All or Nothing? The Impact of School and Classroom Gender Composition on Effort and Academic Achievement*

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Abstract

We take advantage of the random assignment of Korean middle school students to schools and classrooms to estimate the causal impacts of school and classroom gender composition on achievement, effort, and time-use. Assignment to a single-sex school maximizes the achievement of male students. In coeducational schools, male students perform best when more of their classmates are female. Surprisingly, male students assigned to single-sex classes in coed schools perform substantially worse than those in both single-sex schools and coed classrooms suggesting that teacher specialization plays a role in the achievement gains produced by all male schools. Finally, we find no evidence that classroom or school composition affect the outcomes of female students.

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1 Introduction

The role of student gender and the gender composition of peers in the education production function is still not fully understood. Nonrandom selection of students into schools makes it difficult to fully assess the impact of single-sex programs and determine whether single-sex schooling has differential consequences for male and female students. Nonetheless, many countries provide at least some public schooling in gender-segregated classes or schools. In 2006, the United States joined this group 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] Additionally, while most of the expansion in single-sex schooling in the U.S. has taken the form of single-sex *classrooms* within coeducational schools, almost all studies on single-sex education involve comparisons between single-sex and coeducational *schools.*

In this paper, we take advantage of the random assignment of students to schools in the Seoul, South Korea metropolitan area to estimate the impact of gender composition on the academic achievement of middle school students. Our setting contains variation in school gender composition, as students assigned to either single-sex or coeducational (coed) schools, and, within coed schools, variation in classroom gender composition. Some coed schools separate male and female students into single-sex classes, while in schools with coed classrooms, students are exposed to variation in the share of their peers that are female. We find large, positive, and statistically significant benefits of single-sex schooling on male students' achievement: boys within single-sex schools outperform their peers in coed classrooms by approximately 0.16 of a standard deviation. Conversely, male students in coed schools with single-sex classrooms perform the worst, scoring 0.24 of a standard deviation worse than their counterparts in single-sex schools and significantly worse than male students in coed classrooms in multiple subjects. Consistent with previous research and our estimated negative impact of single-sex classes in coed schools, we find that within mixed-gender classes, male students' achievement is increasing in the share of classmates that are female. Finally, we find no evidence that female students' achievement depends on school or classroom gender composition.

One explanation for why single-sex instruction benefits male students in single-sex schools but harms them in coed schools is that teachers and schools are able to specialize when they only teach boys. In Korean middle schools, while students remain with their assigned classroom, they are instructed by multiple teachers. Thus, in coed schools with single-sex classes, teachers instruct both all-male and all-female classes,

[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

limiting their ability to adopt techniques that may best serve students of a given gender. Additionally, we find evidence of school-wide specialization – when allowed, single-sex male schools employ more male teachers than other schools, with students experiencing larger achievement gains when they more likely to have male teachers.

We use information on students' reported effort, time use, and peer and teacher quality to provide supporting evidence of the mechanisms through which class and school gender composition affect 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 both male students in coed schools. We find that male students in single-sex schools report spending 24 minutes more per week on homework and close to an additional hour in extra curricular tutoring ("cram school") relative to those in coed classrooms. These students' increased time spent on academic activities is completely offset by a reduction in time spent with friends and playing computer games. Conversely, male students assigned to single-sex classrooms in coed schools spend less time in cram school and more time watching TV, playing computer games, and hanging out with their friends than their counterparts in single-sex schools. Finally, while male students attending single-sex schools report being less happy to attend school than their peers in coed classrooms, they are more likely report that they understand in-class lectures.

Our findings contribute to literature on the impacts of single-sex schooling. 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 estimate a positive impact of single-sex schooling on male students' achievement.[2] Jackson (2012) uses variation in students assignment to single-sex secondary schools in Trinidad and Tobago (conditional on demand for single-sex schooling) in a instrumental variables framework and finds that the marginal male student does not benefit from attending an all male school, whereas the marginal female student with strong preferences for single-sex schooling experiences higher test scores but takes fewer science courses.[3]

[2]Our focus on middle school students provides two advantages. First, high school students endogenously select into one of two tracks (math/science or humanities/social science) at the end of their freshman year, and College Scholarly Aptitude Test (CSAT) scores 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 schools, selection bias would threaten the identification strategy of the two papers. Furthermore, if there are interaction effects between middle school and high school environments on students' achievement, then we cannot tell the extent to which the two papers' findings are due to attending a single-sex high school *per se,* or the interaction between attending a single-sex middle and a single-sex high school.

[3]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 paper also contributes to the related literature on classroom peer effects.[4] In the first study to take advantage of quasi-experimental variation in classroom gender composition, Hoxby (2000) uses within-school, across-cohort idiosyncratic variation in the share of female elementary and middle school students and estimates that students of both genders have lower performance when they have fewer female classmates. Whitmore (2005) takes advantage of the random assignment of students to classrooms in the Project STAR experiment and finds that an increase in the share of female students raises achievement for students of all genders, but only in lower grades, and by third grade, male students' achievement appears to be decreasing in the share of female classmates. Lavy and Schlosser (2011) use both cross-cohort and within-student variation in cohort gender composition and find similar negative impacts of male students. Furthermore, by examining impacts of classroom gender composition on students' own behavior and the behavior of classmates, the authors hypothesize 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 student behavior.[5]

We build upon these results in several ways. Our setting offers several advantages for isolating the effect of school and classroom gender composition on student outcomes. Many factors that would be considered endogenous in other settings, such as curriculum, peer quality, and school funding are orthogonal to school and classroom gender composition. This allows us to separate the impact of gender composition from peer ability in a setting where, on average, female students earn higher scores than male students. Korean middle school students do not have choice over their courses, so we can rule out students' responding to their school's gender composition by taking a different set of classes. All Korean elementary schools have coed classrooms, allowing us to isolate the contemporaneous impact of school gender composition on achievement.

