Impacts of In-Person School Days on Student Outcomes and Inequality: Evidence from Korean High Schools during the Pandemic[1]

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Abstract

This study examines the one-year impacts of in-person schooling on high school students' outcomes during the COVID-19 pandemic in South Korea. Using high-quality administrative data and a student survey, the study finds that in-person schooling does not significantly affect average test scores, but it reduces educational inequality and enhances noncognitive traits such as class participation, school satisfaction, and career aspirations. The study also reveals that the changes in test score distributions are driven by boys rather than girls. The findings highlight the importance of addressing educational inequality in policy responses to recover from learning loss caused by the pandemic.

Keywords: Schooling modes; in-person schooling; school closure; COVID-19 pandemic; education inequality

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1. Introduction

School closure during the COVID-19 pandemic is unprecedented in terms of intensity and duration worldwide. According to the Organization for Economic Co-operation and Development (OECD), schools around the world were on average totally (partially) closed for 101 (67) days at the upper secondary level, 92 (43) days at the lower secondary level, and 78 (41) days at the elementary level in 2020 (OECD, 2021). School closure was initially accepted as a measure to cope with the pandemic; however, concerns about learning loss and educational inequality have been raised. School closure could have unintended long-term consequences if learning loss through the school disruption results in decreased income (Garca et al., 2020), negative health behaviors (Kenkel et al., 2006), and shortened lifespans (Lleras-Muney, 2005).

This paper studies the impacts of schooling mode (in-person vs. online) on high school students' outcomes during the COVID-19 pandemic in South Korea, where online learning was provided when schools were closed. We take advantage of the fact that the number of in-person school days in 2020 was, on average, 17 weeks shorter than in the pre-pandemic years, but varies across and within regions.

The net impacts of school closure depend on the quality of alternative education and support at home. During the pandemic, modes of alternative education varied across and even within the country. For example, most developed countries provided online education programs when the schools were closed; however, developing countries had difficulties providing alternative education.[1] Furthermore, online learning requires a home environment with internet

[1] Although most developing countries also provided remote learning through online media, TV, or both, a significant proportion of the population did not have access to the internet, computers, or tablet PCs. For example, less than 30 percent of households with children in the Philippines and Lao PDR engaged in remote learning during the

access and adequate space, and the ability of households to support online education varies significantly. For instance, Yasenov (2020) and Bick et al. (2020) find that highly-educated and high-income individuals are more capable of working from home.[2]

Although understanding the learning impacts of school closure is important, measuring the causal effects of school closure on students' outcomes is challenging. Most studies analyze the effect comparing academic achievement before and after the pandemic, and thus they are not able to distinguish the impacts of school closure and other changes that could affect academic achievement during the pandemic, such as childcare inputs and economic downturn (e.g., Maldonado and De Witte, 2022). Furthermore, exams were often canceled or conducted online in 2020, making pre- and post-pandemic comparisons more difficult.[3]

Our study has several advantages to providing credible evidence on the causal effects of school closure on student outcomes. First, we apply a difference-in-differences approach to estimate the impacts of school closure, taking advantage of the fact that in-person school days during the pandemic differed significantly across and even within the studied regions. This approach also allows us to estimate the marginal effect of in-person school days during the pandemic rather than the effect of the overall school closure. Our study is closely related to Jack et al. (2023), who take advantage of a variation in schooling mode within a small geographical

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pandemic (Barron Rodríguez et al., 2021). Therefore, learning loss due to school closure could be small in developed countries and significant in resource-limited settings.

[2] Learning loss also could differ by gender of children because disruptive home environments could affect boys more negatively than girls (Bertrand and Pan, 2013). Danzer and Lavy (2018) also find that boys' academic outcomes are more responsive to parental leave extension than girls'; thus, the effect of in-person school days might differ by gender in part due to different parental responses.

[3] For example, 56 percent of the countries surveyed canceled their standardized evaluation in 2020, and up to 63 percent in 2021 (OECD, 2021). In addition, the difficulty level of the exam has naturally changed over time, and thus comparison of academic achievement before and after the pandemic is unreliable.

region. They find a reduction in pass rates of standardized tests for grades three to eight in the United States with fewer in-person schooling days during the pandemic.[4]

Second, our study utilizes high-quality administrative data on a large scale, in combination with a student survey. South Korea has implemented nationally representative in-person tests for 11th graders even during the pandemic. Many studies in other countries administered tests online during the pandemic, which may not be comparable to previous tests because online testing requires a different skill set, such as digital efficiency (Svaleryd and Vlachos, 2022). In addition, our rich survey data on students allow us to perform extra analysis to offer additional insights into unpacking the mechanisms.

We find no evidence that the increase in in-person school days affects average student performance. However, it reduces the inequality in academic achievement caused by school closures. The students near the bottom tail of the test score distribution face a larger learning gain when in-person school days increase. We also find in-person schooling positively affects noncognitive traits, including school participation, satisfaction, and career aspiration. Regarding heterogeneity, while we find no differential impacts of in-person schooling by parental education, evidence suggests that boys near the bottom tail of the test score distribution are more positively affected by in-person schooling than girls in the similar position. Also, boys' noncognitive traits, such as class participation and school satisfaction, are positively influenced by in-person schooling. With extra in-person schooling, boys also talked more with their parents

[4] Compared to Jack et al. (2023), our study makes a further distinct contribution in several important dimensions. First, we use an individual-level standardized test score administered nationally. In addition, we have detailed student-level survey data, which enables us to assess the impact of change in in-person schooling days on other noncognitive traits. Finally, while Jack et al. (2023) study the impact on grades 3–8 in the United States, our data concerns high school students (equivalent to Grade 11 in the United States) in South Korea.

and reduced online device usage for accessing entertainment and social networking services (SNS) at a much higher rate than girls.

Our study contributes to the literature on how COVID-19 schooling affects students' cognitive and noncognitive outcomes. Research on the effects of school closure on learning is primarily based on before and after pandemic comparisons, and the results are mixed. While many papers report learning loss due to school closures (Contini et al., 2021; Engzell et al., 2021; Schult et al., 2022; Maldonado and De Witte, 2022; Jack et al., 2023), some studies show no significant change (or even improvements) in academic achievement after school attendance was restricted.[5] Notably, to our knowledge, our study is the first to examine the effect of school closure on noncognitive outcomes.

This study also contributes to the literature on the effects of face-to-face versus online education. Most studies on online education before the COVID-19 pandemic focuses only on tertiary education. In general, studies find that offline classes in universities outperform online classes in terms of educational outcomes (Figlio, Rush, and Yin, 2013; Bettinger et al., 2017, Kozakowski, 2019). For example, Bettinger et al. (2017) find that taking online courses hinders future academic performance among university students. Figlio et al. (2013) also find evidence that in-person learning dominates offline learning. They also find that these positive impacts of

[5] For example, Gore et al. (2021) find a small and statistically insignificant increase in mathematics and reading scores for 3rd and 4th graders in Australia, while Birkelun et al. (2021) report an increase in test scores in Denmark. Maldonado and De Witte (2022) find a decrease of 0.17 standard deviations (SDs) in mathematics and 0.19 standard deviations in Dutch among 6th graders in Belgium. Engzell et al. (2021) find a decrease in student achievement by 0.08 SDs for 4th to 7th graders in the Netherlands. Schult et al. (2022) find a decrease of between 0.03 and 0.09 SDs in reading and mathematics in Germany in 2020 compared to previous years. In Italy, Contini et al. (2021) find a decrease of 0.19 SDs in mathematics compared to the previous cohort among 8-year-olds.Lewis et al. (2021) used data from approximately 5.5 million students, finding that 3rd to 8th graders made gains in reading and math at a lower rate than in pre-pandemic periods. The drop was more significant in math than reading and was more pronounced among disadvantaged and younger students.

in-person schooling are particularly strong for male and lower-achieving students. Our study is among the few to compare face-to-face versus online education in the secondary school setting.

2. Institutional Background

2.1 School Closure during the Pandemic in South Korea

The South Korean educational system consists of six years of elementary school, three years of middle school, and three years of high school; each school year is divided into two semesters. The academic year begins on March 1 and ends in the middle of July (first semester), commencing again in August and ending in mid-February (second semester).

In 2020, the Korean Ministry of Education (MOE) delayed the first semester to April 9 and the first semester began with online classes. In May 2020, the MOE opened offline sessions sequentially, starting with high school students.[6] The number of school days in Korea in 2020 was 104 on average at the high school level, 86 days (about 17 weeks) less than the school days of previous years (190 days).[7] School closure days in 2020 varied significantly across regions and even within regions. Sources of across- and within-district variation include 1) confirmed COVID-19 cases within the school, 2) the social distancing policies at the regional level, 3) class size and density, 4) school size, 5) discretion of principals, and 6) superintendents and disease control authorities.

[6] Grade 12 students started offline schooling on May 13th, 11th grade on May 20th, and 10th grade on May 27th.
[7] The minimum number of school days for elementary and secondary schools before the pandemic was 190 days per school year. Thus, from 2015 to 2019, school days are nearly constant at 190. The head of school may reduce the number of school days up to 10 percent (19 days), if necessary, under specific circumstances such as natural disasters. We are unaware of any natural disaster that could reduce the school days during 2015–2020, except for the Pohang earthquake in November 2017. Later, we confirm that our results based on the DID strategy show a parallel trend before the pandemic year, and no significant difference is observed for 2017.

Specifically, school closures were determined by the head of the school, the local office of education, and the disease control authorities.[8] The MOE provided a guideline on school density recommending blending online and offline courses (i.e., offline classes on every alternate day or operating morning and afternoon sessions). For example, schools in regions with a high number of COVID-19 cases were advised to limit the number of students attending school offline by up to two-thirds. Furthermore, small-sized schools (60 students before October 11 and 300 students after October 11) could decide the schooling mode after discussion with the school faculty, parents, and students unless orders were made at the national level.

2.2 Alternative Education during the Pandemic

Online education became the primary mode of learning when the schools were closed in South Korea. Distance learning solutions to be provided by schools while they were closed were largely centralized. Three types of distance learning were introduced to schools: 1) Real-time interactive classes, 2) asynchronous content-based classes, [9] and 3) independent assignment/activity-based classes. *School-On*, an integrated platform designed to allow teachers to create online classrooms, supported their students' learning with daily instructions, and provided counselling (UNESCO, 2022).

TV programs such as the Korean Educational Broadcasting System (EBS) also played a large part in the provision of online education. EBS is a major public broadcasting organization that provides e-learning contents and educational programs. In addition, private education (i.e.,

[8] Based on the COVID-19 prevention management guideline provided by the Ministry of Education, temporary school closures were recommended 1) if there were two or more confirmed cases in school or 2) if the chain of transmission of infection was not able to be tracked.

[9] Teachers provide students with pre-recorded video lectures and learning contents. They monitor whether students are watching and reply to student's questions.

private tutoring and tutoring companies) are one of the primary sources of out-of-school learning inputs in South Korea.

According to Statistics Korea (2021), the purchase rate of EBS textbooks for online learning purposes was 35.1 percent, 3.1 percentage points higher than the previous year. Private tutoring participation for high school students did not change much during the pandemic. The private education participation rate of high school students became 60.7 percent, slightly higher (by 0.3 percentage points) than the previous year. Average private tutoring hours were 5.9 hours per week, which increased by only 0.1 hours. The average monthly expenditure per student was 388,000 Korean won (KRW) (approximately 315 USD), an increase of 5.9 percent compared to the previous year. Conditional on private education participation, the average monthly expenditure per student was 640,000 KRW (approximately 520 USD), an increase of 5.2 percent relative to the previous year.

3. Data and Study Sample

3.1. Data

We use two primary sources of data: in-person school days (school level) in 2020 from the MOE and annual 11th graders' academic achievement (student level) data from the National Assessment of Educational Achievement (NAEA) from 2015 to 2020 which is administered by the Korea Institute of Curriculum and Evaluation (KICE).[10] The NAEA data included all 11th graders in 2015 and 2016, while a sample of 3 percent of high schools was included from 2017

[10] In-person school days in 2020 were collected by the MOE as a response to the request made by the education committee of the national assembly of South Korea. For our research purpose, as the NAEA data do not reveal school names to public, the KICE merged in-person school days with the NAEA data on behalf of us and provided the de-identified data.

to 2020.[11] Thus, we weigh the observations for 2017 to 2020 by the inverse probability of being selected for the sample (1/0.03). The NAEA was administered in June every year before the pandemic; however, in 2020, it was conducted in November 2020. The NAEA data are combined with a student survey measuring school participation, satisfaction, time use, and online device usage.

Table 1 presents the summary statistics. The standardized deviation for the overall score is lower than 1, indicating that variance in test scores falls when taking the average of the three subjects. Roughly half of the students are female. High schools in Korea can be public or private, which can be further autonomous public or autonomous private schools.[12] About 60 percent of the students are in public schools, while the rest are in private schools. Autonomous schools (including public and private autonomous) comprise about 10 percent of the sample. Information on parental education is available for 2018–2020 only, and about 77 percent of the students had at least one of the parents with a college diploma or higher.

Furthermore, our data allow us to compare students' overall perception regarding the class learning environment between in-person classes in 2019 and online classes in 2020

[11] Before 2017, the NAEA was administered nationwide and to a sample of 3 percent of schools nationwide since 2017. Given that the 2017–2020 data select 3 percent of schools, we check the representativeness of the data in two ways. First, in Appendix Figure A2, we compare the distribution of the school days between the entire sample of schools and the schools appearing in our 2020 data. The figure confirms that the distribution of the school days in our data is quite similar to the distribution of the entire sample. In both samples, the bimodal distribution of school days appears evident. Figure A3 checks whether the schools appearing in the 2020 data significantly differ from those in earlier years. Figure A3 also indicates that the distribution of school days is well overlapped with 2020 across all years. As school names are not disclosed to the researchers, the outcome trajectories of the same schools could not be followed over time. For analysis, we exclude international schools and elite schools specialized in science and foreign language from the study sample (2.76 percent of schools are excluded).

