in 2009 were eligible for this program, which provided support (e.g., monetary transfers, additional teachers' aides) in 2010 (Woo et al. forthcoming). When we limit our sample to the 2009 cohort, our results remain qualitatively the same, suggesting our estimated impacts of school and classroom gender composition are not driven by differences in receipt of the government subsidy in 2010 (available upon request).

[24] Online Appendix Figure B.1 shows that, while the distribution of test scores are similar for female students in single-sex schools and coed classrooms, the performance of male students in single-sex schools dominates that of male students in coed classrooms at almost every part of the distribution.

2011). Students may alter their in class effort (e.g., through increasing in-class participation or willingness to ask questions) and parents may change their investments in their children (e.g., by hiring tutors). Second, peer gender composition may affect interactions between students. If boys are more disruptive than girls, an increased share of male classmates may increase the time teachers spend handling disruptions and decrease time available for instruction (e.g., Lavy and Schlosser 2011). Even in the absence of disruptive behavior, if students are distracted by opposite-gender peers, they may learn less within coed settings. Conversely, if female students have higher performance than their male counterparts (as is the case in Korea and the US), and higher ability peers generate positive externalities, an increase in the share of classmates that are female may make it easier for a given student to master his or her coursework. In our setting, we can rule out this channel in mixed-gender classes, as classrooms are explicitly balanced in the prior achievement of students.[25]

Finally, school and class gender composition may affect student achievement by inducing teachers to alter their behavior. Korean teachers report that male and female students often react differently to the same teaching style (Chung et al. 2009). Male elementary and middle school students interact more with their teachers in class and are more likely to ask questions and respond to questions posed by teachers (Jung and Chung 2005). Gender composition may affect teachers' discipline methods. Male and female students report differences in both their experiences of within-school discipline and their support for certain discipline methods. Male students in Korea are more likely to report experiencing corporal and verbal punishment and undergoing inspection of their personal belongings and appearance, and are also more likely to report supporting stricter discipline methods (Mo and Kim 2009).[26] Although theoretically, schools may also adjust other inputs in response to student gender composition (e.g., by adopting different curricula or hiring different teachers), in our setting, schools have limited ability to adjust such inputs.

4.1 Empirical framework

Our key identifying assumptions are (1) within a given district by cohort by gender group, students are randomly assigned to schools and (2) unobservable school characteristics that affect student achievement are uncorrelated with school and class gender composition. If these assumptions hold, ordinary least squares regressions of achievement on school and classroom gender composition that condition on randomization

[25]Conditional on classroom gender composition, school gender composition may still matter if students interact with other students in different classrooms through school-level extracurricular activities. However, within-school interactions between students in different classrooms are quite limited in Korea. Lim et al. (2009) show that less than 15 percent of middle school students participate in an extracurricular club, with participants interacting approximately once per week. Only 13 percent of middle school students join a student board, which meets, on average, only once per quarter.

[26]For instance, 27 percent of male students reported experiencing corporal punishment at least once a week, compared to only 12 percent of female students. However, male students were also more likely to express support for these disciplinary methods. To give an example, 43 percent of male students expressed support for corporal punishment compared to 36 percent of female students.

group fixed effects should generate causal estimates of the average impact of peer gender composition. Our reduced form estimates of peer gender will include both direct peer effects and indirect effects that are driven by changes in teacher, student, and peer inputs. We first model the impact of extensive margin variation in peer gender on student achievement:

$$A_{icst} = \alpha^f SS_s^f + \alpha^m SS_s^m + \beta^f SC_s^f + \beta^m SC_s^m + \mathbf{X_{it}'}\boldsymbol{\lambda^g} + \mathbf{Z_{st}'}\boldsymbol{\eta^g} + \boldsymbol{\xi_{d\times t\times g}} + \epsilon_{icst} \tag{1}$$

Where A_{icst} represents the achievement of student i assigned to class c in school s and year t, $SS_s^f = \mathbf{1}\,[\text{single-sex school}] \times \mathbf{1}\,[\text{female}]$ and $SS_s^m = \mathbf{1}\,[\text{single-sex school}] \times \mathbf{1}\,[\text{male}]$. Similarly, SC_s^g represents the interaction between an indicator for whether a student belongs to a single-sex class within a coed school and an indicator for whether the student has gender g. Therefore, the omitted category for school and classroom gender composition is mixed-gender classes within coed schools. $\mathbf{X_{it}}$ is a vector of indicators for student living arrangements (e.g., both biological parents, single mother, other relative), which proxy for socioeconomic status, and $\mathbf{Z_{st}}$ is a vector of school-specific characteristics.[27] Even though we expect most of these characteristics to be orthogonal to peer gender composition, we include them in our main specifications to reduce residual variation. All student and school control variables are fully interacted with student gender. Finally, we include a set of district by cohort by student gender fixed effects, as random assignment occurs within these groups.[28] Except when otherwise noted, standard errors are clustered within school by year cells to account for correlation of error terms within a given school and year.

Our second model examines the role of gender composition of mixed-gender classes in coed schools:

$$A_{icst} = \delta^f FracFemale_{cst}^f + \delta^m FracFemale_{cst}^m + \mathbf{X_{it}'}\boldsymbol{\lambda^g} + \mathbf{Z_{st}'}\boldsymbol{\eta^g} + \boldsymbol{\xi_{d\times t\times g}} + \epsilon_{icst} \tag{2}$$

Where $FracFemale_{cst}^g$ represents the share of classmates that are female (interacted student gender), standardized to represent deviations from a class with an equal share of male and female students. We use variation in classroom gender composition, rather than cohort gender composition (as in Hoxby (2000) and Lavy and Schlosser (2011)), for two reasons. First, in our setting, students do not have any choice over their classroom assignment, and students spend most of their time with their classmates throughout an academic year. Second, since class size is capped at 35, there is a greater degree of variation in the share of female students in a classroom than the share within a school. However, our estimates are quite similar when we use cohort gender variation in models that include school fixed effects.

[27] School characteristics include the total number of teachers in the school, the fraction teachers classified as experienced, the fraction of teachers belonging to a professional organization, pupils per teacher, school size, the fraction of teachers that are female, whether a school was established by a private entity, and whether a school received government aid in 2010.

[28] Our results are robust to replacing district by gender and year by gender fixed effects with district by year by gender fixed effects (available upon request).

To jointly estimate the impacts of within- and across-school and class variation in gender composition, we combine equations (1) and (2):

$$\begin{aligned} A_{icst} = \quad & \alpha^f SS_s^f + \alpha^m SS_s^m + \beta^f SC_s^f + \beta^m SC_s^m + \delta^f FracFemale_{cst}^f + \delta^m FracFemale_{cst}^m + \\ & \mathbf{X_{it}'}\boldsymbol{\lambda^g} + \mathbf{Z_{st}'}\boldsymbol{\eta^g} + \boldsymbol{\xi_{d\times t\times g}} + \epsilon_{icst}. \end{aligned} \tag{3}$$

In this case, $\hat{\alpha}^g$ represents the estimated impact of moving a student of gender g from a coed classroom with an equal share of male and female students to a single-sex school, $\hat{\beta}^g$ will represent moving the student to a single-sex classroom within a coed school, and $\hat{\delta}^g$ will represent the estimated impact of a marginal increase in the share of students in a coed class that are female, relative to a class with an equal share of male and female students.

The above estimates encompass the overall effects of peer gender on student achievement that may occur through the multiple channels described at the beginning of this section. To understand the mechanisms behind these effects, we examine the extent to which students and teachers adjust their inputs in response to peer gender composition. Furthermore, we conduct a descriptive decomposition exercise by examining the extent to which the achievement gap between single-sex and coed schools decreases once we control for (endogenous) changes in student and teacher inputs.

4.2 Evaluating identification assumptions

We provide two pieces of evidence in support of our identifying assumption of within-district random assignment. First, we test for differences in students' family background across school types. Using student survey data, Lee et al. (2014) show that within a given district, assignment to single-sex schools is uncorrelated with household income, family composition, and parental education. Unfortunately, our dataset only contains a subset of these predetermined student characteristics. We test whether a student's living arrangement is correlated with assignment to a particular type of middle school. Living arrangements serve as a proxy for student SES in that high SES children are more likely to live with both of their biological parents whereas lower SES children are more likely to live with a single parent (Park 2014). As shown in Table 2, the probability of living with a single parent or with both biological parents is uncorrelated with classroom and school gender composition. Only one of the 18 point estimates is statistically significant, and suggests that male students in single-sex schools are slightly more likely (1 percent) to be living with both biological parents. However, we cannot reject that the correlation between school and classroom gender composition and the probability of living with both biological parents is jointly equal to zero ($p = 0.42$). Despite the small magnitude of this difference in student characteristics, we address concerns over endogenous sorting of high

SES male students in three ways. First, we show that our main results are not affected by including controls for student living arrangements. Second, we test for heterogeneity in the impact of single-sex schooling by family background. Finally, we show that our results are robust to to a bounding exercise - described in the following section - which excludes "excess" high achieving students in all male schools.

