NBER WORKING PAPER SERIES

ALL OR NOTHING? THE IMPACT OF SCHOOL AND CLASSROOM GENDER COMPOSITION ON EFFORT AND ACADEMIC ACHIEVEMENT

Soohyung Lee
Lesley J. Turner
Seokjin Woo
Kyunghee Kim

Working Paper 20722
http://www.nber.org/papers/w20722

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2014

We thank Katharine Abraham, Chris Avery, Sandy Black, David Blau, Thomas Dee, John Ham, Muriel Niederle, Alex Ponce-Rodriguez, and Jeff Smith for helpful comments and suggestions. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

All or Nothing? The Impact of School and Classroom Gender Composition on Effort and Academic Achievement
Soohyung Lee, Lesley J. Turner, Seokjin Woo, and Kyunghee Kim
NBER Working Paper No. 20722
December 2014
JEL No. I20,I21,J24

ABSTRACT

We estimate the causal impact of school and classroom gender composition on achievement. We take advantage of the random assignment of Korean middle school students to single-sex schools, co-educational (coed) schools with single-sex classes, and coed schools with mixed-gender classes. Male students attending single-sex classes within coed schools score 0.10 of a standard deviation below male students in mixed-gender classes, and this achievement gap is entirely accounted for by classroom gender composition. Conversely, male students attending single-sex schools outperform their counterparts in mixed-gender classes by 0.15 of a standard deviation. The significant impact of single-sex schools on male students' achievement are not driven by classroom gender composition, but largely accounted for by increases in student effort and study-time. We find little evidence that classroom or school gender composition affect the outcomes of female students.

Soohyung Lee
Department of Economics
University of Maryland
3147B Tydings Hall
College Park, MD 20742
lees@econ.umd.edu

Lesley J. Turner
Department of Economics
University of Maryland
3115E Tydings Hall
College Park, MD 20742
and NBER
turner@econ.umd.edu

Seokjin Woo
Myongji University
34 Geobukgol-ro Seodaemun-gu
Seoul, 120-728, S. Korea
sjwoo@mju.ac.kr

Kyunghee Kim
Korea institute for Curriculum and Evaluation
Jeongdong Bldg.
21-15 Jeongdong-gil Jung-gu
Seoul, 100-784, S. Korea
khee@kice.re.kr

1 Introduction

The impact of interactions with peers on individual outcomes has been extensively studied in economics, in the context of social- and family-networks, neighborhood effects, and within educational settings. Research on peer effects in education provides evidence that peers matter, but underscores the difficulty in identifying the causal impact of potentially endogenously formed groups (e.g., Evans et al. 1992; Manski 1993; Moffitt 2001; Angrist 2014). In this paper, we focus on a particular type of peer effect: the role of student gender and the gender composition of peers in the education production function. Many countries provide some public schooling in gender-segregated classes or schools. The United States joined this group in 2006 when the Department of Education relaxed restrictions on single-sex schooling in public schools, resulting in large increases in the number of schools offering single-sex education and sparking a lively debate between proponents and critics of such policies.[1]

Nonrandom selection of students into schools and classes within schools makes it difficult to fully assess the impact of a student's peers on outcomes. Researchers have designed clever identification strategies that exploit variation in the share of female students within coeducational (coed) schools (e.g., Hoxby 2000) and variation in the probability of assignment to a coed versus single-sex schools (e.g., Jackson 2012). However, there is less evidence of whether estimates based on local variation around an evenly split class can be extrapolated to measure the impact of single-sex classrooms within coed schools. Furthermore, estimated impacts of single-sex schools may not represent the impact of attending a single-sex class within a coed schools, if teachers and schools adjust their curriculum, discipline methods, and other inputs in response to student gender composition. The distinction between single-sex schools and single-sex classrooms within coed schools is policy relevant: while most of the expansion in single-sex schooling in the U.S. since 2006 has taken the form of single-sex *classes* within coed schools, almost all studies on single-sex education involve comparisons between single-sex and coed *schools*.

We address these challenges by examining middle school students in the Seoul, South Korea metropolitan area, a setting that offers close to ideal circumstances for addressing concerns of endogenous sorting and differences in inputs that might be correlated with student gender composition. Within a given district, students are randomly assigned to single-sex schools, coed schools with single-sex classes, and coed schools with mixed-gender classes. Most inputs that would be considered endogenous in other settings, such as curriculum and school funding, are orthogonal to peer gender composition in our context.

[1] See, for instance, Weil's March 2008 *New York Times* article ("Teaching Boys and Girls Separately"), Hollingsworth and Bonner's July 2012 article in the *Christian Science Monitor* ("Why single-sex education is spreading across the US"), Morello's *Indiana Public Radio* May 2014 report ("The Great Gender Debate: Should Boys and Girls Learn Separately?"), and the American Civil Liberties Union's complaint filed against the U.S. Department of Education in May 2014 that single-sex schooling in Florida violates Title IX prohibitions on sex discrimination in federally funded education programs.

We find significant impacts of peer gender composition on male students' achievement but no effect on female students' performance. Male students in coed schools with single-sex classes perform the worst, scoring over 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 scoring 0.15 of a standard deviation above their counterparts in coed classrooms.

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.[2] We show that class- and school-based gender segregation yield significantly different outcomes for male students. In our setting, 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 the recent expansion of single-sex classes in the United States. 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.

We show that increases in study time and effort account for approximately 60 percent of the positive impact of attending a single-sex school on male students' achievement. Male students in single-sex schools are significantly more likely to report being focused on lectures, participating in classroom activities, and preparing in advance for class relative to male students attending coed schools. Male students in single-sex schools report spending more than an additional hour per week on homework and extra curricular tutoring relative to their peers in coeducational settings.

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 style and disciplinary methods, that may best serve students of a given gender. Our findings suggest that, if such specialization exists, it is able to increase achievement by inducing male students to exert more effort towards academic tasks. Although we cannot provide direct evidence of these channels, our findings do suggest that the gains from altering classroom gender composition are not zero-sum if single-sex schooling is an option.

Our paper contributes to an extensive literature on within-school gender peer effects.[3] In the first study to

[2]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.

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

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.[4] Lavy and Schlosser (2011) use both cross-cohort and within-student variation in cohort gender composition and find similar negative impacts of an increase in the share of classmates that are male. 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.[5] Using the random assignment of elementary students to classrooms in the Project STAR experiment, Whitmore (2005) finds that an increase in the share of female students 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.

We also contribute to the literature examining the impacts of single-sex schooling.[6] 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 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. Most similar to our paper's setting, Park et al. (2013) and Choi et al. (2014) estimate the impact of random assignment to coed and single-sex high schools in Seoul on college entrance exam performance. Park et al. (2013) estimate a random effects model while Choi et al. (2014) include district fixed effects and allow for heterogeneous impacts of single-sex schooling across districts; both studies find a positive impact of single-sex schooling on male students' achievement. Different from these two studies, we examine student effort and time use, as well as teacher and peer effort, which provide information on the mechanisms through which peer gender affects academic achievement. Furthermore, our empirical setting allows for a cleaner identification than the high school setting these two papers exploit, because at the end of their initial year, high school students must choose a track, which could be affected by gender peer effects, and the scoring of college entrance exams is not comparable across tracks.

[4] Hoxby (2000) also illustrates that the positive impact of female classmates likely operates through channels beyond the increase in average peer achievement that results from the fact that in her setting, female students earn higher scores than male students, on average.

[5] Garcia-Fontes and Ciccone (2014) argue that using variation in school by grade gender composition for identification will yield biased estimates in the presence of grade retention. As an alternative, they use variation in the gender composition of birth cohorts and estimate positive impacts of female peers on male students' achievement in Spain.

[6] In a review of descriptive studies that compare outcomes of students enrolled in single-sex and coed schools, U.S. Department of Education (2005) reports that 15 out of 43 studies found single-sex school students earned higher test scores coed school students, while only one study found that coed school students outperformed single-sex school students.

Our findings have implications for public policy outside of Korea. Many countries have publicly funded single-sex schools. Since the U.S. 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. 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.[7] 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.

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 are randomly assigned to a school in their district, and students are not allowed to submit preferences over schools during the assignment process.[8] Compliance with random assignment is high, because the only way for 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 schools (mostly for arts and athletics) supervised by the government with separate regulations.[9] Therefore, we observe the vast majority of middle school students and their outcomes. Furthermore, almost all school districts in Seoul contain single-sex schools, coed schools with single-sex classes, and coed schools with mixed-gender classes. Seoul has 11 school districts, which contain approximately 370

[7]Available at: http://www.singlesexschools.org/schools-schools.htm.

[8]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).

