Do single-sex schools make girls less interested in predominantly male majors?*

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Abstract

This study estimates the impact of single-sex schooling on the gender gap in students' choice of college major. Potential endogeneity concerns are alleviated by using two features of the South Korean educational setting: random assignment of students into general high schools in equalized educational districts and college-major-specific admissions policies. Single-sex schooling is found to widen the gender gap in the choice of predominantly male majors by 15.4 percentage points and to reduce in the choice of gender balanced majors by 23.2 percentage points. The results further show that single-sex schooling is associated with reallocation of female students from predominantly male or female majors to gender balanced majors while the net change in the gender gap is not statistically significant for predominantly female majors. One possible mechanism through which single-sex schooling affects college major choice is the imbalanced gender composition of teachers by school type. Increasing the overall proportion of female teachers could encourage more girls to pursue gender-balanced majors instead of predominantly female majors but would be insufficient to attract them to predominantly male majors. To nullify the negative effect of single-sex schooling on the choice of predominantly male majors, all-girls schools need to recruit more male teachers who instruct science and mathematics while maintaining the share of female teachers at or above 57.8 percent. These findings provide policy implications on preferential hiring criteria, with respect to the gender composition of teachers by subject.

Keywords: Single-sex schools, Sex ratio, College major, Gender gap

JEL Classification: C39, I20, J16 (I20, I21, J24)

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1. Introduction

Although more women are going to college in most countries than ever before, they are still making less money than their male counterparts (e.g., Barres, 2006; Goldin, 2006; McDonald & Thornton, 2007; Turner & Bowen, 1999). To account for this gender pay gap, a growing body of research provides evidence that college major explains a substantial portion of it (e.g., Brown & Corcoran, 1997; Cho, Kam, & Lee, 2017; Gill & Leigh, 2000; O'Neill, 2003; Xie & Shauman, 2003; Zafar, 2013). Hence, by understanding why the majority of women continue to select less profitable majors, we can draw policy implications for the gender gap in labor market outcomes.

As a policy designed to reduce this gender gap, single-sex schools in secondary education have been promoted. A large set of empirical studies has found significant effects of classroom or school gender composition on educational outcomes of students in primary and secondary education (e.g., Choi, Park, & Behrman, 2015; Eisenkopf et al., 2015; Hoxby, 2002; Lavy & Schlosser, 2011; Lu & Anderson, 2015; Whitmore, 2005). The positive effects of same gender peers on academic achievement, especially for women, have been explained by arguing that single-sex schools, where opposite gender counterparts are absent, might mitigate negative gender stereotyping and rigid gender roles (Kessels & Hannover, 2008; Pahlke, Bigler, & Patterson, 2014; Patterson, 2012).

Despite extensive literature on the benefits of single-sex schooling, its effects are still under debate as to whether single-sex schooling has persistent effects in the long-run (Anelli & Peri, 2015; Carrell, Hoekstra, & Kuka, 2016; Lu & Anderson, 2015) and as to whether the potential endogeneity of school choice is corrected (Angrist, 2014; Evans et al., 1992; Manski, 1993; Moffitt, 2001; Lee, 2007). If single-sex schooling affects test scores but not long-term outcomes such as career paths and earnings, the rising concerns over school gender composition may be overstated. In contrast, if its effects do not diminish over time, single-sex schooling can explain a portion of the gender gap in the choice of college major and consequently labor market outcomes. On this point, this study links the literature on single-sex schooling to that of the gender gap in major choice by examining the extent to which the gender composition of high school peers affects the choice of college major.

In this research setting, the key analytical challenge for endogeneity lies in two possible correlations between student and school characteristics as well as between students' college experience and major choice. To address this potential endogeneity concern, this study uses the unique educational setting in South Korea. There are two important features of the Korean educational system critical to developing an estimable model of single-sex schooling effects[1]. First, within a given district, students are randomly assigned to high schools if located in equalized education districts comprising a number of all-boys, all-girls, and coeducational schools. In other words, some students may be assigned to a single-sex school regardless of their preference as a result of a lottery administered by each Regional Office of Education. This random assignment through high school admissions lotteries can alleviate the endogeneity of student and school characteristics.

Second, South Korea uses college[2]-major-specific admissions policies, which require a student to make an application decision for a college-major pair jointly[3]. Changing a major is allowed for only a few students when the enrollment capacity for each program is not reached

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[1] Many studies examined the impact of single-sex schooling (often interpreted as "peer effect") using the Korean educational setting. Most of them, however, focused on academic outcomes. (e.g., Kang, 2006; Kim, J. H. Lee, & Y. Lee, 2008; Lee et al., 2014; Pahlke, Hyde, & Allison, 2014; Park, Behrman, & Choi, 2013; Sohn, 2016).

[2] In South Korea, "*college*" refers to two-year colleges and universities while "*university*" refers to four-year colleges and universities. Note that there is no liberal arts college in South Korea. In this paper, the term "*college*" refers to both college and university.

[3] The term "college-major-specific admissions policies" is defined by Bordon and Fu (2015), who examined the equilibrium effects of postponing student choice of major using the Chilean educational setting. For detailed information about Korean college admissions policies, see Cho, Kam, and Lee (2017).

due to student dropout and leave of absence. Thus, the majority of students complete their degree in the major chosen at application based on information collected during high school. This admissions regime enables documentation of the possible long-term effects of single-sex schooling by linking the gender composition of high school peers and major choice in college.

Results show that single-sex schooling widens the gender gap in the choice of predominantly male majors (i.e., Engineering) by 15.4 percentage points compared to coeducational schooling. In contrast, the gender gap in the choice of gender balanced majors (i.e., Science and Business/Economics) is reduced 23.2 percentage points by single-sex schooling. The findings further reveal that single-sex schooling is associated with reallocation of female students from predominantly male or female majors to gender balanced majors while the net change in the gender gap is not statistically significant for predominantly female majors (i.e., Medicine/Public Health, Humanities/Social Science, Education, and Arts/Athletics). These results contradict the findings of Billger (2009) that single-sex schools yield the least segregated college major choices using the U.S. educational setting where endogeneity concerns might be raised due to preference-based school choice.

A possible interpretation of the results is that the imbalanced gender distribution of peers and teachers in single-sex schools induces a stereotype threat in shaping rigid gender roles. This is in line with Halpern et al.'s (2011) argument that sex segregation increases gender stereotyping and legitimizes institutional sexism. This hypothesis is examined in reference to differences in teacher characteristics by school type. The share of female teachers within a school is shown to influence the magnitude of the effect size for the causal relationship between single-sex schooling and the gender gap in major choice. For instance, a single-sex schooling effect on the gender gap in the choice of predominantly male majors can be nullified by increasing the share of female teachers to 57.8 percent. The gap is, however, further widened if all increases in the share of female teachers are caused by rising, ceteris paribus, the proportion of female teachers who instruct science or mathematics. To alleviate the negative impact of single-sex schooling on the choice of predominantly male majors, all girls' schools need to recruit more male teachers who instruct science and mathematics while maintaining the share of female teachers at certain level.

The results have policy implications for the debate on single-sex schooling. Despite its positive effect on academic achievement, particularly for female students, single-sex schooling contributes to widening the gender gap in college major choice. The findings of this study provide insight into one potential mechanism underlying this effect by addressing the skewed gender ratio among teachers in favor of females at all girls' high schools. The value of single-sex education will be further enhanced if a policy intervention effectively encourages a school to recruit more male science and mathematics teachers with the overall proportion of female teachers at or above 0.58 in upper secondary education. This policy will ultimately lead to the promotion of gender equity in science, mathematics, engineering, and mathematics (STEM) disciplines, which are predominantly male fields in most countries.

The rest of this paper proceeds as follows: Section 2 provides institutional background information about the educational system in South Korea, which guides the development of the baseline model of this study. Section 3 describes the data and empirical framework. Section 4 presents estimates from the analyses of longitudinal data. Section 5 discusses the possible channels and mechanisms through which school gender composition affects major choice. Section 6 concludes. The Appendix contains additional details and tables.

2. Institutional background

To alleviate the potential endogeneity issues found in earlier related studies, this study uses the Korean educational setting for two reasons: the random assignment of students into general high schools in equalized education districts and the college-major-specific admissions policies.

2.1. Random assignment in high schools

The Education Statute (now the Framework Act of Education) was established in 1949 to enforce the constitutional right to an equal opportunity for education in South Korea. The statute included the compulsory education scheme at the elementary-level (grades 1-6) and was revised in 1984 to extend it at the lower secondary-level (grades 7-9)[4]. Accordingly, all children aged six on the day before the first day of school are mandated to attend elementary schools[5]. The compulsory elementary education scheme led to a dramatic increase in the number of middle school applicants and intense competition for admission to prestigious schools, in turn. To increase the acceptance rate for top-tier schools, the elementary school curriculum was changed to focus more on preparing students for the middle school entrance exam[6] and parents spent more money on after-school private tutoring for their children. As a result, educational inequality was further exasperated.

Two policies were newly introduced to address educational inequality in secondary education in the late 1960s and early 1970s. In 1968, the Ministry of Culture and Education (now

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[4] South Korea has a homogeneous K-12 education system comprised of 1-3 years of kindergarten education, six years of elementary education, three years of lower secondary education, and three years of upper secondary education. Nursery, pre-k, and kindergarten education are not compulsory but the fees can be partially supported by government. Note that there is no other form of schools such as schools spanning grades K-5, 6-8, 7-8, 7-9, and 9-12.

[5] The first day of school is homogeneous nationwide (September 1 in 1946-1949, June 1 in 1950, April 1 in 1951, and March 1 since 1962-present). The Education Statute was revised in parliament to change the compulsory school-entrance age to six on the last day of the year before the first year of school in 2007 and was effective in the academic year 2009/2010.

[6] The middle school entrance exam was standardized at the school-(1945-1950, 1954-1957, 1966), the province-(1958-1961, 1963-1965, 1967), and the nation- (1951-1953, 1962) levels.

the Ministry of Education)[7] proposed the replacement of middle school entrance exam with a lottery system, which randomly assigned students into middle schools within their school districts. The rationale of the lottery system was to guarantee equal access to lower secondary education for all students regardless of their academic and socioeconomic backgrounds. This lottery system was adopted first in Seoul (1969), later in nine cities[8] (1970), and finally in the whole country (1971). Similar to the consequence of the prior compulsory elementary education scheme, it led to a sharp rise in the number of middle school graduates, resulting in intense competition for elite high school admissions. This phenomenon instigated school stratification in upper secondary education.