For the vast majority of students, initial random assignment to a particular school type is binding. We use school-level KERIS data, and examine the number of students (in grades 7 through 9) who leave a school (quit) or migrate to another school district (transfer). KERIS does not contain separate measures of these outcomes by grade or by student gender. Therefore, we only compare aggregate outcomes in single-sex and coed, single-sex classroom schools relative to coed schools with mixed-gender classrooms. To do so, we estimate a model with school-type indicators, school characteristics, and year and district fixed effects:

$$Y_{st} = \alpha^f SS_s^f + a^m SS_s^m + \beta SC_s + \mathbf{Z'_{st}}\boldsymbol{\eta} + \boldsymbol{\xi_d} + \boldsymbol{\xi_t} + \epsilon_{sdt}. \tag{4}$$

We find evidence of significantly lower – albeit small in magnitude – quit and transfer rates within single-sex schools. Column (1) of Table 3 shows that on average, fewer than 2 of every 100 students quit in a given year, leaving their assigned school, but not enrolling in a different school. Single-sex schools have 0.5 fewer quits per 100 students. The average single-sex middle school has approximately 260 students in 9th grade, thus, our estimate implies an approximately 1.3 student (0.5 percent) reduction in 9th grade quits relative to coed schools. As shown in column (2), estimated impacts on transfer rates for students assigned to single-sex male schools are of a similar magnitude. Taken together, our estimates suggest all male schools have approximately 2.9 (1.1 percent) fewer students exit compared to coed schools with coed classrooms and 4.6 (1.8 percent) fewer students exits than coed schools with single sex classrooms. Given this small magnitude of exit differences across school types, it is unlikely that endogenous quits and transfers would mitigate the initial random assignment within school districts. Nonetheless, we show that our results are robust to a bounding exercise in the spirit of Lee (2009). We assume that all of the excess exits in coed schools with single-sex classes are among male students. We trim the top 0.5 percent of male students in coed schools with coed classrooms and the top 1.8 percent of male students in single-sex schools. to account for these differences in exit rates.

Many features of our setting - which we discuss in Section 2 - support our identifying assumption that school-specific unobservables that affect achievement are uncorrelated with school and class gender composition. We provide additional evidence through two exercises. First, we show that the estimated impact of peer gender is robust to the inclusion of observable school characteristics. Second, we show that our results are not driven by teacher gender composition or attending a privately founded school - the two observable

characteristics that significantly vary with school and class gender composition.

5 Impacts of Peer Gender on Achievement

We first compare the outcomes of students in coed schools to those of their counterparts in single-sex classrooms and single-sex schools in order to examine the impact of extensive margin variation in school and classroom gender composition on student achievement. Table 4 displays estimates from equation (1). Differences in the performance of male students assigned to single-sex schools and single-sex classrooms within coed schools are large and statistically significant across specifications, with male students in single-sex schools scoring 0.19 to 0.26 of a standard deviation above their peers in single-sex classrooms.

Our first specification includes only year and school district fixed effects (fully interacted with gender). Estimates from this model suggest that assignment to a single-sex school increases male students' achievement by a statistically significant 0.14 of a standard deviation, relative to coed school assignment, and by one-fifth of a standard deviation, relative to assignment to a single-sex classroom within a coed school. Our second specification, which controls for students' living arrangements, produces similar results. In our third and preferred specification, we add controls for school characteristics. Our estimates are robust to the inclusion of school-level controls, supporting our assumption that the effects of peer gender are not driven by differences in school characteristics. The estimated impact of assignment to a single-sex school relative to assignment to a coed classroom on male students' achievement increases to 0.17 of a standard deviation. Male students in single-sex schools score more than one-quarter of a standard of a deviation higher than their counterparts in single-sex classrooms within coed schools. Finally, male students assigned to single-sex classes in coed schools score an approximately one-tenth of a standard deviation lower than male students in mixed-gender classes. Column (4) contains results from our bounding exercise to determine whether differential exit rates across school types can explain our results. Our estimates decrease slightly in magnitude but remain large and statistically significant. Given that we assume the excess students in all male schools are positively selected, the point estimates represents a lower bound for the achievement gains due to single-sex schooling. None of our specifications yield significant estimates of the impact of peer gender on female students' achievement. For the remainder of the paper, we report results from models similar to our third specification that include district and year fixed effects and controls for school and student characteristics, all fully interacted with gender.

The impact of gender-segregated education do not appear to be driven by impacts on achievement in specific subject areas. We examine students' performance on reading, English, math, science, and social studies tests. We find no evidence that female students' performance depends on school or class gender

composition in any subject except for English, where female students assigned to coed schools with single-sex classes score approximately one-tenth of a standard deviation lower than female students in fully coed classes (Online Appendix Table B.1). Conversely, in every subject, male students in single-sex schools outperform their counterparts in coed schools. Male students in single-sex classes within coed schools perform significantly worse than their counterparts in coed classrooms in reading, English, and science.

In Table 5, we turn to examine whether variation in the share of classmates that are female affects the performance of students in mixed-gender classes and restrict our sample to students enrolled in coed schools with mixed-gender classrooms. We estimate that male students' achievement is increasing in the share of their classmates that are female in every subject. A 10 percentage point increase in a male student's share of classmates that are female results in an approximately 0.03 standard deviation increase in overall achievement and a 0.03 to 0.04 standard deviation increase in achievement across subjects, on average. Conversely, we do not find a statistically significant relationship between female students' achievement and the share of their classmates that are female, although for every subject, our point estimates are positive.

Finally, we jointly estimate the impact of intensive and extensive margin variation in school and classroom gender composition via equation (3). Our results are consistent with those displayed in Table 4 and Online Appendix Table B.1. Although the estimated impact of an increase in female classmates on achievement is largely insignificant (except in the case of male students' social studies performance) our 95 percent confidence intervals include impacts estimated by Hoxby (2000).[29]

Our estimates suggest that the impact of single-sex education on male students' achievement varies by school gender composition, with single-sex schools increasing achievement and single-sex classrooms within mixed-gender schools decreasing achievement. Thus, the benefits of single-sex schooling for male students are not driven solely by within-class gender peer effects. Male students assigned to single-sex classes in coed schools have few opportunities interact with students outside of their own class.[30] If boy students are more likely to be disruptive, as Lavy and Schlosser (2011) hypothesize, then single-sex male classes should lead to negative impacts on achievement in both single-sex and coed schools.

Since classes are balanced by prior achievement, and female students earn higher test scores than male students on average, within a given school, we would expect male students in classrooms with fewer female students to have higher average prior achievement than male students in classrooms with more female students. This would bias the estimated impact of female classmates on male students' achievement downward,

[29]The estimates from Hoxby (2000) imply that a 10 percentage point increase in the share of classmates that are female increases sixth grade female students' achievement by approximately 0.012 of a standard deviation in reading and 0.017 of a standard deviation in math. A similar increase in female classmates increases sixth grade male students' achievement by 0.012 of a standard deviation in reading and 0.02 of a standard deviation in math.

[30]It could still be the case that the presence of female students within a coed school with single-sex classes is a distraction to male students. However, we find no evidence that an increase in the share of female students within a coed school with single-sex classes affects male students achievement (results available upon request).

suggesting that our estimates represent a lower bound on the positive effects of female peers on male students' achievement. Consistent with this interpretation, when we only use variation in cohort (school by year) gender composition to identify the impact of female classmates in coed classrooms, we estimate that a 10 percentage point increase in female students results in a marginally significant ($p < 0.10$) 0.03 of a standard deviation increase in achievement (Online Appendix Table B.2).

We formally test the hypothesis that students' achievement gains are linear in the share of classmates that are female; p-values from these tests are displayed in Table (6). We cannot reject the hypothesis that the impact of assignment to a single-sex class is equal to the predicted impact of assignment to a coed class with no female students ($p = 0.197$ for female students and $p = 0.926$ for males). In other words, the out-of-sample prediction of the average impact of moving a male student from a classroom with an equal share of male and female students to an all male classroom within a coed school is consistent with our estimate of the impact of assignment to an all male classroom in a coed school. Conversely, we can reject the hypothesis that male students' assignment to a single-sex school is equivalent to this out-of-sample prediction with $p = 0.002$, suggesting that school gender composition affects male students' achievement above and beyond impacts driven by in-class peer effects.[31]

We also investigate whether single-sex schooling affects the distribution of student achievement. We estimate separate models by student gender and take the residuals from a regression of student achievement on our full set of student- and school-level controls and fixed effects. Online Appendix Figure B.2 displays the cumulative distribution of residualized achievement by school type (single-sex, coed with single-sex classes, and fully coed). Peer gender composition appears to affect the bottom of the distribution of female students' achievement. Above the 80th percentile of achievement, female students in all three school types have similar performance, but below this point, female students assigned to mixed-gender schools with single-sex classes have slightly lower achievement than female students in other schools.[32] Assignment to a single-sex school appears to have larger impacts on performance for male students at the middle and bottom of the achievement distribution. Although we find little evidence of differences in the achievement of male students in single-sex schools compared to those in coed classes above the 70th percentile, male students in single-sex classes within mixed-gender schools perform worse than other male students at every point in the

[31] Although in our case, a linear prediction using intensive margin variation in female classmates accurately predicts the impact of an all male class in a coed school, Hoxby (2000) finds evidence of nonlinear gender peer effects, where the impact of a marginal increase in the share of students that are female is larger for cohorts with a high share of female students.