Furthermore, we take advantage of variation in both the intensive and extensive margins of peer gender composition in the same setting and use variation in both school sex composition and classroom sex composition within coed schools. The latter allows us to show that out-of-sample predictions of the impact of moving to a 100 percent male classroom in a coed school using a linear model accurately predicts the impact of assignment to an all-male classroom in coed schools but not the impact of single-sex male schools. Finally, by looking at impacts on student time-use and student, peer, and teacher effort, we provide suggestive evidence of the mechanisms through which single-sex male schools can outperform other arrangements. Our findings suggest that the gains from altering classroom gender composition are not zero-sum if single-sex

[4] Sacerdote (2011) and Epple and Romano (2011) summarize the extensive literature on peer effects in education.

[5] To our knowledge, Strain (2013) is the only paper to examine impact of single-sex classrooms in the context of a coed school. The author uses variation in the availability of single-sex math and reading classes in North Carolina elementary and middle schools in a differences in differences framework, and estimates significant negative impacts of single-sex classes on achievement for students of both genders. However, 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 unobservables that are not fully captured by school, year, and grade fixed effects.

schooling is an option.

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 discuss 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 the outcomes of middle school students the Seoul, South Korea metropolitan area. Due to South Korea's "Equalization Policy", implemented in the 1970s, elementary and middle school students are randomly assigned to a school in their district.[6] A student can be assigned to a coeducational school or single-sex school and the student cannot avoid their assignment unless the student's entire family moves to another school district. Even if the student successfully moves to another school district, he/she is still subject to random assignment. Seoul has 11 school districts, which contain approximately 370 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.[7] Eight districts contain coed, all male single-sex, and all female single-sex schools.[8] We limit our analysis to these districts, which contain 280 schools, although our results are robust to including all eleven Seoul-area districts (available upon request).

Within coed schools that place students in mixed-sex classes, the process through which students are allocated to classrooms and idiosyncratic variation in cohort gender composition provides additional variation in the share of female students in a given classroom. Within a given school, students are assigned to a class, called a "Bahn". 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. Students are assigned to Bahns based on their previous academic performance such that the average achievement of students are uniform across Bahns.[9]

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

[7]All Seoul elementary schools are coed with coed classrooms. During the period we examine, six of the Seoul-area districts completely relied on random assignment to allocate students to high schools, while the remainder had at least some schools that allowed students to submit preference rankings (Choi et al. 2014). Nationwide, approximately half of all Korean high schools belong to districts that randomly assign students to schools (Kim et al. 2008). The remaining districts use competitive entrance exams to assign students to high schools.

[8]We omit two districts that do not contain single-sex male and single-sex female schools, respectively. We omit one additional district that does not contain coed schools with single-sex classes.

[9]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

Many other factors are also 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, serve randomly assigned students, 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, 9, and 11, take NAEA tests in five subjects: reading, math, English, social studies, and science. Although the NAEA tests we will focus on - those given to ninth graders - are not high stakes, their 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 selective high school.[10]

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 especially 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 instance, Booth and Nolen (2012) find that female students in coed

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. Kang (2007) describes the history of Korea's "leveling policy", under which student achievement is equalized across classrooms within a school.

[10]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, in Seoul National University, considered the best college in Korea, over 46 percent of the new enrollees in 2014 graduated from special high schools in Korea (Ministry of Education, Press Release, June 26th, 2014).

groups are less willing to engage in competitive behavior. Conversely, Lee et al. (forthcoming) show that while male middle school students in Seoul are more competitive than their female peers, random assignment to a single-sex school does not reduce the gender gap in willingness to compete.

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. Our data set contains district, school, and classroom identifiers and information on whether a given school is single-sex or coed. Using school and classroom identifiers, we can measure classroom gender composition and identify coed schools that assign students to single-sex classrooms.

We observe a limited set of school-level characteristics, such as the number of teachers, student-teacher ratios, whether a school was established by a private entity, and teacher characteristics. The only student-level demographic data we observe is a student's gender and his or her living arrangements, the latter of which providing a rough proxy for socioeconomic status (SES) in that students living with both biological parents are more likely to come from an advantaged family (e.g., Park 2014). However, we observe an extensive amount of information from a survey given to all students, including measures of student effort, time-use, and perceptions of teacher and peer quality.

3.1 Characteristics of Schools and Students

We limit our sample to students enrolled in a Seoul metropolitan area school. We focus on districts in Seoul that contain all four types of middle schools (e.g., single-sex male and female schools, coed schools with coed classes, and coed schools with single-sex classes). We exclude two districts that do not have all four types of schools; our final sample represents 77 percent of students and 76 percent of schools in Seoul. However, our estimates are robust to using the full set of Seoul schools and students (available upon request).