[9]In Seoul, such specialized schools make up less than 2 percent of the middle schools and less than 1 percent of middle school students.

middle schools. Roughly 30 percent of these schools are single-sex and around 7 percent are coed schools that separate male and female students into single-sex classes.

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 assigned to classes, called "Bahns", of approximately 34 students. Following Korea's "Equalization Policy," the assignment process equalizes prior achievement across Bahns (Kang 2007). Therefore, our setting provides us exogenous variation in peer gender composition in mixed-gender classes, while holding the average quality of peers constant.[10] 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.[11] Within coed schools that place students in mixed-gender classes, this process through which students are allocated to classrooms and idiosyncratic variation in cohort gender composition provides additional variation in the share of students that are female in a given classroom.

Finally, many factors that would be considered endogenous in other settings, such as curriculum and school funding, are held constant across districts, schools, and classrooms. All Seoul area 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 do not charge tuition, participate in the random assignment process, are publicly funded, and use the national curriculum. 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. 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 as the characteristics of teachers, 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,

[10]For instance, if school has 3 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, etc.

[11]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.

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.[12]

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., Park et al. 2013; Choi et al. 2014). 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 Scholarly Aptitude 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.

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 leads to 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)

[12]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 in Korea (Ministry of Education, Press Release, June 26th, 2014).

examine students in middle schools and report gender differences in competitiveness in South Korea and U.K, respectively, which have 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).

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. 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. However, 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). Finally, we supplement our data with a separate school-level dataset called the Korea Education & Research Information Service (KERIS) provided by the Korean Ministry of Education. For each year, the KERIS includes school-level characteristics, such as student-teacher ratios, whether a school was established by a private entity, teacher characteristics, number of bullying incidents and transfers.

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 coed, single-sex male, and single-sex female schools.[13] We limit our analysis to these eight districts, which contain 280 schools representing 76 percent of all schools and 77 percent of students in Seoul.[14]

Table 1 displays the characteristics of students and schools in our sample. As shown in Panel A, the

[13]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.

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

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 and have a smaller share of teachers that belong to a professional teachers' organization.[15] A higher share of all-male schools received support from a government program targeting low-performing schools in 2010.[16] 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 student gender, students attending single-sex classrooms within coed schools have the lowest average performance. 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. As shown in Figure 1, 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.

4 Modeling Gender Composition and Student Achievement

School and class gender composition may affect a given student's achievement through several channels. First, peer gender composition may indirectly affect student achievement by inducing students and their parents to alter their inputs (e.g., Epple and Romano 2011). For example, students may increase their effort or time devoted to studying in response to peer gender composition. Furthermore, parents may alter their investment for their children (e.g., by hiring private tutors).

Second, peer gender may directly affect a student's achievement by altering interactions among students within or outside the classroom. For example, if boys are more disruptive than girls, as in Lavy and Schlosser (2011), an increased share of male classmates may increase the time teachers spend handling disruptions and decrease time available for instruction (e.g., Lazear 2001). 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

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

[16] 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. When we limit our sample to only contain 2009 observations, 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).

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 balanced in prior achievement of students. 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. For example, 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.

Finally, beyond the channels discussed above, school and class gender composition may affect student achievement if teachers adjust their behavior in response to their students' gender composition. Korean teachers report that male and female students often react differently to the same teaching style (Chung et al. 2009). As an example, Jung and Chung (2005) report that male elementary and middle school students have more in-class interactions with their teachers and are more likely to ask questions and respond to questions posed by teachers. In addition, teachers may use different discipline methods depending on gender composition. Male and female students report differences in both their experiences of within-school disciplinary methods 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 compared to female students, but male students are also more likely to report supporting stricter discipline methods (Mo and Kim 2009).[17] Schools may also adjust inputs in response to student gender composition, such as adopting different curricula or hiring different teachers. In our setting, schools have limited ability to adjust such inputs.

The remainder of this section presents our empirical framework for identifying the impact of peer gender composition on student's achievement and other outcomes, including many of the student, parent, and teacher responses we describe above. We then discuss our method for decomposing the impact of peer gender composition on achievement into direct peer effects and indirect effects that occur through changes in student and teacher inputs. Finally, we present evidence supporting the validity of our identification strategy.

[17] 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.

4.1 Empirical framework

Under the identifying assumption that within a given district, students are randomly assigned to schools and classes, ordinary least squares regressions of test scores on school and classroom gender composition and district fixed effects should generate causal estimates of the average impact of single-sex schooling on student achievement. Our estimates of gender peer effects will include both direct peer effects and indirect effects that are driven by changes in teacher and student effort. To examine the impact of extensive margin variation in peer gender on student achievement, we estimate:

$$A_{icst} = \alpha^f SS_s^f + \alpha^m SS_s^m + \beta^f SC_s^f + \beta^m SC_s^m + \mathbf{X'_{it}}\boldsymbol{\lambda^g} + \mathbf{Z'_{st}}\boldsymbol{\eta^g} + \boldsymbol{\xi}_{\mathbf{d}\times\mathbf{g}} + \boldsymbol{\xi}_{\mathbf{t}\times\mathbf{g}} + \epsilon_{icst} \quad (1)$$

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.[18] 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 student gender and year by student gender fixed effects. 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:

$$A_{icst} = \delta^f FracFemale_{cst}^f + \delta^m FracFemale_{cst}^m + \mathbf{X'_{it}}\boldsymbol{\lambda^{\mathbf{g}}} + \mathbf{Z'_{st}}\boldsymbol{\eta^{\mathbf{g}}} + \boldsymbol{\xi}_{\mathbf{d}\times\mathbf{g}} + \boldsymbol{\xi}_{\mathbf{t}\times\mathbf{g}} + \epsilon_{icst} \quad (2)$$

Where $FracFemale_{cst}^g$ represents the share of classmates that are female interacted with an indicator for whether a student is gender g, 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

[18] School-specific characteristics include the total number of teachers in the school, the fraction teachers that are 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.

their 35 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 instead (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):

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

In this case, $\hat{\alpha}^g$ will represent 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 use the three models to examine the extent to which students and teachers adjust their inputs in response to peer gender composition. Furthermore, we conduct decomposition exercises by examining the extent to which the achievement gap between single-sex and coed schools decreases once we control for student and teacher inputs. For example, if differential effort by students within coed and single-sex schools drives the achievement gap between male students in these schools, then we should estimate a smaller achievement gap once we control for student effort in (3).

4.2 Evaluating the assumption of within-district random assignment

Before presenting estimates of the impact of school and classroom gender composition on student outcomes, we provide two pieces of evidence in support of our identifying assumption of within-district random assignment. First, we find no systematic 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 ($p = 0.44$). Nonetheless, we control for student living arrangements in our main specification.

Second, we provide evidence that, 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 do find evidence of significantly lower, albeit quite small in magnitude, quit and transfer rates within single-sex schools. Column (1) of Table 3 shows that on average, 17 of every 1000 students quit in a given year, leaving their assigned school, but not enrolling in a different school. Single-sex schools have 5 fewer quits per 1000 students. The average single-sex middle school has approximately 780 students, with 260 students in 9th grade. Even if all of the quits came from 9th grade, this would only imply a 4 student (2 percent) reduction in quits relative to other school types. As shown in column (2), estimated impacts on transfer rates out of single-sex male schools are of a similar magnitude. Given this small magnitude of transfers and quits, it is unlikely that endogenous quits and transfers would mitigate the initial random assignment within school districts.

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 (1). 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. 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. Furthermore, 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. 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.

Next, we investigate whether the impact of gender-segregated education is driven by impacts on achievement in specific subject areas. We examine students' performance on reading, English, math, science, and social studies tests. As shown in Table 5, we find no evidence that female students' performance depends on school or class gender composition in any subject except for English, where female students in coed schools with single-sex classes score approximately one-tenth of a standard deviation lower than female students in fully coed classes. Conversely, in every subject, male students in single-sex schools outperform their counterparts in coed schools, scoring between 0.13 and 0.17 of a standard deviation higher than boys in coed classes and 0.21 to 0.28 of a standard deviation higher than male students in single-sex classes. Finally, male students in single-sex classes within coed schools perform worse than their counterparts in coed classrooms in every subject, although our estimates are only statistically significant in the case of reading, English, and science.

In Table 6, we turn to examine whether variation in the share of classmates that are female affects the performance of students in mixed-gender classes, limiting 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 0.04 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 also female expect in the case of science, although for every subject, our point estimates are positive.[19]

[19]We also estimate models that include school fixed-effects and obtain similar results (available upon request).

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 Tables 4 and 5, although the impact of an increase in the share of classmates that are female on male students' achievement is no longer statistically significant. 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).[20]

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. This suggests that the benefits of single-sex schooling for male students is 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. 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.

