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# EdTech in COVID Korea

## Learning with Inequality

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## Executive Summary

We find that decades of investment in EdTech helped the Republic of Korea avoid the large-scale average declines in student learning during COVID-19 that took place in much of the rest of the world. Based on our analysis of four different student assessments, measuring learning at different grade levels, we find that average student performance stayed about the same despite the widespread shift to hybrid learning during COVID: An assessment of primary school students showed learning gain, while those in middle and high schools demonstrated a small level of learning loss with increasing learning inequality. Korea's economy, society, and education system are fully engaged in the fourth industrial revolution, which helped prepare them for this challenge. However, these same assessment results show that the number of students in the middle of the performance distribution declined, while the number of students at the top and bottom of the distribution increased across many of the assessments for which data are available. This association between increased inequality and EdTech is common in other contexts and is a cause for concern. We present key elements associated with Korea's protection of average levels of learning, including investing in teachers and education personnel, investing in connective infrastructure, developing high-quality learning materials for use online, and maintaining a stable policy environment. Finally, we discuss policy implications for other countries wishing to protect human capital and increase education system resilience.

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## Introduction

Korea has one of the world's most educated workforces and is among the highest-performing countries in international assessments of education and information and communication technology (ICT). In 2020, Korea ranked third globally on the World Bank's Human Capital Index, first in human capital and research, and second in the ICT indexes of World Intellectual Property Organization's Global Innovation Index. The country also ranked first in the E-Participation Index of the UN e-Government Survey 2020, which measures e-government service, telecommunications infrastructure, and human capital. Since introducing the First Master Plan of ICT Education in 1996, Korea's educational informatization has led to educational innovation and progress by embedding ICT into education systems and facilitating digital learning.

Up until now, there have been limited observed gains nationwide in student learning directly linked to Korea's EdTech investments. EdTech has been a key part of the country's education development, but it was an investment that did not necessarily pay returns in terms of increased student learning. The COVID-19 experience demonstrated the power and promise of EdTech to support student learning on a foundation of teacher and staff EdTech skills, high-quality instructional content, and ease of use linked to high internet connectivity.

For this paper, EdTech is defined as the use of hardware, software, digital content, data, and information systems in education following Hawkins et al. (2021). ICTs are defined as information and communication technologies, consisting of hardware, software, networks, and media for collection, storage, processing, transmission, and presentation of information following World Bank (2003).

The COVID-19 outbreak caused a delay in school reopening for the Spring 2020 semester in Korea. With the extended school closure, the government substituted the reopening of schools with online learning, and 99 percent of elementary, middle, and high school students participated in the full-scale online classes (Yonhap News, April 10, 2020). Schools were fully online from April 9 to May 19, 2020 (see Figure 1). Although the national average in Korea, at 352.7 cases per day (as of July 30, 2021), was lower than other Organisation for Economic Co-operation and Development (OECD) countries, some areas, such as Daegu and Gyeongbuk region, were hard hit and designated as a special control area for infectious diseases by the government (Yonhap News, March 9, 2020).

After school reopening on May 20, 2020, the government limited attendance to no more than two-thirds of students based on local social distancing levels and school situation (MOE 2020d); these limits are still in place at the time of writing. The legal number of school days for elementary, middle, and high school students is 190 days per year, and according to the research by the Ministry of Education (MOE), for all of 2020 school year,[1] students nationally on average had more than half of their school days online (Yonhap News, March 16, 2021).

Korean students were learning online for more than half of their school days in the 2020 school year, the period covered by this analysis. The average number of school days with face-to-face classes for elementary school students in 2020 was 92.3 days, while middle schools had 88.1 days and high schools had 104.1 days (Annex 1). There was a large gap between the Seoul Metropolitan Area (Seoul, Gyeonggi-do, and Incheon) and the other regions (Yonhap News, March 9, 2020), resulting from a concentration of COVID cases in the Seoul Metropolitan Area. In 2020, on average, the Seoul area had only 42.4 school days of face-to-face classes for elementary school students, 45.2 days for middle schools, and 84.9 days for high schools, while Jeollanam-do had a significantly higher number at 136.7 days (elementary schools), 133.4 days (middle schools), and 134 days (high schools). Even though other regions had much higher levels of face-to-face instruction than Seoul metro, most of them attended school in person less than 60 percent of the time.