To mitigate those adverse effects, the Ministry of Culture and Education legislated the high school equalization policy in 1973. As a parallel to the lottery system in middle school admissions, it proposed a random assignment of students into general high schools within their school districts unless they were admitted to special-purpose or vocational high schools[9]. The initial plan of the Ministry of Culture and Education was to execute the high school equalization policy nationwide till 1985. Its nationwide implementation, however, was deferred in 1980 for concerns raised by the uneven distribution of school quality between and within districts in suburban and rural areas. In 1982, the high school equalization policy was revised to address these concerns through rearranging school districts and mandating all general high schools to

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[7] The Ministry of Culture and Education was launched in 1948 and restructured as the Ministry of Education in 1990. The Ministry of Education was further reorganized as the Ministry of Education and Human Resources Development in 2001. The Ministry of Education, Science and Technology was launched in 2008 through merging of the Ministry of Education and Human Resources Development and the Ministry of Science and Technology but was split into the Ministry of Education and the Ministry of Science, ICT and Future Planning in 2013.

[8] Busan, Daegu, Gwangju, Incheon, Jeonju, Daejeon, Chuncheon, Cheongju, and Jeju.

[9] Two types of special-purpose high schools, physical education and arts high schools, were established in 1974 to educate talented students in athletics and arts. In contrast, vocational high schools—for example, commercial, technical, and agricultural high schools—focus more on career and professional training. The special-purpose and vocational high school admissions process is completed before that the general high school admissions process begins to allow their unsuccessful applicants to apply to general high schools.

provide different levels of classes for students of different abilities and after-school supplementary classes. At the same time, science magnet high schools[10] were introduced to minimize the potential disadvantages of gifted students in the equalized high school system.

In spite of these efforts, the high school equalization policy could not be implemented nationwide due to different institutional features of school system in each area municipality. The Regional Offices of Education were hereby delegated the entire authority to grant, modify, and deny (or delay) enforcement of the high school equalization policy in their school districts. The policy was enforced or disregarded based on the infrastructure and other facilities of schools as well as residents' opinions and perceptions of it. As of 2008, 13 Regional Offices of Education fully or partially implemented the high school equalization policy[11]. For convenience, I define such areas as "equalized education districts" in the rest of this paper.

In equalized education districts, three steps were included in the general high school application process. First, middle school seniors submitted an application to their middle schools for general high school admissions in the subsequent academic year. Second, each middle school

[10] Science high schools were established to educate gifted students in science and mathematics. In 1990, to educate linguistically gifted students, foreign language high schools were established. All science high schools are public schools but most foreign language high schools are private schools. The admissions process for science and foreign language high schools is finalized before general high school admissions process begins to allow their unsuccessful applicants to apply to general high schools. Note that the majority of students attend general high schools.

[11] As of 2008, the high school equalization policy was implemented by Seoul, Busan, Daegu, Incheon, Gwangju (partial), Daejeon, and Ulsan (partial) Metropolitan Offices of Education as well as Gyeonggi (partial) Chungcheongbuk (partial), Jeollabuk (partial), Jeollanam (partial), Gyeongsangnam (partial), and Jeju (partial) Provincial Offices of Education. In contrast, Gangwon, Chungcheongnam, and Gyeongsangbuk Provincial Offices of Education did not adopt the high school equalization policy while maintaining the admissions system requiring that all high school applicants should send the application package to each school they want to attend after taking a district-wide entrance exam. Therefore, the high school equalized policy was enforced and implemented in seven metropolitan cities and 21 cities of six provinces: Seoul and Busan (except Gijang-gun) (1974), Daegu (except Dalseong-gun), Gwangju, and Incheon (except Ganghwa-gun, Yeongjong-do, and Ongjin-gun) (1975), Cheongju, Daejeon, Jeju, Jeonju, Masan (now Changwon Masanhoewon-gu and Masanhappo-gu), and Suwon (1979), Changwon (now Changwon Seongsan-gu and Uichang-gu), Jinju, and Seongnam (except Bundang-gu) (1980), Ulsan (except Ulju-gun, 2000), Anyang, Gwacheon, Gunpo, Uiwang (Anyang-kwon), Bucheon, Goyang, and Seongnam (Bundang-gu) (2002), Suncheon and Yeosu (2005), Gimhae (2006), Pohang (2008), Ansan, Gangneung, Gwangmyeong, and Uijeongbu (2013), Yongin (2015), Chuncheon (1979-1991/2013), Gunsan (1980-1990/2000), Iksan (1980-1991/2000), Mokpo (1980-1990/2005), Wonju (1980-1981/2013), Cheonan (1980-1995/2016), and Andong (1980-1990).

sent all collected applications to the Regional Office of Education, which was responsible for the administration and supervision of its school district. Third, the Regional Office of Education assigned applicants to general high schools within their school districts. Although students were asked to list three or four schools in order of preference on the application form, the assignment rule relied heavily on the strict random selection and/or the distance between residence and school to obtain educational equality throughout school districts. Transferring to a neighborhood school was not legally allowed although students did not like their assigned schools[12]. Despite its contribution to an increase in educational equality, this strict random assignment procedure raised a constitutional challenge to Article 31 Section 4 which allows individuals' autonomy with regard to their decisions about educational choice[13].

In response to those challenges, a new assignment rule, "multiple applications-then-lottery assignment," was limitedly implemented to allow students applying for high school admissions to their preferred schools regardless of residential location since the academic year 1996/1997[14]. The multiple applications-then-lottery assignment rule enables schools to fill 30-100 percent of the freshman class through a computerized lottery based on student preferences and the rest of seats through the strict random assignment of students into high schools within their school district subject to residential area[15]. That is, a student can be assigned to the school

[12] Transferring to another school was allowed only if their household address was changed to a location in a different school district. In 2008, the Seoul Metropolitan Office of Education amended its transfer rule to allow students to transfer to a neighborhood school if president in transfer-out school approves a student's transfer and a vacancy in transfer-in school occurs.

[13] Information was retrieved from the National Archives of Korea website: http://www.archives.go.kr/.

[14] The multiple applications-then-lottery assignment was implemented in part as a pilot policy in 1996 (e.g., 23 schools in Seoul) and later was officially enforced in restricted areas of the equalized educational districts (e.g., the fifth school district of Seoul)

[15]The maximum percent allowable for school seats in a manner that reflects student preferences was determined by each Regional Office of Education, concerning the achievement gap within and between schools throughout its districts. For example, in 2002, Gyeonggi Provincial Office of Education implemented a different multiple applications-then-lottery assignment rule in Anyang, Gwacheon, Gunpo, Uiwang (Anyang-kwon) (for 40% of each school's freshmen enrollment capacity), Bucheon (for 100%), Seongnam, Goyang (for 50%), and Suwon (for 70%).

listed as her/his first choice if the sum of students who chose the same school as their first choice does not exceed the maximum number allowable for preference-based admissions. If the school in the first place is full, students are assigned to their second choice. In the final lottery, a student unluckily fails to be offered a place at one of the schools listed on her/his application, s/he is randomly assigned to any school which still has open seats in the freshman class regardless of her/his preference. If all seats in high schools located near residential area are filled, students are assigned to high schools located far from their homes.

Likewise, the high school assignment system is no longer strictly random in equalized education districts but still provides an unique opportunity to study the effects of single-sex schooling due to a similar school choice among high school applicants. Most applicants list schools located near their residential area in order of the prestigious rankings of high schools determined by the school-wide average score of College Scholastic Ability Test (CSAT) and the total number of alumni admitted to top-tier colleges. These information can be easily derived from a handful of newspapers and school placards[16]. If all students list the same schools in the same order based on same information, high school admissions outcomes under the multiple applications-then-lottery assignment are not significantly different from those under the strictly random assignment[17]. Hence, the high school admissions system in equalized education districts can alleviate the potential endogeneity of student characteristics.

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[16] To show how prestigious a school is, most schools voluntarily make and put up a big placard outside of their building. The placard usually reports the total number of graduates admitted to Seoul National University, Yonsei University, Korea University, Pohang University of Science and Technology, and the Korea Advanced Institute of Science and Technology.

[17] The list of preferred high schools was often selected in the same order of the past rankings of schools and a commuting distance to school. To avoid the possibility of assignment to a school located far from residential area, students' application behaviors are often risk-averse rather than risk-seeking. The homogeneity in the application strategies results in the skewed distribution of students' preferred high schools (Lee, 2016). In consequence, both in popular and unpopular high schools, the lottery system is used to admit the applicants.

A new form of high school called autonomous private high school was introduced in 2009 to meet demands for more diverse school choice options. Extensive autonomy in terms of administrative and financial management is provided to autonomous private high schools through the "Core Schools" project by the Ministry of Education. For example, the autonomous private high schools can admit applicants based on eligibility requirements specific to their own admissions criteria and application procedures, determine tuition rates, and design curriculum and instruction. The introduction of autonomous private high school can affect students' school choice which is associated with the potential endogeneity bias between student and school characteristics. Therefore, this study will use the sample of the cohort who entered high schools before 2009 to examine the effect of single-sex schools on the gender gap in the choice of college major.

2.2. A college-major pair admissions rule

South Korea uses college-major-specific admissions policies, which require a student to make an application decision for a college-major pair. In contrast to college-then-major admissions policies widely implemented in Western countries such as Canada and the U.S., students cannot be admitted without declaring their majors[18]. Application to both two-year vocational or technical colleges and four-year research colleges is possible. During an application season, students can make up to three applications to four-year colleges[19]. In the case of two-year colleges, such restriction does not apply. The Korean government specifies three separate periods for the four-year college admissions process. Each college can select a single

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[18] Only a few students are admitted without declaring their majors in a small number of colleges. Bordon and Fu (2015) provided detailed information about college-major-specific and college-then-major admissions policies.

[19] Note that such restriction does not apply in the case of specific four-year colleges – vocational universities (named as "University of Science and Technology"), distance universities (named as "Open University" or "Cyber University"), and the Korea Advanced Institute of Science and Technology.

day for each period. For each period, only one application of a college-major pair is allowed[20] (for detailed information, see Avery, Lee, & Roth, 2014).

Changing a major is allowed only for a few students when the enrollment capacity for each major program is not reached by students on dropout and leave of absence for study abroad, internship, and compulsory military service[21]. This small quota for the transfer-in program intensifies competition for the approval of transfer, which is based on grade point average (GPA). Hence, the majority of students persist in their major firstly chosen during the application period. Accordingly, college major choice is not affected by college-related variables under the college-major-specific admission policies. This admissions regime enables estimation of the effect of single-sex schooling on the gender gap in the choice of college major by using longitudinal data of students from high school to college.

3. Data and empirical framework

Two restricted-use datasets are combined to understand the effect of high school characteristics on students' choice of college major over time: (1) the Korean Education Longitudinal Survey (KELS) and (2) the Korean Educational Statistics Database. Using the merged data, the effect of single-sex schooling on college major choice is empirically examined through multiple regression analyses.