Table 1 provides descriptive statistics for the students and schools in our sample. As shown in Panel A, the average class size, share of teachers with experience, and student to teacher ratios are quite similar across the four types of schools. However, single-sex schools have fewer classes, and all schools that do not offer coed classes are more likely to be classified as private schools and have a higher share of teachers that belong to a professional teachers' organization. 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 outperform males in every subject and in each type of school. Students of both genders in 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 Empirical Framework

Under the identifying assumption that within a given district, students are randomly assigned to schools and classrooms, ordinary least squares (OLS) regressions of test scores on school and classroom gender composition and district fixed effects should generate causal estimates of the impact of single-sex schooling on student achievement. To examine the impact of extensive margin variation in peer gender, we estimate:

$$Y_{icst} = \alpha_s^f SS_s^f + \alpha_s^m SS_s^m + \alpha_c^f SS_c^f + \alpha_c^m SS_c^m + \mathbf{X_{it}'}\boldsymbol{\lambda^g} + \mathbf{Z_{st}'}\boldsymbol{\eta^g} + \boldsymbol{\psi_{d\times g}} + \boldsymbol{\psi_{t\times g}} + \boldsymbol{\psi_g} + \epsilon_{icst} \qquad (1)$$

Where Y_{icst} represents the outcome (e.g., test score) of student i assigned to class c in school s and year t, $SS_s^f = \mathbf{1}$ [single-sex, female school], and likewise, $SS_s^m = \mathbf{1}$ [single-sex, male school]. The variables SS_c^f and SS_c^m indicate assignment to a single-sex classroom, within a coed school, for male and female students, respectively. Therefore, the omitted category for school and classroom gender composition is coed classrooms 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.[11]

Our second model examines the role of within-classroom (intensive margin) variation in gender composition for coed classrooms in coed schools:

[11] 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, and whether a school was established by a private entity.

$$Y_{icst} = \beta^f PctFemale^f_{cst} + \beta^m PctFemale^m_{cst} + \mathbf{X'_{it}}\boldsymbol{\phi^g} + \mathbf{Z'_{st}}\boldsymbol{\varphi^g} + \boldsymbol{\gamma_{d\times g}} + \boldsymbol{\gamma_{t\times g}} + \boldsymbol{\gamma_g} + \nu_{icst} \quad (2)$$

Where $PctFemale^g_{cst}$ represents the share of classmates that are female for students of 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)), since students and their families do not have discretion of their classroom assignment in our setting. However, our estimates are quite similar when we use cohort gender variation instead (available upon request).

Finally, we estimate the impacts of both intensive and extensive margin variation in gender composition in the same model:

$$Y_{icst} = \mathbf{PctFemale'_{cst}}\boldsymbol{\delta^g} + \mathbf{SS'_s}\boldsymbol{\delta^g_s} + \mathbf{SS'_c}\boldsymbol{\delta^g_c} + \mathbf{X'_{it}}\boldsymbol{\pi^g} + \mathbf{Z'_{st}}\boldsymbol{\rho^g} + \boldsymbol{\vartheta_{d\times g}} + \boldsymbol{\vartheta_{t\times g}} + \boldsymbol{\vartheta_g} + \omega_{icst} \quad (3)$$

All of our models include district and year fixed effects and all covariates are fully interacted with gender. Standard errors are clustered at the school-level to account for within-school correlation of error terms.

4.1 Evaluating our assumption of within-district random assignment

Before presenting estimates of the impact of school and classroom gender composition on student outcomes, we provide evidence that our identifying assumption of within-district random assignment holds. Using student survey data, Lee et al. (forthcoming) show that within a given district, assignment to single-sex schools is uncorrelated with household income, family composition, and parental education. Unfortunately, we only observe a subset of these predetermined student characteristics and test whether a student's living arrangement is correlated with assignment to a particular type of middle school. We argue that living arrangements 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.

As shown in Table 2, the probability of living with a single parent or with both biological parents is uncorrelated with classroom and school sex composition, for both the extensive and intensive margins. 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.

5 Impacts on Achievement

We first focus on the impact of extensive margin variation in school and classroom gender composition on student achievement. Table 3 displays estimates from (1). Our first specification, which includes only year and district fixed effects, fully interacted with gender, suggests that assignment to a single-sex school increases male students' achievement by a statistically significant 0.14 standard deviations, 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. Female students' performance does not significantly vary with school and classroom sex composition. Our second specification, which controls for students' living arrangements, produces very similar results. Finally, in our third and preferred specification, we adds controls for school characteristics. Our estimated impact of single-sex school on male students' achievement increases to 0.16 standard deviations, relative to assignment to a coed classroom, and by near a quarter of a standard of a deviation, relative to assignment to a single-sex classrooms in a coed school.

In Table 4, we examine whether the impacts of single-sex schools and classrooms vary by subject. In all five subjects, we find no evidence that female students' performance depends on school or classroom sex composition. Conversely, in every subject, boys who belong to a single-sex school outperform their counterparts in both coed classrooms and single-sex classrooms in coed schools. Compared to male students in coed classrooms, those in boys-only schools score between 0.12 and 0.15 standard deviations higher, but compared to those in coed schools with single sex classrooms, boys-only school students score 0.19 to 0.27 standard deviations higher. Boys enrolled in coed schools that offer single-sex classrooms perform worse than their counterparts in coed classrooms in every subject, although our estimates are only statistically significant in the case of English and science.

5.1 The impact of female classmates in coed classrooms

Next we examine the impact of classroom gender composition on the achievement of male and female students in coed classrooms. We equation (2), and report β^f and β^m - which represent estimates of the impact of an increase in the share of female classmates on the achievement of male and female students. Male students' achievement is increasing in the share of their classmates that are female in every subject (Table 5). A 10 percentage point increase in the share of classmates that are female leads to a 0.04 increase in overall achievement and a 0.03 to 0.04 standard deviation increase in achievement across subjects. Conversely, we do not find a statistically significant relationship between female students' achievement and the share of their classmates that are also female, although for every subject, our point estimates are positive.[12]

[12]We also estimate a models that include school fixed-effects and exclude school-level characteristics, and obtain similar results.