[32] The cumulative distribution of female students' achievement within single-sex schools and fully coed schools are statistically indistinguishable, with a Kolmogorov-Smirnov (K-S) test of equality yielding a p-value of 0.891. We can reject the hypothesis that the distribution of female students' achievement is equal between coed schools with single-sex classes and other school types ($p < 0.001$). However, differences in achievement between these school types are small. For instance, at the 40th percentile of achievement, female students in coed classrooms score approximately 0.01 of a standard deviation higher than female students enrolled in single-sex classes within coed schools.

achievement distribution.[33]

5.1 Alternative outcome measures

Although test scores are generally the preferred measure of student achievement, other studies have found that standardized test scores are subject to gaming behavior. Additionally, test scores cannot measure a student's own assessment of whether he or she has a deep understanding of course material. Thus, we use students' reports of how well they understand lectures as an alternative outcome variable. We create a dummy variable that is equal 1 if a student reports that he or she can understand lectures very well and 0 otherwise and estimate equation (3). As shown in column (1) of Table 7, consistent with our estimated impacts on test scores, male students in single-sex schools are significantly more likely to report understanding lectures than those in single-sex or coed classrooms in coed schools (between 2 and 3 percentage points or 12 and 16 percent, respectively). Peer gender composition does not affect female students' assessments of lecture comprehension.[34]

Second, test scores may not fully encompass all aspects of student welfare. Our data contains a survey question measuring whether students are happy to go to school. We use this measure to examine the relationship between reported happiness and peer gender composition. As shown in column (2) of Table 7, male students in single-sex schools are 3 percentage points (14 percent) less likely to report that they are happy to go to school compared to male students in coed classrooms. However, boys in coeds with gender-segregated classes also report unhappiness comparable to boys in single-sex schools. These findings suggest that the negative impact of an all male classroom on happiness is likely not driven by factors that lead to test score increases.

6 Evidence on Mechanisms

The estimated impact of peer gender composition on achievement represents both direct peer effects and indirect effects that operate through endogenous responses of students and teachers. To test for the importance of changes in inputs, we use student and teacher survey data to create measures of student effort and time use, perceptions of teacher and peer effort, and teachers' teaching and discipline methods.[35]

[33] A K-S test rejects the equality of male students' achievement distributions across school types with $p < 0.001$. To give an example, at the 30th percentile of achievement, male students in single-sex schools score approximately 0.3 of a standard deviation higher than male students in single-sex classrooms within coed schools and approximately 0.1 of a standard deviation higher than those in coed classrooms.

[34] Students who do not answer the specific survey question are excluded from the sample. All of our results are robust to limiting our sample to students who answer all survey questions.

[35] Online Appendix A provides detailed descriptions of this data and the construction of the outcomes we examine.

6.1 Impacts on students' own effort and time-use

To test whether students' own effort responds to peers gender, we use student survey responses from our main dataset to create a summary measure of effort. We sum students' responses to six individual survey questions that ask students to assess how often they come to class prepared, are focused on in-class lectures, study class material in advance, review class material after school, ask questions in class, and actively participate in class. We standardize this composite effort index to have a mean equal to zero and a standard deviation of one. Single-sex schooling leads to substantial increases in male students' effort (Table 8). Male students in single-sex schools report effort that exceeds that of male students in coed classes by 0.14 of a standard deviation. Their effort is approximately 0.08 of a standard deviation higher than the effort reported by their counterparts enrolled in single-sex classes within coed schools. We find little evidence that single-sex schooling systematically alters female students' effort.[36]

The second two columns of Table 8 show the increases in reported effort for male students assigned to single-sex schools are matched with changes in how these students devote their time to academic and leisure activities. Students are surveyed on the time they devote in a given day specific activities, which we group into two broad categories. Specifically, we classify homework and extracurricular tutoring ("cram school") as "academic" activities and watching TV, playing computer games, and hanging out with friends as "leisure" activities. We estimate that male students in single-sex schools spend an additional 12 minutes per day (hour and fifteen minutes per week) on academic activities compared to their peers in coed classes with an equal share of male and female students. Compared to male students in single-sex classes within coed schools, students in single sex schools spend an additional 16 minutes day (close to 2 hours per week) on academic activities. Within coed classrooms, the time that male students devote to these academic activities is not significantly related to the share of their classmates that are female and female students' time use is not significantly related to the gender composition of their peers.[37]

Turning to leisure activities, we estimate that the increase in time that male students in single-sex schools spend on academic activities is more than offset by a reduction in time spent playing computer games, watching TV, and hanging out with friends. These students spend approximately 0.3 fewer hours

[36] Online Appendix Table B.3 presents estimated impacts on the components of our composite effort measure. Assignment to a single-sex school significantly increases male students effort along all measured dimensions. Male students in single-sex classes within coed schools are significantly more likely to report coming to class prepared and asking questions in class than their counterparts in coed schools. Female students in single-sex schools and single-sex classes within coed schools report being more likely to ask questions in class, while female students in coed schools' active participation in class is increasing in the share of classmates that are female. Finally, female students in single-sex schools are significantly less likely to report coming to class prepared than female students in other settings.

[37] In Appendix Table B.4, we report estimates of the impact of peer gender composition on time spent in each activity. Male students in single-sex schools spend an additional 0.06 hours per day (26 minutes per week) on homework and 0.13 hours (55 minutes per week) in "cram school" compared to male students in coed classes. Compared to their counterparts in single-sex classes within coed schools, male students assigned to single-sex schools spend and additional 0.23 hours per day (approximately 1.5 hours per week) in "cram school". Female students' time spent in academic activities does not significantly vary with school and class gender composition.

per day (2 fewer hours per week) on leisure activities compared to male students in coed classes. Compared to male students in single-sex classes within mixed-gender schools, these students spend close to 0.4 fewer hours per day (2.5 fewer hours per week) on leisure. Once again, we find little systematic evidence that female students' time use varies by classroom or school gender composition.[38]

6.2 Impacts on interactions with peers and teachers

As discussed in Section 4, school and class gender composition may have indirect effects on student achievement by altering the behavior of their peers and teachers. Our main dataset includes a small set of variables that provide information on interactions between students. The first measures students' views of whether their classmates are studious. We create an indicator variable that is 1 if a student considers his/her classmates study hard and 0 otherwise (see Appendix A for details) and examine the impact of peer gender on the indicator by estimating equation (3). Students of both genders are more likely to report having hard working peers if more of their classmates are female. As shown in column (1) of Table 9, female students in single-sex schools are 4 percentage points (40 percent) more likely to report having hard working classmates than their counterparts in single-sex classes within coed schools and 50 percent more likely to report hard working classmates than female students in an evenly split coed class. Within coed classes, both male and female students' perception of peer effort is significantly increasing in the share of classmates that are female. Male students in coed schools with single-sex classrooms are approximately 3 percentage points (30 percent) less likely to report having peers that study hard than male students in mixed-gender classes and male students in single-sex schools. This finding is consistent with the hypothesis that male students are more disruptive than female students (e.g., Lavy and Schlosser 2011).

Our main dataset only contains one survey question relating to teacher effort. This question asks students to assess whether their teachers "teach well".[39] We test whether students' assessments of teaching quality systematically varies by school and classroom gender composition. As shown in column (2) of Table 9, perceived teaching quality is not significantly related to class or school gender composition, which suggests that teachers provide instruction that is comparable in quality across schools. Even though teachers are equivalent in terms of their lecture quality, they may still influence on students' achievement by encouraging students to complete their homework, bring textbooks to school, and focus their attention during class. As

[38] As shown in Online Appendix Table B.4, compared to male students in fully coed schools, male students in single-sex schools spend 0.06 fewer hours per day (23 fewer minutes per week) watching TV, 0.11 fewer hours per day (44 fewer minutes per week) playing computer games, and 0.13 fewer hours per day (54 minutes per week) with friends. Compared to their counterparts in single-sex classes within coed schools, male students assigned to single-sex schools spend 0.11 fewer hours per day (47 fewer minutes per week) watching TV, 0.13 fewer hours per day (56 fewer minutes per week) playing computer games, and 0.14 fewer hours per day (58 fewer minutes per week) with friends. Among female students, except in the case of watching TV, none of the time-use categories we examine are significantly related to peer gender composition. Female students in single-sex classes within coed schools spend about 0.08 additional hours per day (34 minutes per week) watching TV than other female students.

[39] The specific expression this question uses can be interpreted as both "teach skillfully" and "teach with enthusiasm."

shown in Online Appendix Table B.3, male students in single-sex schools are more likely to report coming to class prepared and being focused on lectures. Although we categorized these behaviors as measuring student effort, they may also represent, in part, differences in teacher inputs across different school types.

