

Non-Cognitive Consequences of Single-Sex Schooling*

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Abstract Using a national longitudinal data from South Korea, this study investigates the effects of single-sex schooling on three non-cognitive outcomes: depressive symptoms, self-esteem, and school aspirations. Analysis using a differences-in-differences approach reveals that single-sex school attendance improves non-cognitive outcomes, especially for girls, but the results are mixed for boys. These findings are robust across varying definitions of treatment and control groups utilizing single-gender and mixed-gender classes in coeducational schools. While coeducational schooling is attracting greater attention in late-developed countries such as South Korea, this study implies that it might have unintended adverse effects on students' non-cognitive development.

Keywords Single-Sex Schooling, Gender Peer Effect, Non-Cognitive Outcomes, School Formation

JEL Classification I21, J16, J18

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1. INTRODUCTION

Gender peer effects in schools have long been debated in the Western societies such as the United States—especially after the Title IX regulations of the Education Amendments of 1972 were amended in October 2006 to permit schools more flexibility in providing single-sex education overall or single-sex courses in coed schools (Lavy and Schlosser, 2011; Jackson, 2012). A wide range of literature has examined the positive relationship between single-sex schooling and cognitive outcomes, but few studies have examined the impact of single-sex schooling on students' non-cognitive aspects.

More specifically, the literature on gender composition effects at schools can be grouped into two categories. The first examines the effects of the proportion of female students in classes of coed schools on students' academic performance (Whitmore, 2005; Lavy and Schlosser, 2011; Hu, 2015; Gong *et al.*, 2019). Because these studies utilize the proportion of female students, their results are usually not directly related to the effects of single-sex school attendance itself. The second category reviews the effects of single-sex schools (Jackson, 2012; Doris *et al.*, 2013; Sohn, 2016; Dustmann and Ku, 2018; Park *et al.*, 2018; Hahn and Wang, 2019; Jackson, 2021) or the effects of single-sex classes within a co-educational environment (Booth *et al.*, 2014).¹ However, their focus is mainly confined to the effects of single-sex schooling on cognitive outcomes, including academic performance.

Different gender composition in a school could influence adolescents' non-cognitive aspects in various ways. For example, students in mixed-gender classroom environment might feel more pressure to maintain their gender identity in schools (Brutsaert, H, 1999), and then this could lead to less competitive behaviors (Booth and Nolen, 2012) and lower self-confidence (Cribb and Haase, 2016), especially for female students.

To the best of our knowledge, only two studies have hitherto used non-cognitive measures to investigate the causal impact of single-sex schooling: one used risk-taking attitudes (Booth *et al.*, 2014), and the other used arrests and teen pregnancy rates (Jackson, 2021). Booth *et al.* (2014) used undergraduate students in England and found that in single-sex class environment, girls are more likely to have risk-taking attitudes than those in coeducational groups. Jackson (2021) analyzed a policy experiment by utilizing secondary school data in Trinidad and Tobago and found that attending a single-sex schools lead to have fewer arrests for boys and lower teen pregnancy rates for girls. However, both

¹See Doris *et al.* (2013) for a general literature review on studies of single-sex schooling.

are limited in that the subject pool in the study of Booth *et al.* (2014) is not school-aged adolescents but undergraduate students in colleges and the sampled schools in the study of Jackson (2021) are not regular ones but low-performing single-sex and coeducational schools.

In this study, we contribute to the above literature by investigating the causal effects of single-sex school attendance on non-cognitive outcomes for middle school students. Using national longitudinal data from the Korean Children and Youth Panel Survey (KCYPs), we analyze three different non-cognitive outcomes: depressive symptoms (10 items), self-esteem (10 items), and school aspirations (7 items). They are particularly related to non-cognitive skills including psychological stability, learning attitudes and motivations. As widely recognized, these strongly influence social and economic life in the future, including social behavior (e.g., aggressiveness, violence, or criminality), schooling decisions, wages, or choice of occupation (Heckman *et al.*, 2006).

We use the difference-in-differences (DID) approach, drawing on KCYPs panel data, which contain student information surveyed in both the coed elementary school years and single-sex or coed middle school years. The control group includes students assigned to coeducational middle schools, while the treatment group includes students assigned to single-sex middle schools. Observing that many coed middle schools in South Korea maintain gender-segregated class environments by running both female-only and male-only classes, we also examine estimates using two alternative definitions of treatment (single-sex schooling) and control (coed schooling) groups. The first alternative estimation uses single-sex schools (treatment) and mixed-gender classes in coed schools (control), while the second uses single-sex classes in both single-sex and coed schools (treatment) and mixed-gender classes in coed schools (control).

The DID estimation shows that single-sex school attendance improves non-cognitive outcomes, especially for female students. Analyses regarding 10 depressive symptoms confirmed that attending a single-sex school significantly reduces the occurrence of several depressive symptoms in girls by approximately 6.0–9.0 percentage points. When 10 items for self-esteem and 7 items of school aspirations were examined using the same method, we obtained reliable evidence that single-sex schooling improves at least one self-esteem item and at least three school aspiration items by approximately 6.4–11.6 percentage points for female students. For male students, however, the effects of single-sex school attendance on depression are statistically insignificant, and the positive impact of single-sex schooling on boys' self-esteem and school aspirations was difficult to ascertain. Using the alternative definitions of the treatment and control groups, our findings

remain robust when tested.

The remainder of this paper is organized as follows. Section 2 introduces the data and empirical methodology, Section 3 presents the main results, Section 4 performs robustness tests using alternative definitions, and Section 5 concludes the study.

2. DATA AND EMPIRICAL FRAMEWORK

The assignment process of middle school students in South Korea does not depend on academic performance under the Equalization Policy (EP) since 1971, which was implemented for all middle schools (from the seventh to ninth grades). The EP system enforced homogeneous school characteristics between private and public schools: resources, curricula, learning contents, tuition, teacher salaries, quality of teachers, and operation costs (but not capital costs) (OECD, 1998; Kim *et al.*, 2008). However, even under the EP system, each local province still chooses a different process of student assignment. Usually, they use a mixed-standard among lottery-based random assignment, home-to-school distance, or list of students' preferred schools (Seoul Metropolitan Office of Education, 2020). Gender-segregated school environment (single-sex vs. coed schools) is one of important features in education, and thus there could be potential selection into single-sex and coed middle schools. Parents may act strategically before the student assignment process begins when they have strong preference regarding single-sex or coed education. Then the estimates regarding the causal effect of single-sex schooling may be misleading. We consider this endogeneity concern into account by using national longitudinal dataset and differences-in-differences approach.

We use panel data regarding elementary school fourth-grade cohorts obtained from the KCYPS 2010 to analyze the effects of single-sex schooling on non-cognitive outcomes. The KCYPS 2010, conducted by the National Youth Policy Institute in South Korea, is a major, longitudinal, and nationally representative survey conducted to investigate and explain behaviors and changes in adolescents. The survey was conducted from September to December annually during 2010–2016. For this survey, elementary schools across the nation were sampled, and one fourth-grade class was selected per school. There were 2,378 subjects in the first wave and 1,979 in the last wave (tenth graders). The retention rate compared to the initial panel size was 83.2% over the whole period.