We formally test the hypothesis that that students' achievement gains are linear in the share of classmates that are female; p-values from these tests are displayed in Table (7). 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 ($p = 0.152$ for female students and $p = 0.855$ 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.[21]

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

[20] 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.

[21] 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. Several other papers provide evidence against peer effects that are linear in average peer achievement, including Hoxby and Weingarth (2005), Ding and Lehrer (2007), Lavy et al. (2012), Burke and Sass (2013), and Carrell et al. (2013).

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. As shown in column (1) of Table 8, 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). Female students' assessments of lecture comprehension do not significantly depend on peer gender composition.

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 8, 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.

5.2 The impact of peer gender on the distribution of student achievement

Before further exploring the channels through which peer gender affects achievement, we investigate whether single-sex schooling differentially affects the achievement of students at different points in the ability distribution. 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 year and district fixed effects. Figure 2 displays the cumulative distribution of residualized achievement by school type (single-sex, coed with single-sex classes, and fully coed).

In contrast to our results thus far, we do find evidence that peer gender composition matters for female students with low to medium achievement (Panel A). 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. 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.

As shown in Panel B, 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 achievement distribution. 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.

6 Evidence on Mechanisms

Although our setting allows us to rule out many school- and class-level policies that vary with student gender composition, our estimated impact of peer gender composition on achievement will still encompass both direct peer effects and indirect effects that operate through impacts on student and teacher effort. To test for the importance of indirect peer effects, we use survey data containing measures of reported effort, time use, and perceptions of teacher and peer effort.[22]

6.1 Impacts on students' own effort and time-use

To test whether students' own effort responds to the gender composition of their peers, we create a summary measure of effort using students' responses to several survey questions. Specifically, 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 9). Male students in single-sex schools report effort that exceeds that of male students in coed classes by half of a standard deviation. Furthermore, their effort is almost one-third of a standard deviation higher than the effort reported by their counterparts enrolled in single-sex classes in coed schools. We find little evidence that single-sex schooling systematically alters female students' effort.[23]

[22] Appendix A provides a detailed description of the student survey and construction of the outcomes we examine.

[23] Appendix Table B.2 presents estimated impacts on the components of our composite effort measure. For male students, assignment to a single-sex school increases probability of coming to class prepared by 6.3 percentage points (23 percent) relative

The second two columns of Table 9 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 18 minutes day (close to 2 hours per week) on academic activities.[24] 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.

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 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.[25] Once again, we find little systematic evidence that female students' time use varies by classroom or school gender composition.

to assignment to a coed class and by 4 percentage points (15 percent) relative to assignment to a single-sex classroom within a coed school. Male students in single-sex schools are 2.7 percentage points (19 percent) more likely to report being focused on lectures relative to male students in coed classes and schools and 2.8 percentage points (7 percent) more likely to report reviewing class material after school compared to their counterparts in coed classrooms. Male students in single-sex schools are significantly more likely to report asking questions in class compared to those in coed classes (5.4 percentage points or 17 percent) and single-sex classrooms (1.9 percentage points or 6 percent). Finally, single-sex schooling leads to a 2.5 percentage point (17 percent) increase in the probability that male students report actively participating in class relative to assignment to a coed school. Female students in single-sex classes are significantly less likely to come to class prepared relative to those in coed classes, and within coed classes, female students are less likely to report being prepared when they have more female classmates. Female students also report being more comfortable asking questions within single-sex schools and single-sex classes within mixed-gender schools.

[24]In Appendix Table B.3, 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 (25 minutes per week) on homework, relative to those in coed classes with an even split of male and female students. Compared to their counterparts in such students spend 0.12 additional hours per day (50 minutes per week) in "cram school" compared to their counterparts in coed classes and an additional 0.21 hours per day (1.5 hours per week) in extra-curricular tutoring than male students in single-sex classrooms in coed schools.

[25]Male students in single-sex schools spend 0.1 fewer hours per day (42 fewer minutes per week) than those in coed classrooms playing computer games and 0.07 fewer hours per day (30 fewer minutes per week) relative to those in single-sex classrooms in coed schools (Appendix Table B.3). Male students in single-sex schools spend 0.1 fewer hours (45 fewer minutes per week) playing computer games compared to their counterparts in single-sex classes. The difference in time spent with friends for male students in single-sex schools versus those in coed classes is 0.12 hours per day (52 minutes per week). Male students in single-sex schools spend 0.11 fewer hours per day with friends compared to those in single-sex classrooms within coed schools. Among female students, none of the time-use categories we examine are significantly related to peer gender composition.

6.2 Impacts on student interactions and teacher inputs

Our dataset includes a small set of variables that provide information on interactions between students. The first measures students' views of whether their classmates study hard. 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). As shown in column (1) of Table 10, female students in single-sex schools are 13 percentage points (20 percent) more likely to report having hard working classmates than their counterparts in single-sex classes within coed schools. Male students in coed schools with single-sex classrooms are approximately 10 percentage points (15 percent) less likely to report having peers that study hard than male students in mixed-gender classes and male students in single-sex schools. In coed schools with mixed-gender classes, both male and female students with more female peers are significantly more likely to report having hardworking peers. This finding is consistent with the hypothesis that male students are more disruptive than female students (e.g., Lavy and Schlosser 2011).[26]

Our data does not provide the information directly measuring teachers behavior. However, one survey question asks students to assess whether their teachers "teach well".[27] We test whether students' assessments of teaching quality systematically varies by school and classroom gender composition. As shown in column (2) of Table 10, 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.[28]

6.3 Decomposition exercise

This subsection examines 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. Consider the 0.154 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 11, when we control for students' time-use, the gap falls to 0.085 of a standard deviation, a 44 percent reduction compared to our baseline result. When we control

[26] We also examine impacts on bullying incidents using school-level KERIS data. The number of incidents is rare - across all schools, fewer than 4 out of 1000 students report being bullied. This rarity is because the KERIS only collects bullying incidents, serious enough to be reported to schools. As shown in Table B.3, 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 a reduction in bullying of 0.5 per 1000. However, none of these estimates are statistically significant.

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

[28] 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 shown in Appendix Table B.1, 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.

for student effort (column (2)), the achievement gap falls to 0.110 of a standard deviation, a 28 percent reduction compared our the baseline result. 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 becomes 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 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

Thus far, we have shown male students who enroll in single-sex schools consistently outperform male students in other schools. Furthermore, we show that one channel through which single-sex schooling increases male students' achievement may be by increasing these students' effort and the amount of time they spend on academic-related activities. However, we still need to rule out alternative explanations for these findings. As shown in Table 1, single-sex schools are more likely to be private. Furthermore, single-sex schools serving male students have 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 qualification requirements and pay guidelines. These observed efforts to employ more male teachers is consistent with research suggesting that students may learn more when matched to a teacher of the same gender.[29]

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, satisfaction, and

[29] In the context of developing countries, Muralidharan and Sheth (2013) show that female students benefit from having female teachers. Hoffmann and Oreopoulos (2009) find that U.S. college students experience statistically significant, albeit small, benefits from having an instructor of the same sex. However, using data from 15 OECD countries, Cho (2012) finds no correlation between teacher-student gender matches and student achievement.

teacher effort (Table 12).[30] For male students, enrollment in a private school status does not significantly interact with peer gender composition. The one exception is that male students in single-sex private schools are less likely to report understanding class lectures compared to their counterparts in single-sex public schools. 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, perceptions of teaching quality, and satisfaction with school.

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 Table 13, we find a positive relationship between the concentration of male teachers and male students' achievement in single-sex schools.[31] 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 male-only 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 0.22 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 0.20 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 standard deviations higher than their peers in coed classrooms. The remainder of Table 13 examines impacts on our index of student effort, hours spent on academics and leisure, teacher effort, and student satisfaction. We find little evidence that the impact of single-sex schooling on male students varies by teacher gender for any of these outcomes, suggesting that the impact of single-sex male schools on achievement is not solely through these schools' ability to hire more male teachers.

[30] Appendix Table B.4 repeats this exercise, looking at performance on specific subject tests.

[31] Appendix Table B.5 presents results from models examining the impact of teacher gender interacted with peer gender on students' achievement in specific subjects.

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 also provide suggestive evidence that one channel through which single-sex schools affect male students' achievement is through increasing students' effort and time devoted to academic tasks. 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. We can only indirectly examine expectations and instruction technology using information from student surveys. However, 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.

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.

Burke, Mary A. and Tim R. Sass, "Classroom Peer Effects and Student Achievement," *Journal of Labor Economics*, 2013, *31* (1), 51–82.

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.

Ding, Weili and Steven F. Lehrer, "Do Peers Affect Student Achievement in China's Secondary Schools?," *Review of Economics and Statistics*, 2007, *89* (2), 300–312.

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.