Korea's EdTech ecosystem has shown itself to be resilient, the result of an intentionally designed system with strong human capacity, high levels of investment,[2] and a stable policy environment. While this is a 'first draft of history', and further evidence will inform subsequent analysis, it appears that the government's long-term investment in EdTech acted as an insurance policy that paid off in protecting student learning during the pandemic in combination with other

1 The Korean academic year is from March to December.

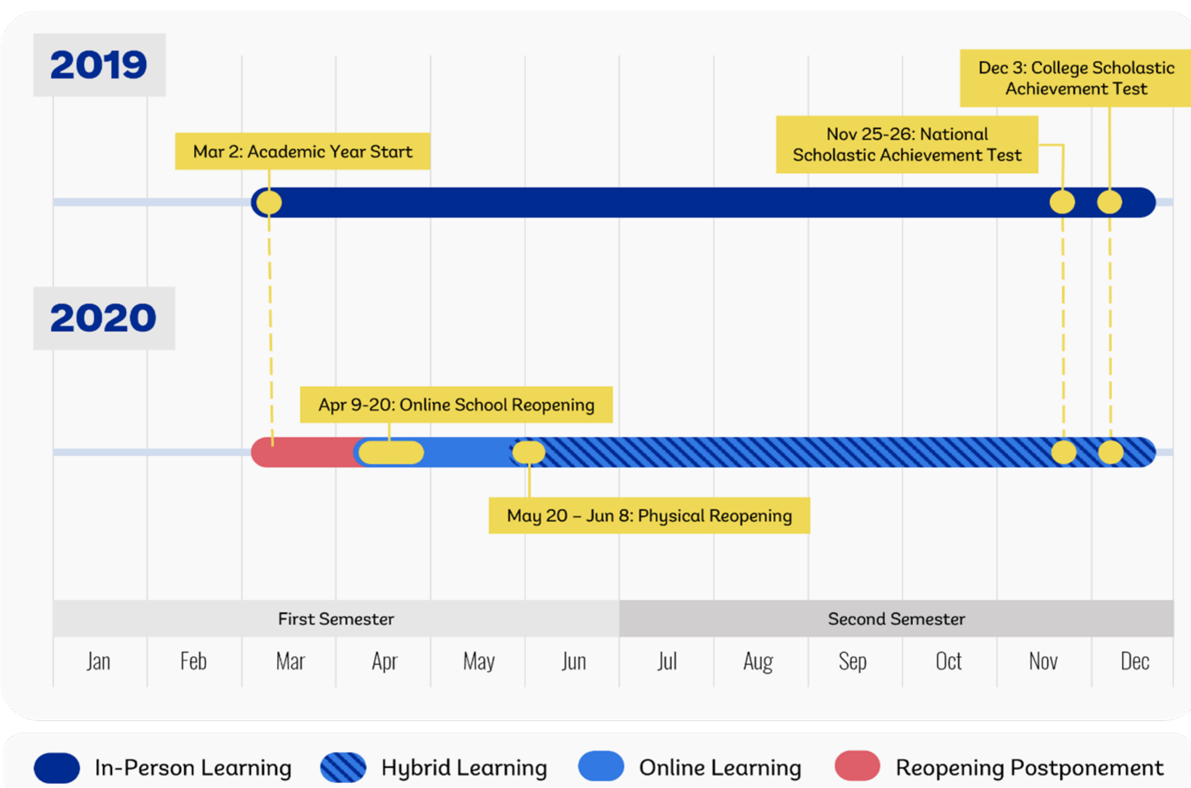
2 The Korean government's budget for EdTech is large and increasing. It was approximately US$1.5 billion in 2020, which is almost four times more than the budget in 2016 in nominal terms (MOE 2021c).

factors. This briefing note explains how Korea applied ICTs to respond to the COVID-19 education disruption and to prepare for future shocks. It analyzes Korea's current EdTech policies, challenges, implementation, and future plans, with a focus on elements that may be of interest and applicable in other countries. It also includes four comparative analyses of national tests and students' school performance before and during the COVID-19 (Table 1). It showed low levels of average student learning loss, while students in the middle and lower academic percentiles tend to be more vulnerable to the negative impacts of school closure.