We implemented a canonical DID framework that contains two time periods (pre vs. post) and two groups (treatment vs. control) to estimate the effects of

single-sex middle schools on students' various non-cognitive outcomes. This methodology is increasingly commonly used to estimate causal relationships. Its great appeal comes from its simplicity and its ability to circumvent many of the endogeneity problems that typically arise when comparing heterogeneous individuals (Bertrand *et al.*, 2007; Stock and Watson, 1946). We utilized data from the third wave (sixth grade) as the pre-intervention period and the fifth wave (eighth grade or second year of middle school) as the post-intervention period in our analyses.

The structure of the KCYPS 2010 is ideal for estimating the effects of single-sex schooling with a DID strategy, since it was initially conducted among in elementary schools, all of which are coeducational. These students were later split into single-sex and coed middle schools. Using data from both the pre-intervention (elementary school age) and post-intervention periods (middle school ages), we calculate changes in outcomes in the treatment group. The change in the control group is also calculated as a benchmark to measure the temporal unobservable changes within the two periods. Then, our strategy for DID estimation is valid under the assumption that the unobservable changes in non-cognitive outcomes within pre- and post-intervention periods are identical for both the control and treatment groups.

The DID estimation for single-sex school attendance is given in Equation (1):

$$Y_{it} = \beta_0 + \beta_1 [Treat_{it} \times After_i] + \beta_2 Treat_{it} + \beta_3 After_i + \lambda_\beta X'_{it} + \delta_a + \varepsilon_{it} \quad (1)$$

where $Treat_{it}$ is an indicator of whether individual i is enrolled in a single-sex school in year t , and $After_i$ is a variable showing whether individual i is enrolled in a middle school in the post-intervention period. β_2 and β_3 represent estimates for linear terms. The key coefficient, β_1 , represents the estimate for the double interaction term $Treat_{it} \times After_i$, which provides a DID estimator for the effects of single-sex schooling on the students' non-cognitive outcomes. This DID estimator eliminates potential unobservable differences between the treatment and control groups. The vector X' includes parents' socioeconomic characteristics (educational attainment, occupation, status of work, and household income), housing types, and students' characteristics (height, weight, and health status). Further details on these covariates are reported in Table 1. δ_a is region (17 administrative provinces) fixed effects, and ε_{it} represents the error term. We enriched the analysis above by dividing the groups by gender.

The outcome of interest is a 0/1 dummy for each non-cognitive item for the three kinds of categories (10 items regarding depression and self-esteem for

each, and 7 items regarding school aspirations); the detailed survey questions are listed in Table 2–4. We also constructed a depression index to identify the proportion of 10 depression symptom items experienced by each student, as well as the self-esteem and school aspirations indices, which indicate the proportion of relevant items responded to in a positive way by a student.

After excluding those subjects who had missing information regarding the key variables, the refined sample was 1,737 sixth graders (47.4% girls and 52.6% boys) enrolled at 198 coeducational elementary schools and their eighth-grade information.² The eighth graders were 341 all-boys school students (97 schools), 293 all-girls school students (87 schools), and 1,103 coeducational school students (282 schools). Table 1 presents the summary statistics for the estimation sample in the pre- and post-intervention periods, i.e., sixth and eighth grade information, in which meaningful differences between single-sex (“SS” in the table) and coeducational (“CE” in the table) middle schools are evident.³ For example, according to the depression index, coed school students were shown more likely to experience depression than single-sex school students in the full sample (Columns 4–6 of Panel A). The mean difference for the two indices of self-esteem and school aspirations show that single-sex school students had a higher probability of feeling positive than those in coed schools. In the following analyses, these differences are examined via empirical models using a rich set of controls, including parent, student, and household characteristics, as described in Panel B.

Utilizing the pre-treatment balance test, Appendix Table A.1 confirms the identifying assumption that each index of three non-cognitive outcomes is statistically similar across single-sex school treatment status during the pre-intervention period (elementary school age), with all but one exception for boys’ depression index.⁴ We also observe that individual and household characteristics appear to have insignificant differences across treatment status, except for the case of detached housing type in the full sample. Thus, the treatment group and control

²Note that the estimated sample is individuals surveyed in all years. The retention rate is 83.2% over the whole survey period. This may lead to the concern of attrition bias. However, after running regressions of baseline characteristics of students who are missing in the subsequent years on treatment indicator, we observed that the estimates are statistically insignificant. Thus, we assume that there is no serious attrition bias in our estimated sample (These results are available upon request from the authors).

³Concerning the response data for the 10 items regarding self-esteem, we utilized second-wave (fifth grade) and sixth-wave (ninth grade) data, as these items were not provided during the third (sixth grade) or fifth (eighth grade) waves of the survey.

⁴Regarding pre-treatment balance test displayed in Appendix Table A.1., we followed a similar approach to that of De Mel *et al.* (2022).

Table 1: Sample Means

	Sixth Graders			Eighth Graders					
	Full	Girls	Boys	Full		Girls		Boys	
				CE	SS	CE	SS	CE	SS
<i>Panel A. Indices of Outcomes</i>									
Depression Index	0.16	0.19	0.13	0.18	0.17	0.21	0.21	0.14	0.14
Self-Esteem Index	0.76	0.76	0.75	0.76	0.78	0.76	0.76	0.76	0.79
School Aspirations Index	0.84	0.85	0.83	0.83	0.85	0.83	0.84	0.84	0.85
<i>Panel B. Covariates</i>									
Female	0.47	1.00	0.00	0.48	0.46	-	-	-	-
Height (in cm)	154.2	154.0	154.4	164.2	163.9	159.9	159.3	168.1	167.9
Weight (in kg)	45.2	43.7	46.5	54.1	56.1	49.7	51.6	58.2	60.0
Students' Health	0.94	0.94	0.94	0.95	0.96	0.95	0.94	0.95	0.97
Father's Education:									
Less than High School	0.03	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.04
High School	0.36	0.34	0.38	0.33	0.41	0.32	0.39	0.35	0.43
Some College	0.56	0.59	0.53	0.59	0.50	0.61	0.55	0.57	0.46
Mother's Education:									
Less than High School	0.02	0.01	0.03	0.02	0.02	0.01	0.01	0.02	0.03
High School	0.45	0.43	0.47	0.42	0.47	0.40	0.47	0.44	0.47
Some College	0.48	0.52	0.45	0.52	0.45	0.55	0.49	0.50	0.42
Parents' Health	0.94	0.96	0.93	0.92	0.95	0.93	0.97	0.92	0.94
Log Household Income	8.30	8.32	8.29	8.33	8.30	8.32	8.33	8.34	8.27
Housing Type:									
Detached	0.19	0.18	0.21	0.18	0.25	0.16	0.23	0.20	0.27
Apartment	0.65	0.67	0.63	0.67	0.61	0.69	0.64	0.65	0.58
Multi-unit	0.13	0.13	0.14	0.14	0.13	0.14	0.12	0.15	0.13
Others	0.02	0.02	0.03	0.01	0.02	0.01	0.02	0.01	0.02
Observations	1,737	824	913	1,103	634	531	293	572	341