To test for teacher responses to student gender composition along other dimensions, we turn to our supplemental data from the KELS teacher survey. Unfortunately, this survey only contains a subset of teachers from sampled schools. Furthermore, although we can identify middle schools in Seoul, we do not observe school identifiers and thus cannot separate coed schools with coed classes from coed schools that segregate male and female students into single sex classes. Thus, we are limited to comparing single-sex schools to coed schools. First, we construct an index of the extent to which teachers report using strict teaching methods (e.g., challenging students, encouraging students to think on their own, asking students questions in class, imposing strict punishments on students who violate the school's code of conduct). Teachers' responses to each individual survey question are summed and standardized to have a mean of zero and standard deviation of one (see Online Appendix A for additional details). As shown in column (1) of Table 10, teachers in all male schools are significantly more likely to report using strict teaching methods relative to teachers in coed schools. Second, we test for differences in homework assigned by teachers in coed versus single-sex schools. Even though all schools must follow the national curriculum, teachers still have discretion over the difficulty of homework they assign and the number of assignments they give. We proxy for homework difficulty using teachers' reports of the expected number of minutes it will take students to complete each assignment. The results in column (2) suggest that teachers in all male schools expect their students to spend 11 more minutes on a given assignment than teachers in coed schools. We examine the number of homework assignments given by teachers in each type of school in column (3). Although not statistically significant, students in all male schools are required to complete almost two additional assignments per subject in a given month (an approximately 30 percent increase) compared to students in coed schools. Teachers in all female schools require students to complete significantly fewer assignments than teachers in other settings.[40]

Finally, we use data from KERIS and the KELS teacher survey to test for impacts on additional measures of student behavior. KERIS contains school-level information on reported severe bullying incidents per 100 students. As shown in column (1) of Table 11, severe bullying is relatively rare, with fewer than 4 out of 1000 students affected. We estimate that single-sex schooling reduces the number of male students bullied by approximately 1.1 per 1000 (an approximately 30 percent reduction at the mean) and female students by 1.4 per 1000 (an approximately 40 percent reduction). Single-sex classrooms within coed schools lead to an

[40]The one type of assignment that female students in single-sex schools are more likely to have to complete are group projects (Online Appendix Table A.6).

insignificant reduction in bullying of 0.5 per 1000. We create alternate measures of student behavior using the KELS teacher survey. We examine the incidence of minor and major behavioral problems. Minor behavioral problems include the extent to which students are late or absent, skip classes, violate the school dress code, do not pay attention in class, are rude to teachers, cheat on assignments or tests, and challenge teachers authority.[41] The major behavioral problems teachers report on include the extent to which students damage school property, steal, threaten or physically attack other students, engage in bullying, and drink or take drugs. We create indices of major and minor behavioral problems by summing over teachers' responses to each survey question and standardizing the resulting measure to have a mean of zero and standard deviation equal to one. We find that assignment to a single-sex school dramatically reduces the incidence of both minor and major behavioral problems among male and female students (Table 11, columns (2) and (3)).

Thus far, we have shown male students who enroll in single-sex schools consistently outperform male students in other schools. These students' teachers use stricter teaching methods and assign more difficult homework assignments. At the same time, male students in single-sex schools exert more effort in school and spend more time on academic activities, perhaps indicating an improvement in noncognitive skills. These results are consistent with a model where teachers endogenously specialize their teaching methods when they only teach male students. If Korean male students lag behind their female peers in noncognitive skills - as is the case in other settings - they may also experience greater returns to instruction focused on improving these skills.

Bertrand and Pan (2013) provide evidence that male students' noncognitive skills are especially sensitive to parental investments, with sons of single mothers lagging behind daughters with the same background.[42] We examine the extent to which male students who likely have such deficits benefit from single-sex schooling by testing for heterogeneity in the impact of peer gender composition by family background. Specifically, we estimate a version of equation (1) in which our measures of school and class gender composition are interacted with an indicator for whether the student lived with a single mother. Table 13 displays the estimated impact of peer gender on overall achievement, student effort and time use, and teacher effort. The impact of assignment to a single-sex school on achievement is 60 percent larger for sons of single mothers than other male students. Furthermore, impacts on time use follows a similar pattern, with sons of single mothers assigned to all male schools increasing their time spent on activities by 80 percent more than male students from other backgrounds. Otherwise, family background does not significantly interact with school and class gender composition except for a small positive impact on male students' perceptions of teacher

[41] Tables A.7 and A.8 display the distribution of teacher responses to each question across the three school types we are able to identify.

[42] Bertrand and Pan (2013) find no evidence that male students' noncognitive skills are affected by school inputs, but in their setting, school and teacher quality is not randomly assigned.

effort in all male schools.

6.3 Decomposition exercise

This subsection provides suggestive evidence on the relative importance of student, teacher, and peer inputs in explaining the impact of school and classroom gender composition on achievement. We estimate equation (3) and include an additional set of controls corresponding to each mechanism. We only include the measures of teacher and peer effort that are included in our main dataset. Consider the 0.16 of a standard deviation achievement gap between male students in single-sex schools and those in coed schools with mixed-gender classrooms. As shown in column (1) of Table 12, when we control for students' time use, the gap falls to 0.09 of a standard deviation, a 45 percent reduction compared to our baseline result. Likewise, when we control for student effort (column (2)), the achievement gap falls to 0.09 of a standard deviation (a 38 percent reduction). Conversely, as shown in columns (3) and (4), controlling for students' perception of peer and teacher effort does not explain any of the the achievement gap between male students in single-sex schools and coed classes. When we include all measures of student effort (column (5)), the achievement gap between male students in single-sex schools and those in coed classes decreases by 65 percent and is insignificant at conventional levels.

In contrast, the achievement gap between male students in single-sex classes within coed schools and male students assigned to a coed class with an even share of male and female students barely changes from our baseline estimate even when we control for student, teacher, and peer inputs. Similarly, we find no systematic changes in the estimated impact of peer gender on females students' achievements as we control for these inputs. Taken together, the results from our decomposition exercise suggests that single-sex schools may primarily improve male students achievement by inducing higher effort and time devoted to academic activities, rather than through differences in teacher quality or positive spillovers due to harder-working peers.

6.4 Evaluating alternative explanations for the impact of single-sex schooling on male students' achievement

Before concluding that single-sex schools are able to raise male students' achievement through teacher specialization and a focus on noncognitive skills, we need to rule out alternative explanations for our main results. As shown in Table 1, single-sex schools are more likely to be private. Furthermore, all male schools employ more male teachers. The latter is likely due to the fact that schools that were privately founded have more discretion over which teachers they hire, even though they cannot deviate from the national qual-

ification requirements and pay guidelines. Past research provides mixed evidence of the impact of having a teacher of the same gender, with some papers finding positive impacts on female students' achievement (Muralidharan and Sheth 2013; Paredes 2014), positive impacts on both male and female students (Dee 2007), or no effect on students of either gender (Cho 2012; Holmlund and Sund 2008). Most relevant to our setting, Lim and Meer (2015) find that female Korean students benefit from having more female teachers, while male students' achievement is not affected by teacher gender.

We first test whether the impact of school and classroom gender composition varies by whether a school was established by a private entity. To do so, we estimate equation (1), and interact school type with an indicator for whether the school was privately founded. We examine impacts of peer gender composition and interactions with enrollment in a private school on student achievement, effort, time-use, and teacher effort; results are displayed in Online Appendix Table B.5. For male students, enrollment in a private school status does not significantly interact with peer gender composition. Thus, the increased likelihood that single-sex schools were privately founded cannot explain the increases in male students' achievement that these schools produce. However, among female students enrolled in single-sex classes within a coed school, we find significant interactions between private school status in the case of their effort, time spent on leisure activities, and perceived teacher effort.[43]

Next, we test whether the larger proportion of male teachers employed by all-male schools contributes to the positive impact of single-sex schooling on male students' effort and achievement. We estimate equation (1), and fully interact school type with the share of teachers that are female (standardized such that zero represents a school with an equal share of male and female teachers). As shown in Online Appendix Table B.7, we find a positive relationship between the concentration of male teachers and male students' achievement in single-sex schools. However, the share of teachers within a school that are female has an overall positive impact on student achievement, and taking into account these offsetting effects, the fact that single sex male schools have fewer female teachers can explain very little of the difference in male students' achievement between coed and single-sex schools. For instance, a linear prediction of male students' achievement gains from assignment to a single-sex school (relative to assignment to a coed class within a coed school), assuming that only 20 percent of the teaching force is female, is 0.23 of a standard deviation. When the share of teachers that are female is increased to 80 percent, we predict that male students in single-sex schools still experience a 0.2 standard deviation increase in achievement. In fact, even if male students in single-sex schools had a 100 percent female teaching force, these students would still score 0.19 of a standard deviation higher than

[43] A subset of private schools have a religious affiliation. Thus, we also test whether assignment to a religiously affiliated private school significantly interacts with school and class gender composition. As shown in Online Appendix Table B.6, students enrolled in such schools have lower achievement, spend less time in academic activities and more time in leisure activities. However, these effects are driven by coed religious schools, while students assigned to religious single-sex schools or religious coed schools with single-sex classes are not negatively affected.

their peers in coed classrooms, suggesting that the impact of single-sex male schools on achievement is not solely through these schools' ability to hire more male teachers. The remainder of Online Appendix Table B.7 examines impacts on our index of student effort, hours spent on academics and leisure, and teacher effort. We find little evidence that the impact of single-sex schooling on male students varies by teacher gender for any of these outcomes except students' perceptions of teacher effort, with students in all male schools perceiving reporting less effort if more of their teachers are female and students in all female students reporting higher teacher effort when more of their teachers are female.