3.1. Data source

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[20] Students do not need to apply for the same major across three colleges (For detailed information, see Cho, Kam, & Lee, 2017). For example, a student can apply to "A" university with a major in "Engineering," "B" university with a major in "Science," and "C" university with a major in "Nursing." This admissions regime allows students to develop their own application strategy maximizing the possibility of being admitted.

[21] Students can take a voluntary leave of absence for study abroad, internship, and compulsory military service. In South Korea, every man over the age of 18 is required to serve in the military for approximately two-years unless he is disabled or under a special condition (for an overview, see Kam, 2016).

For baseline analyses, I use data from the KELS, an ongoing longitudinal study of a nationally representative sample of 6,908 adolescents in the first grade at middle school in South Korea during the 2005-06 school year. Administered by the Korean Educational Development Institute (KEDI), the KELS was launched to investigate the academic and social progress of young adults throughout education and work. The current released data provides rich information on student and school characteristics from 2005 through 2011. To link the characteristics of high school from which a student graduated to a major chosen when first enrolled in a college, I use KELS data collected from 2008 to 2011[22]. The fourth to the sixth waves of the KELS cover student and school characteristics throughout high school. The seventh wave documents the postgraduate outcomes of each student. These four waves of the KELS are analyzed to understand the impact of single-sex schooling on college major choice.

In the next step, I narrow the sample to students who entered in March 2008 and graduated in February 2011 from high schools located in equalized education districts and enrolled in two- or four-year colleges in March 2011. The random assignment of students into high schools in equalized education districts can alleviate the endogeneity concerns. This identification strategy is further confounded by dropping students who transfer to another schools[23]. To identify whether a school is located in an equalized education district and to control for district-level characteristics, school district information is needed. Although the KELS does not provide a school's district code, it provides sufficient information to identify a district for each school by matching 10 variables—an identifier for school location type (capital, metropolitan, urban, and rural), school type (coed, all boy's, and all girls'; national/public and private), school gross floor area, principal's gender, and the number of classes by grade, and the

[22] The sample attrition rate from 2008 to 2011 is 4.60 percent.
[23] Only five students in the sample have transferred to another school during their high school years.

number of students by grades and gender—with equivalent information in the Korean Educational Statistics Database.

The reliability of variables on school characteristics can be increased by matching them across two datasets. Administrated by the KEDI, the Korean Educational Statistics Database is a nationwide census of all schools. It annually collects detailed information about school characteristics ranging from the school gender composition to financing and administration. School-level data is provided by the Korea Education and Research Information Service (KERIS) through the EduData Service System (EDSS). This step also allows information acquisition of the gender composition of teachers by subject for each school. The baseline sample is finally constructed by combining the KELS and the Korean Educational Statistics Database. It includes only schools that are coded as being consistently single-sex or coeducational schools in every year of the sample. Table 1 describes the summary statistics for the baseline sample.

The key outcome variable of this study is college major. The KELS provides detailed information on students' majors. College majors are first categorized into seven fields: Engineering, Science, Medicine/Public Health, Humanities/Social Science, Economics/Business, Education, and Arts/Athletics[24]. The difference in college major distribution across gender is statistically significant at the 1 percent level based on Kolmogorov-Smirnov test. To provide policy-relevant insight into the link of the gender gap in a specific field between upper secondary and higher education, college majors are then classified into three categories based on t-statistics: predominantly male (i.e., Engineering, $t = 20.96$), predominantly female (i.e., Medicine/Public Health, $t = -10.17$; Humanities/Social Science, $t = -4.97$; Education, $t = -7.27$; and Arts/Athletics,

[24] For more detailed information, see Appendix A.

t = -6.22), and gender balanced majors (i.e., Science, t = 1.65; and Business/Economics, t = -1.42). Using the differences between the proportion of males and that of females in a specific major group, I perform a t-test by college type (two- and four-year college) on the null hypothesis that the gender proportions are the same. The results of t-test show the different gender composition of students by field of study across college type. For example, Humanities/Social Science majors are categorized into gender-balanced majors among two-year colleges (t = -0.89) and into predominantly female majors (t = -6.04). Therefore, to minimize the potential conflicting effect, the baseline sample is further narrowed to students who enrolled in four colleges. As reported in Table 2, the college major distribution of the baseline sample is comparable with that of population.

3.2.Empirical framework

To estimate the impact of single-sex schooling on the gender gap in college major choice, a regression model of the following form is estimated.

$$Y_{isdc}^{m} = \alpha^{ss} SS_{isd}^{f} + \alpha^{coed} Coed_{isd}^{f} + \beta SS_{isd} + X_{isdc}'\lambda + Z_{sd}'\eta + \Pi_c'\tau + \rho_d + \varepsilon_{isdc} \quad (1)$$ [25]

where Y_{isdc}^{m} is 1 if a student *i* at high school *s* in school district *d,* selects a major *m* at college *c*, SS_{isd}^{f} is 1 if the student is female, graduating from a single-sex high school, $Coed_{isd}^{f}$ is 1 if the student is female, graduating from a coeducational high school, SS_{isd} is 1 if the student graduated from a single-sex high school, X_{isdc} is a vector of the student's characteristics, Z_{sd} is a vector of high school-specific characteristics, Π_c is a vector of college-specific characteristics, ρ_d is a full set of school district dummies, and ε_{isdc} is the error term. As the parameters of

[25] Equation (1) is guided by Lee, Niederle, and Kang (2014) who examine the effect of single-sex schooling on students' competitiveness.

interest, α^{ss} and α^{coed} estimate the gender gap in college major choice among students in single-sex and coeducational schools, respectively. College majors are classified into three categories—predominantly male, predominantly female, and gender balanced majors. If $\alpha^{ss} < 0$, female students at single-sex schools are less likely to select a major *m* than their male counterparts at single-sex schools. Similarly, if $\beta + \alpha^{ss} - \alpha^{coed} < 0$, female students at single-sex schools are less likely to select a major *m* than their female counterparts at coeducational schools. Male students at single-sex schools are less likely to select a major *m* than their male counterparts if $\beta < 0$. Hence, $\alpha^{ss} - \alpha^{coed}$ $(= \beta + \alpha^{ss} - \alpha^{coed} - \beta)$ measures the effect of single-sex schooling on the gender gap in the choice of a major *m*. If single-sex schooling encourages females to select a major m, $\alpha^{ss} - \alpha^{coed}$ will be positive.

4. Findings

The results do not support the popular hypothesis that single-sex schooling can reduce gender stereotypes. Table 3 displays estimates from Equation (1). Column (1) of Table 3 shows that among students who enroll in four-year colleges after their high school graduation, female students are less likely to select a predominantly male major (i.e., Engineering) by 34.7 percentage points than their male counterparts in single-sex schools and by 19.3 percentage points than their male counterparts in coeducational schools at the 0.01 significance level. On average, single-sex schooling is found to widen the gender gap in the choice of predominantly male majors by 15.4 percentage points compared to coeducational schooling at the 0.05 significant level.[26]

In contrast, female students are more likely to select a predominantly female major (i.e.,

[26] To show the overall single-sex schooling effect on the gender gap in college major choice, I report estimates of Equation (1) using the overall sample (i.e., including two-year colleges) in Appendix B.

Medicine/Public Health, Humanities/Social Science, Education, and Arts/Athletics) by 24.9 percentage points than their male counterparts in single-sex schools and by 32.6 percentage points than their male counterparts in coeducational schools at the 0.01 significance level. In spite of these significant relationships, no statistical difference is found in women's likelihood of selecting a predominantly female major between single-sex and coeducational schools (column (2) of Table 3).

There is no statistically significant gender gap in the choice of gender balanced majors (i.e., Science and Business/Economics) between all girls' and all boys' schools. On the other hand, female students in coeducational schools are less likely to select a gender balanced major by 13.4 percentage points than their male counterparts. Accordingly, the gender gap in the choice of gender balanced majors is reduced by 23.2 percentage points due to single-sex schooling as shown in column (3) of Table 3.

To investigate how students change their intention to major in a specific discipline during high school years, Equation (1) is estimated with intended majors. In this analysis, the sample is narrowed to students who report their intention to attend four-year college after graduating high school in every year of the sample regardless of their actual college placement. Table 4 presents the estimates of single-sex schooling effect on the gender gap in intended college major choice by grade. As reported in column (1) of Table 4, the extent of single-sex schooling effect on the gender gap in the intended choice of predominantly male majors increases as students progress through grades 1-3. For example, on average, single-sex schooling widens the gender gap in the intended choice of predominantly male majors by 1.7 percentage points in the freshman year, by 3.7 percentage points in the sophomore year, and 14.1 percentage points in the senior year. The results further show the contribution of single-sex schooling in reallocation of female students from predominantly male majors to gender balanced majors (columns (1) and (3) in Table 4). Changes in the significance levels of single-sex schooling effect can support no notable gender difference in students' intended major choice by school type in the freshman year. That is, affected by schooling effects specific to school type, students may change their intended college major. The mechanism underlying the single-sex schooling effect will be discussed in the following section.

These findings support that school type matters in recognizing students' own ability or preference in learning. In particular, single-sex schooling is associated with reallocation of female students from predominantly male majors to gender balanced majors while the net change of the gender gap is not statistically significant for predominantly female majors at a conventional level. In other words, all else being equal, female students at single-sex schools are more likely to select a predominantly female major or a gender balanced major than their female counterparts in coeducational schools.

5. Evidence on mechanisms

Although estimates from Equation (1) show whether and to what extent single-sex schooling affects students' decision in selecting a college major, results cannot be interpreted as the sole effect of school gender composition in the student body. Referring back to Table 1, by school type, another significant difference is observed in the proportion of female teachers within a school. This difference is observed more obviously when broken down by private and public schools[27]. The proportion of female teachers in public single-sex schools is higher than that in

[27] Note that the baseline sample only includes general high schools located in equalized education districts. Accordingly, there is no systematic difference between private and public schools in terms of curriculum, instruction, teacher quality, tuition and fees, and building and other physical infrastructure.

their private counterparts, where more autonomy is offered —for example, the proportion of female teachers in public all girls' schools is 0.64 whereas that in their private counterparts is 0.47. In a similar way, the proportion of female teachers in public all boys' schools is 0.52 and that in their private counterparts is 0.16. These statistics support a strong preference of private single-sex schools in hiring teachers who are the same gender as the student body. Motivated by these statistics, I attempt to rule out the indirect single-sex schooling effects possibly associated with the proportion of female teachers within a school.