Note: The KCYPS 2010 provides 10 items regarding depression, 10 items regarding self-esteem, and 7 items about school aspirations, which are listed in Tables 2–4. Panel A includes three indices obtained from these items. Because of space limitations, we do not report descriptive statistics of the following variables in Panel B, which are available from the authors upon request: father's and mother's occupations (manager, office worker, service, sales, technician, and others) and the status of work (wage worker, employer with staff, and others). Log Household Income represents logarithm of yearly household income (units: 10,000 KW).

group during pre-treatment period do not systematically differ in various covariates (Choi *et al.*, 2021). Using data from the fourth and sixth grades of school aspirations, we also found that the null hypothesis of parallel trends could not be rejected in the school aspirations specification. The estimates of the interaction term $Treat \times After$ on the school aspirations index in the parallel trend test were -0.001 (standard error = 0.009) for girls, -0.005 (standard error = 0.013) for boys, and 0.006 (standard error = 0.013) for the full sample. However, it was difficult to proceed with the parallel trends test for depression and self-esteem because these items were surveyed only once in the pre-treatment period.

3. RESULTS

In this section, we present the main results from the DID approach estimation, for which the control group was students assigned to coeducational middle schools, while the treatment group was students assigned to single-sex middle schools.

The estimation results using Specification (1) regarding the impact of single-sex schools on non-cognitive outcomes are presented in Tables 2–4, which report the marginal effects of the interaction term $Treat \times After$ for the separated probit models. Columns 1, 3, and 5 include the dummy $Treat$ for students assigned to single-sex schools, the dummy $After$ for the post-intervention period, and the interaction term $Treat \times After$ to represent the effects of single-sex schooling on students' non-cognitive outcomes. Additionally, Columns 2, 4, and 6 include parent, student, and household characteristics, which absorbed unobserved differences among students' backgrounds, along with regions, which absorbed any cross-regional variations. The estimates are reported separately by gender in Columns 1–4 and for the full sample in Columns 5 and 6. The specifications with the control variables were our preferred specifications, but the qualitative and quantitative results were similar across the specifications with and without controls.⁵ Robust standard errors were clustered at the individual ID level, accounting for both the heteroskedasticity and dependence of each student.

We discuss Columns 2 and 4 for main illustration. We first analyzed each depressive symptom model, as shown in Table 2, based on the 10 depression items from the KCYPS 2010 questionnaire. The point estimates of three items (Items 5, 7, and 8) in Column 2 were found to be statistically significant for girls and the signs of these estimates were negative. Specifically, girls from single-sex schools had lower levels of frequent crying, feeling lonely, and not being interested in anything by 8.2, 9.0, and 6.0 percentage points, respectively.

To gauge the relative magnitude of these effects, we derived each estimate of the base probability that female students in the control group experienced these depressive symptoms (Items 5, 7, and 8), calculated using simple ordinary least

⁵Note that the sample size was somewhat reduced after including a full set of controls because of missing data on (at least) height, weight, or household income. However, we found that when we include the subjects with missing information by replacing the missing covariates with mean values based on individual ID or year and including indicators for missing values in the regressions, the estimates on three non-cognitive outcomes are still similar to our main results (Table 2–4). Furthermore, according to our test, missing status (at least height, weight, or household income) is not statistically different between treatment (single-sex schools) and control (coed schools) groups even after adding other control variables (These results are available upon request from the authors).

squares (OLS) without controls. The estimated base average probabilities were about 26.9% (1.3% from the *After* dummy coefficient and 25.6% from the constant) for frequent crying, 22.7% (5.6% from the *After* dummy coefficient and 17.1% from the constant) for feeling lonely, and 10.7% (1.5% from the *After* coefficient and 9.2% from the constant) for not being interested in anything, respectively. Thus, female students in single-sex schools experience the depressive symptoms of frequent crying, feeling lonely, and not being interested in anything about 30.4% ($\approx 8.2/26.9$), 39.6% ($\approx 9.0/22.7$), and 55.9% ($\approx 6.0/10.7$) less, respectively, relative to female students in coeducational schools.⁶

For boys, as seen in Column 4, only the estimate for Item 10 was statistically significant, and its sign was positive, indicating that boys in single-sex schools were about 5.9 percentage points more likely to feel that everything was tough than those in coed schools. The corresponding relative effect size was 59%, as the calculated base average probability was 10% (-0.5% from the *After* dummy coefficient and 10.5% from the constant). Four other estimates (Items 3–6) were positive as well, although not statistically significant, implying that the beneficial effects of single-sex schooling are not observed for male students. On the other hand, in the full sample (Column 6), students in single-sex schools were less likely to feel the depressive symptoms identified Items 7 and 8 by about 4.0 and 3.5 percentage points, respectively.

The marginal effects of the interaction term $Treat \times After$ in the Depression Index model are reported at the bottom of Table 2, where the index indicates the proportion of items with the response “agree” among the 10 depression items. As shown in Column 2, the estimate was negative and statistically significant, indicating the positive average effects of single-sex schooling on reducing depression levels in girls. The estimate for boys was positive but statistically insignificant. Overall, the results show that single-sex school attendance significantly decreases the average level of depression, especially in girls.

To gain further insight into the extent of the effects of single-sex schooling, we explored two additional non-cognitive outcomes: Self-Esteem and School Aspirations. The analyses of Self-Esteem are reported in Table 3, in which Columns 1 and 2 represent girls, Columns 3 and 4 represent boys, and Columns 5 and 6 report the results for the full sample. In Column 2, the estimates with the controls suggest that single-sex schooling increases girls’ self-esteem, i.e., “I am on an equal plane with others.” (Item 7), in a statistically significant way

⁶We used the estimation approach by base average probability adopted by Cai *et al.* (2009). Due to space limitations, we did not report the parameter estimates for all OLS results without controls, which are available upon request.