Garcia-Fontes, Walter and Antonio Ciccone, "Gender Peer Effects in School, a Birth Cohort Approach," 2014. CEPR Discussion Paper No. DP10042.

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

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.

Hoffmann, Florian and Philip Oreopoulos, "A Professor Like Me: The Influence of Instructor Gender on College Achievement," *Journal of Human Resources*, 2009, *44* (2), 479–494.

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

Hoxby, Caroline M. and Gretchen Weingarth, "School Reassignment and the Structure of Peer Effects," 2005. working paper.

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.

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.

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

_ , Olmo Silva, and Felix Weinhardt, "The Good, The Bad and The Average: Evidence on Ability Peer Effects in Schools," *Journal of Labor Economics*, 2012, *30* (2), 367–414.

Lazear, Edward P., "Educational Production," *Quarterly Journal of Economics*, 2001, *116* (3), 777–803.

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

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.

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, pp. 153–171.

_ , 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.

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.

U.S. Department of Education, "Single-Sex Versus Secondary Schooling: A Systematic Review," 2005. Washington DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development.

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.

Tables and Figures

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 middle school students enrolled in a Seoul-area public school in 2009 and 2010. Excludes 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 are those with 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 mom	(3) Other relative(s)
Female x			
1[Single-sex school]	0.010	-0.005	-0.003
	[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	0.001	-0.010	0.014
	[0.038]	[0.023]	[0.016]
Male x			
1[Single-sex school]	0.012*	-0.003	-0.004
	[0.007]	[0.004]	[0.003]
1[Coed school, single-sex class]	-0.007	0.002	0.011
	[0.011]	[0.005]	[0.008]
1[Coed class] x Fraction female in class	-0.008	-0.012	0.019
	[0.041]	[0.023]	[0.018]
F-test (*p*- value):			
All six coefficients = 0	0.436	0.616	0.437
Female coefficients = 0	0.306	0.281	0.618
Male coefficients = 0	0.249	0.679	0.199
Dependent variable mean	0.86	0.08	0.05
Observations	178,829	178,829	178,829

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, in brackets; * p<0.10, ** p<0.05, *** p<0.01. All regressions include gender, year, and school fixed effects, all fully interacted with gender. "Other relatives" category includes grandparents, siblings, single father, and all other relatives.

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

	(1) Quits per 100 students	(2) Transfers per 100 students
1[Female single-sex school]	-0.505*	-0.151
	[0.252]	[0.111]
1[Male single-sex school]	-0.504*	-0.603**
	[0.225]	[0.230]
1[Coed school, single-sex classes]	-0.009	0.483**
	[0.159]	[0.199]
Test of equality (*p* -value):		
Male SS school = Coed school, single-sex classes	0.082	0.005
Female SS school = Coed school, single-sex classes	0.061	0.058
Dependent variable mean	1.74	3.15
Observations	566	566

Notes: Sample includes schools that report information to KERIS. 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. Both 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 4: The Impact of Single-Sex Schools and Classrooms on Achievement

	(1)	(2)	(3)
Female ×			
1[Single-sex school]	0.015	0.010	-0.002
	[0.034]	[0.032]	[0.047]
1[Coed school, single-sex class]	-0.087	-0.083	-0.063
	[0.055]	[0.052]	[0.055]
Male ×			
1[Single-sex school]	0.140***	0.132***	0.166***
	[0.035]	[0.033]	[0.050]
1[Coed school, single-sex class]	-0.063	-0.059	-0.093**
	[0.042]	[0.037]	[0.044]
Test of equality (*p*- value):			
Male × SS school = Male × SS class	<0.001	<0.001	<0.001
Female × SS school = Female × SS class	0.090	0.098	0.356
Observations	178,829	178,829	178,829
Student controls		X	X
School controls			X

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. 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 by gender fixed effects and year by gender fixed effects and gender main effects. Individual controls include indicators for living arrangement (both biological parents, single mother, single father, grandparents, other relatives, or other adults), 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 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 Single-Sex Schools and Classrooms on Achievement by Subject

	(1) Reading	(2) English	(3) Math	(4) Science	(5) Soc. Studies
Female x					
1[Single-sex school]	-0.005	-0.007	-0.002	-0.007	0.011
	[0.040]	[0.057]	[0.046]	[0.042]	[0.039]
1[Coed school, single-sex class]	-0.048	-0.109*	-0.029	-0.037	-0.063
	[0.051]	[0.065]	[0.053]	[0.043]	[0.047]
Male x					
1[Single-sex school]	0.148***	0.165***	0.164***	0.129***	0.138***
	[0.041]	[0.060]	[0.049]	[0.046]	[0.039]
1[Coed school, single-sex class]	-0.074*	-0.117**	-0.067	-0.089**	-0.069
	[0.041]	[0.052]	[0.043]	[0.038]	[0.043]
Test of equality (*p*- value):					
Male x SS school = Male x SS class	<0.001	<0.001	<0.001	<0.001	<0.001
Female x SS school = Female x SS class	0.477	0.159	0.659	0.597	0.215
Observations	178,829	178,829	178,829	178,829	178,829

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. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes. All test scores standardized to have a mean of zero and standard deviation equal to one.

Table 6: 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	0.189	0.103	0.203	0.189	0.169*	0.185
	[0.146]	[0.132]	[0.180]	[0.140]	[0.099]	[0.127]
Male x						
Fraction female in class	0.366**	0.286*	0.368**	0.281*	0.337**	0.376***
	[0.152]	[0.146]	[0.147]	[0.144]	[0.147]	[0.126]
Observations	128,096	128,096	128,096	128,096	128,096	128,096

Notes: For sample, see Table 1 notes. Sample limited to students attending coed schools with coed classrooms. 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 at school by year level, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes. All test 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 Achievement

	(1) Combined achievement	(1) Reading	(2) English	(3) Math	(4) Science	(5) Social Studies
Female ×						
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] × 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 × SS school = Female × SS class	0.356	0.477	0.160	0.658	0.596	0.216
Female × SS school = Female × Coed class, 100% female	0.413	0.638	0.409	0.423	0.269	0.437
Female × SS class = Female × Coed class, 100% female	0.152	0.346	0.091	0.284	0.130	0.102
Male ×						
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] × 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 × SS school = Male × SS class	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Male × SS school = Male × Coed class, 100% male	0.002	0.003	0.003	0.005	0.005	<0.001
Male × SS class = Male × 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: 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 at school by year level, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes. 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 8: The Impact of School and Classroom Gender Composition on other Academic Outcomes

	(1) Understand lectures	(2) Happy to go to school
Female ×		
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] × Fraction female in class	0.011	0.005
	[0.016]	[0.022]
Test of equality (*p*- value):		
Female × SS school = Female × SS class	0.622	0.723
Female × SS school = Female × Coed class, 100% female	0.749	0.449
Female × SS class = Female × Coed class, 100% female	0.956	0.694
Male ×		
1[Single-sex school]	0.020**	-0.025***
	[0.008]	[0.010]
1[Co-ed school, single sex class]	-0.006	-0.026***
	[0.008]	[0.010]
1[Co-ed class] × Fraction female in class	0.034	0.031
	[0.026]	[0.029]
Test of equality (*p*- value):		
Male × SS school = Male × SS class	0.004	0.955
Male × SS school = Male × Coed class, 100% male	0.010	0.530
Male × SS class = Male × Coed class, 100% male	0.469	0.518
Dependent variable mean	0.15	0.19
Observations	177,771	177,779

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 at school by year level, in brackets; * $p<0.10$, ** $p<0.05$, *** $p<0.01$. For description of individual and school controls, see Table 4 notes.

Table 9: 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]	0.075	-0.028	0.001
	[0.111]	[0.056]	[0.094]
1[Coed school, single-sex class]	0.178	-0.059	0.158
	[0.145]	[0.076]	[0.101]
1[Coed class] × Fraction female in class	-0.010	0.176	-0.187
	[0.235]	[0.155]	[0.266]
Test of equality (*p*- value):			
Female × SS school = Female × SS class	0.472	0.712	0.130
Female × SS school = Female × Coed class, 100% female	0.622	0.216	0.579
Female × SS class = Female × Coed class, 100% female	0.333	0.175	0.145
Male ×			
1[Single-sex school]	0.497***	0.193***	-0.287***
	[0.109]	[0.052]	[0.094]
1[Coed school, single-sex class]	0.170	-0.081*	0.076
	[0.105]	[0.045]	[0.076]
1[Coed class] × Fraction female in class	0.166	-0.125	0.134
	[0.311]	[0.161]	[0.234]
Test of equality (*p*- value):			
Male × SS school = Male × SS class	0.006	<0.001	<0.001
Male × SS school = Male × Coed class, 100% male	0.002	0.138	0.099
Male × SS class = Male × Coed class, 100% male	0.158	0.096	0.252
Dependent variable mean	0	2.6	4.5
Observations	177,682	177,310	177,094

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 at school by year level, in brackets; * p<0.10, ** p<0.05, *** p<0.01. 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 Appendix Tables B.2 and B.3 for estimated impacts of gender composition on effort index components and time spent on specific activities.