7 Conclusions

Past research identifies one of the main channels through which gender composition affects learning as increased disruptions in male-concentrated classrooms (Lavy and Schlosser 2011). Our estimates of the impact of additional female students within coed schools in Korea on achievement are consistent with these findings. However, the large achievement gap between male students in single-sex schools and those in single-sex classrooms within coed schools suggests that within-class peer effects are unlikely to completely drive our results. We find that male students' achievement is maximized by assignment to a single-sex school, and minimized by assignment to a single-sex class within a mixed-gender school. We provide evidence that one channel through which single-sex schools affect male students' achievement is through increasing students' effort and time devoted to academic tasks and that these changes in student inputs could be achieved through teacher specialization. We can rule out differential teacher gender composition and school organization as explanations for differences in outcomes by school gender composition. The channels that remain are the use of different instruction technology by teachers and administrators and different expectations placed on students by parents and teachers in single-sex settings. While we only observe a limited set of proxies for expectations and instruction technology, our results are consistent with a model where teachers in all-male schools may develop specialized teaching techniques to deal with disruptions, while teachers that instruct both male and female students, even in a setting with single-sex classes, have a harder time specializing.

References

Angrist, Joshua D., "The Perils of Peer Effects," *Labour Economics*, 2014, *30*, 98–108.

Autor, David, David Figlio, Krzysztof, Jeffrey Roth, and Melanie Wasserman, "Family Disadvantage and the Gender Gap in Behavioral and Educational Outcomes," 2015. IPR working paper WP-15-16.

Avery, Christopher, Soohyung Lee, and Alvin E. Roth, "College Admissions as Non-Price Competition: The Case of South Korea," 2014. NBER working paper 20744.

Bae, Sang Hoon, Young-Chul Kim, Sang-Jin Ban, Kyung-Chul Huh, Young-Hyun Lee, Byung-Gil Son, Kyung-Chul Huh, Ee gyeong Kim, Jung Na, SoongHee Han, and Chang hwan Kim, "Brief Understanding of Korean Educational Policy," 2011. Korean Educational Development Institute.

Becker, Gary S., William H. J. Hubbard, and Kevin M. Murphy, "Explaining the Worldwide Boom in Higher Education of Women," *Journal of Human Capital*, 2010, *4* (3), 203–241.

Bertrand, Marianne and Jessica Pan, "The Trouble with Boys: Social Influences and the Gender Gap in Disruptive Behavior," *American Economic Journal: Applied Economics*, 2013, *5* (1), 32–64.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes, "Under Pressure? The Effect of Peers on Outcomes of Young Adults," *Journal of Labor Economics*, 2013, *31* (1), 119–153.

Booth, Alison and Patrick Nolen, "Choosing to Compete: How Different are Girls and Boys?," *Journal of Economic Behavior and Organization*, 2012, *81* (2), 542–555.

Carrell, Scott E., Bruce I. Sacerdote, and James E. West, "From Natural Variation to Optimal Policy? The Importance of Endogenous Peer Group Formation," *Econometrica*, 2013, *81* (3), 855–882.

Cho, Insook, "The Effect of Teacher-Student Gender Matching: Evidence from OECD Countries," *Economics of Education Review*, 2012, *31* (3), 54–67.

Choi, Eleanor Jawon, Hyungsik Roger Moon, and Geert Ridder, "Estimation of an Education Production Function under Random Assignment with Selection," *American Economic Review: Papers and Proceedings*, 2014, *104* (5), 206–211.

Chung, Haesook, Jineun Yoo, and Meeyoon Kim, "Gender Equality in Education at Coeducational Secondary Schools," 2009. Korean Women's Development Institute.

Conley, Timothy, Nirav Mehta, Ralph Stinebrickner, and Todd Stinebrickner, "Social Interactions, Mechanisms, and Equilibrium: Evidence from a Model of Study Time and Academic Achievement," 2015. NBER working paper 21418.

Cook, Jason B. and Richard K. Mansfield, "Task-Specific Experience and Task-Specific Talent: Decomposing the Productivity of High School Teachers," 2014. working paper.

Cornwell, Christopher, David B. Mustard, and Jessica Van Parys, "Noncognitive Skills and the Gender Disparities in Test Scores and Teacher Assessments: Evidence from Primary School," *Journal of Human Resources*, 2013, *48* (1), 236–264.

Dee, Thomas S., "Teachers and the Gender Gaps in Student Achievement," *Journal of Human Resources*, 2007, *42* (3), 528–554.

Eisenkopfa, Gerald, Zohal Hessamia, Urs Fischbachera, and Heinrich W. Ursprunga, "Academic Performance and Single-Sex Schooling: Evidence from a Natural Experiment in Switzerland," *Journal of Economic Behavior and Organization*, 2015, *115*, 123–143.

Eliot, Lise, "Single-Sex Education and the Brain," *Sex Roles*, 2013, *69* (7-8), 363–381.

Epple, Dennis and Richard E. Romano, "Peer Effects in Education: A Survey of the Theory and Evidence," in Jess Benhabib, Alberto Bisin, and Matthew O. Jackson, eds., *Handbook of Social Economics*, Vol. 1, Elsevier, 2011, chapter 20, pp. 1053–1163.

Evans, William N., Wallace E. Oates, and Robert M. Schwab, "Measuring Peer Group Effects: A Study of Teenage Behavior," *Journal of Political Economy*, 1992, *100* (5), 966–991.

Flory, Jeffrey A., Andreas Leibbrandt, and John A. List, "Do Competitive Work Places Deter Female Workers? A Large-Scale Natural Field Experiment on Gender Differences in Job-Entry Decisions," *Review of Economic Studies*, forthcoming.

Fortin, Nicole M., Philip Oreopoulos, and Shelly Phipps, "Leaving Boys Behind: Gender Disparities in High Academic Achievement," *Journal of Human Resources*, 2015, *50*, 549–579.

Garlick, Robert, "Academic Peer Effects with Different Group Assignment Policies: Residential Tracking Versus Random Assignment," 2014. World Bank Policy Research Working Paper 6787.

Gneezy, Uri, Muriel Niederle, and Aldo Rustichini, "Performance in Competitive Environments: Gender Differences," *Quarterly Journal of Economics*, 2003, *118* (3), 1049–1074.

Goldin, Claudia, Lawrence F. Katz, and Ilyana Kuziemko, "The Homecoming of American College Women: The Reversal of the College Gender Gap," *Journal of Economic Perspectives*, 2006, *20* (4), 133–156.

Halpern, Diane F., Lise Eliot, Rebecca S. Bigler, Richard A. Fabes, Laura D. Hanish, Janet Hyde, Lynn S. Liben, and Carol Lynn Martin, "The Pseudoscience of Single-Sex Schooling," *Science*, 2011, *333* (6050), 1706–1707.

Hanlon, Harriet W., Robert W. Thatcher, and Marvin J. Cline, "Gender Differences in the Development of EEG Coherence in Normal Children," *Developmental Neuropsychology*, 1999, *16* (3), 479–506.

Hanushek, Eric A., "School Resources," in Eric A. Hanushek and Finis Welch, eds., *Handbook of the Economics of Education, Volume 2*, Elsevier, 2006.

Holmlund, Helena and Krister Sund, "Is the Gender Gap in School Performance Affected by the Sex of the Teacher?," *Labour Economics*, 2008, *15*, 37–53.

Hong, Kang P., "School Preference of Middle School Teachers in Seoul," 2007. KonKuk University Master's Thesis.

Hoxby, Caroline, "Peer Effects in the Classroom: Learning from Gender and Race Variation," 2000. NBER working paper 7867.

Jackson, C. Kirabo, "Single-Sex Schools, Student Achievement, and Course Selection: Evidence from Rule-Based Student Assignments in Trinidad and Tobago," *Journal of Public Economics*, 2012, *96* (1-2), 173–187.

Jacob, Brian A., "Where the Boys Aren't: Non-Cognitive Skills, Returns to School and the Gender Gap in Higher Education," *Economics of Education Review*, 2002, *21* (6), 589–598.

Jung, Kyungah and Haesook Chung, "Gender Equality in Classroom Instruction: Introducing Gender Training for Teachers in the Republic of Korea," 2005. UNESCO Asia and Pacific Regional Bureau for Education.

Kang, Changhui, "Classroom Peer Effects and Academic Achievement: Quasi-Randomization Evidence from South Korea," *Journal of Urban Economics*, 2007, *61* (3), 458–495.

Kim, Taejong, Ju-Ho Lee, and Young Lee, "Mixing versus Sorting in Schooling: Evidence from the Equalization Policy in South Korea," *Economics of Education Review*, 2008, *27* (6), 697–711.

Ku, Hyejin and Do Won Kwak, "Together or Separate: Disentangling the Effects of Single-Sex Schooling from the Effects of Single-Sex Schools," 2015. Working paper.

Lavy, Victor and Analía Schlosser, "Mechanisms and Impacts of Gender Peer Effects at School," *American Economic Journal: Applied Economics*, 2011, *3* (2), 1–33.