To examine the indirect single-sex schooling effects interacting with the share of female teachers within a school, a regression model of the following form is estimated.

$$Y_{isdc}^{m} = \alpha^{ss} SS_{isd}^{f} + \alpha^{coed} Coed_{isd}^{f} + \beta SS_{isd} + \alpha_1^{ss} SS_{isd}^{f} \times FF_{sd} + \alpha_2^{coed} Coed_{isd}^{f} \times FF_{sd}$$
$$+ \beta_1 SS_{isd} \times FF_{sd} + X_{isdc}^{\prime} \lambda + Z_{sd}^{\prime} \eta + \Pi_c^{\prime} \tau + \rho_d + \varepsilon_{isdc} \quad (2)$$

where Y_{isdc}^{m} is 1 if a student *i* at high school *s* in school district *d,* selects a major *m* at college *c*, SS_{isd}^{f} is 1 if the student is female, graduating from a single-sex high school, $Coed_{isd}^{f}$ is 1 if the student is female, graduating from a coeducational high school, SS_{isd} is 1 if the student graduated from a single-sex high school, FF_{sd} is the proportion of female teachers within a school, $SS_{isd}^{f} \times FF_{sd}$, $Coed_{isd}^{f} \times FF_{sd}$, and $SS_{isd} \times FF_{sd}$ are a full set of interaction terms between school type and the proportion of female teachers within a school, X_{isdc} is a vector of the student's characteristics, Z_{sd} is a vector of high school-specific characteristics, Π_c is a vector of college-specific characteristics, ρ_d is a full set of school district dummies, and ε_{isdc} is the error term. The parameters of interest are α^{ss}, α^{coed}, α_1^{ss}, and α_1^{coed} . College majors are classified into three categories— predominantly male, predominantly female, and gender balanced majors. With the same logic of the baseline analyses, $\alpha^{ss} - \alpha^{coed} + (\alpha_1^{ss} - \alpha_2^{coed}) \times FF_{sd}$ measures the effect of single-sex schooling on the gender gap in the choice of a major m. If single-sex schooling encourages females to select a major m, $\alpha^{ss} - \alpha^{coed} + (\alpha_1^{ss} - \alpha_2^{coed})\times FF_{sd}$ will be positive.

Table 5 shows estimates from Equation (2). The results are generally consistent with the findings from Section 4 that supports significant single-sex schooling effects on the gender gap in the choice of college major. The sizable coefficients of the interaction terms provide evidence of the indirect single-sex schooling effects associated with the proportion of female teachers within a school. These findings imply that the teacher gender composition may work as the underlying mechanism through which single-sex schooling affects students' choice of college major. Using this mechanism, a school can offset or enhance the single-sex schooling effects. For example, the negative effect of single-sex schooling on the gender gap in the choice of predominantly male majors can be nullified if a school increases its share of female teachers at or above 57.8 percent. In the same sense, to diminish the single-sex schooling effect on the gender gap in the choice of predominantly female majors and gender balanced majors, a school needs to maintain its share of female teachers in those subject to 41.7 and 23.7 percent, respectively.

Assuming the hypothetical scenario that the proportion of female teachers at private all-girls schools (0.47) is the same as that of public all-girls schools (0.64), the effect of single-sex schooling on the gender gap in the choice of predominantly male majors can turn out to be positive. In this scenario, all else being equal, a part of the female group who used to select a gender balanced major will choose a predominantly male major. Likewise, the teacher gender is found to play an important role in determining the gender gap in the choice of college major at high schools. This is in contrary to the findings of Lee et al. (2014) that found little evidence to support the teacher gender effect on the gender gap in academic achievement across school type.

To further investigate whether the subjects taught by female teachers matter in alleviating single-sex schooling effects on the gender gap in college major choice, additional analyses are conducted. Table 6 reports the estimates of Equation (2) with the proportion of female teachers by subject: science and mathematics versus non-science and mathematics. The hypothetical changes in the proportion of female teachers from the mean-level of all girls' school (0.53) to 0.58, the estimated proportion which can nullify the single-sex schooling effect on the choice of predominantly male majors, with only new hires of female science and mathematics teachers, is found to intensify the effect. On average, the proportion of female teachers at all girls' schools (0.53) comprises of 23.3 percent science and mathematics (0.12) and 76.7 percent non-science and mathematics teachers (0.41). Under this female teacher composition, single-sex schooling widens the gender gap in the choice of predominantly male majors by 17.1 percentage points compared to coeducational schooling at the 0.05 significant level. If all increases in the share of female teachers are induced by rising the proportion of female teachers who instruct science or mathematics while maintaining the proportion of female teachers who instruct non-science or mathematics at 0.41, single-sex schooling broadens the gap by 35.9 percentage points. In contrast, if all increases in the share of female teachers are induced by rising the proportion of female teachers who instruct non-science or mathematics while maintaining the proportion of female teachers who instruct science or mathematics at 0.12, the single-sex schooling effect can be nullified.

These results imply that the overall proportion of female teachers is associated with reallocation of female students from predominantly female majors to gender balanced majors while the proportion of male teachers who instruct science and mathematics is associated with reallocation of female students from gender balanced majors to predominantly male majors.

Based on these findings, I suggest policy measure to reduce the potential negative effects of single-sex schooling on females by recruiting more male science and mathematics teachers in all-girls' high schools while holding the share of female teachers at or above 57.8 percent.[28]

6. Concluding Remarks

There has been a growing promotion of single-sex schools in response to the gender gap in academic outcomes. The significant benefits of single-sex schooling in test scores found in extensive literature provides evidence that schools matter in the short-run but questions whether schools matter in the long-run[29]. The related literature, furthermore, underscores the difficulty in identifying the causal impact of potentially endogenously formed groups. The findings of this study bridge the gap in the literature by addressing the impact of single-sex schooling on the gender gap in the choice of college major which is closest related to postgraduate labor market outcomes. The potential endogeneity concerns are accounted for using the Korean educational setting where students are randomly assigned to high schools within their districts and required to select a major simultaneously with applying to a college.

The results show that single-sex schooling widens the gender gap in the choice of predominantly male majors and reduces that in the choice of gender balanced majors through the reallocation of female students from predominantly male or female majors to gender balanced majors. To identify the potential mechanism underlying this effect, this study examines the teacher gender effect on the gender gap in college major choice across school type motivated by

[28] To support the validity of the findings, I estimate Equations (1) and (2) using Probit model. The results are consistent with ordinary least squares (OLS) regression coefficients. Appendix C reports the estimates of Probit model.

[29] Appendix D reports single-sex schooling effect on the gender gap in students' college major choice using the baseline sample of this study.

the statistics revealed a large skewness in the male-female teacher ratio in favor of student-teacher gender match at single-sex schools. The findings support that single-sex schooling effects on the gender gap in students' college major choice can be addressed by changing the proportion of female teachers.

On this point, this is consistent with the findings of earlier studies that highlighted the importance of teachers as role models (Carrington et al., 2007; Bettinger, & Long, 2005; Dee, 2005, 2007; Holmlund & Sund, 2008). This study can also contribute to the extension of the literature on teacher effects on student outcomes as role models where little attention has been devoted to the understanding of teacher effects on student college major choice. Most studies have focused merely on the effects of teacher's gender or race/ethnicity on student academic outcomes measured by standardized achievement test scores. For example, Winters et al. (2013) found a statistically significant relationship between being assigned to a female teacher and student achievement in secondary education through the analyses of administrative panel data obtained from Florida public schools. Similarly, Lim and Meer (2015) showed that female students perform substantially better on standardized tests when assigned to female teachers using the random assignment of students to Korean middle school classrooms. The findings of this study can enrich this literature, further demonstrating the importance of the gender composition of teachers within a school on the rational choice of college major without stereotype threat.

Paradoxically, single-sex schools have been promoted to reduce stereotype threat in shaping rigid gender roles (Bigler& Signorella, 2011; Park, Behrman, & Choi, 2013; Sullivan, 2009). This conventional belief was cemented by the supporting results of relevant studies which showed the positive relationship between single-sex schooling and academic achievement, especially for female students. Contrary to popular belief, the results of this study suggests that single-sex schooling can increase the gender gap in the choice of college major unless a school has a balanced gender composition of teachers. The results imply that same-gender peer effects are sufficient to alleviate stereotype threat effects on specific subject test scores but are insufficient to address stereotype threat effects on major choice.[30]

The results of this study also point to the fact that increasing the overall proportion of female teachers could encourage more female students to pursue gender-balanced majors instead of predominantly female majors but would be insufficient to attract them to predominantly male majors. To nullify the negative effect of single-sex schooling on the choice of predominantly male majors, all girls' schools need to recruit more male teachers who instruct science and mathematics while maintaining the share of female teachers at 57.8 percent. This might be because female science and mathematics teachers at all girls' schools are more likely to encourage female students, who consider Engineering (i.e., predominantly male majors) or Science (i.e., gender balanced majors) as their major, to select a Science major. As female science and mathematics teachers earned a degree from Science or Education majors (i.e., science or mathematics education) which are gender balanced or predominantly female majors, Engineering majors could not be well-acquainted field for them. Hence, they might motivate female students to select a Science major, which is their more familiar field. Therefore, along with promoting gender diversity in the teacher body, the systematic teacher training on career counseling is necessary to encourage more female students to select predominantly male majors.

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[30] To simply compare the extent of single-sex schooling effect on the gender gap in teacher, peer, and class attachment, supplementary analyses are conducted. Appendix E reports the estimates of regression parameters.

References

Anelli, M., & Peri, G. (2015). Peer gender composition and choice of college major (NBER Working Paper No. 18744). Retrieved from the National Bureau of Economic Research website: http://www.nber.org/papers/w18744.

Angrist, J. D. (2014). The perils of peer effects. *Labour Economics, 30*, 98-108.

Avery, C., Lee, S., & Roth, A. E. (2014). College admissions as non-price competition: The case of South Korea. (NBER Working Paper No. w20774). Retrieved from the National Bureau of Economic Research website: http://www.nber.org/papers/w20774.

Barres, B. (2006), iDoes Gender Matter?, *Nature, 442*, 133-136.

Bettinger, E. P., & Long, B. T. (2005). Do faculty serve as role models? The impact of instructor gender on female students. *American Economic Review, 95*(2), 152-157.

Bigler, R. S., & Signorella, M. L. (2011). Single-sex education: New perspectives and evidence on a continuing controversy. *Sex Roles, 65*(9-10), 659-669.

Billger, S. M. (2009). On reconstructing school segregation: The efficacy and equity of single-sex schooling. *Economics of Education Review, 28*(3), 393-402.

Bordon, P., & Fu, C. (2015). College-major choice to college-then-major choice. *The Review of Economic Studies, 82*(4), 1247-1288.

Brown, C. & Corcoran, M. (1997). Sex based differences in school content and the male-female wage gap, *Quarterly Journal of Economics, 99*, 31-44.

Carrell, S. E., Hoekstra, M., & Kuka, E. (2016). The long-run effects of disruptive peers (NBER Working Paper No. 22042). Retrieved from the National Bureau of Economic Research website: http://www.nber.org/papers/w22042.