**Table 1. List of national and regional tests for learning loss analysis**

| Number | Assessment | Grade | Time | Region | Result |
|---|---|---|---|---|---|
| 1 | National Scholastic Achievement Test | 9 and 11 | November 2020 | National | A modest level of learning loss for both grades affected by the school closure |
| 2 | College Scholastic Ability Test (CSAT) | 12 | December 2020 | National | An absence of learning loss during COVID-19 |
| 3 | Students' school performance in Seoul | 8 and 9 | 2018–2020 | Seoul | A small level of learning loss among the lower-performing students and some gains in the number of higher-performing students during COVID-19 |
| 4 | Students' school performance in Gyeongsangnam-do | 3, 8, and 10 | 2019–2021 | Gyeongsangnam-do | Learning gain for 3rd graders and little learning loss with increasing learning inequality for 8th and 10th graders |

**Figure 1. Timeline of school closure, online/hybrid learning, and national assessments in Korea**

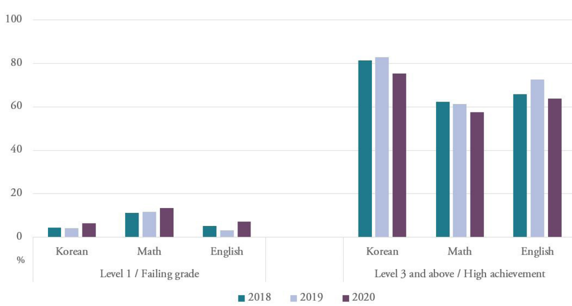


## Protecting Student Learning During COVID-19

Korea successfully protected student learning during the pandemic, suffering low levels of learning loss. To mitigate expected student learning loss due to the school closure in March 2020, the Korean government shifted to online learning starting in April 2020 and implemented national online and hybrid forms of learning during the 2020–2021 school years. The available empiric evidence indicates that the country successfully protected student learning, with only modest decreases in learning, one of the few countries globally to do so.

**The 2020 National Scholastic Achievement Test.** The MOE conducted the National Scholastic Achievement Test in November 2020 for a nationally representative sample of seniors in middle school (9th grade) and the penultimate year in high school (11th grade). According to the government policy, the test was taken by 3 percent of all Korean middle and high school students (21,179 students) to prevent the competition between schools and their excessive focus on testing. The result from 2020 shows learning losses when compared to previous years (Figures 2 and 3). This was the first official evidence for learning loss caused by COVID-19 on a national scale.

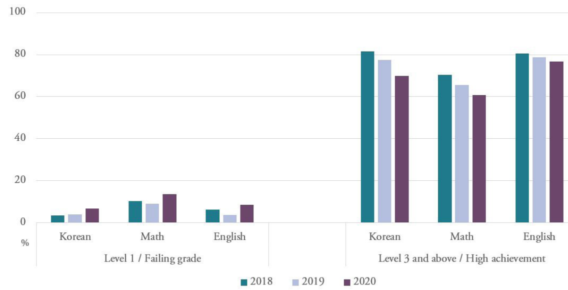
**Figure 2. Percentage of students in academic achievement Level 1[3] versus Level 3 and above (9th grade students)**




*Source: MOE 2021b.*

The test shows a modest increase in the number of students failing the exam as well as a slight decrease in those achieving the highest scores. The result shows an average of 3.3 percent increase in Level 1 for both grades and a 5.7 percent decrease in students from Level 3 and above. Taken together, the result highlights the modest level of learning loss for middle and high schools affected by the school closure. It is the standardized test evaluating students' academic level every year, and there was no indication that there was any change in difficulty of the tests in 2020.

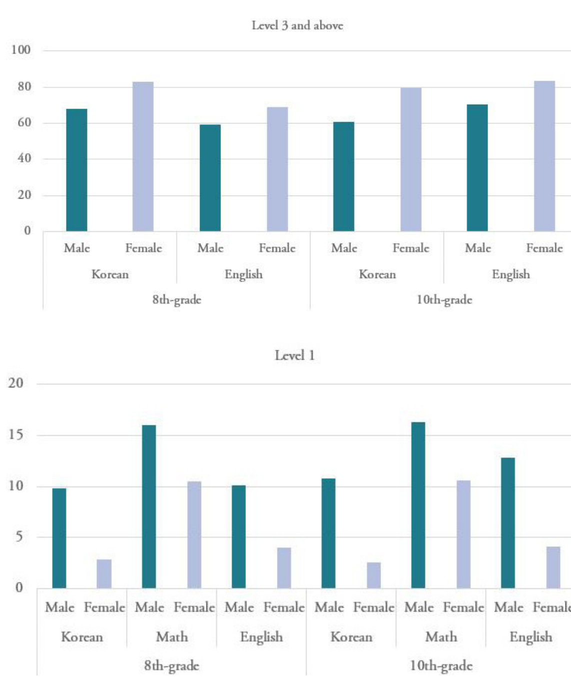
**Figure 3. Percentage of students in the academic achievement level (11th grade students)**




*Source: MOE 2021b.*

These results also highlight that in Korean and English, the percentage of female students attaining Level 3 and above is higher than for male students in the National Scholastic Achievement Test, though male students have a higher rate at Level 1 in all subjects. The comparison of math for Level 3 and above did not show a high significance level. Overall, female students tend to have higher achievement levels, which is also seen in other education levels (Figure 4).