[12] Public autonomous schools are the Korean version of American Charter schools in the sense that these public schools are given the autonomy to choose their own curriculum and administrative operation. Private autonomous schools are like their public counterparts in that they possess the same autonomy, but unlike public autonomous schools, they are financially independent from the government. Most prestigious high schools in Korea are private autonomous schools since schools can select well-performing students before these students go on to apply to regular high schools (Hahn et al., 2018; Enforcement Decree of the Elementary and Secondary Education Act, Articles 91-3 and 91-4).

(Appendix Figure A1). During the pandemic, students in our sample reported negative class environments in learning, friendship, and a sense of belonging. While the concentration in class seems to increase, the students reported that study amount and time decreased.[13] Not surprisingly, private education time increased during the pandemic. Furthermore, communication with teachers regarding class and interaction with friends significantly decreased in 2020. Students also found it challenging to keep a regular daily schedule during the pandemic.

3.2. Outcome Variables

We examine four sets of outcome variables. First, the primary outcome variables of interest, are students' standardized test scores and their distribution: the likelihood of having low, middle, and high grades in overall, Korean, math, and English. Test scores are standardized by each year and subject. The average of the three standardized test scores provides the overall score; in case of missing values in one or two subjects, we take the average of the available test scores.

Figure 1 shows the density of the overall, Korean, Math, and English standardized test scores over time. As they are standardized by each year, the average and SD of each year's distributions are 0 and 1, respectively. Notably, we find thicker tails in the test score distributions in 2020, especially at below −1.5 SD and above 1.5 SD. We hypothesize that part of the difference may be due to school closure, although these changes could be not only due to school closure but also factors such as household income shocks and changes in parenting style during the pandemic. Thus, we use the thresholds of −1.5 SD and 1.5 SD to define the indicators of belonging to low (i.e., standardized test score below −1.5 SD), middle (between −1.5 SD and 1.5

[13] For instance, the survey asks whether "the amount of study" during the remote class period in 2020 decreased, equal, or increased relative to the in-person class in 2019. For each question, we construct a variable by assigning the value of −1 if the student responds "decreased," 0 if "similar," and 1 if "increased."

SD), and high grades (higher than 1.5 SD). The percentage of students belonging to the low (high) grades is different for each subject but constitutes roughly the bottom (top) 5–10 percent of the test score distribution.

Second, we explore whether noncognitive traits such as class participation, school satisfaction, and career aspirations are affected by differential days of in-person schooling. Each outcome is an index, the average of indicators for three to seven related questions. Third, we examine the use of online devices by type, such as the usage for studying (participating in online classes or online study materials), entertainment, social media, and search for information. For each type, we create a dummy variable indicating the device usage of three or more hours daily. Finally, we examine students' time use, including frequency of conversation and leisure time with parents, time for reading and exercising, private education, and watching public educational TV programs. Table A1 presents details of the definitions.

4. Empirical Strategies

We take advantage of the fact that in-person school days vary significantly even within the same region, and thus we use a difference-in-differences (DID) approach.

$$Y_{ist} = \alpha + \sum_{\substack{\tau=2015 \\ \tau \neq 2019}}^{2020} \beta_\tau \, 1[t = \tau] \times SchDays_s + \lambda \, SchDays_s + \gamma_j + \delta_t + \zeta_j t + \theta \, X_{ist} + \varepsilon_{it}, \qquad (1)$$

where Y_{ist} is the dependent variable for student i, school s, and year t. $SchDays_s$ is the number of in-person school days in 2020 for school s (measured in 10 days term).[14] We use 2019 as the base year and include the interaction terms between the number of school days as of 2020 for each school and the year dummies. The coefficient of interest is β_{2020}, which captures the effect of in-person schooling over online education during school closure.[15] γ and δ are living zone and year fixed effects, respectively.[16] $\zeta_j t$ is a living zone-specific time trend. The control vector X includes students' gender and school-specific factors, such as the number of students, whether a school is autonomous, single-sex, public/private, and school location (metropolitan city, small towns, or rural). We also control for the number of confirmed COVID-19 cases in each region.[17] To address the potential concern for multiple hypothesis testing, we also report the false discovery rate (FDR) q-value following Anderson (2008), along with a traditional p-value.

It would be concerning if the difference in school days during the pandemic is systematically related to factors that could affect student outcomes, such as parental education. Appendix Table A2 explores the determinants of school days by regressing school days in 2020 on several factors with and without living zone fixed effects. Column (1), without living zone fixed effects, shows that some characteristics are correlated with school days. On average, conditional on other characteristics, school size and city size negatively correlate with school

[14] In-person school days in 2020 measure treatment intensity, and there are nearly negligible differences in school days before the pandemic. We apply school days in 2020 to all years (including pre-pandemic years 2015–2019) in order to capture the unobserved difference between the schools with a relatively high number of school days and the schools with a lower number of school days in 2020 in a DID framework.

[15] As we use school days which vary by school, instead of students' actual attendance days in 2020, our estimate is close to the intention-to-treat effect rather than the treatment-effect-on-treated effect.

[16] Living zones are similar to the commuting zones in the United States (Autor and Dorn, 2013), constructed by the Statistics Development Institute of the National Statistical Office based on the actual living areas of residents. There are 58 living zones.

[17] The number of COVID-19 confirmed cases is matched at the finer regional level (228 regions) than the living zone and thus are not subsumed by the living zone fixed effects.

days. Column (2) includes living zone fixed effects, which further mutes the significance of those characteristics. Overall, the results indicate that in-person school days are not related to school types and school-level average characteristics, such as parents' education or the percentage of female students.

Our DID estimators could be biased if unobservable characteristics correlated with in-person school days could affect students' outcomes. For instance, schools' guide and communication quality with parents and students during the pandemic could be different between schools with higher and lower in-person school days, and this could affect students' performance. However, as these factors are unobservable, we are not able to test their potential impact on our results. Therefore, the results should be interpreted with this caveat in mind.

Based on the 2020 data, school days averaged 101 with a standard deviation of 18 days. After subtracting the average school days by 58 clusters, the demeaned school days was 6, indicating that roughly 30 percent of the overall school days remained after taking out the cluster-level average. Appendix Figure A4 plots the demeaned school days in 2020, showing a normal distribution. This result contrasts with the bimodal distribution (likely caused by the difference in the region as a large city such as Seoul had more COVID-19 confirmed cases and had fewer school attendance days) in school days before removing the cluster-level average. Similarly, Figure A5 depicts the residual in-person school days in 2020 for each school in the map after taking out the average in-person school days by living zone clusters. The figure does not display a particular pattern across living zones. These exercises together indicate that while differences across clusters explain some variances, a modest variation left in the school days during the pandemic and this within-cluster variation in school days appears to be somewhat idiosyncratic and normally distributed.

Since the empirical analysis is based on DID estimators, the crucial assumption is that the outcome difference is constant among schools between 2015 and 2019. If the coefficients for the interaction terms between year dummies (2015–2018) and school days are significant, the parallel trend assumption might be violated.

5. Results

5.1. Changes in Test Scores (Failure Rate) during the Pandemic

Before we present our main results, we start by presenting the overall changes in failure rates of each subject before and after the pandemic, compared to the base year of 2019 in Figure 2.[18] This depiction provides a sense of the overall impact of the pandemic, although this over-time comparison may partly reflect the difference in test difficulty across years and cohort differences. The red x mark shows the differences in failure rates between 2020 and the base year. Similarly, hollow black circles show the differences between the base year and the years before the pandemic (2015–2018). Although some fluctuations appear over time, failure rates are similar in pre-pandemic years and significantly higher in 2020 for all subjects. Failure rates in 2020 were 6.2, 12.9, and 7.9 percent for Korean, Math, and English, respectively. These scores increased by 2.4, 4.1, and 4.4 percentage points compared to 2019, respectively. Figure 2 also illustrates the heterogeneous changes in in-person school days in 2020 by parental education level and students' genders. Notably, failure rates increased in 2020 and were more concentrated among male (compared to female) students and those with lower in-person school days.

[18] Results are categorized into four categories based on the test score of a student: excellent, average, poor, and failure. The specific cut-off for each subject-year for this category is determined by the KICE.

5.2. Effects on the Levels and Distributions of Test Scores

We next examine whether the schooling mode drove the changes in test scores during the pandemic. Figure 3 and Table 2 report the results on the impacts of in-person schooling on overall, Korean, Math, and English test scores. Figure 3 plots the estimated β_τ, as specified in equation (1), with the year 2019 serving as the base year. β_{2000} captures the marginal impacts of the number of in-person school days (measured in 10 days) on standardized test scores during the pandemic. It first confirms that the parallel trends assumption is satisfied as the interaction term coefficients from 2015 to 2018 are small and statistically insignificant. More importantly, school attendance days during the pandemic did not significantly affect average academic achievements for any subjects or overall scores. Table 2 shows that the magnitude of the coefficients is small and not statistically significant; thus, our estimates are also relatively precise. For example, we can capture any effects greater than 0.045 ($= 0.023 \times 1.96$) SDs of average test scores at the 5 percent significance level. Corresponding numbers for Korean, Math, and English scores are 0.041 ($= 0.021 \times 1.96$), 0.053 ($= 0.027 \times 1.96$), and 0.043 ($= 0.022 \times 1.96$) SDs, respectively.

Moving beyond the average treatment effects, we study whether in-person schooling has *distributional* effects. For example, in-person schooling could have different effects regarding baseline test scores. Figure 4 plots the estimated β_τ in equation (1), which shows the effects of in-person school days during the pandemic on the percentage of students with low grades (less than −1.5 SDs), middle grades (between −1.5 SDs and 1.5 SDs), and high grades (>1.5 SDs). The figure first confirms that the pre-trend assumption is satisfied, as the 2015–2018 coefficients are small and statistically insignificant. Furthermore, we find a decrease in the percentage of

students with low grades and an increase in students with middle grades for all study subjects in 2020 as the school days increase.

Table 3 provides its regression analog. The increase of 10 in-person school days decreases the percentage of students with low grades by 0.8, 0.9, 1.1, and 1.0 percentage points (Panel A) in overall, Korean, Math, and English scores, respectively. Since 6.0, 7.1, and 6.2 percent of students in Korean, Math, and English are in the low-grade level with test scores lower than −1.5 SDs, these changes represent roughly 15.0 (= 0.9/6.0), 15.5 (= 1.1/7.1), and 16.1 (= 1.0/6.2) percent increases for each subject. At the same time, the portion of students with middle grades increases by 1.1, 1.0, 1.6, and 1.2 percentage points in overall Korean, Math, and English scores (Panel B).

The combined results indicate that in-person schooling decreases inequality of academic performance by reducing the percentage of students with low performance and increasing the percentage of students with middle performance; however, we find no evidence that in-person schooling (in place of online education) changes the average test scores.

5.3. Effects on Noncognitive Traits, Online Device Usage, and Time Use

In this section, we study how in-person schooling affects noncognitive traits, including class participation, school satisfaction, career aspiration, and study behaviors. Figure 5 and Table 4 show that class participation, school satisfaction, and career aspiration significantly increased for those students in schools with more in-person school days in 2020. A 10-day increase in in-person school days increased class participation, school satisfaction, and career aspiration index by 0.7, 0.7, and 0.5 percentage points, respectively.

Next, we examine whether in-person schooling affects the use of online devices. Figure 6 and Table 5 show the effect on the time use of online devices. Students with more school attendance days spent less time on online devices for studying (column 1) than students with less school days; a 10-day increase in in-person school days reduced the likelihood of using online devices for studying for more than 3 hours per day by 0.9 percentage points.[19] This result is not surprising because virtual education was provided when schools closed. We find no evidence that in-person schooling changed the time to use online devices for purposes outside of studying, such as entertainment, SNS, and searching for information.

Figure 7 and Table 6 examine the changes in time use at home and out of school including the frequency of conversation with parents (columns 1 and 2), leisure time with parents (column 3), time on reading and exercising (columns 4 and 5), private education (column 6), and watching EBS program (column 7). We generally find no significant impacts of school days on these outcomes.

5.4. Heterogeneous Effects by Parental Education Level and Students' Gender

This section explores whether the impacts of in-person schooling differ by parental education level and students' gender. Figure A6 presents results on the overall distribution of the test scores by parental education (parents with a college diploma or higher vs. those with a high school diploma or lower).

We also present impacts of in-person schooling on those outcomes by parental education level. Tables A3 and A4 present results for estimating equation (1) by parental education level

[19] It also leads to a reduction in the likelihood of using online devices for studying purposes, as measured by using more than one hour a day, by 1.2 percentage points (not shown).

(columns 1-2) and students' gender (columns 3-4) for each outcome variable. Panel A presents the impacts on standardized test scores, and panel B shows distributions of test scores.

We test whether the impacts of in-person schooling on these outcomes are different by parental education through a triple interaction term between an indicator of low parental education, in-person school days, and the pandemic year (2020). Figures A7 and A8 present estimated coefficients and 90% confidence intervals for each outcome variable. The estimated coefficient on the triple interaction term indicates the differential effect by parental education (i.e., the effect on those with low parental education subtracted by that on those with high parental education). We find that the students with low parental education tend to benefit more than the students with high parental education with increased in-person schooling, although the difference is not statistically significant, except for a few outcomes. For instance, the impacts on the likelihood of having a high grade in English (Figure A7) as well as career aspiration and conversation with parents regarding study (Figure A8) are higher for students with lower levels of parental education than those with higher levels of parental education.

Figures A9–A11 show the results by gender. Similarly, Figure A9 presents results on the overall distribution of the test scores. Table A3 presents the impacts on standardized test scores (panel A) and distributions of test scores (panel B) by gender. Figures A10 and A11 formally test the differential effects by gender using the triple interaction term (i.e. the effect on boys subtracted by the effect on girls).

We find that test scores increased more among boys than girls with increased in-person schooling although the differences in average test scores are not statistically significant in general. We also find that male students drive changes in the distribution of test scores more than female students. For example, male students show a decrease in the proportion of lower

performers and an increase in middle performers as schools are open, while such a pattern is less pronounced among female students (Table A3), with the difference being statistically significant (Figure A10). Figure A11 also shows evidence that in-person schooling affects more for boys than girls in terms of class participation, school satisfaction, career aspiration, and use of online devices for more than three hours a day for entertainment and SNS purposes (boys use less with increased school days than girls), and time to talk with parents about studying (boys talk more with the increased in-person school days).