Table 2: Estimates of the Effects of Single-Sex Schooling on Depression

	Girls Sample		Boys Sample		Full Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Depression Item</i>						
1. I feel no energy.	0.002 [0.034]	-0.017 [0.034]	-0.005 [0.031]	-0.010 [0.032]	-0.001 [0.023]	-0.011 [0.023]
2. I feel unhappy, sad or depressed.	-0.016 [0.034]	-0.026 [0.035]	-0.009 [0.028]	-0.017 [0.029]	-0.012 [0.022]	-0.017 [0.022]
3. I have a lot of worries.	-0.016 [0.043]	-0.020 [0.044]	0.056 [0.037]	0.055 [0.039]	0.022 [0.028]	0.021 [0.029]
4. I feel like I want to die.	-0.015 [0.028]	-0.025 [0.029]	0.005 [0.024]	0.008 [0.022]	-0.004 [0.018]	-0.005 [0.018]
5. I often cry.	-0.075* [0.038]	-0.082** [0.041]	0.014 [0.029]	0.001 [0.028]	-0.029 [0.024]	-0.031 [0.024]
6. When things are going wrong, I often think It's my fault.	0.035 [0.038]	0.027 [0.040]	0.022 [0.035]	0.027 [0.035]	0.028 [0.026]	0.028 [0.026]
7. I feel lonely.	-0.074** [0.035]	-0.090** [0.040]	-0.013 [0.028]	-0.010 [0.027]	-0.041* [0.022]	-0.040* [0.023]
8. I'm not interested in anything.	-0.056* [0.029]	-0.060* [0.035]	-0.013 [0.025]	-0.014 [0.024]	-0.033* [0.019]	-0.035* [0.021]
9. I'm not hopeful for the future.	-0.029 [0.032]	-0.038 [0.034]	-0.020 [0.028]	-0.023 [0.028]	-0.025 [0.021]	-0.029 [0.022]
10. Everything is tough.	-0.030 [0.031]	-0.042 [0.035]	0.058** [0.027]	0.059* [0.034]	0.017 [0.021]	0.016 [0.021]
Depression Index	-0.027 [0.019]	-0.036* [0.020]	0.009 [0.017]	0.010 [0.017]	-0.008 [0.013]	-0.010 [0.013]
Controls	No	Yes	No	Yes	No	Yes
Observations	1,648	1,606	1,826	1,773	3,474	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. The treatment group includes students from a single-sex school, while the control group comprises students from a coeducational school. The depression index indicates the proportion of 10 depression symptom items experienced by a student. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

by 6.9 percentage points. The relative effect size for single-sex schooling was 8%, compared to that of coeducational schools, as the computed base average probability for the control group was 86.3%. Notably, after controlling for various characteristics, we observed that the signs for 8 estimates (Items 2–8 and 10) among the 10 items support the positive impact of single-sex schooling on girls' self-esteem.

The positive impact of single-sex schooling on boys' self-esteem (Column 4) is also observed for Item 3, i.e., "I feel like I have a lot of good attributes," in a

Table 3: Estimates of the Effects of Single-Sex Schooling on Self-Esteem

	Girls Sample		Boys Sample		Full Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Self-Esteem Item</i>						
1. I am satisfied with myself.	-0.027 [0.032]	-0.023 [0.034]	0.055** [0.022]	0.045 [0.028]	0.017 [0.019]	0.019 [0.020]
2. Sometimes I feel like I am useless.	-0.051 [0.036]	-0.057 [0.038]	-0.014 [0.036]	-0.002 [0.036]	-0.032 [0.025]	-0.028 [0.026]
3. I feel like I have a lot of good attributes.	0.019 [0.042]	0.032 [0.042]	0.074** [0.037]	0.069* [0.039]	0.029* [0.028]	0.050* [0.028]
4. I am able to do things as well as others.	0.045 [0.032]	0.046 [0.033]	-0.023 [0.028]	-0.026 [0.029]	0.008 [0.021]	0.005 [0.021]
5. I don't have much to be proud of.	-0.049 [0.041]	-0.055 [0.042]	-0.033 [0.040]	-0.026 [0.040]	-0.041 [0.029]	-0.042 [0.029]
6. I feel useless at times.	-0.002 [0.036]	-0.002 [0.036]	0.035 [0.034]	0.032 [0.035]	0.017 [0.024]	0.016 [0.025]
7. I am on an equal plane with others.	0.071** [0.035]	0.069* [0.037]	0.029 [0.035]	0.017 [0.035]	0.048** [0.024]	0.041* [0.025]
8. I wish I could respect myself more.	-0.027 [0.041]	-0.013 [0.041]	0.029 [0.040]	0.017 [0.040]	0.002 [0.029]	0.002 [0.029]
9. I am a failure.	0.004 [0.037]	0.003 [0.038]	-0.007 [0.036]	-0.009 [0.037]	-0.003 [0.026]	-0.004 [0.026]
10. I am optimistic for myself.	-0.0002 [0.036]	0.004 [0.036]	-0.007 [0.036]	-0.008 [0.036]	-0.003 [0.025]	-0.001 [0.025]
Self-Esteem Index (reversed sign: 2, 5, 6, 8, and 9)	0.023 [0.019]	0.024 [0.020]	0.012 [0.016]	0.008 [0.016]	0.018 [0.012]	0.016 [0.013]
Controls	No	Yes	No	Yes	No	Yes
Observations	1,648	1,606	1,826	1,773	3,474	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. The treatment group includes students from a single-sex school, while the control group comprises students from a coeducational school. The self-esteem index indicates the proportion of items that were responded in a positive way by a student after the signs of Items 2, 5, 6, 8, and 9 were reversed. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

statistically significant way by 6.9 percentage points. However, the signs for the four other estimates (Items 4, 6, 8, and 10) were not consistent with the positive impact on boys' self-esteem, implying that the positive benefits for boys are still ambiguous.

The analysis regarding School Aspirations is based on seven items as presented in Table 4. The estimates for Items 4–6 in Column 2 were significantly positive at 6.4, 9.7, and 11.6 percentage points, respectively. These estimates for the three items represent aspiration increases of 7.6% (significant role of school

life), 11.9% (huge role of studying at school), and 15.1% (usefulness of school learning), respectively, compared to that of coeducational schools, when the relevant base average probabilities for the control group (84.7%, 81.7%, and 76.8%) were considered. Notably, we observed that the point estimates for all seven items had positive signs for girls. Furthermore, the point estimate for the School Aspirations Index reported at the bottom of Table 4 was positive and statistically significant. The index increased by 5.9 percentage points when a girl is assigned to a single-sex middle school rather than a coed school. In sum, we can confirm that girls at single-sex schools are more likely to have positive attitudes toward studying at school compared to girls in coed schools.

However, the effect of all-boys schools on the school aspirations was not statistically significant for most items, and the signs of some point estimates were even negative. Only the point estimate for Item 7, which asked students if their school lives would be helpful for their future social lives, was positive and statistically significant, at 6.8 percentage points. The point estimate in the School Aspirations Index reported in Table 4 was also not statistically significant, implying an ambiguous impact of single-sex schooling on boys' school aspirations.