Carrington, B., Francis, B., Hutchings, M., Skelton, C., Read, B., & Hall, I. (2007). Does the gender of the teacher really matter? Seven-to eight-year-olds' accounts of their interactions with their teachers. *Educational Studies, 33*(4), 397-413.

Cho, S., Kam, J., & Lee, S. (2017). Efficient supply of human capital: Role of college major. forthcoming in *The Singapore Economic Review*. DOI: http://dx.doi.org/10.1142/S0217590817500047.

Choi, J., Park, H., & Behrman, J. R. (2015). Separating boys and girls and increasing weight? Assessing the impacts of single-sex schools through random assignment in Seoul. S*ocial Science & Medicine, 134*, 1-11.

Dee, T. S. (2005). A teacher like me: Does race, ethnicity, or gender matter?. *American Economic Review, 95*(2), 158-165.

Dee, T. S. (2007). Teachers and the gender gaps in student achievement. *Journal of Human Resources, 42*(3), 528-554.

Eisenkopf, G., Hessami, Z., Fischbacher, U., & Ursprung, H. W. (2015). Academic performance and single-sex schooling: Evidence from a natural experiment in Switzerland. *Journal of Economic Behavior & Organization, 115*, 123-143.

Evans, W. N., Oates, W. E., & Schwab, R. M. (1992). Measuring peer group effects: A study of teenage behavior. *Journal of Political Economy, 100*(5), 966-991.

Gill, A. M., & Leigh, D. E. (2000). Community college enrollment, college major, and the gender wage gap. *Industrial & Labor Relations Review, 54*(1), 163-181.

Goldin, C., Katz, L., & Kuziemko, I. (2006). The homecoming of American college women: The reversal of the college gender gap. *Journal of Economic Perspectives, 20*(4), 133-156.

Halpern, D. F., Eliot, L., Bigler, R. S., Fabes, R. A., Hanish, L. D., Hyde, J., & Martin, C. L. (2011). The pseudoscience of single-sex schooling. *Science, 333*(6050), 1706-1707.

Holmlund, H., & Sund, K. (2008). Is the gender gap in school performance affected by the sex of the teacher?. *Labour Economics, 15*(1), 37-53.

Hoxby, C. M. (2002). The power of peers. *Education next, 2*(2). Retrieved from the Education Next website: http://educationnext.org/.

Kam, J. H. (2016). Academic and social integration of Korean male college students after their military obligation. Retrieved from https://sites.google.com/site/jihyekam/research.

Kang, C. (2007). Classroom peer effects and academic achievement: Quasi-randomization evidence from South Korea. *Journal of Urban Economics, 61*(3), 458-495.

Kessels, U., & Hannover, B. (2008). When being a girl matters less: Accessibility of gender-related self-knowledge in single-sex and coeducational classes and its impact on students' physics-related self-concept of ability. *British Journal of Educational Psychology, 78*(2), 273-289.

Kim, T., Lee, J. H. & Lee, Y. (2008). Mixing versus sorting in schooling: Evidence from the equalization policy in South Korea. *Economics of Education Review, 27*(6), 697–711.

Lavy, V., & Schlosser, A. (2011). Mechanisms and impacts of gender peer effects at school. *American Economic Journal: Applied Economics, 3*(2), 1-33.

Lee, L. F. (2007). Identification and estimation of econometric models with group interactions, contextual factors and fixed effects, *Journal of Econometrics, 140*(2), 333-374.

Lee, J. (2016). A study on general high school allocation system and related issues in educational equalized area. *Secondary Education Research, 64*(3), 725-749.

Lee, S., Niederle, M., & Kang, N. (2014). Do single-sex schools make girls more competitive?. *Economics Letters, 124*(3), 474-477.

Lee, S., Turner, L. J., Woo, S., & Kim, K. (2014). All or nothing? The impact of school and classroom gender composition on effort and academic achievement (NBER Working Paper No. 20722). Retrieved from the National Bureau of Economic Research website: http://www.nber.org/papers/w20722.

Lim, J., & Meer, J. (2015). The Impact of Teacher-Student Gender Matches: Random Assignment Evidence from South Korea (NBER Working Paper No. w21407). Retrieved from the National Bureau of Economic Research website: http://www.nber.org/papers/w21407.

Lu, F., & Anderson, M. L. (2015). Peer effects in microenvironments: The benefits of homogeneous classroom groups. *Journal of Labor Economics, 33*(1), 91-122.

Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The Review of Economic Studies, 60*(3), 531-542.

McDonald, J. A., & Thornton, R. J. (2007). Do new male and female college graduates receive unequal pay?. *Journal of Human Resources, 42*(1), 32-48.

Moffitt, R. A. (2001). Policy interventions, low-level equilibria, and social interactions. Social dynamics, 4(45-82), 6-17. S. Durlauf and P. Young (Eds.), *Social Dynamics*. Cambridge, MA: MIT Press.

O'Neill, J. (2003). The gender gap in wages, circa 2000. *American Economic Review, 93*(2), 309-314.

Park, H., Behrman, J. R., & Choi, J. (2013). Causal effects of single-sex schools on college entrance exams and college attendance: Random assignment in Seoul high schools. *Demography, 50*(2), 447-469.

Patterson, M. M. (2012). Self-perceived gender typicality, gender-typed attributes, and gender stereotype endorsement in elementary-school-aged children. *Sex roles, 67*(7-8), 422-4

Pahlke, E., Bigler, R. S., & Patterson, M. M. (2014). Reasoning about single-sex schooling for girls among students, parents, and teachers. *Sex Roles, 71*(5-8), 261-271.

Pahlke, E., Hyde, J. S., & Allison, C. M. (2014). The effects of single-sex compared with coeducational schooling on students' performance and attitudes: A meta-analysis. The effects of single-sex compared with coeducational schooling on students' performance and attitudes: A meta-analysis. *Psychological Bulletin, 140*(4), 1042-1072.

Sohn, H. (2016). Mean and distributional impact of single-sex high schools on students' cognitive achievement, major choice, and test-taking behavior: Evidence from a random assignment policy in Seoul, Korea. *Economics of Education Review, forthcoming.* doi:10.1016/j.econedurev.2016.02.007.

Sullivan, A. (2009). Academic self-concept, gender and single-sex schooling. *British Educational Research Journal, 35*(2), 259-288.

Turner, S. E., & Bowen, W. G. (1999). Choice of major: The changing (unchanging) gender gap. *Industrial & Labor Relations Review, 52*(2), 289-313.

Whitmore, D. (2005). Resource and peer impacts on girls' academic achievement: Evidence from a randomized experiment. *American Economic Review, 95*(2), 199-203.

Winters, M. A., Haight, R. C., Swaim, T. T., & Pickering, K. A. (2013). The effect of same-gender teacher assignment on student achievement in the elementary and secondary grades: Evidence from panel data. *Economics of Education Review, 34*, 69-75.

Xie, Y., & Shauman, K. (2003). *Women in Science: Career Processes and Outcome*s. Cambridge, MA: Harvard University Press.

Zafar, B. (2013). College major choice and the gender gap. *Journal of Human Resources, 48*(3), 545-595.

Table 1. School and Student Characteristics

	Single-sex school		Coeducational school	
	All-boys school	All-girls school	Male	Female
	(1)	(2)	(3)	(4)
A. School-level characteristics				
School founded by private entity (%)	68.22	64.65	33.33	
No. of total students	1258.95	1314.30	1248.32	
No. of seniors	428.28	449.93	424.86	
No. of total female students	0.00	1314.30	587.79	
No. of female seniors	0.00	449.93	206.42	
No. of total classes	34.46	35.44	33.88	
No. of senior classes	11.72	12.02	11.53	
Class size	36.32	37.00	36.66	
Senior class size	36.31	37.34	36.66	
No. of teachers	72.70	74.86	71.58	
Students per teacher	17.24	17.53	17.40	
Proportion of female teachers	0.27	0.53	0.48	
- In private schools	0.16	0.47	0.26	
- In public schools	0.52	0.64	0.59	
Proportion of science and math female teachers	0.07	0.12	0.12	
- In private schools	0.04	0.11	0.07	
- In public schools	0.14	0.16	0.15	
Proportion of regular teachers	0.90	0.90	0.92	
Average teacher age	43.33	42.38	41.34	
Average teacher years of schooling	16.79	16.74	16.87	
Proportion of college admitted students	0.79	0.84	0.83	
Proportion of 4-year college admitted students	0.66	0.65	0.62	
No. of observations	107	99	78	
B. Student-level characteristics				
Family income (2010 10,000 won)	453.69	350.04	406.02	446.35
Educational cost (2010 10,000 won)	67.24	58.12	58.51	61.40
Four-year college (%)	78.42	72.41	79.70	72.38
College Scholastic Ability Test scores				
- Korean	0.20	0.38	0.10	0.32
- English	0.22	0.33	0.07	0.36
- Math	0.38	0.21	0.17	0.14
- Social studies	0.11	0.13	0.13	0.17
- Science	0.26	0.06	0.21	0.06
College Major (%)				
- Predominantly male majors	38.60	10.06	33.08	11.05
- Predominantly female majors	34.04	61.21	27.82	67.40
- Gender balanced majors	27.36	28.74	39.10	21.55
No. of observations	329	348	133	181

Notes: Sample is limited to students graduating from high schools in equalized education districts. Each CSAT subject score is standardized to have a mean equal to 0 and standard deviation equal to 1. The distribution difference in college major is statistically significant at the 1 percent level based on Kolmogorov-Smirnov test.

Table 2. College Major Distribution

Entrance year = 2011	Total (1)	Men (2)	Women (3)
A. Population			
All (%)			
- Engineering	25.06	40.16	8.97
- Science	7.62	7.55	7.69
- Medicine/Public Health	8.58	4.98	12.43
- Humanities/Social Science	22.32	17.26	27.71
- Business/Economics	14.76	14.67	14.85
- Education	5.29	2.64	8.11
- Arts/Athletics	16.37	12.74	20.24
No. of observations	635,350	327,927	307,470
Four-year college (%)			
- Engineering	24.32	36.43	10.63
- Science	11.64	11.01	12.35
- Medicine/Public Health	5.65	3.45	8.15
- Humanities/Social Science	25.41	20.38	31.10
- Business/Economics	15.20	15.74	14.59
- Education	5.64	3.79	7.72
- Arts/Athletics	12.13	9.19	15.46
No. of observations	381,735	202,751	179,031
B. KELS Sample			
All (%)			
- Engineering	22.81	37.01	10.4
- Science	12.11	15.15	9.45
- Medicine/Public Health	8.78	4.33	12.67
- Humanities/Social Science	25.03	19.91	29.49
- Business/Economics	16.25	15.58	16.82
- Education	5.25	2.38	7.75
- Arts/Athletics	9.79	5.63	13.42
No. of observations	991	462	529
Four-year college (%)			
- Engineering	24.53	37.02	12.63
- Science	13.48	16.57	10.53
- Medicine/Public Health	3.91	1.93	5.79
- Humanities/Social Science	28.03	22.1	33.68
- Business/Economics	16.44	14.92	17.89
- Education	5.93	3.04	8.68
- Arts/Athletics	7.68	4.42	10.79
No. of observations	742	362	380

Notes: Panel A includes all students who newly enrolled in colleges which consider CSAT scores in admissions decisions such as university, university of education, industrial university, junior college, technical college, and polytechnic college. Panel B is limited to students graduating from high schools in equalized education districts. The distribution difference in college major by a school type is statistically significant at the 1 percent level based on Kolmogorov-Smirnov test.
Source: Statistical yearbook of education, Korean Educational Development Institute and Ministry of Education.