The finding that test scores increased more among boys than girls with increased in-person schooling is consistent with previous research that suggests that boys may be more susceptible to negative outcomes in broken families (Bertrand and Pan, 2013). There are several possible explanations for this gender difference. For example, boys may be more likely to participate in classroom discussions and group activities, which can enhance their learning and engagement. Alternatively, boys may be more motivated by competition and grades, which can be more readily achieved in a traditional classroom setting. Lastly, boys may be more easily distracted in the online learning setting than girls compared to a classroom setting.

6. Discussion and Conclusion

In many countries, schools were forced to close during the pandemic. Investigating whether students could meet their educational goals under such circumstances and recognizing individuals who face higher learning challenges are of significant policy relevance.

We examine the effects of the additional in-person school days on the performance and noncognitive traits of high school students in South Korea during the COVID-19 pandemic. Our analysis focuses on when schools were closed and online instruction was implemented as an

alternative. As a means of identification, we leverage the variation in the number of in-person school days in 2020 across and within regions. While the marginal effect of the school days on the average test scores is not statistically significant, the results indicate that in-person schooling reduces inequality in academic performance. The students who derived the least benefits from online education (relative to in-person classes) were likely those with initially low baseline test scores.

Furthermore, our findings indicate that in-person schooling also positively affects other vital aspects of education, such as class attendance, school satisfaction, and career aspirations. Our study offers rare evidence that supports the significance of in-person schooling for developing noncognitive traits during the pandemic; however, we could not assess whether these impacts can be sustained in the long run. Investigating the long-term effects on noncognitive traits would be essential for future research.

Regarding external validity, it is crucial to consider the quality of alternative education. The study was conducted in South Korea, where online education was relatively high in quality. However, in other settings with limited experience with remote learning and lower quality online education, the effects of school closures could potentially be more detrimental. Therefore, future research could examine how the quality of alternative education affects students' outcomes during the pandemic and identify strategies to improve the quality of online education as a viable alternative to in-person schooling.

Our findings align with previous studies indicating that school closure contributes to increase of inequality in education during the pandemic. Therefore, addressing educational inequality should be a critical factor in policy responses to address and recover from learning loss during the pandemic. To this end, targeted interventions, additional tutoring, mentoring, or

personalized learning, could be implemented to support students with low baseline test scores who derived the least benefits from online education.

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Table 1: Summary Statistics

Variables	2015–2016			2017–2019			2020		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
Panel A: Test Scores									
Korean score (std)	842,727	0.00	1.00	39,129	0.00	1.00	10,365	0.00	1.00
Math score (std)	841,445	0.00	1.00	39,142	0.00	1.00	10,366	0.00	1.00
English score (std)	843,284	0.00	1.00	39,136	0.00	1.00	10,353	0.00	1.00
Overall score (std)*	843,664	0.00	0.87	39,188	0.00	0.88	10,400	0.00	0.88
Panel B: Noncognitive traits									
Class participation [0~1]	842,514	0.74	0.27	39,079	0.77	0.26	10,326	0.75	0.27
School satisfaction [0~1]	842,531	0.85	0.20	39,082	0.86	0.20	10,324	0.85	0.20
Career aspiration [0~1]	842,507	0.78	0.27	39,079	0.81	0.26	10,325	0.82	0.25
Study behaviors [0~1]	842,450	0.73	0.34	39,068	0.76	0.34	10,318	0.78	0.33
Panel C: Time Use									
Conversation with parents (about school, ≥once a week)	842,431	0.79	0.41	39,059	0.83	0.38	10,306	0.81	0.39
Conversation with parents (about study, ≥once a week)	842,360	0.73	0.45	39,043	0.76	0.43	10,303	0.72	0.45
Leisure time with parents (≥once a week)	842,255	0.25	0.44	39,031	0.32	0.47	10,297	0.36	0.48
Reading time (≥30 min)	842,315	0.24	0.43	39,059	0.23	0.42	10,310	0.22	0.41
Exercise time (≥30 min)	841,974	0.59	0.49	39,051	0.56	0.50	10,312	0.51	0.50
Online device usage (Study) [≥3h]				38,949	0.03	0.18	10,265	0.08	0.28
Online device usage (SNS) [≥3h]	841,977	0.10	0.29	38,979	0.12	0.33	10,281	0.15	0.36
Online device usage (Search) [≥3h]	841,904	0.02	0.15	38,974	0.03	0.16	10,277	0.03	0.17
Online device usage (Leisure) [≥3h]				39,011	0.14	0.34	10,279	0.25	0.43
EBS online class [0~1]	837,341	0.35	0.48	38,860	0.33	0.47	10,226	0.40	0.49
Panel D: Student and School Characteristics									
Female	843,664	0.48	0.50	39,211	0.47	0.50	10,418	0.51	0.50
Number of Students	843,298	338.58	106.73	39,211	294.89	99.01	10,378	243.96	76.44
School type (Public)	843,664	0.58	0.49	39,211	0.58	0.49	10,418	0.57	0.50
School type (Private)	843,664	0.42	0.49	39,211	0.42	0.49	10,418	0.43	0.50
School type (Autonomous)	843,664	0.10	0.30	39,211	0.11	0.31	10,418	0.11	0.31
Boys school	843,664	0.25	0.43	39,211	0.25	0.43	10,418	0.21	0.41
Girls school	843,664	0.22	0.42	39,211	0.20	0.40	10,418	0.22	0.42
Metropolitan city	843,664	0.44	0.50	39,211	0.41	0.49	10,418	0.39	0.49
Small towns	843,664	0.45	0.50	39,211	0.46	0.50	10,418	0.41	0.49
Rural region	843,664	0.12	0.32	39,211	0.13	0.34	10,418	0.20	0.40
Parent's education (College diploma or higher)				19,522	0.77	0.42	8,216	0.77	0.42

Notes: This table shows summary statistics of the data that we use in our analysis. The variables listed in panels A-C are the outcomes and those in panel D is the control variable, except for the parent's education which are available only for 2018-2020. Online device usage time ('study' and 'leisure' purpose) are available only for 2018–2020.

* Overall score is the average of the standardized score of Korean, Math, and English. If a score of one subject is missing, we use the average of the other two subjects. If score of only one subject is available, we use that value for the overall score.

Table 2: Effects of In-Person School Days on Test Scores

	(1)	(2)	(3)	(4)
Variables	Overall score	Korean score	Math score	English score
School days × 2020	0.014	0.026	-0.004	0.022
	(0.023)	(0.022)	(0.027)	(0.022)
	[0.545]	[0.239]	[0.899]	[0.329]
		{0.494}	{0.899}	{0.494}
Observations	892,846	891,816	890,547	892,367
R-squared	0.114	0.100	0.083	0.102

Notes: Standard errors are clustered at the living zone level and are reported in parentheses. Traditional p-value is reported in bracket and False Discovery Rate (FDR) q-value is reported in curly bracket, following the procedure by Anderson (2008). *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Effects of In-Person School Days on Test Score Distributions

	(1) Overall score	(2) Korean score	(3) Math score	(4) English score
		Panel A: P(Score ≤ –1.5 SDs)		
School days× 2020	-0.008**	-0.009*	-0.011**	-0.010**
	(0.004)	(0.004)	(0.005)	(0.005)
	[0.039]	[0.057]	[0.019]	[0.035]
		{0.057}	{0.053}	{0.053}
Mean of dep. variable	0.057	0.060	0.071	0.062
R-squared	0.042	0.045	0.033	0.044
		Panel B: P(–1.5 SD < Score< 1.5 SDs)		
School days× 2020	0.011**	0.010**	0.016**	0.012**
	(0.005)	(0.005)	(0.006)	(0.006)
	[0.036]	[0.048]	[0.011]	[0.049]
		{0.049}	{0.033}	{0.049}
Mean of dep. variable	0.901	0.900	0.889	0.893
R-squared	0.027	0.022	0.034	0.032
		Panel C: P(1.5 SDs≤ Score)		
School days× 2020	-0.003	-0.001	-0.004	-0.002
	(0.005)	(0.003)	(0.006)	(0.005)
	[0.509]	[0.800]	[0.492]	[0.656]
		{0.800}	{0.800}	{0.800}
Mean of dep. variable	0.042	0.041	0.040	0.046
R-squared	0.036	0.026	0.034	0.040
Observations	892,846	891,816	890,547	892,367

Notes: Standard errors are clustered at the living zone level and are reported in parentheses. Traditional p-value is reported in bracket and False Discovery Rate (FDR) q-value is reported in curly bracket, following the procedure by Anderson (2008). *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Effects of In-Person School Days on School Participation and Satisfaction

Variables	(1) Class participation [0~1]	(2) School satisfaction [0~1]	(3) Career aspiration [0~1]	(4) Study behaviors [0~1]
School days	0.007***	0.007***	0.005*	0.0002
× 2020	(0.003)	(0.002)	(0.003)	(0.005)
	[0.005]	[0.0002]	[0.057]	[0.968]
	{0.010}	{0.001}	{0.076}	{0.968}
Mean of dep var	0.757	0.855	0.800	0.753
Observations	891,514	891,532	891,506	891,431
R-squared	0.021	0.009	0.012	0.029

Notes: Standard errors are clustered at the living zone level and are reported in parentheses. Traditional p-value is reported in bracket and False Discovery Rate (FDR) q-value is reported in curly bracket, following the procedure by Anderson (2008). *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Effects of In-Person School Days on Online Device Usage

Variables	(1) Study (≥ 3 hour/day)	(2) Entertainment (≥ 3 hour/day)	(3) SNS (≥ 3 hour/day)	(4) Search (≥ 3 hour/day)
School days × 2020	-0.009*** (0.003) [0.003] {0.012}	-0.008 (0.005) [0.114] {0.228}	-0.004 (0.003) [0.259] {0.346}	-0.001 (0.002) [0.499] {0.499}
Mean of dep var	0.045	0.160	0.116	0.025
Observations	49,174	49,250	890,832	890,750
R-squared	0.015	0.033	0.026	0.004

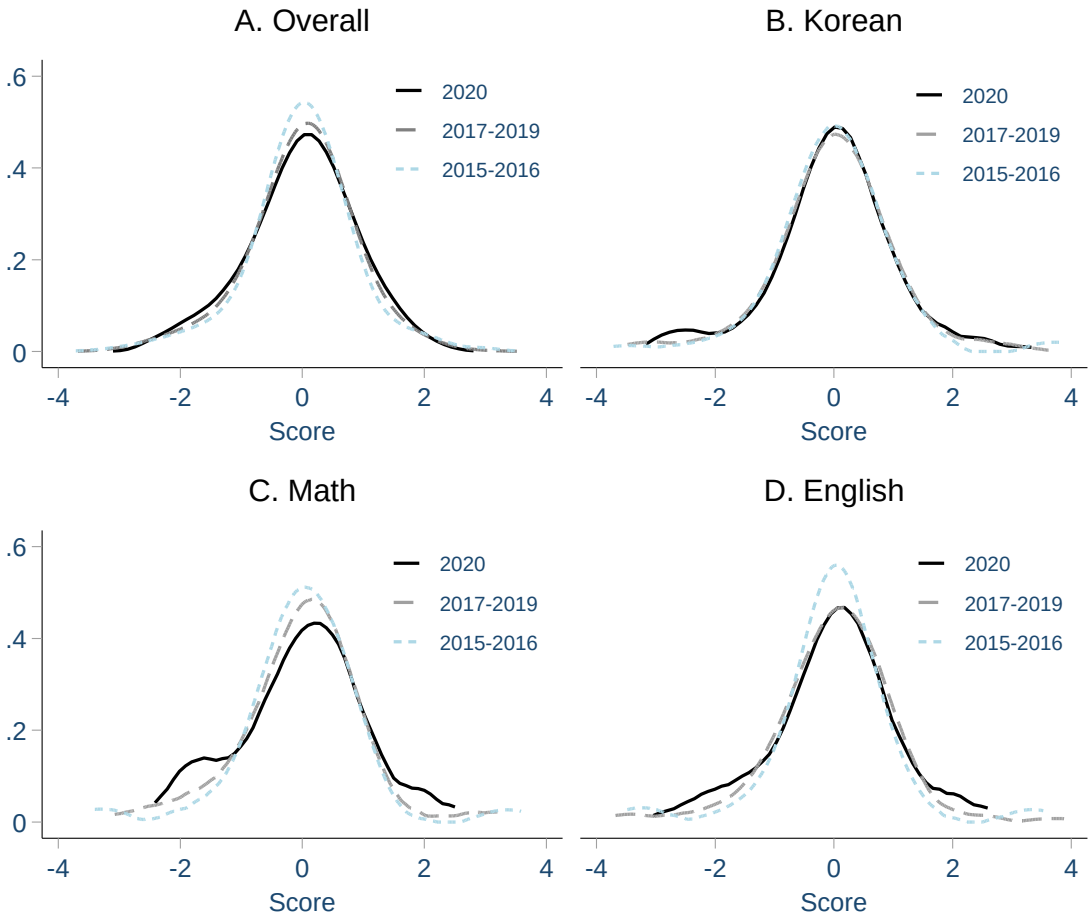
Notes: Data for column 1 and 2 (online device usage for study and entertainment purposes) exists for years 2017–2020. Standard errors are clustered at the living zone level and are reported in parentheses. Traditional p-value is reported in bracket and False Discovery Rate (FDR) q-value is reported in curly bracket, following the procedure by Anderson (2008). *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Effects of In-Person School Days on Time Use

Variables	(1) Talk with parents about friendship (≥ once a week)	(2) Talk with parents about study (≥ once a week)	(3) Leisure time with parents (≥ once a week)	(4) Time on reading (≥ 30 min/day)	(5) Time on exercising (≥ 30 min/day)	(6) Participated in private education [binary]	(7) Watched EBS broadcast [binary]
School days × 2020	-0.002	0.002	-0.003	-0.007*	0.0002	-0.012	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.011)	(0.005)
	[0.609]	[0.642]	[0.410]	[0.066]	[0.956]	[0.279]	[0.040]
	{0.749}	{0.749}	{0.718}	{0.231}	{0.956}	{0.651}	{0.231}
Mean of dep var	0.813	0.746	0.305	0.236	0.563	0.657	0.345
Observations	891,391	891,301	891,178	891,279	890,932	34,481	886,025
R-squared	0.016	0.013	0.014	0.010	0.103	0.028	0.031