Table 10: The Impact of School and Classroom Gender Composition on Teacher and Classmate Effort

	(1) Classmates study hard	(2) Teaching quality
Female ×		
1[Single-sex school]	0.133***	0.019
	[0.030]	[0.013]
1[Co-ed school, single sex class]	0.053	-0.005
	[0.037]	[0.011]
1[Co-ed class] × Fraction female in class	0.229***	-0.033
	[0.073]	[0.020]
Test of equality (*p*- value):		
Female × SS school = Female × SS class	0.058	0.063
Female × SS school = Female × Coed class, 100% female	0.695	0.045
Female × SS class = Female × Coed class, 100% female	0.245	0.477
Male ×		
1[Single-sex school]	-0.004	-0.001
	[0.029]	[0.012]
1[Co-ed school, single sex class]	-0.098***	0.004
	[0.027]	[0.013]
1[Co-ed class] × Fraction female in class	0.151**	0.027
	[0.074]	[0.031]
Test of equality (*p*- value):		
Male × SS school = Male × SS class	0.002	0.687
Male × SS school = Male × Coed class, 100% male	0.099	0.529
Male × SS class = Male × Coed class, 100% male	0.589	0.366
Dependent variable mean	0.67	0.14
Observations	178,829	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 at school by year level, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes.

Table 11: 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]	0.005	-0.014	-0.009	-0.004	-0.007
	[0.034]	[0.043]	[0.046]	[0.046]	[0.032]
1[Coed school, single-sex class]	-0.035	-0.086*	-0.067	-0.064	-0.056
	[0.039]	[0.050]	[0.053]	[0.054]	[0.038]
1[Coed class] × Fraction female in class	0.079	0.126	0.113	0.136	0.081
	[0.100]	[0.140]	[0.143]	[0.146]	[0.101]
Test of equality (*p*- value):					
Female × SS school = Female × SS class	0.395	0.247	0.373	0.359	0.299
Female × SS school = Female × Coed class, 100% female	0.579	0.363	0.459	0.421	0.440
Female × SS class = Female × Coed class, 100% female	0.250	0.093	0.181	0.157	0.137
Male ×					
1[Single-sex school]	0.085**	0.110**	0.155***	0.155***	0.061
	[0.038]	[0.047]	[0.051]	[0.051]	[0.038]
1[Coed school, single-sex class]	-0.080**	-0.123***	-0.103**	-0.104**	-0.096***
	[0.036]	[0.042]	[0.045]	[0.045]	[0.035]
1[Coed class] × Fraction female in class	0.247**	0.216	0.220	0.216	0.240*
	[0.124]	[0.146]	[0.155]	[0.155]	[0.123]
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	0.007	0.002	0.002	0.007
Male × SS class = Male × Coed class, 100% male	0.52	0.847	0.935	0.961	0.723
Observations	176,197	177,682	178,829	177,872	176,197
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

Notes: For sample, see Table 1 notes. 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, clustered at school by year level, in brackets; * p<0.10, ** p<0.05, *** p<0.01. 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 9 and Appendix A for a description of the student time-use and effort measures. See Table 10 and Appendix A for a description of the teacher and peer input measures.

Table 12: Heterogeneity in the Impact of School and Classroom Gender Composition: Public versus Private Schools

	(1) Overall Achievement	(2) Student effort index	(3) Hours: academic	(4) Hours: leisure	(5) Teacher effort	(6) Understand lectures	(7) Happy to go to school
Private	0.103	-0.099	0.105	-0.043	-0.008	0.005	-0.023**
	[0.065]	[0.132]	[0.065]	[0.101]	[0.017]	[0.011]	[0.011]
Female × **1**[Single-sex school]	-0.076	-0.012	-0.163**	0.228	0.032	0.001	-0.015
	[0.089]	[0.234]	[0.078]	[0.170]	[0.031]	[0.017]	[0.014]
× Private	0.093	0.008	0.180*	-0.278	-0.028	0.005	0.001
	[0.100]	[0.267]	[0.103]	[0.198]	[0.034]	[0.020]	[0.018]
Female × **1**[Co-ed school, same sex class]	-0.003	0.483**	0.037	-0.052	0.011	0.026**	0.023
	[0.057]	[0.192]	[0.096]	[0.121]	[0.012]	[0.012]	[0.017]
× Private	-0.092	-0.598**	-0.132	0.328*	-0.040**	-0.041**	-0.052**
	[0.106]	[0.251]	[0.147]	[0.185]	[0.020]	[0.016]	[0.021]
Male × **1**[Single-sex school]	0.138*	0.560***	0.196**	-0.237	-0.002	0.035***	-0.027*
	[0.084]	[0.179]	[0.080]	[0.158]	[0.018]	[0.012]	[0.016]
× Private	0.043	-0.129	-0.013	-0.066	0.006	-0.029*	0.008
	[0.100]	[0.213]	[0.099]	[0.181]	[0.025]	[0.016]	[0.018]
Male × **1**[Co-ed school, same sex class]	-0.047	0.247**	-0.114*	0.006	-0.004	0.003	-0.028*
	[0.044]	[0.119]	[0.064]	[0.096]	[0.015]	[0.011]	[0.015]
× Private	-0.073	-0.181	0.048	0.124	0.021	-0.025	0.010
	[0.089]	[0.211]	[0.095]	[0.154]	[0.027]	[0.017]	[0.020]
Observations	178,829	177,682	177,310	177,094	177,872	177,771	177,779

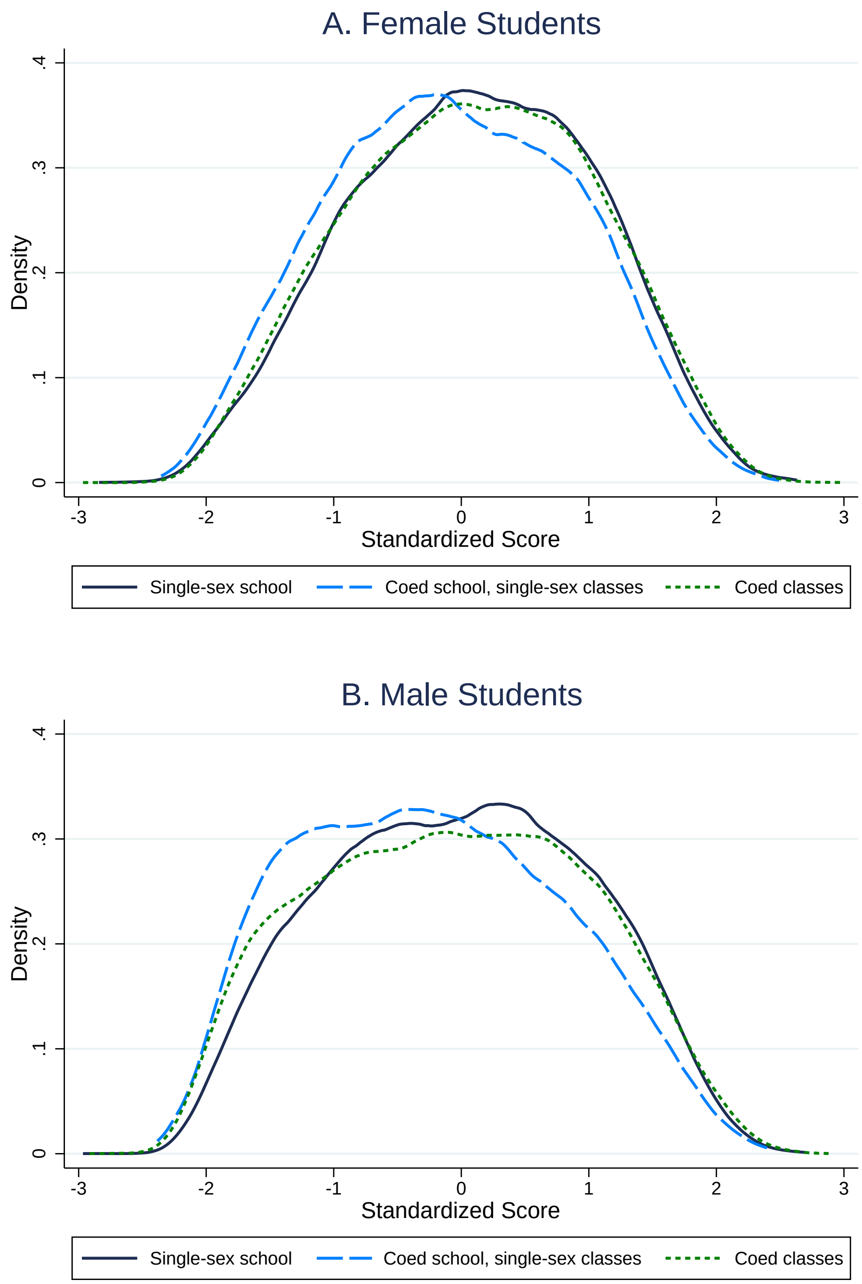
Notes: For sample, see Table 1 notes. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes. Regressions also include controls for whether a school is private, fully interacted with gender, and an interaction between private school status and an indicator for single-sex school.