Our finding that the achievement of male students is increasing in the share of their classmates that are female is consistent with results obtained by Hoxby (2000), Whitmore (2005), and Lavy and Schlosser (2011). However, unlike these other studies, we do not find any evidence that the impact of single-sex schooling varies by student socioeconomic status (available upon request) or that female students' achievement is significantly related to the share of their classmates that are also female.

5.2 Intensive and extensive margin variation in gender composition

Finally, we jointly estimate the impact of intensive and extensive margin variation in classroom gender composition via equation (3). The impact of extensive margin variation consistent with the estimates displayed in Tables 3 and 4. As shown in Table 6, we cannot reject a test of the hypothesis that achievement gains are linear in the share of classmates that are female. 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 is consistent with our estimate of the impact of assignment to an all male classroom in a coed school.

The negative impacts of single-sex classrooms in coed schools are consistent with the results obtained by Hoxby (2000), Whitmore (2005), and Lavy and Schlosser (2011). However, the fact that we find large differences in the achievement of male students assigned to single-sex classrooms in coed versus single-sex schools suggests that our estimates are not driven solely by within-classroom 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.

6 Evidence on Mechanisms

Our setting allows us to rule out many school- and classroom-level policies that might vary with gender composition. All schools follow the national curriculum and and the allocation of students to classrooms is independent of gender and achievement. Schools cannot offer teachers higher pay to attract higher quality teachers and the length of the academic year and hours of instruction on school days are not flexible. Large differences in our estimates of the impact of single-sex schools and single-sex classrooms within coed schools for male students suggest that within-classroom peer effects are not driving our results. 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 indirectly examine expectations and instruction technology by looking at students' reported effort, time use, and perceptions

of teacher and peer effort.[13]

6.1 Impacts on student effort

Single-sex schools increase male students' effort across a variety of dimensions. In Table 7, we report estimates of the impact of school and classroom gender composition on students' self-reported effort within and outside of school. For male students, assignment to a single-sex school increases probability of coming to class prepared by 6.3 percentage points (23 percent) relative 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. Similarly, male students in single-sex schools are 2.6 percentage points (19 percent) more likely to report being focused on lectures relative to male students in coed classes and schools and are 2.6 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 (5.3 percentage points or 16 percent) and single-sex classrooms (1.8 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.

We create a summary measure of student effort by summing students responses across these items. We standardize our composite index of student effort to have a mean equal to zero and a standard deviation of one. As shown in column 7 of Table 7, male students in single-sex schools report participation that exceeds that of male students in coed classes by approximately half of a standard deviation. and close to a third of a standard deviation higher than their counterparts in single-sex classes in coed schools.

We find little systematic evidence that single-sex schooling affects the effort of female students. Female students in single-sex classes are significantly less likely to come to class prepared relative to those in coed classes, but within coed classes, female students are less likely to report being prepared when they have more female classmates. Similar to male students, female students report being more comfortable asking questions within a single-sex environment.

6.2 Impacts on student time use

In Table 8, we 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 to homework, extracurricular tutoring and test prep ("cram school"), watching TV, playing computer games, and hanging out with friends.

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

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. Furthermore, such students spend 0.12 additional hours per day (50 minutes per week) compared to their counterparts in coed classes and 0.22 more hours per day (1.5 hours per week) than male students in single-sex classrooms in coed schools. 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.

Turning to leisure activities, we estimate that the increase in time spent on homework and in cram school for single-sex school boys is more than offset by a reduction in time spent playing computer games and hanging out with friends. 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. Finally, we estimate that the difference in time spent with friends for male students in single-sex schools versus those in coed classrooms is 0.12 hours per day (52 minutes per week) and that boys in single-sex schools spend 0.13 fewer hours per day (58 fewer minutes per week) with friends than those in single-sex classrooms in coed schools. Once again, we find little systematic evidence that female students' time use varies by classroom or school gender composition.

6.3 Impacts on satisfaction and teacher and peer effort

In Table 9, examine student reports of teacher and peer effort and students' satisfaction with school. Column (1) displays the estimated impact of school and classroom gender composition on students' evaluations of whether their classmates study hard. Female students in single-sex schools are significantly more likely to report having hard working classmates than their counterparts in coed schools (13 percentage points or 20 percent). Female students assigned to single-sex classrooms in coed schools are not significantly more likely to report having hardworking classmates compared to coed classroom students with an even share of male and female classmates while male students in coed schools with single-sex classrooms are significantly less likely to have peers that study hard. Finally, both male and female students in coed classrooms are significantly more likely to report having hardworking classmates as their proportion of female classmates increases.

Although the scope for nonrandom sorting of teachers to classrooms and schools is small, teacher effort may still respond to the gender mix of their classroom. However, as shown in column (2), teacher effort is not significantly related to class or school gender composition. Finally, while 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 to 16 percent, respectively), they 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.

6.4 Heterogeneous impacts by teacher gender

As shown in Table 1, single-sex schools are more likely to be private. Furthermore, all male single-sex schools have more male teachers. The latter is likely due to the fact that privately founded schools 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. 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. Given these findings and since the hiring of teachers is one of the only factors that private schools have discretion over, and private schools are most likely to be single-sex, we want to determine whether the positive impacts we find for male students in single-sex schools are driven by teachers gender.