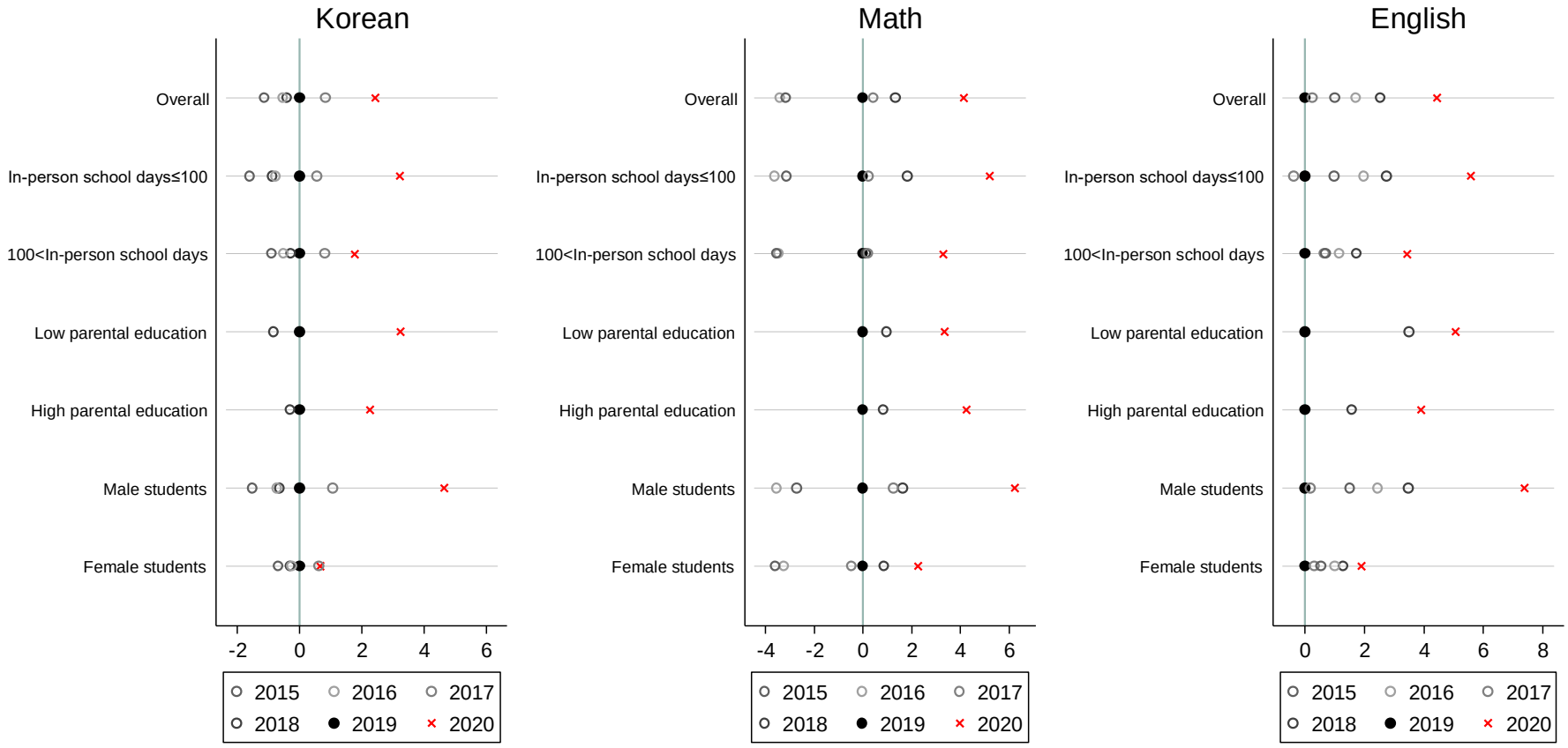
Notes: Data for column 6 (participation in private education) exists for years 2018-2020. Standard errors are clustered at the living zone level and are reported in parentheses. Traditional p-value is reported in bracket and False Discovery Rate (FDR) q-value is reported in curly bracket, following the procedure by Anderson (2008). *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Distributions of Test Scores Before and During the Pademic



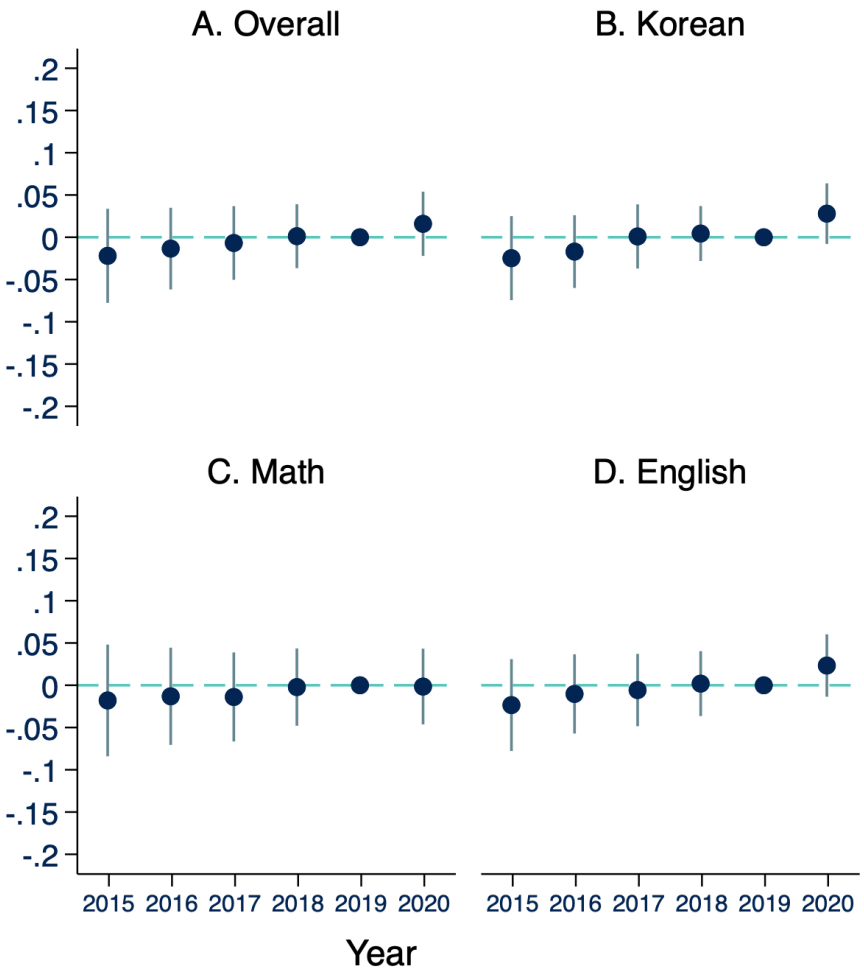
Notes: Each sub-figure plots kernel density plot of the standardized test score by subject (Overall, Korean, Math, and English) and year (2020, 2017–2019, and 2015–2016).

Figure 2: Changes in Failure Rates (%) from 2015 to 2020



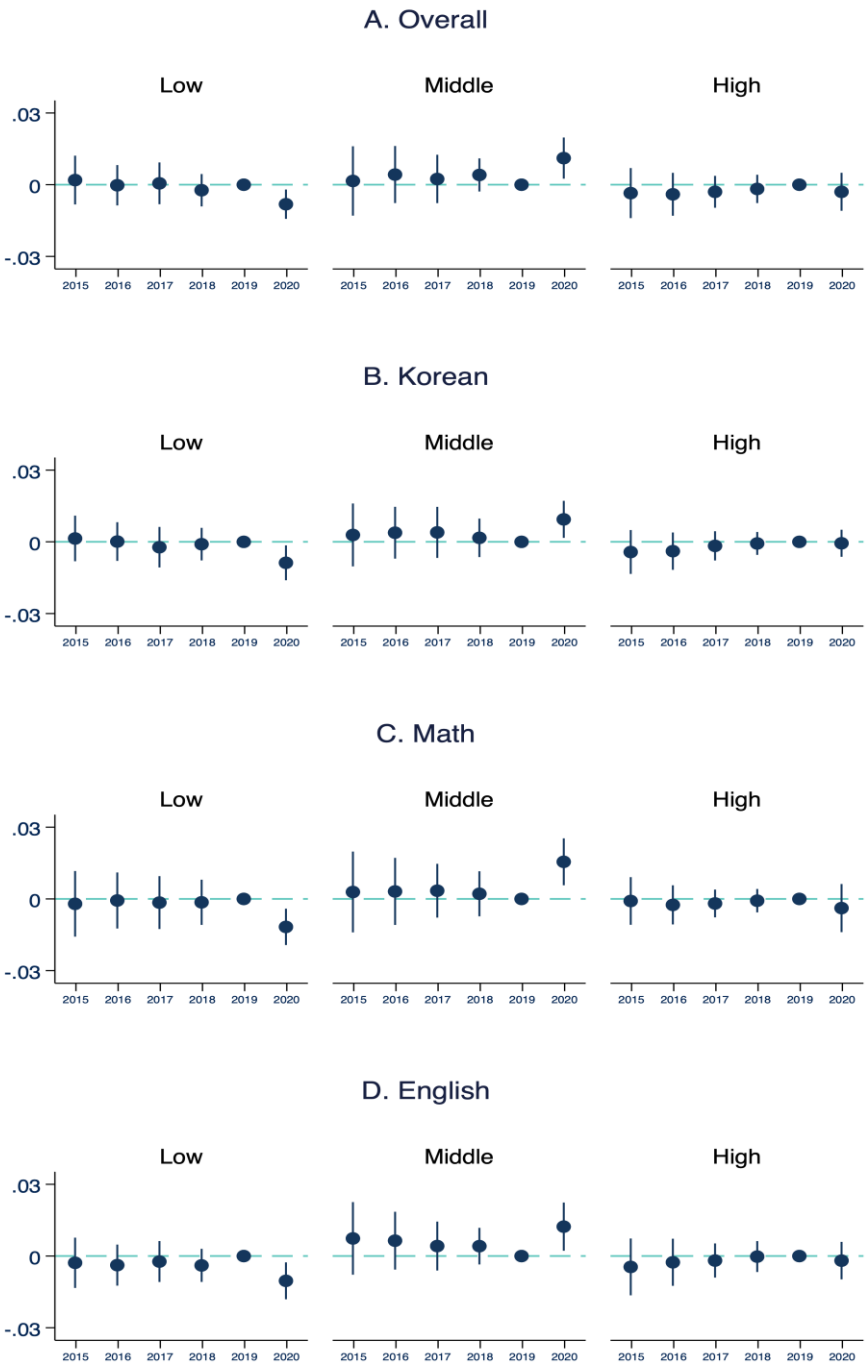
Notes: This figure plots the percentage change difference in failure rate from 2015 to 2020 (base year is 2019). Results are categorized into four categories: excellent, average, poor, and failure. Fail rates in 2020 were 6.2% for Korean, 12.9% for Math, and 8.9% for English. Fail rates in 2019 were 3.8% for Korean, 10.2% for Math, and 4.7% for English.

Figure 3: Effects of In-Person School Days on Test Scores



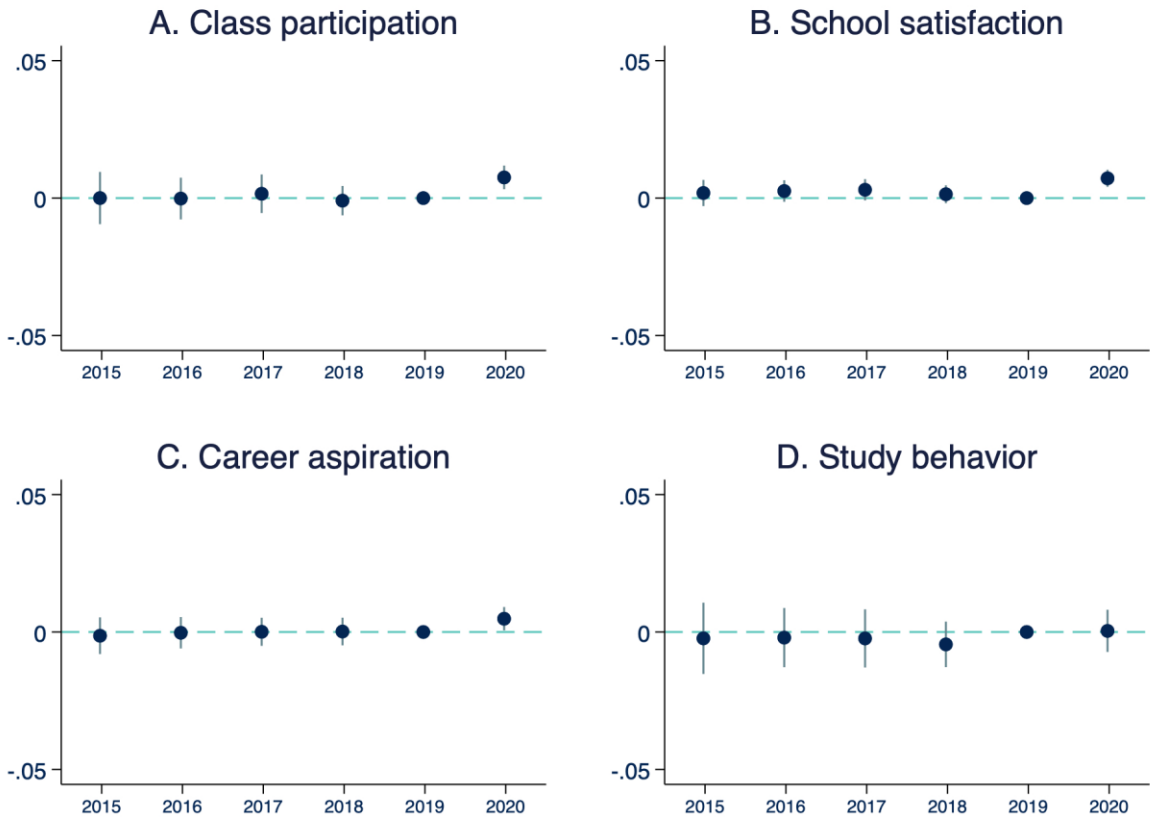
Notes: Each figure plots coefficient estimates (β_τ) with the 90 percent confidence intervals based on equation (1). The robust standard errors clustered at the living zone level.