Lee, David, "Training, Wages, and Sample Selection: Estimating Sharp Bounds on Treatment Effects," *Review of Economic Studies*, 2009, *76* (3), 1071–1102.

Lee, Jungmin and Hye Yeon Park, "Gender Peer Effects: Evidence from the Transition from Single-Sex to Coeducational High Schools (Boy Meets Girl)," 2013.

Lee, Soohyung, Muriel Niederle, and Namwook Kang, "Do Single-Sex Schools Make Boys and Girls More Competitive?," *Economics Letters*, 2014, *124* (3), 474–477).

Lenroot, Rhoshel K., Nitin Gogtay, Deanna K. Greenstein, Elizabeth Molloy Wells, Gregory L. Wallace, Liv S. Clasen, Jonathan D. Blumenthal, Jason Lerch, Alex P. Zijdenbos, Alan C. Evans, Paul M. Thompson, and Jay N. Giedd, "Sexual Dimorphism of Brain Developmental Trajectories During Childhood and Adolescence," *NeuroImage*, 2007, *36* (4), 1065–1073.

Lim, Jaegeum and Jonathan Meer, "The Impact of Teacher-Student Gender Matches: Random Assignment Evidence from South Korea," 2015. NBER working paper 21407.

Lim, Jiyeon, Jungju Kim, Shinyoung Kim, and Min Kim, "Activities of Children and Adolescents in Korea," 2009. National Youth Policy Institute Policy Brief.

Link, Susanne, "Single-Sex Schooling and Student Performance: Quasi-Experimental Evidence from South Korea," 2012. Ifo working paper 146.

Lu, Fangwen and Michael L. Anderson, "Peer Effects in Microenvironments: The Benefits of Homogeneous Classroom Groups," *Journal of Labor Economics*, forthcoming.

Manski, Charles F., "Identification of Endogenous Social Effects: The Reflection Problem," *Review of Economic Studies*, 1993, *60* (3), 531–542.

Mo, Sanghyun and Heejin Kim, "Human Rights of Korean Children and Adolescents Compared to International Standard," 2009. National Youth Policy Institute Policy Brief.

Moffitt, Robert, "Policy Interventions, Low-Level Equilibria, and Social Interactions," in Steven N. Durlauf and H. Peyton Young, eds., *Social Dynamics*, Washington, DC: Brookings Institution Pres, 2001.

Muralidharan, Karthik and Ketki Sheth, "Bridging Education Gender Gaps in Developing Countries: The Role of Female Teachers," 2013. NBER working paper 19341.

Niederle, Muriel and Lise Vesterlund, "Do Women Shy Away From Competition? Do Men Compete Too Much?," *Quarterly Journal of Economics*, 2007, *122* (3), 1067–1101.

OECD, "Education at a Glance 2014: OECD Indicators," 2014. OECD Publishing.

Ost, Ben, "How Do Teachers Improve? The Relative Importance of Specific and General Human Capital," *American Economic Journal: Applied Economics*, 2014, *6* (2), 127–151.

Paredes, Valentina, "A Teacher Like Me or a Student Like Me? Role Model Versus Teacher Bias Effect," *Economics of Education Review*, 2014, *39*, 38–49.

Park, Hyunjoon, "Single Parenthood and Children's Education in South Korea: An Update," in Hyunjoon Park and Kyung keun Kim, eds., *Korean Education in Changing Economic and Demographic Contexts*, Springer, 2014.

_ , Jere R. Behrman, and Jaesung Choi, "Causal Effects of Single-Sex Schools on College Entrance Exams and College Attendance: Random Assignment in Seoul High Schools," *Demography*, 2013, *50* (2), 447–469.

Sacerdote, Bruce, "Peer Effects in Education: How Might They Work, How Big Are They and How Much Do We Know Thus Far?," in Eric A. Hanushek, Stephen Machin, and Ludger Woessmann, eds., *Handbook of the Economics of Education*, Vol. 4, Elsevier, 2011, chapter 4, pp. 249–277.

_ , "Experimental and Quasi-Experimental Analysis of Peer Effects: Two Steps Forward?," *Annual Review of Economics*, 2014, *6*, 253–272.

Schneeweis, Nicole and Martina Zweimüller, "Girls, Girls, Girls: Gender Composition and Female School Choice," *Economics of Education Review*, 2012, *31* (4), 482–500.

Sohn, Hosung, "Distributional Impact of Gender Segregation on Student Performance: Evidence from Randomized Block Designs," 2013. Working paper.

Steele, Claude M., Steven J. Spencer, and Joshua Aronson, "Contending with Group Image: The Psychology of Stereotype and Social Identity Threat," *Advances in Experimental Social Psychology*, 2002, *34*, 379–440.

Strain, Michael R., "Single-Sex Classes and Student Outcomes: Evidence from North Carolina," *Economics of Education Review*, 2013, *36*, 73–87.

Whitmore, Diane, "Resource and Peer Impacts on Girls' Academic Achievement: Evidence from a Randomized Experiment," *American Economic Review: Papers and Proceedings*, 2005, *95* (2), 199–203.

Woo, Seokjin, Soohyung Lee, and Kyunghee Kim, "Carrot and Stick? Impact of a Low-Stakes School Accountability Program on Student Achievement," *Economic Letters*, forthcoming.

Tables

Table 1: Characteristics of Students and Schools by School and Classroom Gender Composition

	A. Coed School		B. Single-sex school	
	(1) Coed classrooms	(2) Single-sex classrooms	(3) Boys only	(4) Girls only
A. School-level characteristics				
Number of classes	9.7	9.9	7.7	7.7
Class size	34.8	34.4	33.6	33.9
Fraction female in class	0.47	0 or 1	0	1
Fraction female teachers	0.73	0.61	0.41	0.65
Fraction experienced teachers	0.74	0.72	0.71	0.70
School founded by private entity	0.06	0.61	0.87	0.89
Fraction teachers in professional org.	0.36	0.45	0.42	0.48
Pupils per teacher	20.8	20.4	20.2	20.1
Government support in 2010	0.11	0	0.16	0.03
Observations (school by year)	377	23	90	76
B. Student-level characteristics				
Achievement: male students	-0.08	-0.25	-0.02	--
Reading	-0.19	-0.32	-0.11	--
English	-0.12	-0.34	-0.08	--
Math	-0.01	-0.17	0.04	--
Science	-0.04	-0.17	0.03	--
Social studies	-0.001	-0.12	0.04	--
Achievement: female students	0.09	-0.07	--	0.09
Reading	0.20	0.09	--	0.22
English	0.15	-0.08	--	0.14
Math	0.01	-0.12	--	0.001
Science	0.04	-0.06	--	0.06
Social studies	-0.003	-0.13	--	0.01
Observations (students)	128,096	7,726	23,132	19,875

Notes: Ninth grade students enrolled in a Seoul-area middle school in 2009 and 2010, excluding students in three districts that do not contain at least one of each type of middle school (coed classes, coed school with single-sex classes, single-sex male, and single-sex female). Experienced teachers have at least two years of experience. Teacher professional organizations are called unions, but do not practice collective bargaining on behalf of teachers. Number of observations used to measure whether a school received government support in 2010 is 283. Subject test scores are standardized to have a mean equal to zero and standard deviation equal to one (within the Seoul metropolitan area). Overall achievement is the sum of a student's raw achievement on all five subject tests, standardized to have mean zero, standard deviation equal one (within the Seoul metropolitan area).

Table 2: Correlations between Family Structure and School and Classroom Gender Composition

	(1) Both biological parents	(2) Single mother	(3) Other relative(s)
Female [x]			
1[Single-sex school]	0.009	-0.005	-0.002
	[0.006]	[0.004]	[0.003]
1[Coed school, single-sex class]	-0.008	0.009	0.001
	[0.012]	[0.009]	[0.005]
1[Coed class] [x] Fraction female in class	-0.007	-0.008	0.018
	[0.040]	[0.023]	[0.017]
Male [x]			
1[Single-sex school]	0.014*	-0.004	-0.005
	[0.007]	[0.004]	[0.003]
1[Coed school, single-sex class]	-0.006	0.002	0.010
	[0.012]	[0.005]	[0.008]
1[Coed class] [x] Fraction female in class	-0.006	-0.010	0.014
	[0.043]	[0.024]	[0.018]
F-test (*p*- value):			
All six coefficients = 0	0.419	0.697	0.497
Female coefficients = 0	0.401	0.387	0.612
Male coefficients = 0	0.214	0.628	0.232
Dependent variable mean	0.86	0.08	0.05
Observations	178,829	178,829	178,829

Notes: See Table 1 notes for sample. Estimates represent the impact of assignment to the specified school/classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects. "Other relatives" include: grandparents, siblings, single father, and all other relatives.