To do so, 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). We find a positive relationship between the concentration of male teachers and male students' achievement in single-sex schools (Table 10). However, even boys in single-sex male schools where 60 percent of their teachers are female still experience a 0.15 standard deviation increase in achievement relative to those in coed classrooms. Our point estimates suggest that only when the share of teachers that are female reaches 90 percent does assignment to a single-sex school not lead to achievement gains for male students. The remainder of Table 10 examines impacts on our index of student effort, hours spent on academics (homework and cram school) and leisure (watching TV, playing computer games, and spending time with friends), 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' discretion to hire more male teachers.[14]

[14] We find no evidence that the impact of school and classroom gender composition varies with whether a school was established by a private entity (available upon request).

6.5 Bullying and Transfers

Finally, we would like to rule the possibility that our estimated impacts are driven by students' differentially leaving single-sex schools or coed schools with single-sex classrooms. We gather information from the Korea Education & Research Information Service yearbook of schools (KERIS), which includes school-level information of the number of bullying incidents and small number of students who leave a school or migrate to another school district. The latter two variables are correlated with bullying incidents because victims of bullying may not file complaints to school but rather move to another school district to switch schools. Unfortunately, KERIS does not contain separate measures of these outcomes by grade or by student gender, therefore, we can 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:

$$Y_{st} = \phi_s^f SS_s^f + \phi_s^m SS_s^m + \phi_c SS_c + \mathbf{Z'_{st}}\boldsymbol{\eta} + \boldsymbol{\psi_d} + \boldsymbol{\psi_t} + \epsilon_{sdt} \tag{4}$$

We first examine impacts on reported bullying incidents, which are rare. Across all schools, approximately 4 out of 1000 students report being bullied. As shown in Table 11, we estimate that single-sex schooling reduces the number of male students bullied by approximately 1 per 1000 (an approximately 30 percent reduction at the mean) and female students by 2 per 1000 (an approximately 41 percent reduction). We find no evidence that single-sex classrooms within coed schools lead to a reduction in bullying.

The remainder of Table 11 examines whether the number of students that quit or migrate to a different school vary by school and classroom gender composition. On average, 20 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 (a 25 percent reduction). 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, which is not likely to drive our results. Estimated impacts on transfer rates are of a similar magnitude.

7 Conclusion

Past literature identifies one of the main effects through which gender composition affects learning is through increased disruptions in male-concentrated classrooms (e.g., Lavy and Schlosser 2011 and Figlio 2007). Our findings provide suggestive evidence that teachers in all male schools may develop specialized teaching techniques to deal with disruptions, while teachers that teach both male and female students, even in a

setting with single-sex classes, may have a harder time specializing. Similar to the conclusions of Lavy and Schlosser 2011, we can rule out the possibility that the estimated benefits of single-sex schooling for boys are driven by classroom peer effects, as male students in single-sex classrooms within coed schools do not experience the same benefits.[15]

Our findings have implications for public policy outside of Korea. Many countries have publicly funded single-sex schools. Beginning in 2006, after the U.S. Department of Education relaxed restrictions on single-sex education, U.S. 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 involved single-sex classrooms within coed schools.[16] 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.

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[15] Angrist (2013) argues that most causal estimates of the impact of peers find little evidence in support of substantial peer effects in education.

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

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Tables and Figures

Table 1: Characteristics of Students and Schools by Classroom and School 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
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 two 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. Overall achievement is the sum of a student's achievement on all five subject tests, standardized to have mean zero, standard deviation equal one.

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] share female	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] share female	-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 Single Sex Schools and Classrooms on Achievement

	(1)	(2)	(3)
Female x			
1[Single-sex school]	0.015	0.010	-0.001
	[0.046]	[0.043]	[0.060]
1[Coed school, single-sex class]	-0.087	-0.083	-0.051
	[0.072]	[0.068]	[0.071]
Male x			
1[Single-sex school]	0.140***	0.132***	0.155**
	[0.047]	[0.044]	[0.064]
1[Coed school, single-sex class]	-0.063	-0.059	-0.087
	[0.053]	[0.047]	[0.058]
Test of equality (*p*- value):			
Male x SS school = Male x SS class	0.001	<0.001	<0.001
Female x SS school = Female x SS class	0.198	0.210	0.584
Observations	178,829	178,829	178,829
Student controls		X	X
School controls			X

*Note*s: 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 4: 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]	-0.004	-0.006	-0.001	-0.006	0.011
	[0.050]	[0.073]	[0.057]	[0.050]	[0.050]
1[Coed school, single-sex class]	-0.036	-0.095	-0.017	-0.027	-0.054
	[0.064]	[0.080]	[0.067]	[0.056]	[0.062]
Male [x]					
1[Single-sex school]	0.139***	0.154**	0.153**	0.120**	0.128***
	[0.051]	[0.078]	[0.062]	[0.057]	[0.049]
1[Coed school, single-sex class]	-0.070	-0.112*	-0.061	-0.084*	-0.065
	[0.052]	[0.066]	[0.057]	[0.047]	[0.055]
Test of equality (*p*- value):					
Male [x] SS school = Male [x] SS class	<0.001	0.001	0.002	<0.001	0.002
Female [x] SS school = Female [x] SS class	0.695	0.357	0.847	0.781	0.418
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 3 notes. All test scores standardized to have a mean of zero and standard deviation equal to one.