Figure 4: Effects of In-Person School Days on Test Score Distributions



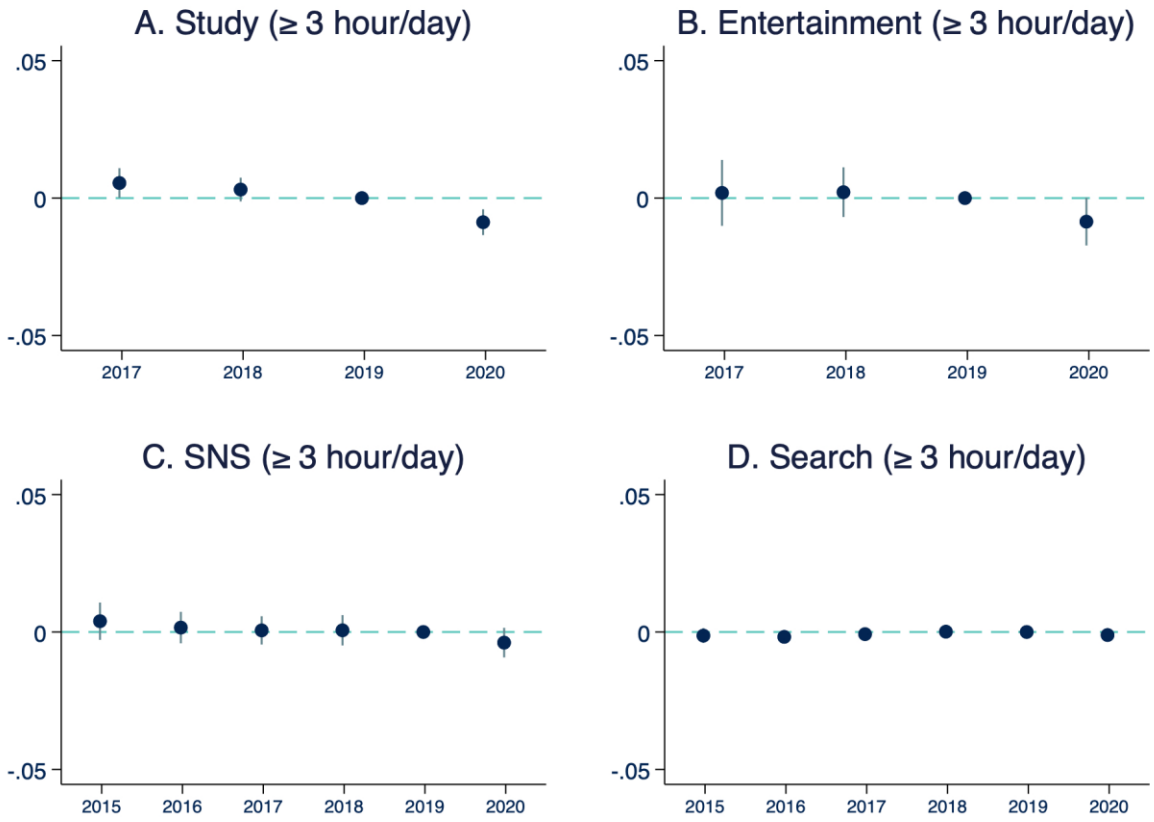
Notes: Each figure plots coefficient estimates (β_τ) with the 90 percent confidence intervals (CIs) based on equation (1). For sub-figure with a heading "Low", outcome is the binary variable indicating whether the standardized test score is below –1.5 SDs. For sub-figure with a heading "Middle", outcome is the binary variable indicating whether the standardized test score is above –1.5 SDs and below 1.5 SDs. For sub-figure with a heading "High", outcome is the binary variable indicating whether the standardized test score is above 1.5 SDs. Robust standard errors clustered at the living zone level.

Figure 5: Effects of In-Person School Days on Noncognitive Traits



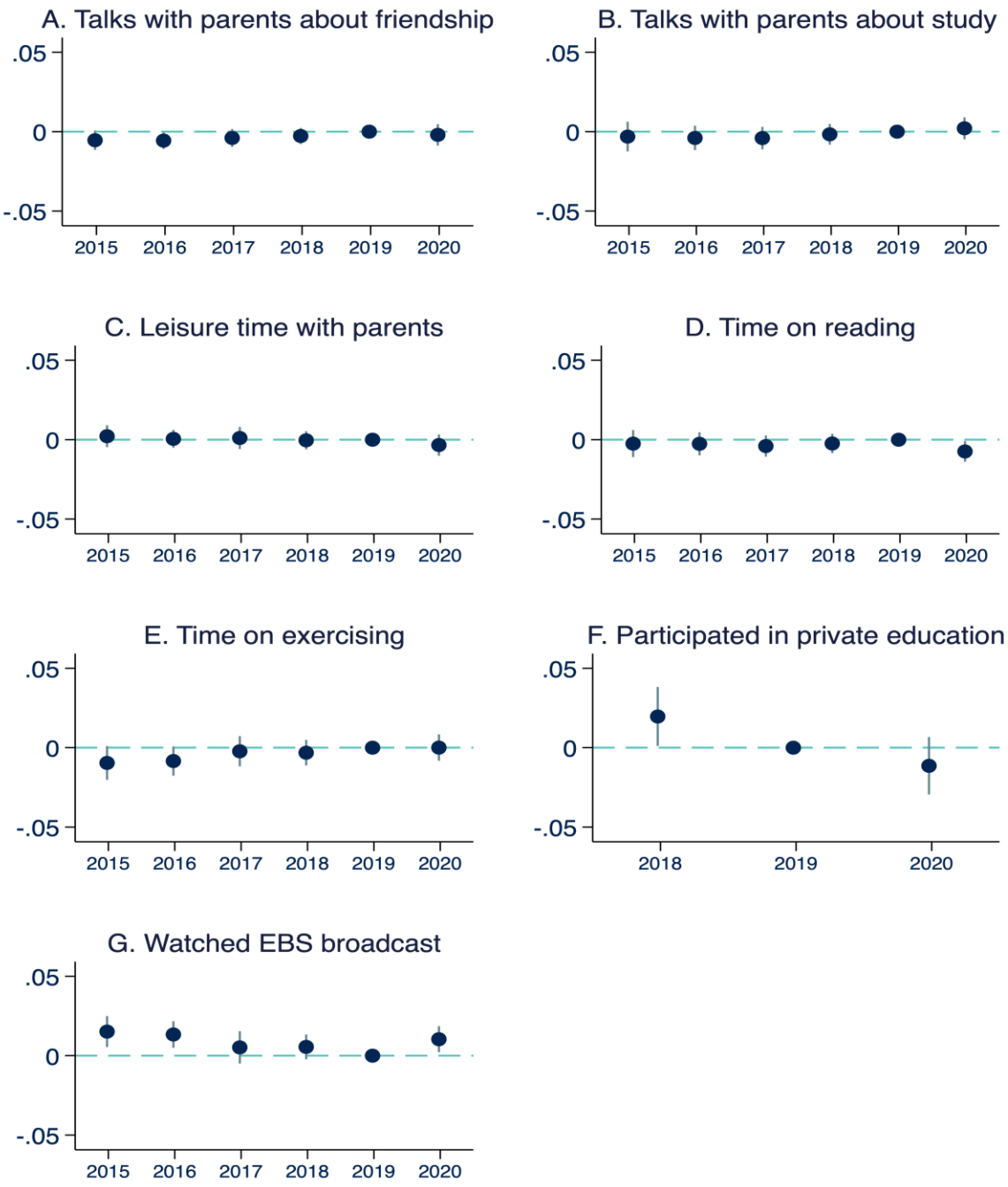
Notes: Each sub-figure plots the coefficient estimates of the interaction between school days and year dummies (with 2019 as the base year) from separate regressions, with other outcomes (as reported in Table 4) as the outcome. The vertical line represents the 90 percent confidence intervals (CIs), calculated with the robust standard errors clustered at the living zone level.

Figure 6: Effects of In-Person School Days on Online Device Usage



Notes: Each sub-figure plots the coefficient estimates of the interaction between school days and year dummies (with 2019 as the base year) from separate regressions, with other outcomes (as reported in Table 4) as the outcome. The vertical line represents the 90 percent confidence intervals (CIs), calculated with the robust standard errors clustered at the living zone level.

Figure 7: Effects of In-Person School Days on Time Use



Notes: Each sub-figure plots the coefficient estimates of the interaction between school days and year dummies (with 2019 as the base year) from separate regressions, with other outcomes (as reported in Table 4) as the outcome. The vertical line represents the 90 percent confidence intervals (CIs), calculated with the robust standard errors clustered at the living zone level.

Appendix Tables and Figures

Table A1: Description of the Variables

Variables	Description
Class participation	This variable is created by taking the average of the four dummy variables, where each dummy variable takes value 1 if the student "strongly agree" or "agree", and 0 if "strongly disagree" or "disagree" to the following questions. Whether the student (1) takes good care of the study materials and supplies necessary for class; (2) tends to focus in class; (3) asks questions in class (4) actively participates in class activities such as discussion and lab experiments.
School satisfaction	This variable is created by taking the average of seven dummy variables, where each dummy variable takes value 1 if the student "strongly agree" or "agree", and 0 if "strongly disagree" or "disagree" to the following questions. Whether the student (1) earns recognition from his/her teacher; (2) has a teacher nearby who is kind and is interested in the student; (3) gets along well with his/her friends; (4) has a close friend to discuss issues in mind; (5) is performing well in school; (6) enjoys going to school; (7) feels oneself is improving by attending in school.
Career aspiration	This variable is created by taking the average of six dummy variables, where each dummy variable takes value 1 if the student "strongly agree" or "agree", and 0 if "strongly disagree" or "disagree" to the following questions. Whether the student (1) has clear career goals; (2) knows one's interest and strength by school activities, hobbies, and volunteer work; (3) considers one's will more than the opinion of people nearby (parents, siblings, teachers) when choosing his/her future career; (4) searches the required information in choosing one's career ; (5) clearly knows which jobs exist in the field one is interested in; (6) can distinguish the strength and weakness of the career path one plans to pursue.
Study behaviors	This variable is created by taking the average of three dummy variables, where each dummy variable takes value 1 if the student "strongly agree" or "agree", and 0 if "strongly disagree" or "disagree" to the following questions. Whether the student (1) can clearly distinguish the important information from what one has learned in class; (2) can connect the newly learnt knowledge in class to one's own thoughts; (3) can easily organize important information to better comprehend when studying.
Online device usage (3h) – Study	= 1 if the student spends at least three hour per day engaging in the following activity, = 0 if one spends less than three hour a day: studying (e.g. participating in online classes or online study materials)
Online device usage (3h) - Entertainment	= 1 if the student spends at least three hour per day engaging in the following activity, = 0 if one spends less than three hour a day: Leisure (e.g. playing games, listening to music, or watching videos)
Online device usage (3h) - Social media	= 1 if the student spends at least three hour per day engaging in the following activity, = 0 if one spends less than three hour a day: Communication (e.g. chatting or social media)
Online device usage (3h) - Search	= 1 if the student spends at least three hour per day engaging in the following activity, = 0 if one spends less than three hour a day: Search on current issues (e.g. searching on information one is interested in, including the news and new information)
Talk to parents about friendship	= 1 if the student engages in the following activity at least one or two times a week, = 0 if engages less than once or twice a month: have a conversation with parents on school life and friends.

Talk to parents about study	= 1 if the student engages in the following activity at least one or two times a week, = 0 if engages less than once or twice a month: have a conversation with parents on study.
Leisure time with parents	=1 if the student engages in the following activity at least one or two times a week, = 0 if engages less than once or twice a month: spend one's leisure time with his/her parents.
Spend time on reading	= 1 if the student spends at least 30 minutes a day engaging in the following activity, = 0 if one engages less than 30 minutes a day: reading books as hobby
Spend time on exercising	= 1 if the student engages in the following activity at least one or two times a week, = 0 if engages less than once or twice a month: exercise (excluding the exercise class hours in school)
Participate in private Education	= 1 if the student participates in private education on at least one subject (Korean, Math, English), = 0 if one does not participate at all.
Watched EBS broadcast	= 1 if the student watches classes provided by Korea's Education Broadcast System on at least one subject (Korean, Math, English), = 0 if one does not participate at all.

Notes: This table describes the definition of the outcome variables reported in Tables 4–6.

Table A2: Explaining Variation in School Days

	(1)	(2)
Parent's education (College diploma or higher)	20.25**	4.142
	(8.181)	(5.744)
Proportion of female students	11.05	-4.664
	(9.528)	(6.007)
Number of Students	-0.106***	-0.034***
	(0.021)	(0.008)
Public School	-1.874	1.684
	(2.623)	(1.790)
Autonomous School	1.981	-2.330
	(6.053)	(3.851)
Public*Autonomous Dummy	-4.420	-0.333
	(6.905)	(4.045)
Female School	-0.930	1.263
	(5.459)	(3.412)
Male School	8.697	-2.110
	(5.480)	(3.456)
Metropolitan City	-11.01**	6.076*
	(4.438)	(3.208)
Small town	-5.335	-1.671
	(3.571)	(1.837)
COVID-19 cases	-0.010	-0.003
	(0.010)	(0.003)
Living zone fixed effects	No	Yes
Observations	209	209
R-squared	0.364	0.906

Notes: This table shows the results from a regression where the outcome is the number of in-person school days in 2020. Column (1) reports the results without living zone fixed effects and column (2) reports the results after controlling for the living zone fixed effects. The independent variables are the average values at the school level using 2020 data.