Table 3. Single-Sex Schooling Effect on Student Major Choice

	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
All			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_{all}^{ss})	-0.318***	0.176***	0.142**
	(0.054)	(0.062)	(0.056)
- Students in coeducational schools (α_{all}^{coed})	-0.237***	0.385***	-0.148***
	(0.055)	(0.053)	(0.056)
1 if attending a single-sex schools (β_{all})	0.109*	0.057	-0.167***
	(0.059)	(0.059)	(0.056)
R-square	0.177	0.211	0.087
No. of observations	991	991	991
Four-year college			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_{4yr}^{ss})	-0.347***	0.249***	0.098
	(0.064)	(0.074)	(0.061)
- Students in coeducational schools (α_{4yr}^{coed})	-0.193***	0.326***	-0.134**
	(0.058)	(0.059)	(0.064)
1 if attending a single-sex schools (β_{4yr})	0.174***	-0.015	-0.159***
	(0.056)	(0.064)	(0.061)
R-square	0.182	0.197	0.074
No. of observations	742	742	742
Gap reduction due to single-sex schooling			
- All (α_{all}^{ss}- α_{all}^{coed})	-0.080	-0.209**	0.289***
	(0.073)	(0.082)	(0.074)
- Four-year college (α_{4yr}^{ss}- α_{4yr}^{coed})	-0.154*	-0.077	0.232***
	(0.079)	(0.093)	(0.082)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 4. Single-Sex Schooling Effect on Intended Major Choice

Sample: Intended to attend four-year colleges	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
No. of observations	622	622	622
Freshman			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_1^{ss})	-0.124***	0.111	-0.037
	(0.041)	(0.081)	(0.053)
- Students in coeducational schools (α_1^{coed})	-0.107*	0.146**	-0.129**
	(0.057)	(0.058)	(0.052)
1 if attending a single-sex schools (β_1)	0.040	0.063	-0.064
	(0.055)	(0.071)	(0.056)
R-square	0.160	0.133	0.091
Junior			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_2^{ss})	-0.135***	0.133	-0.022
	(0.047)	(0.080)	(0.057)
- Students in coeducational schools (α_2^{coed})	-0.098*	0.238***	-0.191***
	(0.052)	(0.079)	(0.059)
1 if attending a single-sex schools (β_2)	0.070	0.089	-0.173**
	(0.055)	(0.083)	(0.067)
R-square	0.159	0.151	0.102
Senior			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_2^{ss})	-0.277***	0.334***	0.102
	(0.061)	(0.083)	(0.070)
- Students in coeducational schools (α_2^{coed})	-0.136**	0.202**	-0.093
	(0.053)	(0.089)	(0.068)
1 if attending a single-sex schools (β_2)	0.175***	-0.115	-0.082
	(0.060)	(0.091)	(0.072)
R-square	0.174	0.132	0.092
Gap reduction due to single-sex schooling			
- 1st grade: (α_1^{ss}- α_1^{coed})	-0.017	-0.036	0.092
	(0.065)	(0.101)	(0.069)
- 2nd grade: (α_2^{ss}- α_2^{coed})	-0.037	-0.106	0.169**
	(0.069)	(0.107)	(0.081)
- 3rd grade: (α_2^{ss}- α_2^{coed})	-0.141*	0.132	0.195**
	(0.075)	(0.123)	(0.094)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 5. Teacher Gender Effect on College Major Choice

Sample: Four-year college	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.609***	0.714***	-0.104
	(0.100)	(0.134)	(0.128)
- Students in coeducational schools (α^{coed})	-0.063	-0.034	0.097
	(0.151)	(0.128)	(0.137)
1 if attending a single-sex schools (β)	0.529***	-0.382***	-0.147
	(0.097)	(0.118)	(0.105)
Teacher gender effect			
- Proportion of female teachers (η_1)	0.571**	-0.376	-0.195
	(0.221)	(0.288)	(0.241)
- × students in single-sex schools (α_1^{ss})	0.681***	-1.063***	0.382
	(0.211)	(0.259)	(0.235)
- × students in coeducational schools (α_1^{coed})	-0.264	0.729***	-0.465*
	(0.271)	(0.247)	(0.239)
- × 1 if attending a single-sex schools (β_1)	-0.953***	0.984***	-0.031
	(0.230)	(0.272)	(0.227)
R-square	0.199	0.219	0.081
No. of observations	742	742	742
Gap reduction due to single-sex schooling by school type, s_i			
$s_i =$ (proportion of female teachers)			
- Private all boys' schools (0.16)	-0.396***	0.461***	-0.065
	(0.118)	(0.138)	(0.133)
- Private all girls' schools (0.47)	-0.103	-0.094	0.197**
	(0.081)	(0.092)	(0.083)
- Private coed schools (0.26)	-0.301***	0.282**	0.019
	(0.096)	(0.114)	(0.109)
- Public all boys' schools (0.52)	-0.056	-0.184*	0.240***
	(0.085)	(0.095)	(0.085)
- Public all girls' schools (0.64)	0.058	-0.399***	0.341***
	(0.105)	(0.114)	(0.100)
- Public coed schools (0.59)	0.011	-0.309***	0.299***
	(0.095)	(0.104)	(0.092)
Proportion of female teachers: Gap → 0	0.578	0.417	0.237

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 6. Teacher Gender Effect on Student Major Choice by Subject

Sample: Four-year college	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.631***	0.729***	-0.097
	(0.088)	(0.130)	(0.132)
- Students in coeducational schools (α^{coed})	-0.062	-0.088	0.150
	(0.155)	(0.126)	(0.136)
1 if attending a single-sex schools (β)	0.497***	-0.350***	-0.147
	(0.097)	(0.125)	(0.111)
Teacher gender effect			
- Proportion of female science/math teachers (η_1)	0.784	-1.181	0.396
	(0.693)	(0.828)	(0.885)
- × students in single-sex schools (α_1^{ss})	-0.590	-0.217	0.806
	(1.106)	(1.034)	(0.959)
- × students in coeducational schools (α_1^{coed})	1.767	-1.569	-0.197
	(1.307)	(1.196)	(1.250)
- × 1 if attending a single-sex schools (β_1)	-0.412	0.920	-0.508
	(1.206)	(1.153)	(1.181)
- Proportion of female non-science/math teachers (η_2)	0.514	-0.108	-0.405
	(0.396)	(0.410)	(0.519)
- × students in single-sex schools (α_2^{ss})	1.157**	-1.391***	0.233
	(0.514)	(0.495)	(0.478)
- × students in coeducational schools (α_2^{coed})	-0.958	1.659***	-0.701
	(0.627)	(0.462)	(0.580)
- × 1 if attending a single-sex schools (β_2)	-1.080*	0.954*	0.126
	(0.558)	(0.496)	(0.571)
R-square	0.207	0.230	0.086
No. of observations	742	742	742
Gap reduction due to single-sex schooling by school type, s_{ij}			
s_{ij} = (proportion of female science/math teachers, proportion of female non-science/math teachers)			
- Private all boy's schools (0.04, 0.12)	-0.410***	0.505***	-0.095
	(0.117)	(0.136)	(0.134)
- Private all girl's schools (0.11, 0.36)	-0.067	-0.132	0.199**
	(0.087)	(0.096)	(0.088)
- Private coed schools (0.07, 0.20)	-0.312***	0.302***	0.010
	(0.095)	(0.110)	(0.108)
- Public all boy's schools (0.14, 0.39)	-0.075	-0.183*	0.258***
	(0.088)	(0.093)	(0.086)
- Public all girl's schools (0.16, 0.47)	0.047	-0.400***	0.352***
	(0.108)	(0.110)	(0.101)
- Public coed schools (0.15, 0.43)	-0.014	-0.291***	0.305***
	(0.096)	(0.100)	(0.092)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Appendix (not for publication)

Do single-sex schools make girls less interested in predominantly male majors?

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A. Categorization of College Majors

Table A.1. Categorization of Major Department into Seven Major Fields

Major field of study	Major department
- Engineering	Architecture, Civil Construction/Urban Engineering, Transportation, Mechanical/Metallurgical Engineering, Electricity/Electronics, Precision/Energy, Materials, Computers/Communication, Industrial Engineering, Chemical Engineering, Mechatronics Engineering, Applied Engineering, General Engineering
- Science	Agriculture/Fisheries, Biology, Chemistry/Environmental Science, Food/Nutrition, Mathematics, Physics, Astronomy/Geology
- Medicine/Public Health	Medical Science, Nursing, Pharmacy, Therapeutics & Public Health
- Humanities/Social Science	Linguistics/Literature, Humanities, Law, Social Science
- Business/Economics	Business Administration, Economics
- Education	General Education, Early Childhood Education, Special Education, Elementary Education, Secondary Education
- Arts/Athletics	Design, Applied Arts, Dancing/Athletics, Fine/Formative Arts, Drama/Cinema, Music