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

	(1) Overall Achievement	(2) Student effort index	(3) Hours: academic	(4) Hours: leisure	(5) Teacher effort	(6) Understand lectures	(7) Happy to go to school
Fraction teachers female in school (μ = 0.5)	0.453**	0.723*	0.260	-0.194	-0.015	0.027	0.027
	[0.187]	[0.398]	[0.189]	[0.304]	[0.037]	[0.031]	[0.035]
Female x **1**[Single-sex school]	0.032	0.148	0.028	-0.135	0.011	0.010	-0.004
	[0.062]	[0.117]	[0.088]	[0.112]	[0.015]	[0.009]	[0.011]
x Fraction teachers female in school	-0.218	-0.736	-0.397	1.046**	0.054	-0.022	-0.039
	[0.276]	[0.550]	[0.373]	[0.488]	[0.060]	[0.040]	[0.046]
Female x **1**[Co-ed school, same sex class]	-0.038	0.014	-0.057	0.206*	-0.012	-0.007	-0.015
	[0.073]	[0.161]	[0.095]	[0.118]	[0.015]	[0.010]	[0.011]
x Fraction teachers female in school	-0.153	1.304	0.060	-0.521	0.037	0.089*	0.088
	[0.303]	[0.912]	[0.470]	[0.523]	[0.065]	[0.052]	[0.067]
Male x **1**[Single-sex school]	0.210***	0.523***	0.211***	-0.316***	0.005	0.023***	-0.016*
	[0.049]	[0.111]	[0.053]	[0.087]	[0.012]	[0.008]	[0.009]
x Fraction teachers female in school	-0.502**	-0.326	-0.165	0.453	-0.055	-0.017	-0.088**
	[0.209]	[0.450]	[0.224]	[0.386]	[0.042]	[0.034]	[0.041]
Male x **1**[Co-ed school, same sex class]	-0.050	0.126	0.001	0.074	0.015	-0.003	-0.018
	[0.069]	[0.165]	[0.062]	[0.106]	[0.022]	[0.013]	[0.013]
x Fraction teachers female in school	-0.137	0.501	-0.587**	-0.099	-0.054	-0.005	-0.013
	[0.267]	[0.739]	[0.298]	[0.482]	[0.103]	[0.062]	[0.074]
Observations	178,829	177,682	177,310	177,094	177,872	177,771	177,779

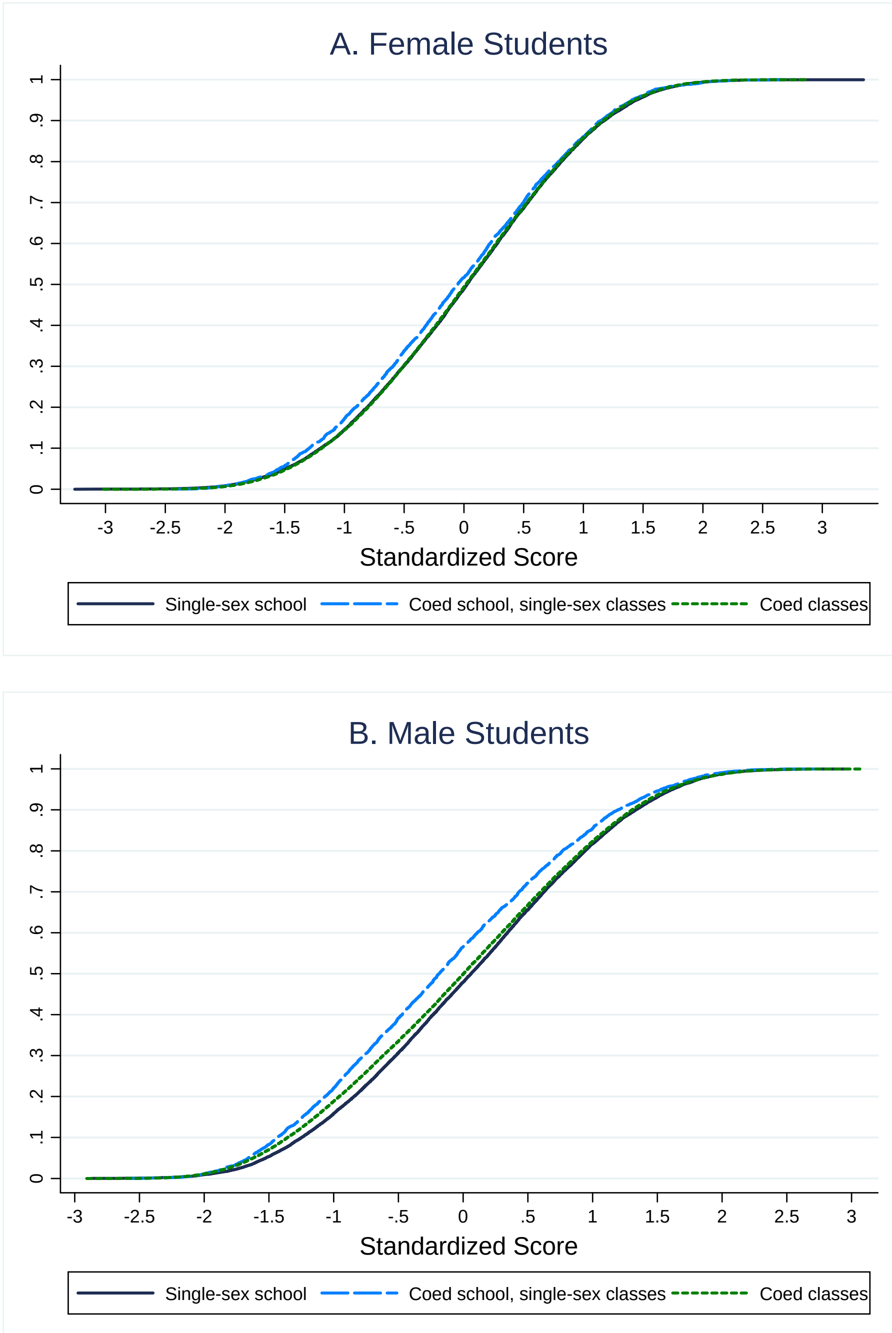
Notes: For sample, see Table 1 notes. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. Share teachers female denotes the fraction of teachers in a given school and year that are female, standardized such that zero indicates an equal share of male and female teachers. For description of individual and school controls, see Table 4 notes. Regressions also include controls for the share of teachers that are female, fully interacted with gender, and an interaction between the share of teachers that are female and an indicator for single-sex school.

Figure 1: The Distribution of Student Achievement by School and Classroom Gender Composition



Notes: For sample, see Table 1 notes. Achievement is standardized to have a mean of zero, standard deviation of one.

Figure 2: The Cumulative Distribution of Achievement by Peer Gender Composition



Notes: For sample, see Table 1 notes. Cumulative distribution of residual achievement (from regressions of achievement on student controls, school controls, and year and district fixed effects, separately estimated by gender). Kolmogorov-Smirnov test of equality of distributions for female students (p-value): single-sex school = coed school with coed classes: $p = 0.891$; coed school with single-sex classes = coed school with coed classes: $p < 0.001$; single-sex school = coed school with single-sex classes : $p < 0.001$. Kolmogorov-Smirnov test of equality of distributions for male students (p-value): single-sex school = coed school with coed classes: $p < 0.001$; coed school with single-sex classes = coed school with coed classes: $p < 0.001$; single-sex school = coed school with single-sex classes : $p < 0.001$.

A Data Appendix

Our primary data source comes from the Korean Ministry of Education and contains National Assessment of Educational Achievement (NAEA) test scores for all ninth grade students. Students are tested in reading (Korean), math, English, science, and social studies. This data set also contains information from a survey that students complete regarding their time use and experiences in school. We also use school-level administrative data from the Korean Education and Research Information Service (KERIS). KERIS contains information on bullying, student exits, and a limited set of school and teacher characteristics.