Table A3: Effect of In-Person School Days on Test Scores and Distributions by Parental Education and Gender

Outcomes	(1) Low parental education	(2) High parental education	(3) Boys	(4) Girls
Panel A: Test scores				
Overall score	0.0357	-0.0135	0.0191	-0.00136
	(0.0299)	(0.0451)	(0.0306)	(0.0186)
Korean	0.0724**	0.00328	0.0408	-0.00343
	(0.0358)	(0.0436)	(0.0288)	(0.0204)
Math	-0.00335	-0.0408	-0.00337	-0.00841
	(0.0355)	(0.0528)	(0.0354)	(0.0218)
English	0.0409	0.000257	0.0240	0.00689
	(0.0288)	(0.0421)	(0.0298)	(0.0185)
Panel B: Test score distributions				
P(Overall <=-1.5 SD)	-0.0111	-0.0123**	-0.0139**	-0.00164
	(0.0109)	(0.00604)	(0.00567)	(0.00257)
P(Korean <=-1.5 SD)	-0.0174	-0.0104*	-0.0145**	-0.00226
	(0.0110)	(0.00619)	(0.00643)	(0.00254)
P(Math <=-1.5 SD)	-0.0149*	-0.00668	-0.0150**	-0.00784*
	(0.00829)	(0.00814)	(0.00709)	(0.00439)
P(English <=-1.5 SD)	-0.0191*	-0.0108*	-0.0182***	-0.000565
	(0.0101)	(0.00625)	(0.00674)	(0.00257)
P(-1.5 SD<Overall <1.5 SD)	0.0124	0.0193*	0.0178***	0.00598
	(0.0126)	(0.0109)	(0.00567)	(0.00704)
P(-1.5 SD<Korean <1.5 SD)	0.0204	0.0146**	0.0167***	0.00348
	(0.0125)	(0.00646)	(0.00507)	(0.00585)
P(-1.5 SD<Math <1.5 SD)	0.0211	0.0103	0.0221***	0.00880
	(0.0130)	(0.0121)	(0.00721)	(0.00804)
P(-1.5 SD<English <1.5 SD)	0.0128	0.0130	0.0193***	0.00577
	(0.0104)	(0.0107)	(0.00682)	(0.00680)
P(Overall>1.5 SD)	-0.00128	-0.00698	-0.00392	-0.00434
	(0.00412)	(0.0115)	(0.00512)	(0.00614)
P(Korean>1.5 SD)	-0.00301	-0.00417	-0.00217	-0.00122
	(0.00446)	(0.00713)	(0.00364)	(0.00487)
P(Math>1.5 SD)	-0.00614	-0.00362	-0.00715	-0.000961
	(0.00767)	(0.0136)	(0.00844)	(0.00579)
P(English>1.5 SD)	0.00631	-0.00216	-0.00113	-0.00521
	(0.00405)	(0.0114)	(0.00505)	(0.00582)

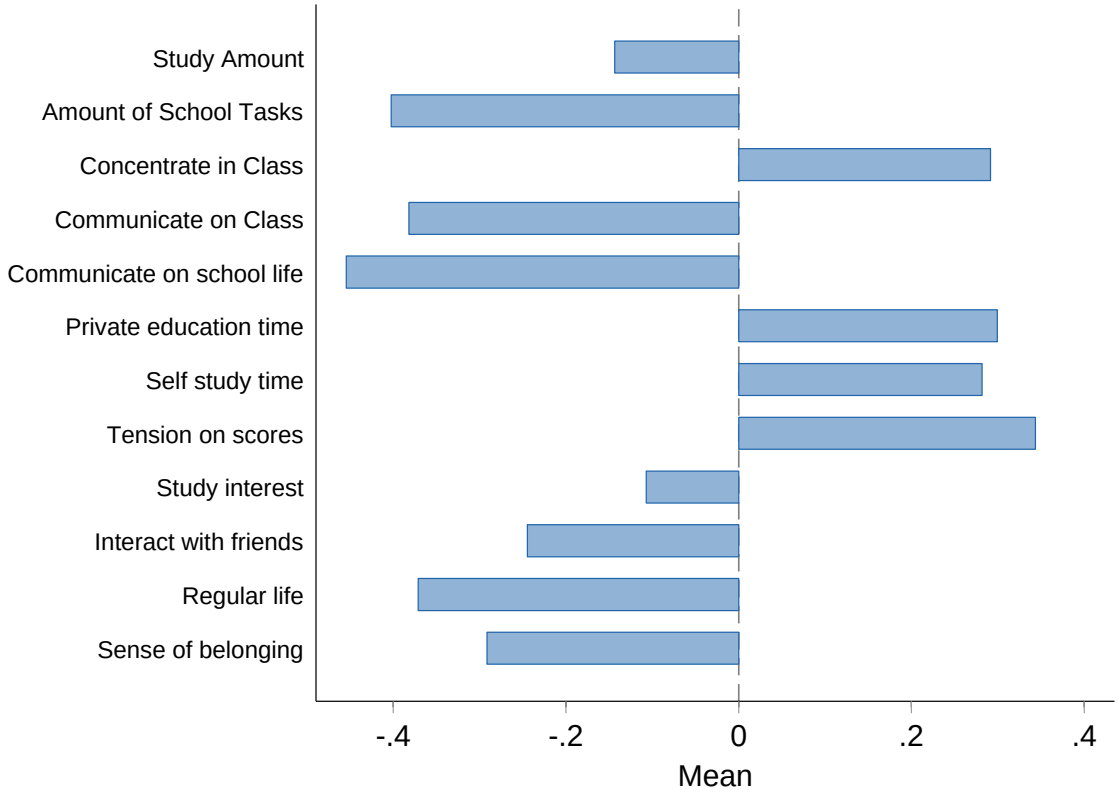
Notes: Each cell represents the estimates on school days interacted with the year 2020 indicator (as per eq. 1) from separate regressions for sub-samples of students, divided by parental level of education and gender. Standard errors are clustered at the living zone level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Effect of In-Person School Days on Noncognitive Tratis and Time Use by Parental Education and Gender

Outcomes	(1) Low parental education	(2) High parental education	(3) Boys	(4) Girls
Panel A: Noncognitive traits				
Class participation	0.00771	0.00425	0.0110***	0.00444
	(0.00958)	(0.00502)	(0.00280)	(0.00414)
School satisfaction	0.00646	0.00654*	0.0101***	0.00492*
	(0.00599)	(0.00350)	(0.00275)	(0.00290)
Career aspiration	0.00501	0.00390	0.00601**	0.00224
	(0.00584)	(0.00497)	(0.00300)	(0.00396)
Study behaviors	0.00151	0.00120	-0.00223	0.00244
	(0.0103)	(0.00656)	(0.00638)	(0.00498)
Panel B: Online device usage				
Study(>=3 hours/day)	-0.0321***	-0.00636	-0.00798**	-0.0121***
	(0.00716)	(0.00400)	(0.00390)	(0.00450)
Entertainment(>=3 hours/day)	-0.0151	0.00313	-0.0126*	-0.00166
	(0.0152)	(0.00807)	(0.00712)	(0.00577)
SNS(>=3 hours/day)	-0.000477	-0.00310	-0.0114***	0.00680
	(0.0120)	(0.00513)	(0.00316)	(0.00408)
Search(>=3 hours/day)	-0.00382	0.000204	-0.000735	-0.000813
	(0.00561)	(0.00263)	(0.00215)	(0.00179)
Panel C: Time use				
Talk with parents about friendship	-0.00137	-0.0125	-0.00191	-0.00553
(≥ once a week)	(0.0107)	(0.00760)	(0.00524)	(0.00458)
Talk with parents about study	0.00354	-0.00204	0.00962**	-0.00881
(≥ once a week)	(0.0132)	(0.00770)	(0.00477)	(0.00558)
Leisure time with parents	0.00555	-0.000719	-0.00437	-0.00202
(≥ once a week)	(0.0144)	(0.00932)	(0.00697)	(0.00541)
Time on reading	0.00227	-0.00444	-0.00405	-0.00789
(≥ 30 min/day)	(0.0149)	(0.00700)	(0.00512)	(0.00552)
Time on exercising	0.00123	-0.00300	-0.00273	-0.00213
(≥ 30 min/day)	(0.0137)	(0.0136)	(0.00641)	(0.00745)
Participated in private education	-0.0177	-0.00954	-0.0105	-0.00743
[binary]	(0.0151)	(0.00997)	(0.0153)	(0.0141)
Watched EBS broadcast	-0.0145	0.00982	0.00255	0.0221***
[binary]	(0.0132)	(0.0103)	(0.00748)	(0.00673)

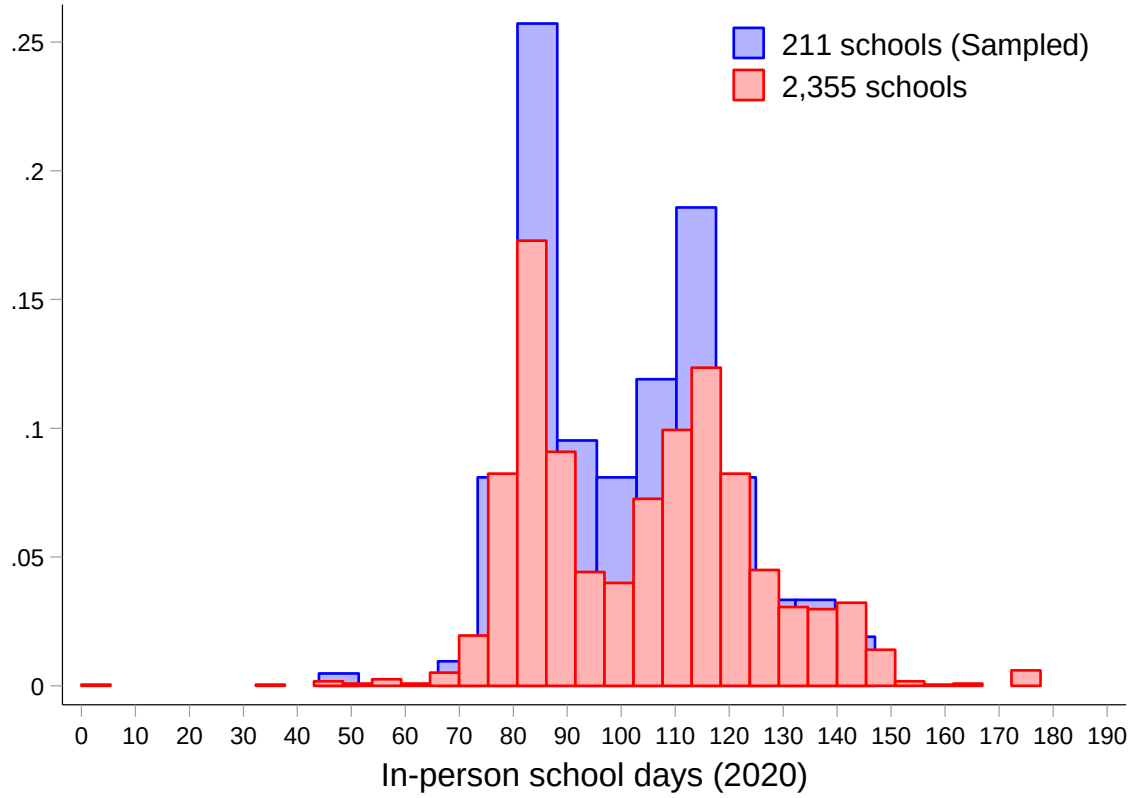
Notes: Each cell represents the estimates on school days interacted with the year 2020 indicator (as per eq. 1) from separate regressions for sub-samples of students, divided by parental level of education and gender. Standard errors are clustered at the living zone level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure A1: Remote Class Environment Survey Results (2020)



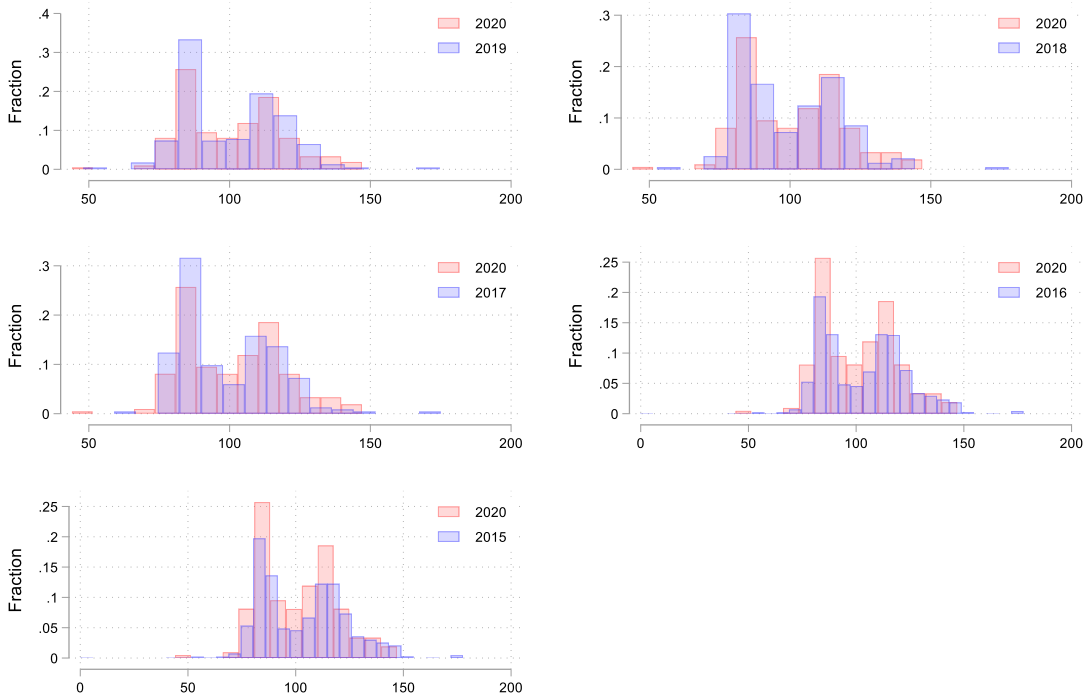
Notes: This figure summarizes how students' perceived learning environment has changed between 2019 and 2020. The students are asked to evaluate their perception on remote class environment in 2020 relative to in-person class in 2019 for each category, such as study amount, amount of school tasks, etc. Student's answer is coded as –1, 0, 1 if the student responded as decrease, same, and increase, respectively. The figure shows the average value of a student's response to each category. For instance, a negative value for the 'study amount' indicates that higher number of students perceived the study amount to decrease in remote class environment in 2020 relative to the study amount in-person class environment in 2019.