Table 3: The Impact of School and Classroom Gender Composition on Quits and Transfers

	(1) Quits/100 students	(2) Transfers/100 students
1[Female single-sex school]	-0.502*	-0.138
	[0.236]	[0.207]
1[Male single-sex school]	-0.494**	-0.625***
	[0.174]	[0.204]
1[Coed school, single-sex classes]	0.002	0.499***
	[0.128]	[0.168]
Test of equality (*p* -value):		
Male SS school = Coed school, single-sex classes	0.018	0.001
Female SS school = Coed school, single-sex classes	0.035	0.049
Dependent variable mean	1.74	3.15
Observations	561	561

Notes: KERIS data on Seoul middle schools in 2008 and 2009. Dependent variables represent outcomes for all students in grades 7 through 9. Each column represents a separate regression. Robust standard errors, clustered by school district, in brackets; * p<0.10, ** p<0.05, *** p<0.01. Regressions include district by year fixed effects and control for: number of classes, average students per class, number of teachers, fraction of experienced teachers, fraction of teachers belonging to a union, fraction of teachers that are female, pupils per teacher, and whether the school was founded by a private entity.

Table 4: The Impact of Single-Sex Schools and Classrooms on Achievement

	(1)	(2)	(3)	(4)
Female [x]				
1[Single-sex school]	0.015	0.010	-0.002	-0.002
	[0.034]	[0.032]	[0.046]	[0.046]
1[Coed school, single-sex class]	-0.087	-0.083	-0.063	-0.063
	[0.056]	[0.052]	[0.055]	[0.055]
Male [x]				
1[Single-sex school]	0.140***	0.132***	0.166***	0.134***
	[0.035]	[0.033]	[0.050]	[0.048]
1[Coed school, single-sex class]	-0.062	-0.058	-0.091**	-0.084*
	[0.041]	[0.037]	[0.044]	[0.044]
Test of equality (*p*- value):				
Male [x] SS school = Male [x] SS class	<0.001	<0.001	<0.001	<0.001
Female [x] SS school = Female [x] SS class	0.091	0.098	0.358	0.358
Observations	178,829	178,829	178,829	178,087
Student controls		X	X	X
School controls			X	X
Bounds based on differential quit/transfer rates				X

Notes: See Table 1 notes for sample. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects. Individual controls include indicators for living arrangement (both biological parents, single mother, single father, grandparents, other relatives, or other adults), all fully interacted with student gender. School controls include: number of classes, average students per class, number of teachers, fraction of experienced teachers, fraction of teachers belonging to a union, fraction of teachers that are female, pupils per teacher, and whether the school was founded by a private entity, all fully interacted with student gender. Dependent variable represents the sum of reading, English, math, science, and social studies test scores, standardized to have a mean of zero and standard deviation equal to one.

Table 5: The Impact of Classroom Gender Composition on Achievement

	(1) Combined	(2) Reading	(3) English	(4) Math	(5) Science	(6) Soc. Studies
Female [x]						
Fraction female in class	0.162	0.077	0.179	0.159	0.149	0.162
	[0.147]	[0.133]	[0.181]	[0.142]	[0.099]	[0.127]
Male [x]						
Fraction female in class	0.341**	0.259*	0.348**	0.257*	0.317**	0.351***
	[0.150]	[0.143]	[0.146]	[0.142]	[0.146]	[0.125]
Observations	128,096	128,096	128,096	128,096	128,096	128,096

Notes: See Table 1 notes for sample; coed schools with coed classrooms only. Estimates represent the impact of increasing the share classmates that are female, relative to an even split between female and male students. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). See Table 4 notes for description of individual and school controls. All test scores standardized to have a mean of zero and standard deviation equal to one.

Table 6: The Impact of School and Classroom Gender Composition on Achievement

	(1) Combined achievement	(2) Reading	(3) English	(4) Math	(5) Science	(6) Social Studies
Female [x]						
1[Single-sex school]	-0.003	-0.005	-0.008	-0.003	-0.008	0.010
	[0.047]	[0.040]	[0.057]	[0.046]	[0.042]	[0.040]
1[Coed school, single-sex class]	-0.065	-0.048	-0.110*	-0.030	-0.038	-0.064
	[0.055]	[0.051]	[0.065]	[0.053]	[0.043]	[0.048]
1[Coed class] [x] Fraction female in class	0.142	0.065	0.165	0.134	0.129	0.142
	[0.147]	[0.131]	[0.179]	[0.142]	[0.099]	[0.129]
Test of equality (*p*- value):						
Female [x] SS school = Female [x] SS class	0.356	0.477	0.160	0.658	0.596	0.216
Female [x] SS school = Female [x] Coed class, 100% female	0.413	0.638	0.409	0.423	0.269	0.437
Female [x] SS class = Female [x] Coed class, 100% female	0.152	0.346	0.091	0.284	0.130	0.102
Male [x]						
1[Single-sex school]	0.154***	0.138***	0.154**	0.156***	0.117**	0.125***
	[0.051]	[0.042]	[0.061]	[0.050]	[0.047]	[0.040]
1[Coed school, single-sex class]	-0.103**	-0.083**	-0.127**	-0.074*	-0.099**	-0.081*
	[0.045]	[0.042]	[0.053]	[0.044]	[0.039]	[0.043]
1[Coed class] [x] Fraction female in class	0.237	0.185	0.230	0.158	0.235	0.258**
	[0.157]	[0.149]	[0.155]	[0.149]	[0.150]	[0.129]
Test of equality (*p*- value):						
Male [x] SS school = Male [x] SS class	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Male [x] SS school = Male [x] Coed class, 100% male	0.002	0.003	0.003	0.005	0.005	<0.001
Male [x] SS class = Male [x] Coed class, 100% male	0.855	0.900	0.886	0.948	0.818	0.515
Observations	178,829	178,829	178,829	178,829	178,829	178,829

Notes: See Table 1 notes for sample. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). See Table 4 notes for description of individual and school controls. Combined achievement is the sum of test scores in all subjects, standardized to have a mean of zero and standard deviation equal to one. All subject scores standardized to have a mean of zero and standard deviation equal to one.

Table 7: The Impact of School and Classroom Gender Composition on other Academic Outcomes

	(1) Understand lectures	(2) Happy to go to school
Female x		
1[Single-sex school]	0.009	-0.008
	[0.009]	[0.008]
1[Co-ed school, single sex class]	0.005	-0.004
	[0.009]	[0.012]
1[Co-ed class] x Fraction female in class	0.007	0.005
	[0.017]	[0.022]
Test of equality (*p*- value):		
Female x SS school = Female x SS class	0.592	0.723
Female x SS school = Female x Coed class, 100% female	0.624	0.450
Female x SS class = Female x Coed class, 100% female	0.935	0.692
Male x		
1[Single-sex school]	0.020***	-0.025**
	[0.008]	[0.010]
1[Co-ed school, single sex class]	-0.006	-0.025***
	[0.008]	[0.009]
1[Co-ed class] x Fraction female in class	0.031	0.030
	[0.025]	[0.029]
Test of equality (*p*- value):		
Male x SS school = Male x SS class	0.003	0.999
Male x SS school = Male x Coed class, 100% male	0.011	0.532
Male x SS class = Male x Coed class, 100% male	0.492	0.539
Dependent variable mean	0.15	0.19
Observations	177,771	177,779

*Note*s: See Table 1 notes for sample. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). See Table 4 notes for description of individual and school controls.

Table 8: The Impact of School and Classroom Gender Composition on Student Effort and Time Use

	(1) Effort index	(2) Hours: academic	(3) Hours: leisure
Female ×			
1[Single-sex school]	0.019	-0.027	0.002
	[0.030]	[0.055]	[0.093]
1[Coed school, single-sex class]	0.051	-0.057	0.157
	[0.035]	[0.076]	[0.102]
1[Coed class] × Fraction female in class	0.036	0.142	-0.145
	[0.065]	[0.156]	[0.267]
Test of equality (*p*- value):			
Female × SS school = Female × SS class	0.400	0.719	0.135
Female × SS school = Female × Coed class, 100% female	0.979	0.296	0.662
Female × SS class = Female × Coed class, 100% female	0.503	0.238	0.185
Male ×			
1[Single-sex school]	0.139***	0.192***	-0.288***
	[0.032]	[0.052]	[0.094]
1[Coed school, single-sex class]	0.060**	-0.080*	0.075
	[0.029]	[0.046]	[0.077]
1[Coed class] × Fraction female in class	0.023	-0.113	0.158
	[0.090]	[0.159]	[0.231]
Test of equality (*p*- value):			
Male × SS school = Male × SS class	0.014	<0.001	<0.001
Male × SS school = Male × Coed class, 100% male	0.004	0.121	0.111
Male × SS class = Male × Coed class, 100% male	0.166	0.110	0.213
Dependent variable mean	0	2.6	4.5
Observations	177,277	177,310	177,094

*Note*s: See Table 1 notes for sample. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). For description of individual and school controls, see Table 4 notes. The effort index represents the sum of the students responses to whether they (1) come prepared to school, (2) are focused on lectures, (3) study class materials in advance, (4) review class material after school, (5) ask questions in class, and (6) actively participate in class, standardized to have a mean of zero and standard deviation of one. Time use measures represent hours per day spent on the specified activity. Academic activities include homework and cram school. Leisure activities include watching TV, playing computer games, and spending time with friends. See Online Appendix Tables B.3 and B.4 for estimated impacts of gender composition on effort index components and time spent on specific activities.