On the other hand, observing the effects of single-sex schools on the full sample (Column 6), we found that most estimates were positive, and estimates of Items 5–7 and the School Aspirations Index were statistically significant, suggesting that, on average, single-sex school attendance improved students' school aspirations-related non-cognitive aspects.⁷

In Table A.3., we carried out a heterogeneity analysis using information on household income (in month) and self-reported exam ranges of four subject (Korean, Math, English, and Science) with eight scales that span from less than 64 to more than 96 (0 lowest score and 100 highest score).⁸ We divided our sample into two groups (bottom and top) based on the 50% quantile of the household income (45 million won (US\$ 3,474)) and into three groups (bottom, middle, and top) based on the exam range data: the bottom quantile (less than quantile 25%) is less than 74 and the top quantile (above quantile 75%) is more than 90. When we test on the outcome of each index (depression index, self-esteem in-

⁷We also found qualitatively similar patterns when we use sixth wave (ninth grade) instead of fifth wave of the KCYPS (Table A.4), indicating that the effects of single-sex schooling on three non-cognitive aspects do not disappear in the last year of middle school, particularly for female students.

⁸The KCYPS 2010 provides information on self-reported exam ranges from middle school ages. There are also variables about self-evaluated exam level (from poor to excellent) and satisfaction with exam scores (from dissatisfied to satisfied), but we do not use these variables in the heterogeneity analyses.

Table 4: Estimates of the Effects of Single-Sex Schooling on School Aspirations

	Girls Sample		Boys Sample		Full Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>School Aspirations Item</i>						
1. Studying at school has an important meaning to me.	-0.008 [0.036]	0.009 [0.036]	-0.024 [0.032]	-0.03 [0.032]	-0.016 [0.024]	-0.014 [0.024]
2. What you learn in school is important.	0.028 [0.033]	0.034 [0.033]	0.009 [0.032]	0.007 [0.032]	0.019 [0.023]	0.021 [0.023]
3. School life will play an important role in my growth.	0.024 [0.032]	0.039 [0.033]	0.023 [0.031]	0.019 [0.031]	0.023 [0.022]	0.027 [0.023]
4. School life will play a significant role in my future.	0.057* [0.033]	0.064* [0.036]	-0.013 [0.033]	-0.034 [0.034]	0.020 [0.024]	0.013 [0.023]
5. Studying at school will play a huge role in choosing my future career.	0.093*** [0.036]	0.097** [0.042]	0.005 [0.035]	0.009 [0.035]	0.047* [0.025]	0.052** [0.026]
6. What I learn in school will be useful to me.	0.105*** [0.038]	0.116** [0.045]	0.053 [0.035]	0.041 [0.036]	0.079*** [0.026]	0.075*** [0.028]
7. School life will help me in my social life in the future.	0.053* [0.030]	0.059 [0.035]	0.078** [0.032]	0.068* [0.036]	0.067*** [0.022]	0.062** [0.025]
School Aspirations Index	0.050** [0.023]	0.059** [0.023]	0.019 [0.021]	0.011 [0.021]	0.034** [0.015]	0.034** [0.016]
Controls	No	Yes	No	Yes	No	Yes
Observations	1,648	1,606	1,826	1,773	3,474	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. The treatment group includes students from a single-sex school, while the control group comprises students from a coeducational school. The school aspirations index indicates the proportion of items that were responded in a positive way by a student. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

dex, and school aspirations index), we found out that student groups with low household income and low exam scores show stronger relationship between attending single-sex schools and non-cognitive outcomes, especially for the school aspiration outcome of female students.

4. ROBUSTNESS TESTS

Unlike many Western countries, many coeducational secondary schools in South Korea provide separate instruction for male and female students. According to our data, while 36.5 percent of students study at single-sex middle schools, 51 percent of students attend mixed-gender classes in coeducational middle schools. Notably, about 12.5 percent of students study at single-gender classes in coed schools. It should also be noted that, in the Korean middle

school system, students belonging to a particular class group (typically comprising 20–30 students) take almost all of their courses together for the entire academic year. Therefore, for a more in-depth analysis of this unique situation, we adopted two alternative definitions of our treatment and control groups.⁹

First, we examined the effects of single-sex school attendance compared to mixed-gender class attendance at coed schools after dropping students in single-gender classes at coed schools (Definition A: $T_{DefA_{it}}$ in Equation (2)). In this examination, the sample size was reduced from 1,737 to 1,520 students (3,474 to 3,040 observations).

$$Y_{it} = \beta_0 + \beta_1 [T_{DefA_{it}} \times After_i] + \beta_2 T_{DefA_{it}} + \beta_3 After_i + \lambda_\beta X'_{it} + \delta_a + \varepsilon_{it} \quad (2)$$

Second, to check further robustness, we focused on the effects of *single-gender classes* rather than those of *single-sex schools*. In this case, the treatment group included students from both single-sex schools and single-gender classes at coed schools, while the control group only comprised students from mixed-gender classes at coed schools (Definition B: $T_{DefB_{it}}$ in Equation (3)). In this examination, we maintained the sample size of the original analysis (1,737 students). See Appendix Table A.2 for the clarification between Definitions A and B.

$$Y_{it} = \beta_0 + \beta_1 [T_{DefB_{it}} \times After_i] + \beta_2 T_{DefB_{it}} + \beta_3 After_i + \lambda_\beta X'_{it} + \delta_a + \varepsilon_{it} \quad (3)$$

Estimated results with a full set of controls for depression, self-esteem, and school aspirations after applying these two definitions are reported in Tables 5–6. Definition A of Table 5 for the outcome of depression showed that, for the girls' sample (Column 1), the marginal effect size after controls in Items 5, 7, and 8 were 8.9, 9.2, and 7.2 percentage points, respectively, which are statistically significant and similar to our main results (8.2, 9.0, and 6.0) shown in Table 2. When we used Definition B for the girls' sample (Column 4), the corresponding estimates, 7.3, 6.9, and 6.7 percentage points, were slightly smaller but still similar to the main results. For boys (Columns 2 and 5) with controls, however, the estimates for most items were statistically insignificant for both Definitions A and B, as with the main results in Table 2. Therefore, we confirm that our results

⁹The robustness analysis could be conducted using three dummy variables because we have three different categories: students at single-sex schools, students of single-sex classes in coed schools, and students of mixed-gender classes in coed schools. However, we could not get into a reliable conclusion out of this attempt because the sample size of the second group (students of single-sex classes in coed schools) was very limited that only 108 girls and 109 boys belonged to that group in the given sample.