Figure A2: Comparison between Full Sample and Sample in 2020



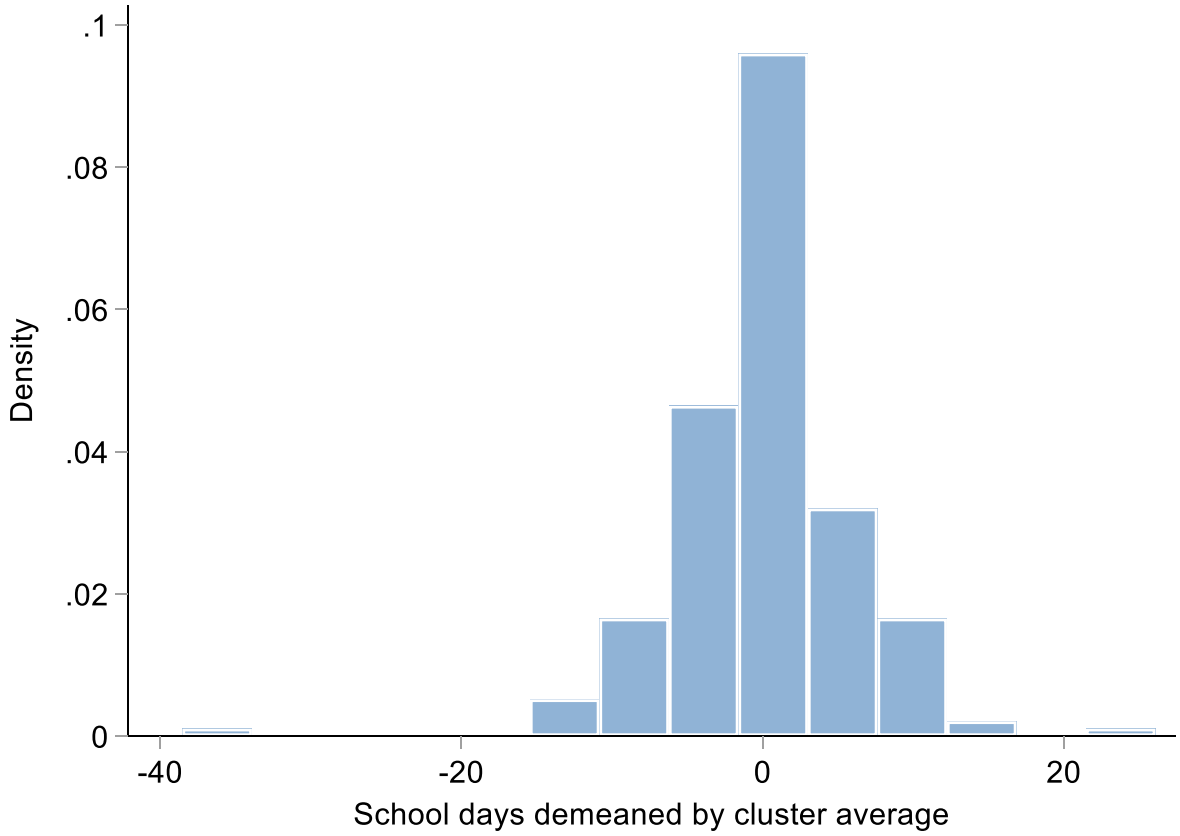
Notes: This figure shows the distribution of the school days in 2020, for sampled schools in 2020 and for all schools in 2020.

Figure A3: Distributions of School Days



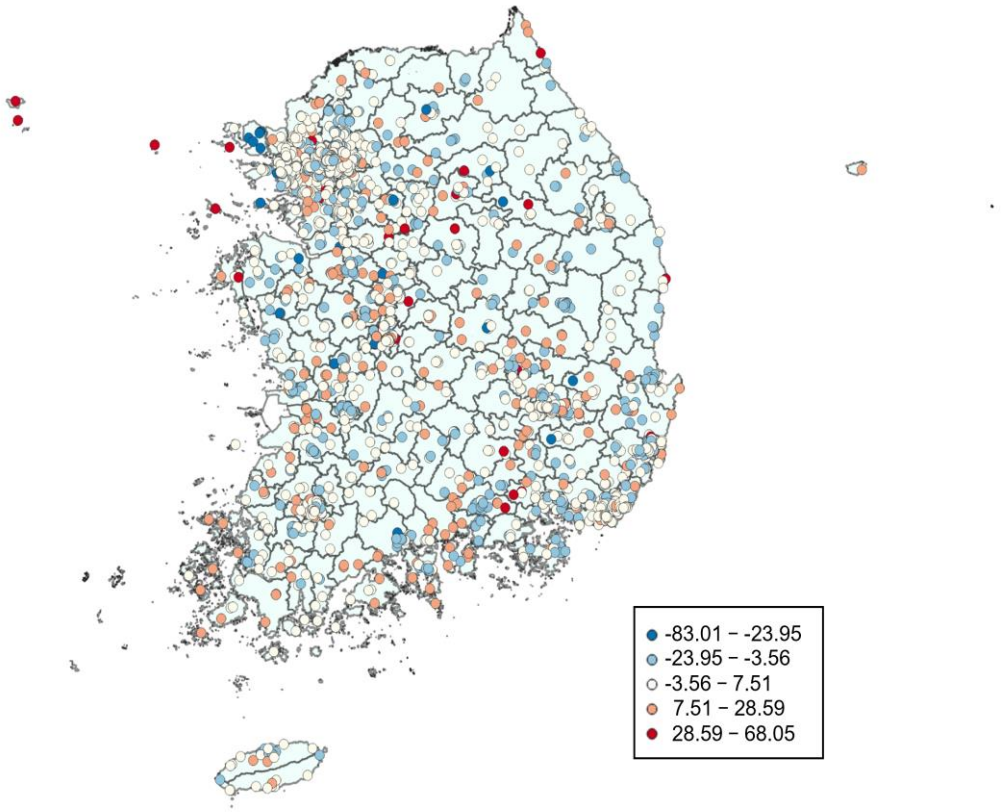
Notes: Each sub-figure shows the distribution of the school days in our sample, comparing schools sampled in 2020 and schools sampled in earlier years (2015–2019).

Figure A4: In-Person School Days



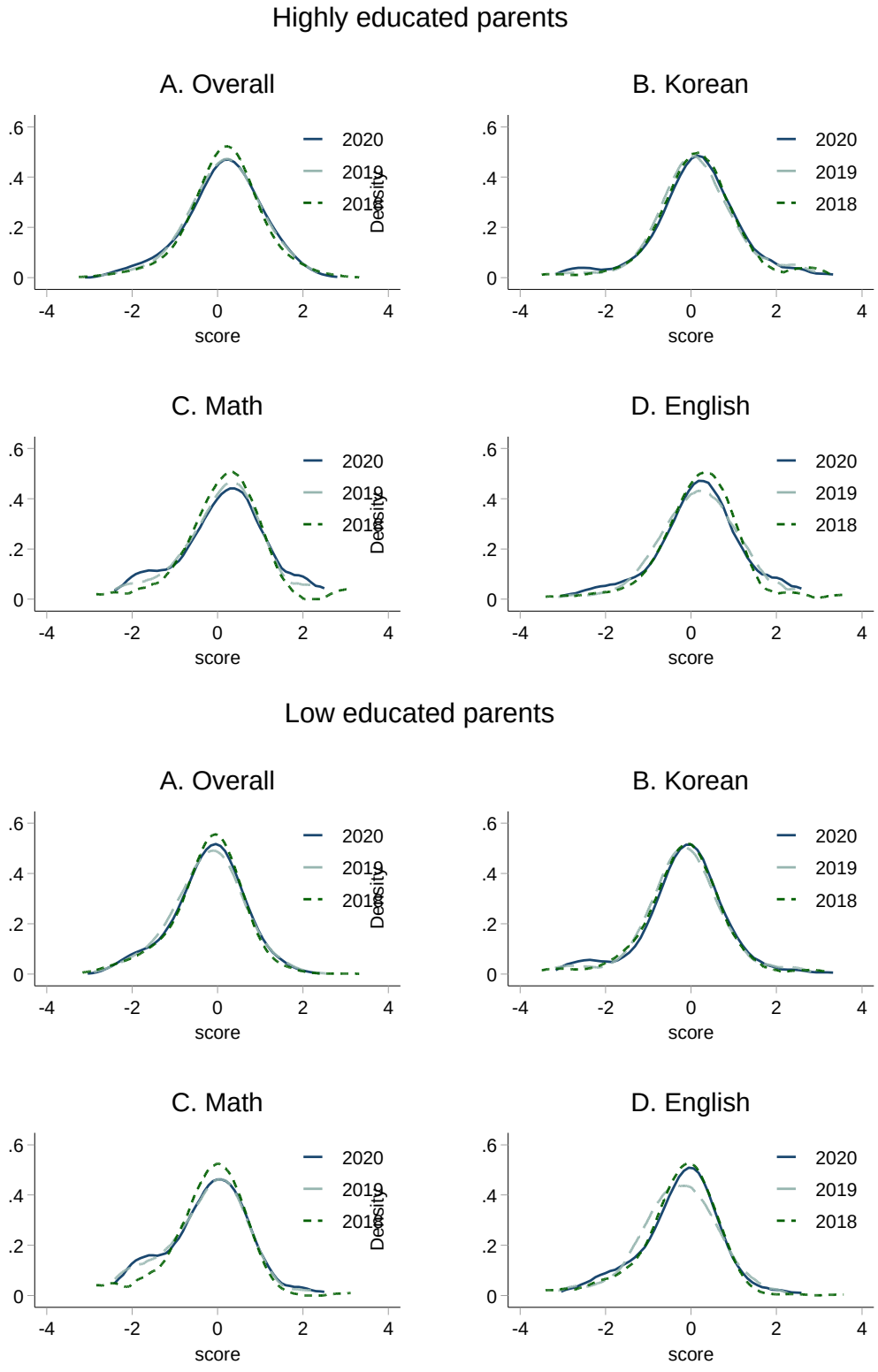
Notes: This figure shows the distribution of the school days in 2020, after taking out average school days at the living zone level.

Figure A5: Number of In-Person School Days in South Korea by Region



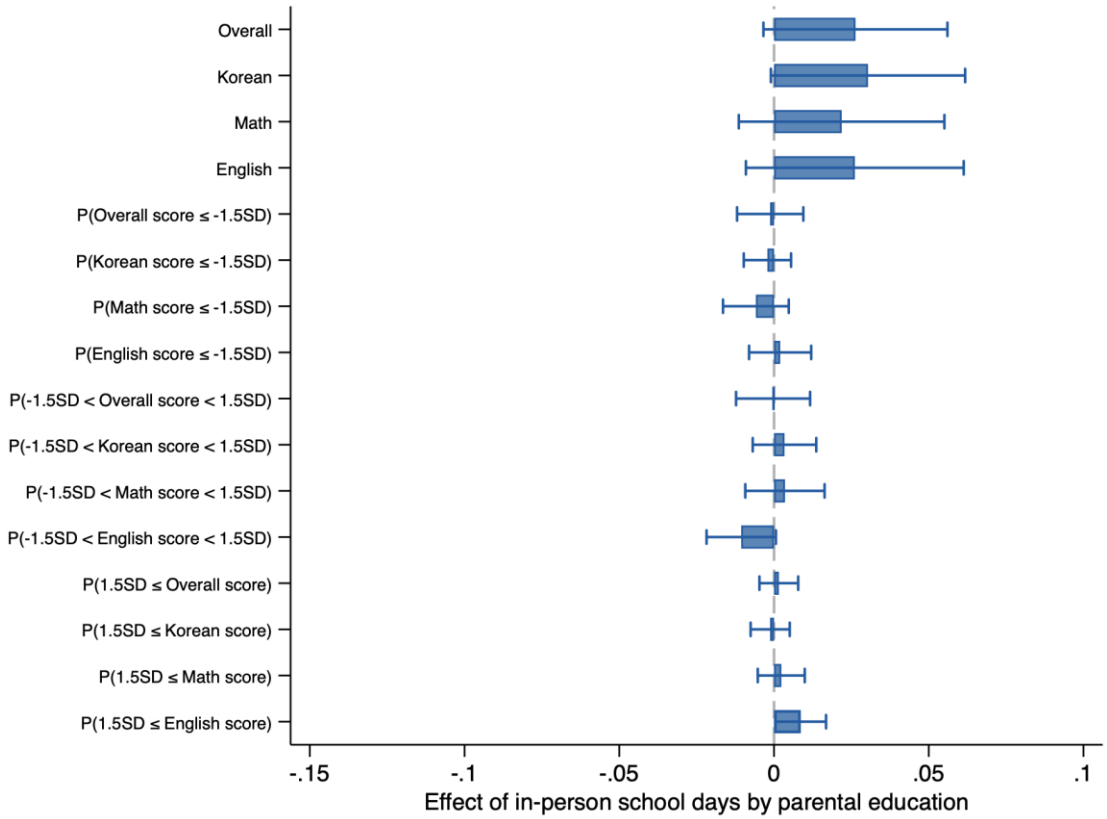
Notes: The dots represent the residual in-person school days in 2020, de-meaned by living zone clusters (n=57). The dot colors represent the quintile categories for the demeaned in-person school days, from blue (smallest school day residual) to red (largest school day residual).