A.1 NAEA Tests

All South Korean students at grades 6, 9, and 11, participate in the NAEA in June of each year. The NAEA was introduced in 1998 and was initially administrated to a subset of schools based on sampling and then expanded to all schools from 2008. By law, summary statistics of a school's performance at the NAEA is publicly available at the school's website and that of the Ministry of Education. For each subject, we standardize students' score to have a mean of zero and standard deviation equal to one. We construct a measure of overall achievement by summing raw scores across all five subjects and standardizing to have a mean of zero and standard deviation equal to one.

A.2 Student Survey

Our measures of student effort are derived from survey questions which ask students to choose one of four options (strongly disagree, disagree, agree, or strongly agree) in response to a statement. Students were classified as *coming to class prepared* if they strongly agreed with the statement "I bring textbooks, homework, and materials related to classes to school." Students were classified as being *focused on lectures* if they strongly agreed with the statement "I concentrate on what teachers say during classes." Students who *studied material in advance* were those who strongly agreed or agreed with the statement "I study textbook materials in advance to get ready for school lectures." Students who *reviewed after school* strongly agreed or agreed with the statement "I study the lecture materials I learned during the day." Those who *asked questions during class* indicated that they strongly agreed or agreed with the statement "I ask questions to teachers during the class or right after the class." *Active participants* were students who strongly agreed with the statement "I actively participate in classroom activities – e.g., science experiment, discussions, group activities." Our composite student effort index is constructed by summing students responses to each of the above six measures, standardized to have a mean of zero and standard deviation of one. Table A.1 displays the distribution of responses to each survey item by school type.

Measures of student time use are derived from survey questions which ask students to chose one of five categories of time use for the specified activity. We convert these categories into a continuous measure of time use: "0 hours" is coded as 0, "between 0 and 1 hour" is coded as 0.5 hours, "between 1 and 2 hours" is coded as 1.5 hours, "between 2 and 3 hours" is coded as 2.5 hours, and "3 or higher" is coded as 3.5 hours. Tables A.2 and A.3 display the distribution of student responses to these questions by school and class gender composition.

Our measures of classmate and teacher inputs come from survey questions where students choose one of four options (strongly disagree, disagree, agree, or strongly agree) in response to a statement. We classify a student as indicating that his/her *classmates study hard* if he or she strongly agrees or agrees with the statement "the students in my school study hard in general." A student is classified as indicating his/her high *teaching quality* if he/she strongly agrees with the statement "my teachers [homeroom and subject teachers] teach skillfully/with enthusiasm." Likewise, our alternative measures of student outcomes come from survey questions where students choose one of the same four options. A student is classified as *understanding lectures* if he/she strongly agrees with the statement "I can understand the textbook materials with classroom lectures (without additional help from cram school)." Finally, a student is considered to be *happy to go to school* if he/she strongly agrees with the statement "I am happy to go to school." Table A.4 displays the distribution of student responses by survey question and school type.

Table A.1: Student Effort Index Components by School and Class Gender Composition

	A. Coed School		B. Single-sex school	
	(1) Coed classrooms	(2) Single-sex classrooms	(3) Boys only	(4) Girls only
A. Coming to class prepared				
strongly disagree	0.01	0.01	0.02	0.01
disagree	0.12	0.12	0.13	0.09
agree	0.59	0.60	0.55	0.66
strongly agree	0.27	0.27	0.31	0.25
Observations	127,361	7,702	23,045	19,822
B. Focused on lectures				
strongly disagree	0.02	0.02	0.03	0.02
disagree	0.25	0.27	0.26	0.21
agree	0.59	0.58	0.55	0.64
strongly agree	0.14	0.13	0.16	0.13
Observations	127,308	7,701	23,049	19,817
C. Study material in advance				
strongly disagree	0.21	0.20	0.22	0.19
disagree	0.56	0.57	0.54	0.59
agree	0.20	0.19	0.19	0.20
strongly agree	0.04	0.04	0.05	0.02
Observations	127,275	7,700	23,031	19,811
D. Review after school				
strongly disagree	0.15	0.14	0.17	0.12
disagree	0.47	0.48	0.47	0.48
agree	0.33	0.32	0.30	0.36
strongly agree	0.05	0.05	0.06	0.04
Observations	127,316	7,699	23,037	19,816
E. Ask questions in class				
strongly disagree	0.18	0.15	0.16	0.16
disagree	0.51	0.52	0.49	0.52
agree	0.26	0.28	0.29	0.28
strongly agree	0.05	0.05	0.07	0.04
Observations	127,266	7,700	23,029	19,806
F. Actively participate				
strongly disagree	0.06	0.05	0.07	0.04
disagree	0.27	0.27	0.27	0.25
agree	0.53	0.54	0.50	0.58
strongly agree	0.14	0.14	0.17	0.12
Observations	127,292	7,698	23,036	19,812

Notes: For sample, see Table 1 notes.

Table A.2: Student Time Use by School and Class Gender Composition: Academic Activities

	A. Coed School		B. Single-sex school	
	(1) Coed classes	(2) Single-sex classes	(3) All male	(4) All female
A. Homework				
0 hours	0.15	0.14	0.13	0.10
less than 1 hour	0.59	0.57	0.56	0.58
1-2 hours	0.22	0.25	0.25	0.27
2-3 hours	0.03	0.03	0.03	0.03
3 or more hours	0.02	0.02	0.03	0.01
Mean	0.74	0.78	0.83	0.82
Observations	127,168	7,688	23,025	19,807
B. Cram school				
0 hours	0.30	0.37	0.30	0.32
less than 1 hour	0.04	0.04	0.04	0.03
1-2 hours	0.13	0.12	0.12	0.13
2-3 hours	0.21	0.18	0.19	0.21
3 or more hours	0.33	0.30	0.36	0.30
Mean	1.89	1.69	1.92	1.80
Observations	127,120	7,692	23,009	19,786

Notes: For sample, see Table 1 notes.

Table A.3: Student Time Use by School and Class Gender Composition: Leisure Activities

	A. Coed School		B. Single-sex school	
	(1) Coed classrooms	(2) Single-sex classrooms	(3) Boys only	(4) Girls only
A. Watching TV				
0 hours	0.09	0.07	0.09	0.09
less than 1 hour	0.23	0.21	0.25	0.22
1-2 hours	0.37	0.38	0.38	0.36
2-3 hours	0.18	0.20	0.17	0.19
3 or more hours	0.13	0.15	0.11	0.15
Mean	1.57	1.69	1.50	1.64
Observations	127,060	7,681	23,002	19,794
B. Computer games				
0 hours	0.23	0.22	0.11	0.37
less than 1 hour	0.23	0.21	0.22	0.23
1-2 hours	0.29	0.30	0.35	0.23
2-3 hours	0.15	0.16	0.19	0.10
3 or more hours	0.10	0.11	0.13	0.07
Mean	1.28	1.34	1.55	0.94
Observations	127,021	7,678	22,991	19,786
C. With friends				
0 hours	0.08	0.08	0.08	0.09
less than 1 hour	0.28	0.27	0.28	0.32
1-2 hours	0.29	0.28	0.30	0.26
2-3 hours	0.16	0.16	0.15	0.14
3 or more hours	0.19	0.21	0.18	0.19
Mean	1.65	1.69	1.62	1.57
Observations	126,985	7,674	22,980	19,776

Notes: For sample, see Table 1 notes.

Table A.4: Alternative Outcomes and Teacher and Peer Inputs by School and Class Gender Composition

	A. Coed School		B. Single-sex school	
	(1) Coed classrooms	(2) Single-sex classrooms	(3) Boys only	(4) Girls only
A. Understand lectures				
strongly disagree	0.04	0.04	0.04	0.03
disagree	0.21	0.24	0.19	0.22
agree	0.60	0.59	0.58	0.63
strongly agree	0.15	0.14	0.19	0.12
Observations	127,235	7,700	23,025	19,811
B. Happy to go to school				
strongly disagree	0.05	0.05	0.06	0.04
disagree	0.17	0.18	0.19	0.17
agree	0.58	0.60	0.56	0.64
strongly agree	0.20	0.17	0.18	0.16
Observations	127,249	7,702	23,035	19,793
C. Classmates study hard				
strongly disagree	0.05	0.04	0.07	0.01
disagree	0.30	0.33	0.33	0.15
agree	0.55	0.55	0.51	0.70
strongly agree	0.10	0.08	0.10	0.14
Observations	127,299	7,698	23,038	19,811
D. Teaching quality				
strongly disagree	0.02	0.02	0.03	0.01
disagree	0.12	0.12	0.11	0.10
agree	0.72	0.72	0.66	0.76
strongly agree	0.13	0.14	0.19	0.13
Observations	127,305	7,705	23,050	19,812

Notes: For sample, see Table 1 notes.