Table 5: Estimates on Depression: Using Alternative Definitions of Treatment and Control Groups

Treatment Group Control Group	Definition A			Definition B		
	Single-Sex School			Single-Gender Class		
	Mixed-Gender Class			Mixed-Gender Class		
	Girls Sample	Boys Sample	Full Sample	Girls Sample	Boys Sample	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Depression Item</i>						
1. I feel no energy.	-0.041 [0.036]	-0.002 [0.033]	-0.017 [0.024]	-0.060* [0.035]	0.006 [0.031]	-0.023 [0.023]
2. I feel unhappy, sad or depressed.	-0.035 [0.037]	-0.020 [0.030]	-0.024 [0.024]	-0.037 [0.034]	-0.023 [0.028]	-0.027 [0.022]
3. I have a lot of worries.	-0.025 [0.046]	0.028 [0.004]	0.006 [0.030]	-0.034 [0.042]	-0.001 [0.037]	-0.015 [0.028]
4. I feel like I want to die.	-0.035 [0.032]	0.005 [0.023]	-0.011 [0.019]	-0.036 [0.039]	0.001 [0.022]	-0.016 [0.018]
5. I often cry.	-0.089** [0.043]	-0.01 [0.030]	-0.039 [0.026]	-0.073* [0.038]	-0.032 [0.031]	-0.043* [0.024]
6. When things are going wrong, I often think It's my fault.	0.019 [0.041]	0.012 [0.037]	0.017 [0.028]	0.004 [0.038]	-0.007 [0.034]	-0.0003 [0.025]
7. I feel lonely.	-0.092** [0.043]	-0.028 [0.029]	-0.051** [0.025]	-0.069* [0.037]	-0.044 [0.029]	-0.052** [0.023]
8. I'm not interested in anything.	-0.072** [0.040]	-0.026 [0.027]	-0.050** [0.024]	-0.067* [0.035]	-0.041 [0.028]	-0.054** [0.023]
9. I'm not hopeful for the future.	-0.042 [0.036]	-0.042 [0.031]	-0.042* [0.024]	-0.045 [0.034]	-0.052* [0.031]	-0.048** [0.023]
10. Everything is tough.	-0.051 [0.038]	0.039 [0.032]	0.001 [0.022]	-0.049 [0.035]	0.010 [0.027]	-0.017 [0.020]
Depression Index	-0.046** [0.021]	-0.002 [0.018]	-0.020 [0.014]	-0.047** [0.019]	-0.015 [0.017]	-0.029** [0.013]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,399	1,556	2,955	1,606	1,773	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. For Definition A, the treatment group includes students from single-sex schools and the control group comprises students from mixed-gender classes at coeducational schools. For Definition B, the treatment group includes students from both single-sex schools and single-gender classes at coed schools, and the control group only comprises students from mixed-gender classes at coed schools. The depression index indicates the proportion of 10 depression symptom items experienced by a student. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

regarding depressive symptoms are robust to alternative definitions of the treatment and control groups, which strongly support our conclusion that single-sex school attendance decreases the risk of feeling depressed, especially for female

Table 6: Estimates on Self-Esteem: Using Alternative Definitions of Treatment and Control Groups

Treatment Group Control Group	Definition A			Definition B		
	Single-Sex School			Single-Gender Class		
	Mixed-Gender Class			Mixed-Gender Class		
	Girls	Boys	Full	Girls	Boys	Full
	Sample	Sample	Sample	Sample	Sample	Sample
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Self-Esteem Item</i>						
1. I am satisfied with myself.	-0.024 [0.036]	0.057* [0.032]	0.027 [0.022]	-0.020 [0.033]	0.057* [0.031]	0.025 [0.020]
2. Sometimes I feel like I am useless.	-0.049 [0.038]	-0.008 [0.037]	-0.028 [0.027]	-0.028 [0.035]	-0.015 [0.035]	-0.022 [0.025]
3. I feel like I have a lot of good attributes.	0.026 [0.044]	0.067* [0.041]	0.047 [0.030]	0.007 [0.040]	0.057 [0.037]	0.031 [0.027]
4. I am able to do things as well as others.	0.022 [0.032]	-0.034 [0.031]	-0.010 [0.022]	-0.018 [0.030]	-0.032 [0.030]	-0.027 [0.021]
5. I don't have much to be proud of.	-0.051 [0.044]	-0.009 [0.031]	-0.031 [0.030]	-0.030 [0.040]	0.016 [0.039]	-0.008 [0.028]
6. I feel useless at times.	-0.007 [0.038]	0.032 [0.037]	0.013 [0.026]	-0.014 [0.035]	0.021 [0.034]	0.004 [0.024]
7. I am on an equal plane with others.	0.072* [0.039]	0.023 [0.037]	0.046* [0.027]	0.060* [0.035]	0.025 [0.034]	0.041* [0.025]
8. I wish I could respect myself more.	-0.019 [0.043]	0.034 [0.042]	0.006 [0.030]	-0.025 [0.041]	0.048 [0.039]	0.011 [0.028]
9. I am a failure.	0.013 [0.039]	-0.003 [0.038]	0.005 [0.027]	0.024 [0.037]	0.013 [0.035]	0.017 [0.026]
10. I am optimistic for myself.	0.005 [0.038]	-0.001 [0.038]	0.004 [0.027]	0.008 [0.035]	0.013 [0.036]	0.012 [0.025]
Self-Esteem Index (reversed sign: 2, 5, 6, 8, and 9)	0.020 [0.020]	0.006 [0.017]	0.013 [0.013]	0.009 [0.019]	0.003 [0.016]	0.007 [0.012]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,399	1,556	2,955	1,606	1,773	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. For Definition A, the treatment group includes students from single-sex schools and the control group comprises students from mixed-gender classes at coeducational schools. For Definition B, the treatment group includes students from both single-sex schools and single-gender classes at coed schools, and the control group only comprises students from mixed-gender classes at coed schools. The self-esteem index indicates the proportion of items that were responded in a positive way by a student after the signs of Items 2, 5, 6, 8, and 9 were reversed. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.
 * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

students.

Table 7: Estimates on School Aspirations: Using Alternative Definitions of Treatment and Control Groups

Treatment Group Control Group	Definition A			Definition B		
	Single-Sex School Mixed-Gender Class			Single-Gender Class Mixed-Gender Class		
	Girls Sample	Boys Sample	Full Sample	Girls Sample	Boys Sample	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)
<i>School Aspirations Item</i>						
1. Studying at school has an important meaning to me.	0.019 [0.038]	-0.022 [0.034]	-0.004 [0.025]	0.022 [0.034]	-0.002 [0.031]	0.007 [0.023]
2. What you learn in school is important.	0.039 [0.036]	0.001 [0.034]	0.021 [0.025]	0.036 [0.034]	-0.004 [0.031]	0.017 [0.023]
3. School life will play an important role in my growth.	0.052 [0.036]	0.004 [0.033]	0.025 [0.024]	0.053 [0.034]	-0.016 [0.031]	0.016 [0.022]
4. School life will play a significant role in my future.	0.071* [0.039]	-0.024 [0.036]	0.020 [0.025]	0.056 [0.035]	-0.005 [0.032]	0.024 [0.023]
5. Studying at school will play a huge role in choosing my future career.	0.106** [0.046]	0.010 [0.036]	0.057** [0.028]	0.088** [0.040]	0.011 [0.034]	0.049* [0.025]
6. What I learn in school will be useful to me.	0.124** [0.048]	0.022 [0.037]	0.069** [0.029]	0.100** [0.042]	-0.006 [0.035]	0.042 [0.026]
7. School life will help me in my social life in the future.	0.052 [0.036]	0.050 [0.038]	0.055** [0.026]	0.027 [0.029]	0.034 [0.032]	0.029 [0.022]
School Aspirations Index	0.065*** [0.024]	0.006 [0.023]	0.034** [0.016]	0.055** [0.022]	0.0001 [0.021]	0.026* [0.015]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,399	1,556	2,955	1,606	1,773	3,381