Figure A6: Distributions of Test Scores by Parental Education



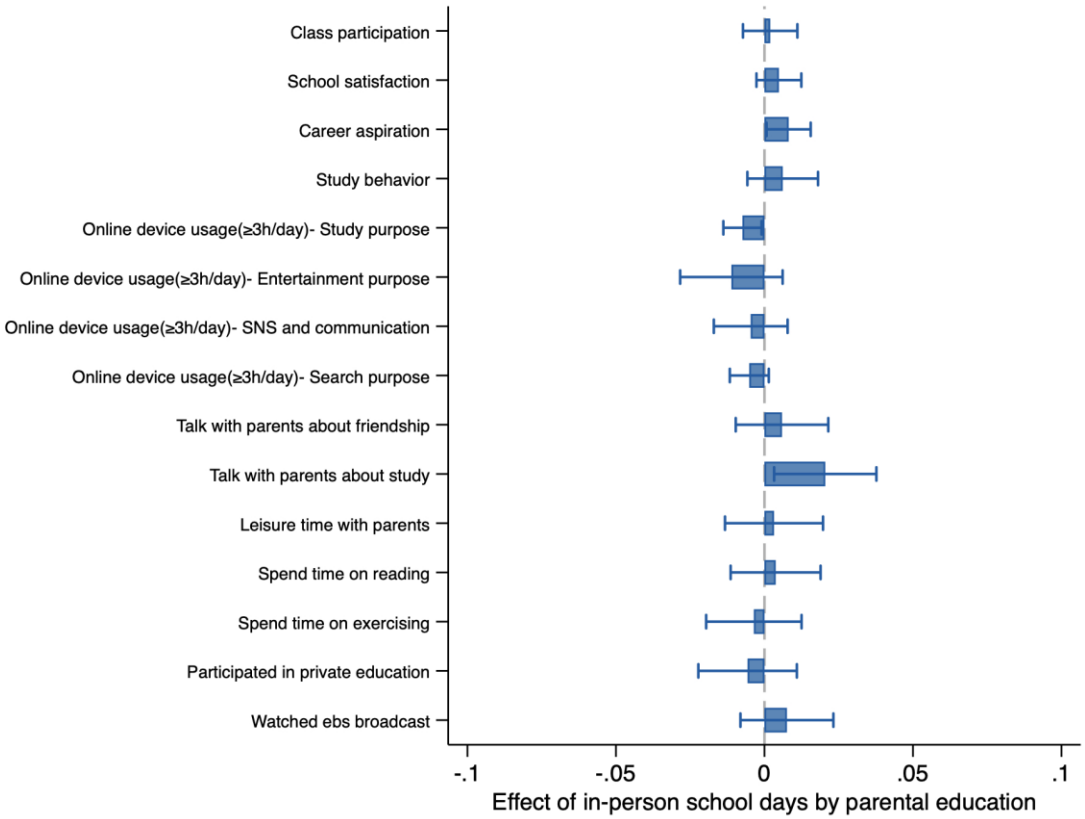
Notes: Each sub-figure plots kernel density plot of the standardized test score by subject (Overall, Korean, Math, and English) and year (2020, 2017–2019, and 2015–2016). The upper panel is drawn using the sample of students with highly educated parents and the lower panel is for low educated parents.

Figure A7: Effects of In-Person School Days on Test Scores and Distributions by Parental Education



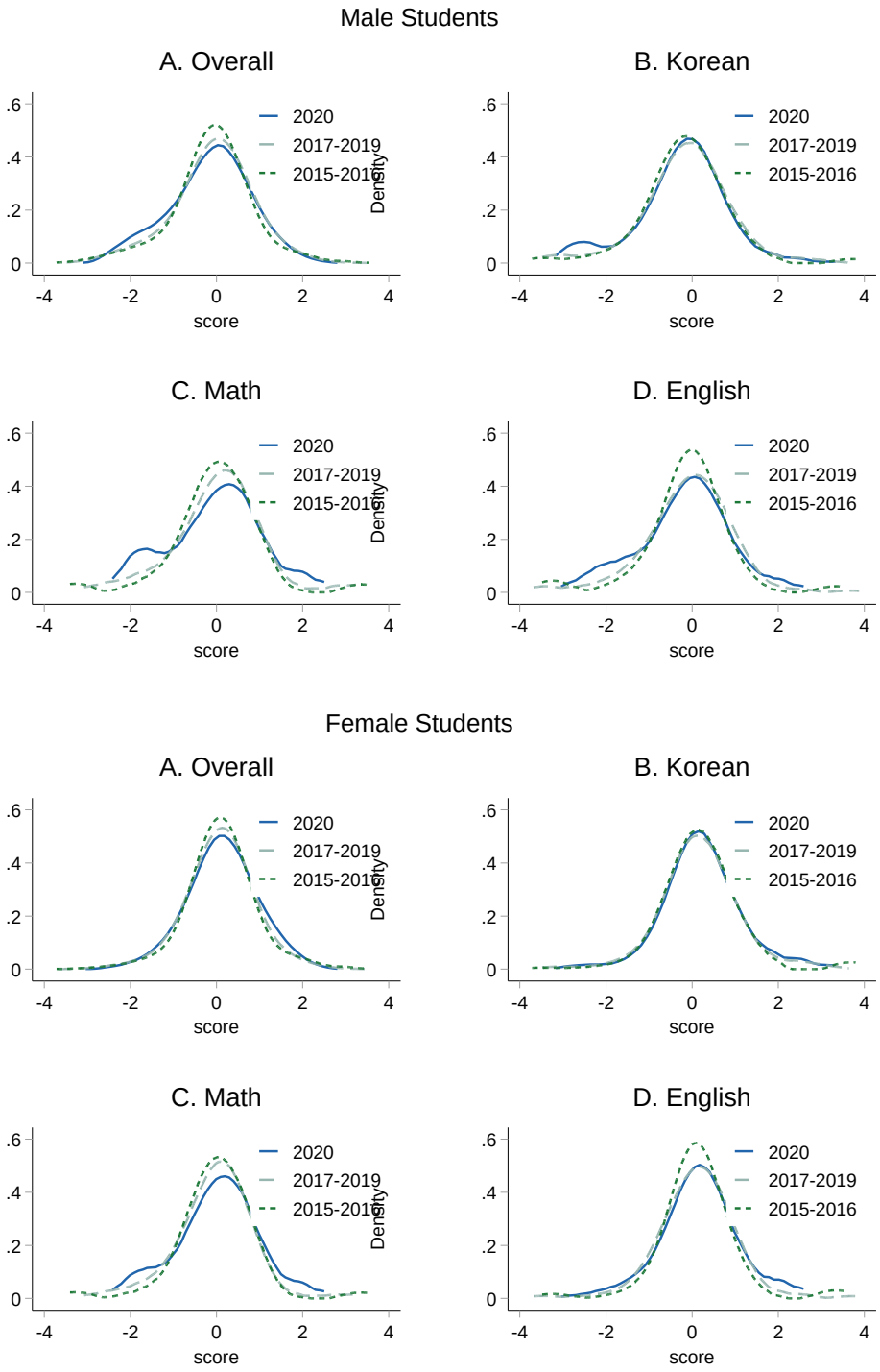
Notes: This figure plots the estimated coefficient on the triple interaction term between an indicator of low parental education, in-person school days, and the pandemic year of 2020. The 90 percent CIs are calculated with robust standard errors clustered at the living zone level.

Figure A8: Effects of In-Person School Days on School Participation and Satisfaction, Online Device Usage, Time use by Parental Education



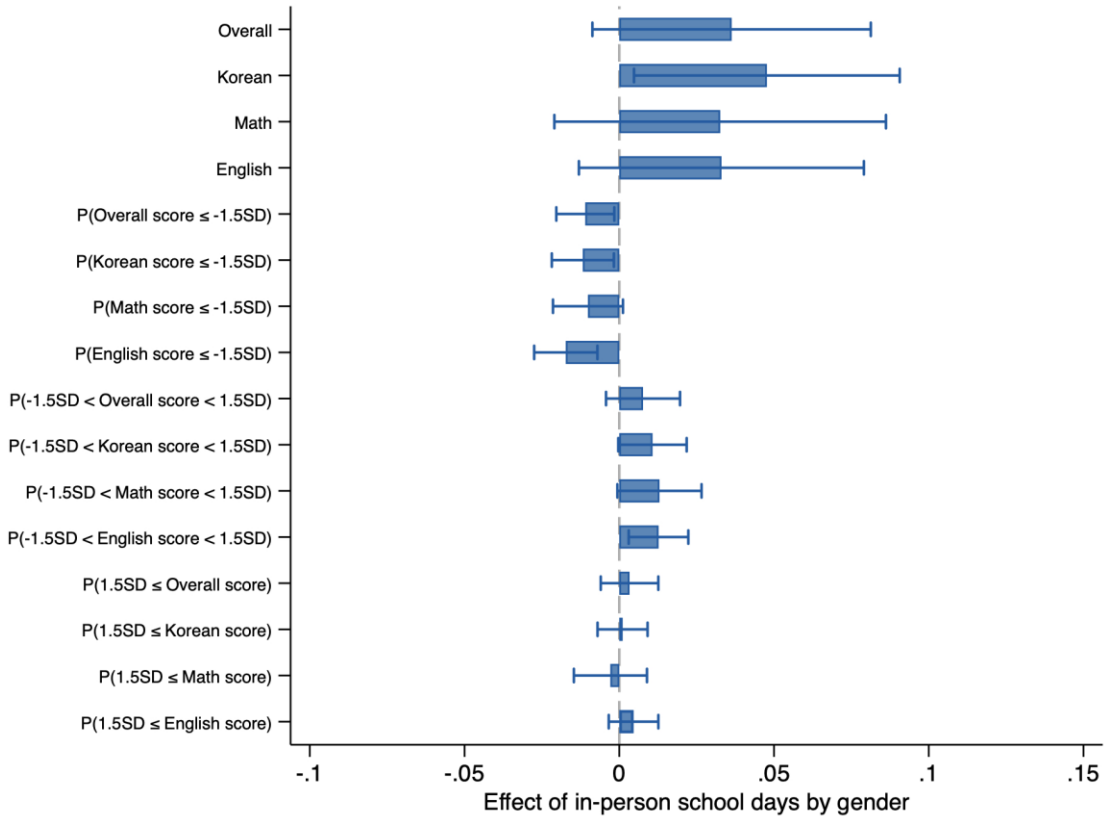
Notes: This figure plots the estimated coefficient on the triple interaction term between an indicator of low parental education, in-person school days, and the pandemic year of 2020. The 90 percent CIs are calculated with robust standard errors clustered at the living zone level.

Figure A9: Distributions of Test Scores by Gender



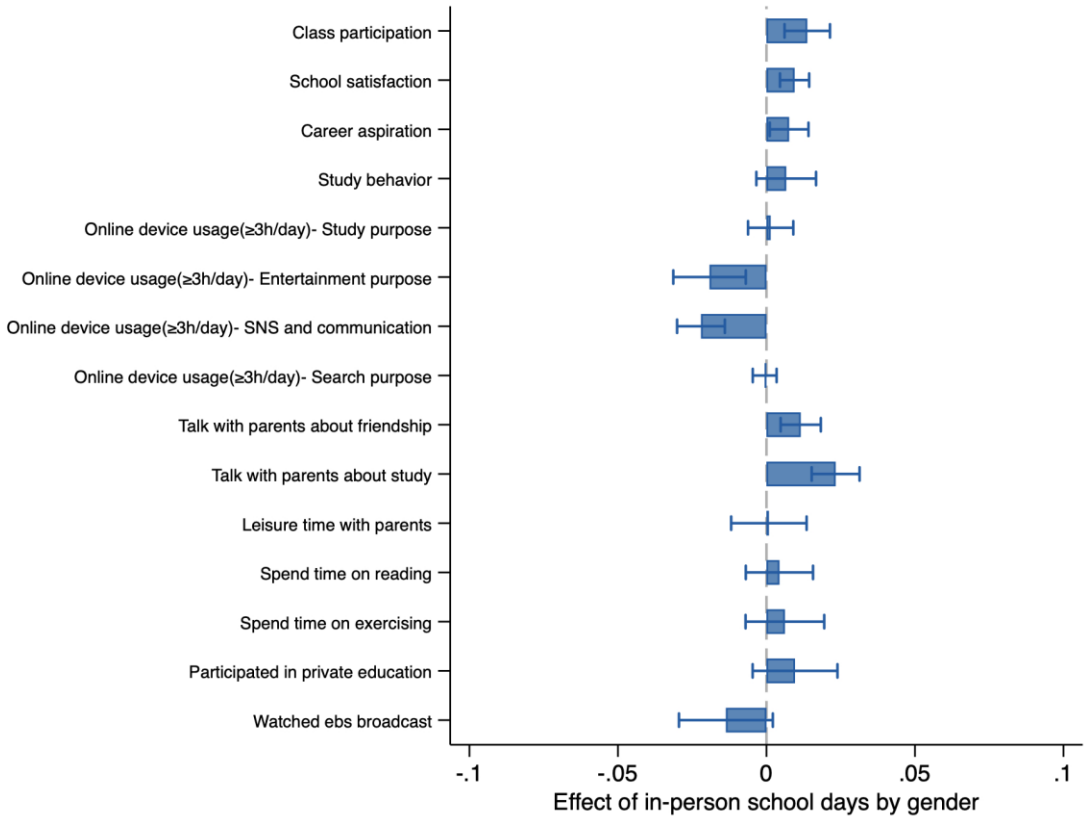
Notes: Each sub-figure plots kernel density plot of the standardized test score by subject (Overall, Korean, Math, and English) and year (2020, 2017–2019, and 2015–2016). The upper panel is drawn using the sample of male students and the lower panel is using female students.

Figure A10: Effects of In-Person School Days on Test Scores and Distributions by Gender



Notes: This figure plots the estimated coefficient on the triple interaction term between an indicator of male students, in-person school days, and the pandemic year of 2020. The 90 percent CIs are calculated with robust standard errors clustered at the living zone level.

Figure A11: Effects of In-Person School Days on School Participation and Satisfaction, Online Device Usage, Time Use by Gender



Notes: This figure plots the estimated coefficient on the triple interaction term between an indicator of male students, in-person school days, and the pandemic year of 2020. The 90 percent CIs are calculated with robust standard errors clustered at the living zone level.