B. Results using Overall Sample

Table B.1. Single-Sex Schooling Effect on Intended Major Choice

Sample: All	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
No. of observations	991	991	991
Freshman			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_1^{ss})	-0.060**	0.076	-0.003
	(0.027)	(0.051)	(0.032)
- Students in coeducational schools (α_1^{coed})	-0.119***	0.122**	-0.094***
	(0.032)	(0.048)	(0.035)
1 if attending a single-sex schools (β_1)	-0.009	0.026	-0.054
	(0.033)	(0.056)	(0.035)
R-square	0.098	0.108	0.060
Junior			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_2^{ss})	-0.103***	0.061	0.025
	(0.032)	(0.059)	(0.046)
- Students in coeducational schools (α_2^{coed})	-0.089**	0.194***	-0.113***
	(0.035)	(0.053)	(0.040)
1 if attending a single-sex schools (β_2)	0.067*	0.053	-0.115***
	(0.035)	(0.054)	(0.044)
R-square	0.130	0.124	0.070
Senior			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_2^{ss})	-0.245***	0.273***	0.059
	(0.046)	(0.068)	(0.050)
- Students in coeducational schools (α_2^{coed})	-0.160***	0.303***	-0.126***
	(0.039)	(0.055)	(0.045)
1 if attending a single-sex schools (β_2)	0.131***	-0.028	-0.074
	(0.049)	(0.063)	(0.054)
R-square	0.146	0.154	0.074
Gap reduction due to single-sex schooling			
- 1st grade: (α_1^{ss}- α_1^{coed})	0.059	-0.046	0.091**
	(0.038)	(0.069)	(0.044)
- 2nd grade: (α_2^{ss}- α_2^{coed})	-0.015	-0.133*	0.138**
	(0.043)	(0.073)	(0.059)
- 3rd grade: (α_2^{ss}- α_2^{coed})	-0.085	-0.029	0.185***
	(0.057)	(0.087)	(0.066)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district fixed effects and dummy for intending four-year college are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table B.2. Teacher Gender Effect on College Major Choice

Sample: All	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.481***	0.442***	0.039
	(0.085)	(0.123)	(0.110)
- Students in coeducational schools (α^{coed})	-0.136	0.087	0.049
	(0.169)	(0.140)	(0.133)
1 if attending a single-sex schools (β)	0.359***	-0.247**	-0.112
	(0.121)	(0.116)	(0.097)
Teacher gender effect			
- Proportion of female teachers (η_1)	0.427*	-0.143	-0.284
	(0.242)	(0.267)	(0.232)
- × students in single-sex schools (α_1^{ss})	0.429**	-0.633***	0.204
	(0.179)	(0.234)	(0.192)
- × students in coeducational schools (α_1^{coed})	-0.202	0.588**	-0.386
	(0.295)	(0.258)	(0.235)
- × 1 if attending a single-sex schools (β_1)	-0.657***	0.780***	-0.123
	(0.251)	(0.261)	(0.207)
R-square	0.185	0.221	0.089
No. of observations	991	991	991
Gap reduction due to single-sex schooling by school type, s_i			
$s_i =$ (proportion of female teachers)			
- Private all boy's schools (0.16)	-0.245*	0.16	0.085
	(0.129)	(0.138)	(0.123)
- Private all girl's schools (0.47)	-0.049	-0.219***	0.268***
	(0.076)	(0.083)	(0.076)
- Private coed schools (0.26)	-0.182*	0.038	0.144
	(0.104)	(0.112)	(0.101)
- Public all boy's schools (0.52)	-0.018	-0.280***	0.297***
	(0.078)	(0.084)	(0.076)
- Public all girl's schools (0.64)	0.058	-0.426***	0.368***
	(0.095)	(0.100)	(0.087)
- Public coed schools (0.59)	0.026	-0.365***	0.339***
	(0.086)	(0.091)	(0.081)

Notes: Sample is limited to student graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table B.3. Teacher Gender Effect on Student Major Choice by Subject

Sample: All	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.487***	0.413***	0.075
	(0.080)	(0.120)	(0.112)
- Students in coeducational schools (α^{coed})	-0.110	0.027	0.084
	(0.169)	(0.140)	(0.129)
1 if attending a single-sex schools (β)	0.366***	-0.213*	-0.153
	(0.121)	(0.120)	(0.100)
Teacher gender effect			
- Proportion of female science/math teachers (η_1)	0.242	-0.808	0.566
	(0.803)	(0.816)	(0.829)
- × students in single-sex schools (α_1^{ss})	-0.750	0.877	-0.128
	(0.969)	(0.896)	(0.896)
- × students in coeducational schools (α_1^{coed})	1.736*	-0.701	-1.035
	(1.033)	(1.070)	(1.140)
- × 1 if attending a single-sex schools (β_1)	0.472	-0.070	-0.402
	(1.187)	(1.067)	(1.104)
- Proportion of female non-science/math teachers (η_2)	0.575	0.180	-0.756
	(0.450)	(0.379)	(0.477)
- × students in single-sex schools (α_2^{ss})	0.850*	-1.099***	0.249
	(0.437)	(0.422)	(0.416)
- × students in coeducational schools (α_2^{coed})	-0.936*	1.200***	-0.264
	(0.551)	(0.439)	(0.535)
- × 1 if attending a single-sex schools (β_2)	-1.098*	1.021**	0.077
	(0.560)	(0.442)	(0.527)
R-square	0.192	0.230	0.094
No. of observations	991	991	991
Gap reduction due to single-sex schooling by school type, s_{ij}			
s_{ij} = (proportion of female science/math teachers, proportion of female non-science/math teachers)			
- Private all boy's schools (0.04, 0.12)	-0.262**	0.173	0.089
	(0.13)	(0.138)	(0.122)
- Private all girl's schools (0.11, 0.36)	-0.007	-0.269***	0.276***
	(0.08)	(0.083)	(0.079)
- Private coed schools (0.07, 0.20)	-0.194*	0.036	0.158
	(0.102)	(0.109)	(0.098)
- Public all boy's schools (0.14, 0.39)	-0.028	-0.29***	0.319***
	(0.078)	(0.083)	(0.075)
- Public all girl's schools (0.16, 0.47)	0.065	-0.443***	0.378***
	(0.094)	(0.096)	(0.088)
- Public coed schools (0.15, 0.43)	0.018	-0.367***	0.348***
	(0.084)	(0.087)	(0.08)

Notes: Sample is limited to student graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

C. Robustness Check using Probit model

Table C.1. Single-Sex Schooling Effect on College Major Choice

Probit (Marginal effects at mean)	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
All			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_{all}^{ss})	-0.253***	0.190***	0.158***
	(0.039)	(0.069)	(0.058)
- Students in coeducational schools (α_{all}^{coed})	-0.166***	0.412***	-0.139***
	(0.026)	(0.050)	(0.045)
1 if attending a single-sex schools (β_{all})	0.093**	0.065	-0.172***
	(0.041)	(0.072)	(0.057)
Pseudo R-square	0.184	0.169	0.076
No. of observations	991	991	991
Four-year college			
Gap in intended major choice: Boys-Girls			
- Students in single-sex schools (α_{4yr}^{ss})	-0.273***	0.283***	0.108*
	(0.045)	(0.079)	(0.062)
- Students in coeducational schools (α_{4yr}^{coed})	-0.147***	0.364***	-0.121**
	(0.033)	(0.061)	(0.052)
1 if attending a single-sex schools (β_{4yr})	0.151***	-0.027	-0.162***
	(0.041)	(0.077)	(0.061)
Pseudo R-square	0.182	0.157	0.064
No. of observations	742	742	742
Gap reduction due to single-sex schooling			
- All (α_{all}^{ss}- α_{all}^{coed})	-0.309	-0.66***	0.935***
	(0.311)	(0.247)	(0.228)
- Four-year college (α_{4yr}^{ss}- α_{4yr}^{coed})	-0.571*	-0.235	0.699***
	(0.333)	(0.271)	(0.24)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table C.2. Teacher Gender Effect on Student Major Choice

Probit (Marginal effects at mean) Sample: Four-year college	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.455***	0.708***	-0.094
	(0.067)	(0.085)	(0.120)
- Students in coeducational schools (α^{coed})	-0.114	-0.049	0.139
	(0.129)	(0.147)	(0.141)
1 if attending a single-sex schools (β)	0.367***	-0.443***	-0.143
	(0.054)	(0.117)	(0.100)
Teacher gender effect			
- Proportion of female teachers (η_1)	0.536**	-0.431	-0.200
	(0.222)	(0.347)	(0.230)
- × students in single-sex schools (α_1^{ss})	0.746***	-1.274***	0.379
	(0.229)	(0.304)	(0.239)
- × students in coeducational schools (α_1^{coed})	-0.101	0.888***	-0.537**
	(0.327)	(0.305)	(0.234)
- × 1 if attending a single-sex schools (β_1)	-0.905***	1.184***	-0.043
	(0.206)	(0.327)	(0.217)
Pseudo R-square	0.202	0.177	0.070
No. of observations	742	742	742
Gap reduction due to single-sex schooling by school type, s_i			
$s_i =$ (proportion of female teachers)			
- Private all boy's schools (0.16)	-1.466**	1.402***	-0.240
	(0.597)	(0.407)	(0.382)
- Private all girl's schools (0.47)	-0.427	-0.295	0.603**
	(0.348)	(0.271)	(0.249)
- Private coed schools (0.26)	-1.131**	0.855**	0.032
	(0.485)	(0.333)	(0.313)
- Public all boy's schools (0.52)	-0.259	-0.568**	0.739***
	(0.349)	(0.283)	(0.258)
- Public all girl's schools (0.64)	0.143	-1.225***	1.065***
	(0.410)	(0.347)	(0.314)
- Public coed schools (0.59)	-0.024	-0.952***	0.929***
	(0.376)	(0.315)	(0.286)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table C.3. Teacher Gender Effect on Student Major Choice by Subject

Sample: Four-year college	Predominantly male majors (1)	Predominantly female majors (2)	Gender balanced majors (3)
Gap in major choice: Boys-Girls			
- Students in single-sex schools (α^{ss})	-0.480***	0.721***	-0.089
	(0.064)	(0.081)	(0.126)
- Students in coeducational schools (α^{coed})	-0.122	-0.128	0.215
	(0.114)	(0.142)	(0.147)
1 if attending a single-sex schools (β)	0.345***	-0.402***	-0.144
	(0.056)	(0.126)	(0.107)
Teacher gender effect			
- Proportion of female science/math teachers (η_1)	0.760	-1.512	0.397
	(0.567)	(1.100)	(0.794)
- × students in single-sex schools (α_1^{ss})	-0.653	-0.131	0.742
	(0.920)	(1.212)	(0.920)
- × students in coeducational schools (α_1^{coed})	2.170*	-1.647	-0.043
	(1.196)	(1.464)	(1.221)
- × 1 if attending a single-sex schools (β_1)	-0.510	1.161	-0.525
	(0.894)	(1.484)	(1.106)
- Proportion of female non-science/math teachers (η_2)	0.482	-0.048	-0.425
	(0.339)	(0.516)	(0.474)
- × students in single-sex schools (α_2^{ss})	1.310***	-1.712***	0.262
	(0.451)	(0.579)	(0.479)
- × students in coeducational schools (α_2^{coed})	-0.844	1.979***	-0.900
	(0.653)	(0.584)	(0.567)
- × 1 if attending a single-sex schools (β_2)	-0.970**	1.084*	0.108
	(0.437)	(0.619)	(0.526)
R-square	0.212	0.187	0.075
No. of observations	742	742	742
Gap reduction due to single-sex schooling by school type, s_{ij}			
s_{ij} = (proportion of female science/math teachers, proportion of female non-science/math teachers)			
- Private all boy's schools (0.04, 0.12)	-1.578***	1.587***	-0.354
	(0.56)	(0.406)	(0.395)
- Private all girl's schools (0.11, 0.36)	-0.294	-0.387	0.64**
	(0.332)	(0.284)	(0.265)
- Private coed schools (0.07, 0.20)	-1.226***	0.954***	-0.007
	(0.447)	(0.326)	(0.316)
- Public all boy's schools (0.14, 0.39)	-0.375	-0.552**	0.814***
	(0.35)	(0.281)	(0.261)
- Public all girl's schools (0.16, 0.47)	0.091	-1.223***	1.138***
	(0.408)	(0.336)	(0.312)
- Public coed schools (0.15, 0.43)	-0.142	-0.887***	0.976***
	(0.37)	(0.304)	(0.282)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district, school region type, and college decile rank fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. College characteristics such as dummies for private college and being located in metropolitan areas are also controlled. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