Note: All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. For Definition A, the treatment group includes students from single-sex schools and the control group comprises students from mixed-gender classes at coeducational schools. For Definition B, the treatment group includes students from both single-sex schools and single-gender classes at coed schools, and the control group only comprises students from mixed-gender classes at coed schools. The school aspirations index indicates the proportion of items that were responded in a positive way by a student. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The estimation results for the Self-Esteem model derived using alternative definitions of our treatment and control groups produce similar outcomes to our main results (Table 3) for girls in Columns 1 and 4 of Table 6. The point estimates in Item 7 amount to 7.2 percentage points when Definition A is used and 6.0 percentage points when Definition B is used, which are comparable to 6.9 percentage points observed in Table 3. Most signs of the point estimates in 10 items are also consistent with the positive impact on girls' self-esteem. However,

we still confirm that the positive impact of single-sex schooling on boys' self-esteem is difficult to ascertain, as shown in Columns 2 and 5 of Table 6, because only about half the estimates have favorable signs (after considering the reversed signs).

Finally, when we used Definitions A and B in Table 7 for the outcomes of School Aspirations, we were able to confirm that the point estimates for girls were similar to those in the main DID estimates in Table 4. The results indicate that single-sex environment increases the outcomes of Items 4–6 by about 7–12 percentage points when Definition A was used and increases the outcomes of Items 5–6 by about 9–10 percentage points when Definition B was used: the corresponding marginal effect sizes of our main results for School Aspirations were about 6–11 percentage points in Table 4. The estimates for the School Aspirations Index were also positive and statistically significant, with similar magnitudes of the estimates to our main results in Table 4.

None of the estimates (seven items) for boys were statistically significant, and some were negative. The point estimates for boys in the School Aspirations Index were also insignificant, implying an ambiguous impact of single-sex schooling on boys' school aspirations.

In conclusion, while attending a single-sex school improved both the self-esteem and school aspirations of students, this positive effect was driven almost entirely by benefits to girls. The results of this study are consistent with the finding of Cribb and Haase (2016) that girls in coeducational environments tend to have poorer self-esteem.¹⁰ Moreover, the improved school aspirations identified in our study may explain the positive impact of single-sex schooling on students' academic performance, as revealed by recent studies (e.g., Dustmann and Ku, 2018; Hahn and Wang, 2019; Jackson, 2021).

5. CONCLUSION

This paper offers novel evidence on the effects of single-sex schooling on students' non-cognitive aspects by focusing on depressive symptoms, self-esteem, and school aspirations based on three definitions of treatment and control groups: single-sex schools vs. coed schools, single-sex schools vs. mixed-gender classes in coed schools, and single-gender classes in both single-sex and coed schools vs. mixed-gender classes in coed schools. As a whole, our analysis suggests that

¹⁰They concluded that the poorer self-esteem in coeducational environments for girls is owing to a greater internalization of appearance. The negative associations between socio-cultural attitudes toward appearance and self-esteem in adolescent girls are attenuated by single-sex school environment.

single-sex school attendance positively affects students' non-cognitive aspects, particularly among girls. For boys, the results are mixed or ambiguous.

Our findings have important insights both in terms of gender-segregated school formation and students' non-cognitive performances. From an education perspective, our results support the previous literature, which has mostly included academic benefits from single-sex schooling, in a complementary sense of considering non-cognitive measures. Coeducational schooling is becoming more common in late-developed countries like South Korea. For instance, according to the *Statistical Yearbook of Education*, published by Korean Educational Development Institute, the share of single-sex schools decreased significantly from 39.7% to 22.2% between 1999 and 2019. This study suggests that the rapid expansion of coed schooling might have unintended adverse effects for adolescents' non-cognitive development.

On the other hand, the amount of single-sex education in the US has shown an increasing trend since Title IX of the US Education Act was amended in 2006 to permit single-sex classes within coeducational public schools (Lavy and Schlosser, 2011). This study provides supplementary scientific evidence to be considered in an ongoing debate over the pros and cons of single-sex schooling in Western societies. The benefits of single-sex education may be beyond improved academic achievements, and thus more comprehensive discussions should be pursued concerning gender-related school formation.

From an academic perspective, in general, we know little about whether and how single-sex or coeducational schooling affects various non-cognitive skills of adolescents, so more research is needed on which specific elements of schooling formation may affect a wide range of students' performance.

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APPENDIX

Table A.1: Pre-Treatment Balance Test

	Girls Sample (1)	Boys Sample (2)	Full Sample (3)
<i>Outcome: Non-Cognitive Index Variables</i>			
Depression Index	0.020 [0.020]	-0.032* [0.017]	-0.009 [0.013]
Self-Esteem Index	-0.013 [0.017]	0.018 [0.015]	0.004 [0.011]
School Aspirations Index	-0.032 [0.020]	0.007 [0.019]	-0.012 [0.014]
<i>Outcome: Covariates</i>			
Height	-0.506 [0.411]	-0.008 [0.467]	-0.209 [0.310]
Weight	0.620 [0.523]	0.467 [0.594]	0.519 [0.394]
Father's Education	-0.056 [0.059]	0.056 [0.059]	-0.010 [0.041]
Mother's Education	-0.062 [0.058]	-0.021 [0.056]	-0.039 [0.040]
Log Household Income	0.054 [0.034]	-0.045 [0.031]	0.005 [0.023]
Housing Type: Detached	0.036 [0.030]	0.047 [0.030]	0.041* [0.021]
Housing Type: Apartment	-0.022 [0.036]	-0.049 [0.035]	-0.037 [0.025]
Housing Type: Multi-unit	-0.024 [0.026]	0.008 [0.024]	-0.005 [0.018]
Controls	Yes	Yes	Yes
Observations	809	889	1,698

Note: Outcomes are each index of three non-cognitive variables and each individual characteristic for pre-treatment period (elementary school age). We use the variables of father's and mother's education with 5-scales. We regress each outcome variable and present the coefficient estimates of single-sex school attendance (treatment status). All regressions control for students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects. Standard errors are reported in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Alternative Definitions of Treatment and Control Group

	Definition A		Definition B	
	Treatment Group	Control Group	Treatment Group	Control Group
All-girls school	✓		✓	
All-boys school	✓		✓	
Single-gender class in coed school			✓	
Mixed-gender class in coed school		✓		✓

Note: The KCYPS 2010 survey asked questions on the three types of schools (all-girls, all-boys, and coeducational school) and the respondents of coed schools were asked to choose between single-gender class and mixed-gender class. We constructed two alternative definitions of treatment and control groups by using this information for robustness check analysis.