Table 5: The Impact of Classroom Gender Composition in coed Classrooms on Achievement

	(1) Combined	(2) Reading	(3) English	(4) Math	(5) Science	(6) Soc. Studies
Female [x]						
Share female in class	0.194	0.108	0.210	0.194	0.172	0.189
	[0.194]	[0.174]	[0.244]	[0.187]	[0.126]	[0.165]
Male [x]						
Share female in class	0.376**	0.293*	0.378**	0.290*	0.346**	0.385***
	[0.179]	[0.167]	[0.179]	[0.174]	[0.168]	[0.145]
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 by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 3 notes. All test scores standardized to have a mean of zero and standard deviation equal to one.

Table 6: The Impact of Single-Sex Schools, Single-Sex Classrooms, and Gender Composition in coed Classrooms on Achievement

	(1) Combined	(2) Reading	(3) English	(4) Math	(5) Science	(6) Soc. Studies
Female [x]						
1[Single-sex school]	-0.002	-0.004	-0.007	-0.002	-0.007	0.010
	[0.060]	[0.050]	[0.073]	[0.058]	[0.050]	[0.051]
1[Coed school, single-sex class]	-0.052	-0.037	-0.096	-0.018	-0.028	-0.056
	[0.071]	[0.065]	[0.081]	[0.068]	[0.057]	[0.063]
1[Coed class] [x] share female	0.142	0.066	0.167	0.135	0.130	0.143
	[0.200]	[0.177]	[0.246]	[0.192]	[0.128]	[0.172]
Test of equality (*p*- value):						
Female [x] SS school = Female [x] SS class	0.584	0.695	0.358	0.846	0.779	0.419
Female [x] SS school = Female [x] Coed class, 100% female	0.541	0.724	0.541	0.546	0.384	0.557
Female [x] SS class = Female [x] Coed class, 100% female	0.331	0.543	0.238	0.477	0.295	0.248
Male [x]						
1[Single-sex school]	0.142**	0.130**	0.142*	0.144**	0.108*	0.115**
	[0.065]	[0.052]	[0.080]	[0.064]	[0.058]	[0.050]
1[Coed school, single-sex class]	-0.099	-0.079	-0.123*	-0.069	-0.095*	-0.077
	[0.060]	[0.053]	[0.068]	[0.058]	[0.049]	[0.057]
1[Coed class] [x] share female	0.248	0.193	0.241	0.168	0.244	0.266*
	[0.190]	[0.175]	[0.195]	[0.185]	[0.176]	[0.153]
Test of equality (*p*- value):						
Male [x] SS school = Male [x] SS class	<0.001	<0.001	0.001	0.002	<0.001	0.002
Male [x] SS school = Male [x] Coed class, 100% male	0.011	0.014	0.021	0.027	0.017	0.003
Male [x] SS class = Male [x] Coed class, 100% male	0.808	0.852	0.982	0.882	0.774	0.528
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 by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of individual and school controls, see Table 3 notes. All test scores standardized to have a mean of zero and standard deviation equal to one.

Table 7: Impacts of School and Classroom Gender Composition on Student Effort

	(1) Bring textbooks	(2) Focused on lectures	(3) Study material in advance	(4) Review after school	(5) Ask questions in class	(6) Actively participate	(7) Composite index
Female x							
1[Single-sex school]	-0.028**	0.007	0.005	0.008	0.033*	0.008	0.075
	[0.012]	[0.009]	[0.010]	[0.016]	[0.017]	[0.008]	[0.130]
1[Coed school, single-sex class]	-0.009	0.001	0.012	0.014	0.042***	0.017*	0.177
	[0.015]	[0.010]	[0.012]	[0.015]	[0.015]	[0.009]	[0.145]
1[Coed class] x share female	-0.054*	-0.006	0.004	0.005	0.027	0.015	-0.010
	[0.033]	[0.019]	[0.027]	[0.030]	[0.034]	[0.018]	[0.258]
Test of equality (*p*- value):							
Female x SS school = Female x SS class	0.200	0.537	0.536	0.708	0.556	0.310	0.498
Female x SS school = Female x Coed class, 100% female	0.951	0.471	0.862	0.819	0.420	0.980	0.664
Female x SS class = Female x Coed class, 100% female	0.386	0.808	0.563	0.592	0.221	0.456	0.348
Male x							
1[Single-sex school]	0.063***	0.026***	0.014	0.026*	0.053***	0.025***	0.487***
	[0.012]	[0.009]	[0.011]	[0.013]	[0.015]	[0.007]	[0.130]
1[Coed school, single-sex class]	0.023*	0.004	-0.001	0.010	0.035**	0.004	0.174
	[0.013]	[0.008]	[0.009]	[0.013]	[0.016]	[0.010]	[0.123]
1[Coed class] x share female	-0.043	0.022	0.037	0.040	-0.008	0.011	0.175
	[0.028]	[0.023]	[0.031]	[0.038]	[0.045]	[0.026]	[0.350]
Test of equality (*p*- value):							
Male x SS school = Male x SS class	0.003	0.012	0.155	0.275	0.286	0.039	0.022
Male x SS school = Male x Coed class, 100% male	0.012	0.006	0.081	0.035	0.057	0.031	0.006
Male x SS class = Male x Coed class, 100% male	0.934	0.271	0.300	0.158	0.233	0.535	0.198
Dependent variable mean	0.27	0.14	0.24	0.38	0.32	0.14	0
Observations	177,930	177,875	178,829	178,829	178,829	177,838	177,682

*Note*s: 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 3 notes. The composite index represents the sum of the dependent variables in the first six columns, standardized to have a mean of zero and standard deviation of one.