D. Single-Sex Schooling Effect on Academic Achievement

Table D.1. Single-Sex Schooling Effect on CSAT Score

	Korean (1)	English (2)	Math (3)	Total (4)
All				
Gap in intended major choice: Boys-Girls				
- Students in single-sex schools (α_{all}^{ss})	0.246**	-0.110	0.252*	0.142
	(0.123)	(0.143)	(0.134)	(0.127)
- Students in coeducational schools (α_{all}^{coed})	0.149	-0.059	0.207**	0.106
	(0.113)	(0.112)	(0.093)	(0.092)
1 if attending a single-sex schools (β_{all})	0.016	0.240*	0.064	0.109
	(0.118)	(0.126)	(0.123)	(0.112)
R-square	0.107	0.140	0.156	0.146
No. of observations	822	822	822	822
Four-year college				
Gap in intended major choice: Boys-Girls				
- Students in single-sex schools (α_{4yr}^{ss})	0.409***	-0.013	0.337**	0.260*
	(0.130)	(0.159)	(0.152)	(0.138)
- Students in coeducational schools (α_{4yr}^{coed})	0.096	-0.010	0.149	0.084
	(0.112)	(0.128)	(0.096)	(0.093)
1 if attending a single-sex schools (β_{4yr})	-0.116	0.189	-0.024	0.015
	(0.111)	(0.141)	(0.112)	(0.107)
R-square	0.139	0.142	0.189	0.167
No. of observations	624	624	624	624
Gap reduction due to single-sex schooling				
- All (α_{all}^{ss}- α_{all}^{coed})	0.097	-0.051	0.045	0.035
	(0.169)	(0.183)	(0.164)	(0.159)
- Four-year college (α_{4yr}^{ss}- α_{4yr}^{coed})	0.313*	-0.003	0.188	0.177
	(0.180)	(0.209)	(0.184)	(0.174)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

E. Single-Sex Schooling and School Attachment

Table E.1. Teacher, Peer, Class Attachment Variable Construct

Variable		Item	Response Options	Cronbach's alpha
Teacher Relationship	Q2.	[School climate] To what extent do you agree with each of the following statements? *Teachers in my school* 5) fully understand their students in general. 6) never ignore what students say. 7) discipline students fairly. 8) fully understand difficult problems that I have. 9) are generous to praise students. 10) are willing to help me if I encounter a problem	(1) Disagree strongly (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Agree strongly	1st grade: 0.872 2nd grade: 0.870
Teacher Effort	Q3.	To what extent do you agree with each of the following statements? *Teachers in my school* 1) teach hard. 2) are respectful. 3) are very knowledgeable about what they teach. 4) are enthusiastic about teaching. 5) want students to study hard. 6) dislike students if they do not study hard. 7) emphasize the importance of class rank. 8) push all students to preview what they will learn and review what they learned in classes.	(1) Disagree strongly (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Agree strongly	1st grade: 0.740 2nd grade: 0.744
Peer Relationship	Q2.	[School climate] To what extent do you agree with each of the following statements? *Students in my class* 11) have good relationship with each other. 12) easily become friends. 13) respect and care for me. 14) help me to solve difficult homework problems.	) Disagree strongly) Disagree) Neither agree nor disagree) Agree) Agree strongly	1st grade: 0.843 2nd grade: 0.849

Table E.1. Teacher, Peer, Class Attachment Variable Construct (*continued*)

Variable		Item	Response Options	Cronbach's alpha
Class distraction	Q5.	To what extent do you agree with each of the following statements? *In class, I* 1) am noisy and disorder. *recoded* 2) focus my attention. 3) am willing to learn. 4) frequently ask questions.	(1) Disagree strongly (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Agree strongly	1st grade: 0.756 2nd grade: 0.653
Class participation	Q7.	How much time do you usually pay attention to class? 1) Korean class (k) 2) English class (e) 3) Math class (m)	(1) 10 minutes and less (2) 11-20 minutes (3) 21-30 minutes (4) 31-40 minutes (5) 41 minutes and over	1st grade: 0.766 (k) 0.760 (e) 0.779 (m) 2nd grade: 0.704 (k) 0.742 (e) 0.814 (m)
	Q8.	To what extent do you think you understand in class? 1) Korean class (k) 2) English class (e) 3) Math class (m)	(1) 20% and less (2) 21-40% (3) 41-60% (4) 61-80% (5) 81% and over	

Table E.2. Single-Sex Schooling Effect on Teacher, Peer, and Class Attachment

Sample: All	Teacher		Peer		Class		
	Relationship	Effort	Relationship	Distraction		Participation	
					Korean	English	Math
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
No. of observations	944	944	944	944	944	944	944
Freshman							
Gap in intended major choice: Boys-Girls							
- Students in single-sex schools (α_1^{ss})	-0.100	0.037	0.390***	-0.048	0.129	0.315**	-0.163
	(0.115)	(0.126)	(0.125)	(0.110)	(0.123)	(0.147)	(0.124)
- Students in coeducational schools (α_1^{coed})	-0.092	-0.110	-0.083	-0.116	0.160	0.256**	-0.138
	(0.123)	(0.137)	(0.130)	(0.142)	(0.127)	(0.127)	(0.123)
1 if attending a single-sex schools (β_1)	-0.066	-0.007	-0.297**	-0.002	0.020	0.060	0.071
	(0.131)	(0.153)	(0.149)	(0.133)	(0.139)	(0.136)	(0.117)
R-square	0.107	0.067	0.073	0.082	0.085	0.098	0.092
Junior							
Gap in intended major choice: Boys-Girls							
- Students in single-sex schools (α_2^{ss})	0.192	0.036	0.307***	-0.077	0.280**	0.306**	-0.122
	(0.118)	(0.122)	(0.104)	(0.112)	(0.112)	(0.119)	(0.132)
- Students in coeducational schools (α_2^{coed})	-0.009	-0.214	0.040	-0.217*	0.236*	0.195*	-0.070
	(0.114)	(0.130)	(0.117)	(0.124)	(0.138)	(0.108)	(0.129)
1 if attending a single-sex schools (β_2)	-0.109	-0.101	-0.050	-0.140	-0.049	0.061	0.105
	(0.124)	(0.148)	(0.127)	(0.119)	(0.126)	(0.113)	(0.120)
R-square	0.102	0.066	0.071	0.070	0.089	0.107	0.105
Gap reduction due to single-sex schooling							
- 1st grade: (α_1^{ss}- α_1^{coed})	-0.008	0.147	0.473***	0.068	-0.031	0.059	-0.025
	(0.175)	(0.193)	(0.180)	(0.172)	(0.179)	(0.183)	(0.164)
- 2nd grade: (α_2^{ss}- α_2^{coed})	0.202	0.249	0.267*	0.139	0.044	0.110	-0.052
	(0.161)	(0.179)	(0.157)	(0.166)	(0.167)	(0.155)	(0.177)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table E.3. Single-Sex Schooling Effect on Teacher, Peer, and Class Attachment

Sample: Four-year college	Teacher		Peer		Class		
	Relationship	Effort	Relationship	Distraction	Participation		
					Korean	English	Math
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
No. of observations	706	706	706	706	706	706	706
Freshman							
Gap in intended major choice: Boys-Girls							
- Students in single-sex schools (α_1^{ss})	-0.058	0.126	0.367***	-0.031	0.170	0.330**	-0.052
	(0.127)	(0.147)	(0.137)	(0.137)	(0.128)	(0.160)	(0.128)
- Students in coeducational schools (α_1^{coed})	-0.169	-0.035	0.054	-0.003	0.202	0.313**	-0.039
	(0.119)	(0.153)	(0.139)	(0.145)	(0.143)	(0.143)	(0.129)
1 if attending a single-sex schools (β_1)	-0.102	0.023	-0.249	0.064	-0.026	0.029	0.019
	(0.143)	(0.170)	(0.154)	(0.139)	(0.138)	(0.143)	(0.120)
R-square	0.111	0.098	0.081	0.108	0.082	0.098	0.080
Junior							
Gap in intended major choice: Boys-Girls							
- Students in single-sex schools (α_2^{ss})	0.220*	0.126	0.406***	-0.047	0.321**	0.327**	-0.032
	(0.132)	(0.129)	(0.113)	(0.129)	(0.133)	(0.127)	(0.145)
- Students in coeducational schools (α_2^{coed})	0.055	-0.147	0.011	-0.154	0.230	0.328***	0.027
	(0.135)	(0.130)	(0.129)	(0.145)	(0.158)	(0.119)	(0.137)
1 if attending a single-sex schools (β_2)	-0.078	-0.118	-0.186	-0.162	-0.051	0.123	0.033
	(0.142)	(0.159)	(0.131)	(0.136)	(0.133)	(0.117)	(0.122)
R-square	0.112	0.075	0.105	0.087	0.093	0.101	0.099
Gap reduction due to single-sex schooling							
- 1st grade: (α_1^{ss}- α_1^{coed})	0.111	0.161	0.313*	-0.027	-0.032	0.016	-0.012
	(0.183)	(0.221)	(0.187)	(0.189)	(0.189)	(0.204)	(0.170)
- 2nd grade: (α_2^{ss}- α_2^{coed})	0.165	0.273	0.395**	0.107	0.091	-0.001	-0.059
	(0.189)	(0.182)	(0.172)	(0.199)	(0.195)	(0.174)	(0.195)

Notes: Sample is limited to students graduating from high schools in equalized education districts. School district fixed effects are included. Other controls include the logarithm of household income and educational expenses and school characteristics such as a dummy for private school, class size, student-teacher ratio, proportion of female teachers, proportion of regular teachers, the average teacher age, teachers' average years of schooling, and proportion of students who went to a college. Robust standard errors, clustered at school level, are reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 0.1, 0.05, and 0.01 levels, respectively.