B Additional Figures and Tables

Table B.1: The Impact of School and Classroom Gender Composition on Bullying Incidents

	(1) Bullying per 100 students
1[Female single-sex school]	-0.140
	[0.077]
1[Male single-sex school]	-0.115
	[0.065]
1[Coed school, single-sex classes]	-0.051
	[0.068]
Test of equality (*p* -value):	
Male SS school = Coed school, single-sex classes	0.439
Female single-sex = coed school, single-sex classes	0.233
Dependent variable mean	0.36
Observations	508

Notes: Sample includes schools that report information to KERIS. Dependent variable is the number of bullying incidents reported by all students in grades 7 through 9. Each column represents a separate regression. Robust standard errors, clustered by school district, in brackets; * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Both 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 B.2: Impacts of School and Classroom Gender Composition on Student Effort

	(1) Come to class prepared	(2) Focused on lectures	(3) Study material in advance	(4) Review after school	(5) Ask questions in class	(6) Actively participate
Female ×						
1[Single-sex school]	-0.028***	0.007	0.005	0.008	0.033**	0.008
	[0.011]	[0.008]	[0.010]	[0.013]	[0.014]	[0.008]
1[Coed school, single-sex class]	-0.008	0.000	0.013	0.014	0.041***	0.017**
	[0.015]	[0.010]	[0.013]	[0.014]	[0.014]	[0.009]
1[Coed class] × Fraction female in class	-0.054*	-0.006	0.004	0.005	0.026	0.015
	[0.029]	[0.017]	[0.024]	[0.028]	[0.032]	[0.016]
Test of equality (*p*- value):						
Female × SS school = Female × SS class	0.174	0.511	0.484	0.675	0.586	0.284
Female × SS school = Female × Coed class, 100% female	0.944	0.406	0.854	0.797	0.358	0.977
Female × SS class = Female × Coed class, 100% female	0.363	0.807	0.521	0.572	0.204	0.413
Male ×						
1[Single-sex school]	0.063***	0.027***	0.014	0.028**	0.054***	0.025***
	[0.010]	[0.008]	[0.009]	[0.011]	[0.013]	[0.007]
1[Coed school, single-sex class]	0.023**	0.003	-0.001	0.010	0.035**	0.004
	[0.011]	[0.007]	[0.008]	[0.011]	[0.014]	[0.008]
1[Coed class] × Fraction female in class	-0.043	0.021	0.037	0.039	-0.008	0.011
	[0.027]	[0.021]	[0.029]	[0.035]	[0.040]	[0.023]
Test of equality (*p*- value):						
Male × SS school = Male × SS class	0.001	0.004	0.115	0.162	0.222	0.017
Male × SS school = Male × Coed class, 100% male	0.007	0.003	0.047	0.016	0.029	0.019
Male × SS class = Male × Coed class, 100% male	0.932	0.262	0.277	0.136	0.194	0.493
Dependent variable mean	0.27	0.14	0.24	0.38	0.32	0.14
Observations	177,930	177,875	178,829	178,829	178,829	177,838

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, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes.

Table B.3: Impacts of School and Classroom Gender Composition on Student Time Use

	(1) Hours spent on homework	(2) Hours spent in cram school	(3) Hours spent watching TV	(4) Hours spent computer games	(5) Hours spent with friends
Female ×					
1[Single-sex school]	0.004	-0.033	0.009	0.039	-0.047
	[0.023]	[0.045]	[0.037]	[0.033]	[0.035]
1[Coed school, single-sex class]	-0.003	-0.057	0.082**	0.057	0.019
	[0.029]	[0.065]	[0.037]	[0.039]	[0.038]
1[Coed class] × Fraction female in class	0.010	0.167	-0.044	0.006	-0.144
	[0.056]	[0.133]	[0.098]	[0.086]	[0.101]
Test of equality (*p*- value):					
Female × SS school = Female × SS class	0.836	0.726	0.062	0.632	0.116
Female × SS school = Female × Coed class, 100% female	0.971	0.136	0.630	0.533	0.691
Female × SS class = Female × Coed class, 100% female	0.847	0.129	0.102	0.365	0.159
Male ×					
1[Single-sex school]	0.063***	0.130***	-0.054*	-0.104***	-0.128***
	[0.024]	[0.039]	[0.032]	[0.040]	[0.029]
1[Coed school, single-sex class]	0.016	-0.096**	0.057*	0.030	-0.012
	[0.028]	[0.042]	[0.031]	[0.037]	[0.024]
1[Coed class] × Fraction female in class	-0.101	-0.025	0.007	0.001	0.124
	[0.076]	[0.118]	[0.082]	[0.098]	[0.086]
Test of equality (*p*- value):					
Male × SS school = Male × SS class	0.146	<0.001	0.002	0.001	<0.001
Male × SS school = Male × Coed class, 100% male	0.776	0.067	0.279	0.073	0.150
Male × SS class = Male × Coed class, 100% male	0.437	0.105	0.197	0.584	0.258
Dependent variable mean	0.77	1.88	1.58	1.28	1.64
Observations	177,688	177,607	177,537	177,476	177,415

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, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 4 notes. Time use measures represent hours per day spent on the specified activity.

Table B.4: Heterogeneity in the Impact of School and Classroom Gender Composition: Public versus Private Schools, Achievement by Subject

	(1) Reading	(2) English	(3) Math	(4) Science	(5) Social Studies
Private	0.101*	0.076	0.057	0.127**	0.106*
	[0.060]	[0.063]	[0.063]	[0.062]	[0.056]
Female x **1**[Single-sex school]	-0.051	-0.119	-0.104	-0.020	-0.044
	[0.073]	[0.110]	[0.082]	[0.075]	[0.074]
x Private	0.068	0.136	0.143	0.006	0.062
	[0.087]	[0.123]	[0.095]	[0.084]	[0.085]
Female x **1**[Coed school, single-sex class]	-0.031	-0.003	0.023	-0.002	-0.002
	[0.054]	[0.081]	[0.063]	[0.037]	[0.044]
x Private	-0.014	-0.169	-0.061	-0.065	-0.101
	[0.101]	[0.124]	[0.104]	[0.085]	[0.092]
Male x **1**[Single-sex school]	0.135**	0.128	0.136*	0.091	0.131**
	[0.066]	[0.104]	[0.081]	[0.075]	[0.061]
x Private	0.025	0.049	0.050	0.066	0.003
	[0.082]	[0.116]	[0.096]	[0.092]	[0.079]
Male x **1**[Coed school, single-sex class]	-0.073	-0.021	-0.043	-0.043	-0.030
	[0.045]	[0.062]	[0.048]	[0.037]	[0.036]
x Private	0.006	-0.167*	-0.028	-0.065	-0.075
	[0.085]	[0.097]	[0.087]	[0.080]	[0.086]
Observations	178,829	178,829	178,829	178,829	178,829

Notes: See Table 12 notes. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01.

Table B.5: Heterogeneity in the Impact of School and Classroom Gender Composition by Teacher Gender: Achievement by Subject

	(1) Reading	(2) English	(3) Math	(4) Science	(5) Soc. Studies
Fraction teachers female in school (μ = 0.5)	0.397**	0.365*	0.378**	0.493***	0.400**
	[0.163]	[0.203]	[0.175]	[0.163]	[0.168]
Female x **1**[Single-sex school]	0.030	0.053	0.043	0.000	0.018
	[0.051]	[0.075]	[0.066]	[0.055]	[0.049]
x Fraction teachers female in school	-0.199	-0.418	-0.311	-0.013	-0.034
	[0.227]	[0.336]	[0.284]	[0.237]	[0.219]
Female x **1**[Co-ed school, same sex class]	-0.003	-0.094	-0.017	-0.009	-0.046
	[0.071]	[0.079]	[0.068]	[0.062]	[0.066]
x Fraction teachers female in school	-0.294	-0.039	-0.044	-0.195	-0.116
	[0.301]	[0.370]	[0.312]	[0.235]	[0.256]
Male x **1**[Single-sex school]	0.190***	0.205***	0.209***	0.172***	0.167***
	[0.042]	[0.054]	[0.045]	[0.045]	[0.043]
x Fraction teachers female in school	-0.445**	-0.489**	-0.518***	-0.479***	-0.319*
	[0.178]	[0.246]	[0.200]	[0.183]	[0.176]
Male x **1**[Co-ed school, same sex class]	-0.017	-0.099	-0.023	-0.046	-0.037
	[0.090]	[0.093]	[0.087]	[0.076]	[0.098]
x Fraction teachers female in school	-0.262	0.049	-0.134	-0.141	-0.126
	[0.278]	[0.287]	[0.261]	[0.224]	[0.272]
Observations	178,829	178,829	178,829	178,829	178,829

Notes: See Table 13 notes. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. Share teachers female denotes the fraction of teachers in a given school and year that are female, standardized such that zero indicates an equal share of male and female teachers.