Table 8: 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 [x]					
1[Single-sex school]	0.004	-0.032	0.009	0.039	-0.047
	[0.028]	[0.051]	[0.043]	[0.037]	[0.042]
1[Co-ed school, single sex class]	0.000	-0.048	0.079*	0.051	0.017
	[0.033]	[0.080]	[0.042]	[0.045]	[0.041]
1[Co-ed class] [x] share female	0.010	0.167	-0.044	0.006	-0.144
	[0.066]	[0.167]	[0.124]	[0.106]	[0.129]
Test of equality (*p*- value):					
Female [x] SS school = Female [x] SS class	0.921	0.864	0.133	0.787	0.143
Female [x] SS school = Female [x] Co-ed class, 100% female	0.977	0.220	0.697	0.595	0.754
Female [x] SS class = Female [x] Co-ed class, 100% female	0.912	0.255	0.192	0.500	0.255
Male [x]					
1[Single-sex school]	0.058*	0.124**	-0.052	-0.100*	-0.123***
	[0.031]	[0.050]	[0.040]	[0.051]	[0.035]
1[Co-ed school, single sex class]	0.018	-0.094*	0.056*	0.029	-0.014
	[0.033]	[0.049]	[0.034]	[0.042]	[0.029]
1[Co-ed class] [x] share female	-0.097	-0.019	0.005	-0.003	0.120
	[0.090]	[0.136]	[0.104]	[0.122]	[0.100]
Test of equality (*p*- value):					
Male [x] SS school = Male [x] SS class	0.297	<0.001	0.008	0.011	0.002
Male [x] SS school = Male [x] Co-ed class, 100% male	0.852	0.126	0.393	0.159	0.232
Male [x] SS class = Male [x] Co-ed class, 100% male	0.561	0.178	0.293	0.686	0.369
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 3 notes. Time use measures represent hours per day spent on the specified activity.

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

	(1) Classmates study hard	(2) Teacher puts in effort	(3) Understand lectures	(4) Happy to go to school
Female [x]				
1[Single-sex school]	0.134***	0.019	0.009	-0.008
	[0.038]	[0.017]	[0.009]	[0.010]
1[Co-ed school, single sex class]	0.060	-0.005	0.004	-0.003
	[0.045]	[0.011]	[0.010]	[0.012]
1[Co-ed class] [x] share female	0.229**	-0.033	0.011	0.005
	[0.096]	[0.022]	[0.015]	[0.024]
Test of equality (*p*- value):				
Female [x] SS school = Female [x] SS class	0.177	0.112	0.630	0.720
Female [x] SS school = Female [x] Co-ed class, 100% female	0.763	0.101	0.754	0.506
Female [x] SS class = Female [x] Co-ed class, 100% female	0.417	0.508	0.940	0.724
Male [x]				
1[Single-sex school]	-0.011	-0.002	0.019*	-0.027**
	[0.039]	[0.014]	[0.010]	[0.012]
1[Co-ed school, single sex class]	-0.095***	0.005	-0.006	-0.025***
	[0.032]	[0.014]	[0.009]	[0.010]
1[Co-ed class] [x] share female	0.157*	0.028	0.035	0.032
	[0.086]	[0.032]	[0.027]	[0.028]
Test of equality (*p*- value):				
Male [x] SS school = Male [x] SS class	0.028	0.662	0.010	0.907
Male [x] SS school = Male [x] Co-ed class, 100% male	0.204	0.577	0.023	0.528
Male [x] SS class = Male [x] Co-ed class, 100% male	0.732	0.368	0.461	0.568
Dependent variable mean	0.67	0.14	0.15	0.19
Observations	178,829	177,872	177,771	177,779

*Note*s: 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 3 notes.

Table 10: Heterogeneity in the Impact of School and Classroom Gender Composition by Teacher Gender

	(1) Achievement	(2) Student effort index	(3) Hours: academic	(4) Hours: leisure	(5) Teacher effort	(6) Understand lectures	(7) Happy to go to school
Female x **1**[Single-sex school]	0.033	0.148	0.024	-0.131	0.012	0.010	-0.004
	[0.079]	[0.136]	[0.113]	[0.132]	[0.018]	[0.011]	[0.013]
x Share teachers female	-0.217	-0.740	-0.373	1.024*	0.050	-0.022	-0.039
	[0.366]	[0.618]	[0.483]	[0.607]	[0.075]	[0.045]	[0.053]
Female x **1**[Coed school, single-sex class]	-0.022	0.014	-0.045	0.194	-0.011	-0.007	-0.015
	[0.100]	[0.152]	[0.125]	[0.142]	[0.016]	[0.010]	[0.011]
x Share teachers female	-0.174	1.302	0.050	-0.512	0.035	0.090	0.088
	[0.375]	[0.895]	[0.553]	[0.628]	[0.069]	[0.055]	[0.067]
Male x **1**[Single-sex school]	0.199***	0.504***	0.206***	-0.312***	0.003	0.022**	-0.018*
	[0.063]	[0.131]	[0.069]	[0.113]	[0.014]	[0.010]	[0.011]
x Share teachers female	-0.504*	-0.322	-0.172	0.460	-0.054	-0.018	-0.088*
	[0.268]	[0.520]	[0.296]	[0.504]	[0.048]	[0.039]	[0.050]
Male x **1**[Coed school, single-sex class]	-0.049	0.119	0.007	0.067	0.014	-0.003	-0.018
	[0.095]	[0.194]	[0.068]	[0.127]	[0.019]	[0.013]	[0.016]
x Share teachers female	-0.101	0.531	-0.551	-0.134	-0.052	-0.002	-0.008
	[0.362]	[0.856]	[0.337]	[0.565]	[0.087]	[0.053]	[0.082]
Observations	178,829	177,682	177,310	177,094	177,872	177,771	177,779