Table A.3: Estimates of the Effects of Single-Sex Schooling: Heterogeneity Analysis

Outcome: Index	Girls Sample				Boys Sample			
	Depression	Self-Esteem	School Aspirations	Obs.	Depression	Self-Esteem	School Aspirations	Obs.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Household Income</i>								
Bottom	-0.047 [0.031]	0.032 [0.030]	0.079** [0.038]	775	0.026 [0.026]	0.006 [0.023]	0.012 [0.031]	896
Top	-0.024 [0.028]	0.020 [0.027]	0.045 [0.029]	833	-0.008 [0.023]	0.012 [0.024]	0.023 [0.029]	877
<i>Exam: Korean</i>								
Bottom	-0.033 [0.046]	0.032 [0.041]	0.150** [0.052]	444	0.008 [0.032]	0.006 [0.029]	-0.032 [0.039]	636
Middle	-0.048 [0.032]	0.033 [0.033]	-0.010 [0.036]	621	0.003 [0.029]	0.008 [0.026]	0.028 [0.037]	690
Top	-0.024 [0.033]	0.008 [0.031]	0.051 [0.037]	543	0.017 [0.031]	0.010 [0.032]	0.059 [0.038]	447
<i>Exam: Math</i>								
Bottom	-0.063* [0.037]	0.036 [0.035]	0.111** [0.043]	638	0.029 [0.032]	0.010 [0.027]	-0.038 [0.038]	729
Middle	-0.013 [0.037]	0.009 [0.036]	0.021 [0.038]	517	-0.013 [0.028]	0.016 [0.029]	0.048 [0.041]	537
Top	-0.024 [0.034]	0.021 [0.032]	0.037 [0.040]	453	0.013 [0.028]	-0.011 [0.033]	0.042 [0.034]	507
<i>Exam: English</i>								
Bottom	-0.058 [0.038]	0.016 [0.035]	0.100** [0.044]	606	0.029 [0.031]	0.020 [0.027]	-0.035 [0.039]	740
Middle	-0.015 [0.042]	0.015 [0.041]	-0.018 [0.046]	463	0.015 [0.034]	0.011 [0.030]	0.060* [0.035]	503
Top	-0.031 [0.029]	0.039 [0.029]	0.072** [0.033]	539	-0.013 [0.026]	-0.020 [0.030]	0.027 [0.035]	530
<i>Exam: Science</i>								
Bottom	-0.045 [0.034]	0.047 [0.032]	0.076* [0.041]	709	0.025 [0.030]	-0.003 [0.027]	-0.011 [0.038]	782
Middle	-0.035 [0.038]	0.007 [0.037]	0.044 [0.039]	504	0.002 [0.028]	-0.007 [0.029]	0.029 [0.036]	568
Top	-0.010 [0.036]	-0.006 [0.035]	0.029 [0.036]	395	-0.012 [0.034]	0.043 [0.034]	0.039 [0.037]	423

Note: The outcomes are each index of depression, self-esteem, and school aspirations. The bottom of household income is 45 million won or less in month (US\$ 3,474) (50% quantile). We used variables of four subjects' (Korean, Math, English, and Science) self-reported exam range with eight scales from less than 64 to more than 96: the lowest score is 0 and the highest score is 100. The bottom of each exam is less than 74 (25% quantile) and the top of each exam is more than 90 (75% quantile). All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Estimates of the Effects of Single-Sex Schooling on Three Non-Cognitive Outcomes using the Third and Sixth Waves of the KCYPS

	Girls Sample (1)	Boys Sample (2)		Girls Sample (3)	Boys Sample (4)
<i>Depression Item</i>			<i>Self-Esteem Item</i>		
1. I feel no energy.	0.033 [0.036]	-0.011 [0.031]	1. I am satisfied with myself.	-0.030 [0.034]	0.051* [0.029]
2. I feel unhappy, sad or depressed.	0.008 [0.033]	0.033 [0.030]	2. Sometimes I feel like I am useless.	-0.059 [0.038]	-0.009 [0.036]
3. I have a lot of worries.	0.016 [0.046]	-0.005 [0.037]	3. I feel like I have a lot of good attributes.	0.026 [0.042]	0.079** [0.040]
4. I feel like I want to die.	0.030 [0.030]	0.008 [0.022]	4. I am able to do things as well as others.	0.043 [0.033]	-0.023 [0.029]
5. I often cry.	-0.034 [0.043]	0.011 [0.030]	5. I don't have much to be proud of.	-0.055 [0.042]	-0.034 [0.041]
6. When things are going wrong, I often think It's my fault.	0.058 [0.042]	-0.003 [0.034]	6. I feel useless at times.	0.003 [0.036]	0.033 [0.035]
7. I feel lonely.	-0.064* [0.037]	-0.026 [0.029]	7. I am on an equal plane with others.	0.071* [0.038]	0.023 [0.035]
8. I'm not interested in anything.	-0.025 [0.028]	0.019 [0.025]	8. I wish I could respect myself more.	0.017 [0.041]	-0.022 [0.040]
9. I'm not hopeful for the future.	-0.019 [0.035]	-0.035 [0.031]	9. I am a failure.	0.001 [0.038]	-0.012 [0.037]
10. Everything is tough.	-0.007 [0.033]	0.029 [0.029]	10. I am optimistic for myself.	0.005 [0.035]	-0.005 [0.036]
Depression Index	-0.0003 [0.021]	0.002 [0.018]	Self-Esteem Index (reversed sign: 2, 5, 6, 8, and 9)	0.020 [0.020]	0.015 [0.018]
Controls	Yes	Yes		Yes	Yes
Observations	1,600	1,785		1,600	1,785
<i>School Aspirations Item</i>					
1. Studying at school has an important meaning to me.	0.051 [0.038]	0.033 [0.034]			
2. What you learn in school is important.	0.060 [0.037]	0.038 [0.034]			
3. School life will play an important role in my growth.	0.049 [0.034]	0.030 [0.033]			
4. School life will play a significant role in my future.	0.070* [0.038]	0.013 [0.034]			
5. Studying at school will play a huge role in choosing my future career.	0.067* [0.039]	0.052 [0.036]			
6. What I learn in school will be useful to me.	0.156*** [0.050]	0.071* [0.039]			
7. School life will help me in my social life in the future.	0.070* [0.037]	0.057 [0.035]			
School Aspirations Index	0.074** [0.024]	0.042* [0.023]			
Controls	Yes	Yes			
Observations	1,600	1,785			

Note: The sample is students from third (sixth grader; elementary school age) and sixth (ninth grader; middle school age) waves of the KCYPS 2010. All regressions except the index variable are probit and the reported DID estimates represent the marginal effects of the mean value, which are obtained using the Stata command *inteff*. Robust standard errors clustered at the individual ID level are reported in parentheses. Controls include students, parents, and house characteristics, as well as region (17 administrative provinces) fixed effects.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.