Table 9: The Impact of School and Classroom Gender Composition on Teacher and Classmate Effort

	(1) Classmates study hard	(2) Teaching quality
Female x		
1[Single-sex school]	0.052***	0.020
	[0.017]	[0.013]
1[Co-ed school, single sex class]	0.010	-0.005
	[0.016]	[0.011]
1[Co-ed class] x Fraction female in class	0.175**	-0.036*
	[0.073]	[0.020]
Test of equality (*p*- value):		
Female x SS school = Female x SS class	0.025	0.063
Female x SS school = Female x Coed class, 100% female	0.395	0.034
Female x SS class = Female x Coed class, 100% female	0.059	0.409
Male x		
1[Single-sex school]	-0.003	-0.001
	[0.011]	[0.012]
1[Co-ed school, single sex class]	-0.028***	0.005
	[0.010]	[0.013]
1[Co-ed class] x Fraction female in class	0.090**	0.025
	[0.039]	[0.031]
Test of equality (*p*- value):		
Male x SS school = Male x SS class	0.020	0.681
Male x SS school = Male x Coed class, 100% male	0.038	0.552
Male x SS class = Male x Coed class, 100% male	0.385	0.384
Dependent variable mean	0.10	0.14
Observations	177,846	177,872

Notes: For sample, see Table 1 notes. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, clustered by school×cohort, * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). For description of individual and school controls, see Table 4 notes.

Table 10: The Impact of School Gender Composition on Teaching Methods

	(1) Strict teaching methods	Homework	
		(2) Expected minutes/assignment	(3) Number of assignments/month
1[Male single-sex school]	0.628**	10.9***	1.8
	[0.258]	[2.6]	[1.2]
1[Female single-sex school]	0.172	0.7	-0.7***
	[0.135]	[2.1]	[0.2]
Dependent variable mean	0	30.6	6.3
Observations	304	316	310

*Note*s: Sample includes teachers of 9th grade students enrolled in a Seoul area school in 2007 that participated in the KELS survey. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. Strict teaching methods represents an index of the extent to which teachers reported (1) challenging students, (2) asking students questions in class, (3) encouraging students to think on their own, and (4) whether the school imposed punishments on students who violated the code of conduct, standardized to have a mean of zero and standard deviation of one. See Online Appendix Table A.5 for additional details. Number of homework assignments includes assignments related to (1) solving practice problems, (2) completing exercises in textbooks, (3) textbook readings, (4) writing short essays, (5) completing individual projects, and (6) completing group projects. See Online Appendix Table A.6 for additional details.

Table 11: The Impact of School Gender Composition on Bullying and Student Behavior Problems

		Behavior Problems	
	(1) Bullying per 100 students	(2) Minor	(3) Major
1[Male single-sex school]	-0.117**	-0.933***	-0.541***
	[0.049]	[0.082]	[0.170]
1[Female single-sex school]	-0.138**	-0.682***	-0.784***
	[0.061]	[0.081]	[0.076]
1[Coed school, single-sex classes]	-0.050	--	--
	[0.054]		
Dependent variable mean	0.35	0	0
Observations	508	316	315

*Note*s: Each column represents a separate regression. Column 1 sample includes Seoul area middle schools that reported information to KERIS in 2008 and 2009. Columns 2 and 3 sample includes teachers of 9th grade students enrolled in a Seoul area school in 2007 that participated in the KELS survey. Column 1 dependent variable is the number of bullying incidents reported by all students in grades 7 through 9. Column 2 dependent variable is an index of teachers' perceptions of minor behavioral problems including the extent to which students (1) are late to school, (2) are absent from school, (3) skip classes, (4) violate the school dress code, (5) do not pay attention in class, (6) are rude to teachers, (7) cheat, and (8) challenge teachers' authority, standardized to have a mean of zero and standard deviation of one. See Online Appendix Table A.7 for additional details. Column 3 dependent variable is an index of teachers' perceptions of major behavioral problems including the extent to which students (1) bully their classmates, (2) damage school property, (3) steal, (4) threaten other students, (5) physically attack other students, and (6) drink or take drugs, standardized to have a mean of zero and standard deviation of one. See Online Appendix Table A.8 for additional details. Robust standard errors, clustered by school district (column 1) or school (columns 2 and 3), in brackets; * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Column 1 regressions include district fixed effects and controls for: number of classes, average students per class, number of teachers, fraction of experienced teachers, fraction of teachers belonging to a union, fraction of teachers that are female, pupils per teacher, and whether the school was founded by a private entity.

Table 12: The Relative Importance of Student, Teacher, and Peer Inputs in Explaining the Impact of Peer Gender on Achievement

	(1)	(2)	(3)	(4)	(5)
Female ×					
1[Single-sex school]	0.006	-0.012	-0.004	0.000	-0.009
	[0.034]	[0.041]	[0.045]	[0.046]	[0.032]
1[Coed school, single-sex class]	-0.036	-0.078	-0.066	-0.063	-0.053
	[0.039]	[0.049]	[0.054]	[0.055]	[0.038]
1[Coed class] × Fraction female in class	0.077	0.101	0.099	0.131	0.063
	[0.100]	[0.134]	[0.137]	[0.146]	[0.099]
Test of equality (*p*- value):					
Female × SS school = Female × SS class	0.372	0.260	0.342	0.335	0.331
Female × SS school = Female × Coed class, 100% female	0.606	0.440	0.530	0.462	0.511
Female × SS class = Female × Coed class, 100% female	0.254	0.132	0.201	0.171	0.189
Male ×					
1[Single-sex school]	0.085**	0.094**	0.154***	0.154***	0.055
	[0.038]	[0.045]	[0.050]	[0.050]	[0.038]
1[Coed school, single-sex class]	-0.080**	-0.122***	-0.101**	-0.103**	-0.098***
	[0.036]	[0.042]	[0.044]	[0.045]	[0.036]
1[Coed class] × Fraction female in class	0.247**	0.208	0.202	0.207	0.232*
	[0.124]	[0.142]	[0.153]	[0.155]	[0.122]
Test of equality (*p*- value):					
Male × SS school = Male × SS class	<0.001	<0.001	<0.001	<0.001	<0.001
Male × SS school = Male × Coed class, 100% male	0.002	0.011	0.002	0.002	0.010
Male × SS class = Male × Coed class, 100% male	0.519	0.811	0.997	0.999	0.788
Observations	175,591	175,591	175,591	175,591	175,591
Additional controls:					
Student Inputs × Gender					
- Time use	YES	NO	NO	NO	YES
- Effort	NO	YES	NO	NO	YES
Peer inputs × Gender	NO	NO	YES	NO	NO
Teacher inputs × Gender	NO	NO	NO	YES	NO

*Note*s: See Table 1 notes for sample. Dependent variable is combined achievement across subjects. Estimates represent the impact of assignment to the specified school and and classroom gender composition relative to a coed classroom with equal number of female and male students. Each column represents a separate regression. Robust standard errors, school×cohort, * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). For description of individual and school controls, see Table 4 notes. Additional controls include student time spent on academic activities, student effort, peer inputs, and teacher inputs. See Table 8 and Online Appendix A for a description of the student time-use and effort measures. See Table 9 and Online Appendix A for a description of the teacher and peer input measures.

Table 13: Heterogeneity in the Impact of School and Classroom Gender Composition by Family Structure

	(1) Overall Achievement	(2) Student effort index	(3) Hours: academic	(4) Hours: leisure	(5) Teacher effort
Single mother	-0.442***	-0.315***	-0.697***	0.547***	0.005
	[0.017]	[0.016]	[0.026]	[0.037]	[0.006]
x Female	0.001	0.029	-0.023	0.127**	-0.007
	[0.020]	[0.020]	[0.035]	[0.052]	[0.007]
Female x **1**[Single-sex school]	-0.005	0.017	-0.028	-0.005	0.019
	[0.047]	[0.030]	[0.055]	[0.093]	[0.013]
x Single mother	0.041	0.027	0.033	0.068	0.005
	[0.029]	[0.031]	[0.056]	[0.072]	[0.010]
Female x **1**[Co-ed school, single-sex class]	-0.070	0.052	-0.058	0.160	-0.006
	[0.055]	[0.037]	[0.078]	[0.104]	[0.011]
x Single mother	0.076	-0.010	0.025	-0.042	0.011
	[0.047]	[0.051]	[0.079]	[0.125]	[0.018]
Male x **1**[Single-sex school]	0.159***	0.136***	0.176***	-0.280***	-0.001
	[0.050]	[0.031]	[0.051]	[0.093]	[0.012]
x Single mother	0.097***	0.048	0.146***	0.005	0.020*
	[0.032]	[0.032]	[0.054]	[0.076]	[0.012]
Male x **1**[Co-ed school, single-sex class]	-0.096**	0.060**	-0.095**	0.080	0.004
	[0.044]	[0.030]	[0.048]	[0.073]	[0.013]
x Single mother	0.059	0.014	0.127	0.030	0.021
	[0.057]	[0.064]	[0.118]	[0.139]	[0.019]
Observations	178,829	177,277	177,310	177,094	177,872

*Note*s: For sample, see Table 1 notes. Each column represents a separate regression. Robust standard errors, school×cohort, * p<0.10, ** p<0.05, *** p<0.01. All regressions include district×year×gender fixed effects and individual and school controls (fully interacted with gender). For description of individual and school controls, see Table 4 notes.