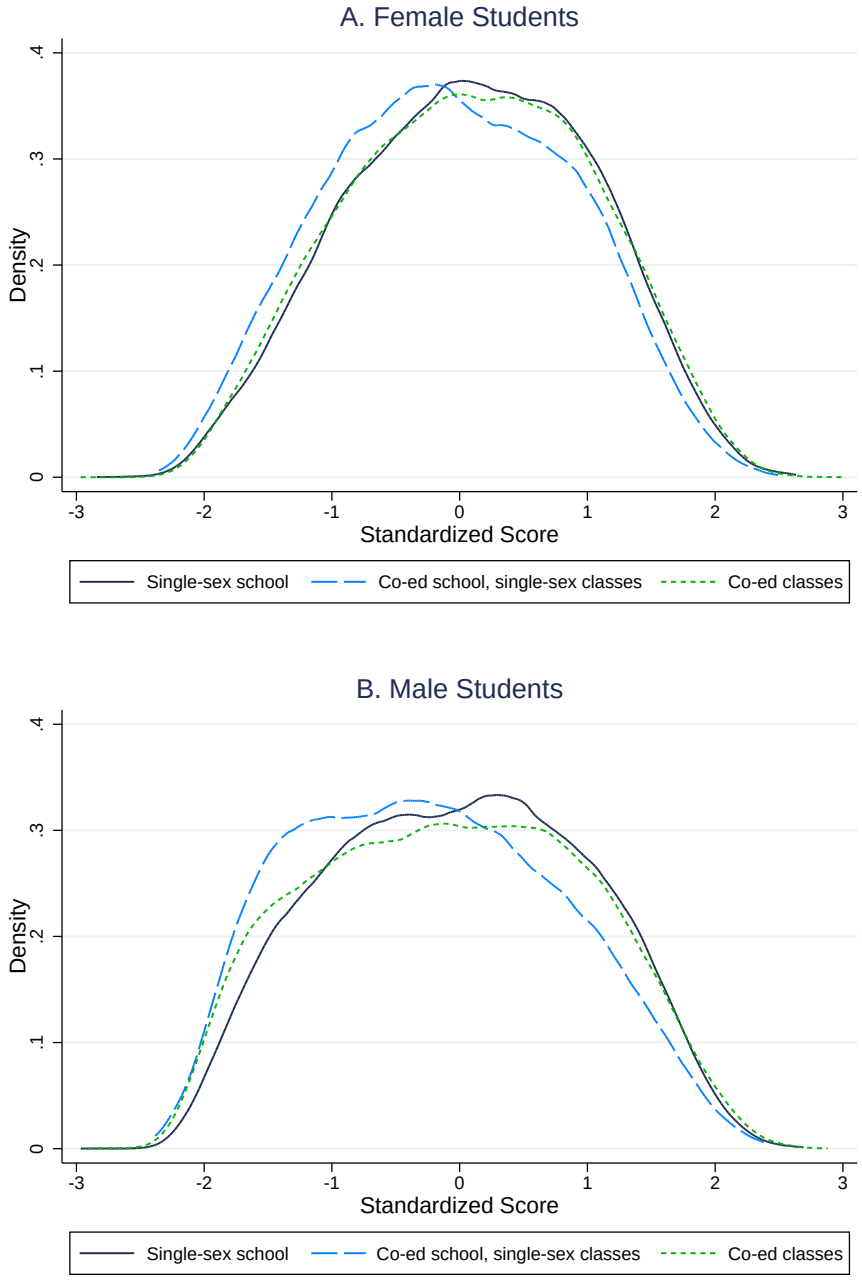
*Note*s: For sample, see Table 1 notes. Each column represents a separate regression. Robust standard errors, clustered by school, in brackets; * p<0.10, ** p<0.05, *** p<0.01. Share teachers female denotes the fraction of teachers in a given school and year that are female, standardized such that zero indicates an equal share of male and female teachers. For description of individual and school controls, see Table 3 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.

Table 11: Impacts of School and Classroom Gender Composition on Bullying and Transfers

	(1) Bullying per 100 students	(2) Quits per 100 students	(3) Transfers per 100 students
1[Female single-sex school]	-0.147**	-0.506***	-0.153
	[0.068]	[0.192]	[0.220]
1[Male single-sex school]	-0.108*	-0.467***	-0.577***
	[0.060]	[0.169]	[0.196]
1[Coed school, single-sex class]	-0.064	-0.009	0.460**
	[0.068]	[0.142]	[0.205]
Dependent variable mean	0.355	1.731	3.154
Observations	504	561	561
School controls	X	X	X

*Note*s: For sample, see Table 1 notes. Each column represents a separate regression. Robust standard errors, clustered by school district, in brackets; * p<0.10, ** p<0.05, *** p<0.01. For description of school controls, see Table 3 notes.

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



Notes: For sample, see Table 1 notes.

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 administrated for 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, standardize score (mean = 0, sd = 1). We construct a measure of overall achievement by summing raw scores across all five subjects and standardizing (mean = 0, sd = 1).

A.2 Student Survey

All measures of student effort (Table 7) 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." *Actively participants* were students who strongly agreed with the statement "I actively participate in classroom activities – e.g., science experiment, discussions, group activities."

Student time use measures (Table 8) are all 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.

Our measures of classmate and teacher effort 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 *teacher puts in effort* if he/she strongly agrees with the statement "my teachers [homeroom and subject teachers] put a lot of effort into teaching." 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."