**Figure 4. Student percentage by gender in different academic levels**

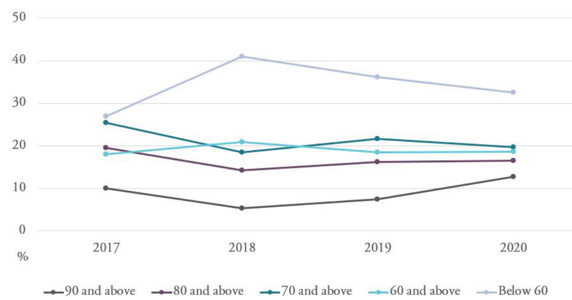



*Source: MOE 2021b.*

3 Academic achievement level represents the students' level of comprehension and achievement in the curriculum. It is classified into four levels, ranging from Level 1 (equivalent to failure) to Level 4 (highest mark).

**CSAT in 2020.** Another national test also shows an absence of learning loss during the pandemic. The 2020 CSAT took place in December 2020, and 493,433 applicants took it in person, consisting of high school seniors (70.2 percent), high school graduates (27.0 percent), and people who took the general equivalency diploma exam (2.8 percent). While the test covers seven subjects, English was used to measure learning loss since, unlike most other subjects, it is graded based on an absolute scale. Figure 5 shows its comparison with tests before the pandemic.

**Figure 5. Student percentage for the English test in CSAT (2017–2020)**




*Source: 2017–2020 CSAT results analysis from Korea Institute for Curriculum and Evaluation (KICE).*[4]

### Box 1. Analysis of the CSAT's level of difficulty

According to the MOE, the 2020 CSAT's difficulty level was equivalent to prior years. In the annual meeting for the National Council of Superintendents of Education on July 3, 2021, the Council recommended that the MOE make the test easier, considering students could not carry out the normal learning activities during school closure. However, the MOE responded that it is hard to adjust the difficulty of CSAT since it would result in another equity issue (Dongyang Daily, September 20, 2020). KICE, the institute developing the CSAT, also confirmed that the difficulty level of the 2020 test was the same as prior years.[5] After the test, multiple organizations analyzed it and indicated that, in general, the difficulty level is similar to the 2019 CSAT (Table 2).

**Table 2. Difficulty analysis by Korean institutions**

| Institute | Subject | Analysis of difficulty level | Source |
|---|---|---|---|
| Korean Council for University Education | General | The general difficulty of the 2020 CSAT is similar to the 2019 CSAT but easier than two practice tests in 2020.[6] | Press briefing by the Korean Council for University Education on December 3, 2020[7] |
| | English | Same as 2019 CSAT but easier than the September practice test | |
| | Korean | Slightly easier than 2019 CSAT and two practice tests | |
| | Math | More difficult than 2019 CSAT and the September practice test | |
| Jaeil Private Educational Institute | English | Same as 2019 CSAT but easier than the September practice test | Interview with Mr. Kion Han, the Chairman of Jaeil Private Educational Institute[8] |
| | Korean | Same as 2019 CSAT but easier than the September practice test | |
| | Math | Same as 2019 CSAT | |
| Jongro Private Educational Institute | English | Same as 2019 CSAT | Chungcheong Daily News[9] |
| Daesung Academic Development Institute | English | There were no new types of questions, and it is similar to the 2019 CSAT and the last two practice tests. | Interview by Mr. Young-deok Lee, the President of Daesung Academic Development Institute[10] |

4 https://www.kice.re.kr/boardCnts/list.do?boardID=1500230&m=0302&s=suneung#contents
5 Communication from KERIS, July 26, 2021.
6 There are two practice tests for CSAT every year, which are organized in June and September.
7 http://www.ccdailynews.com/news/articleView.html?idxno=2020448
8 http://www.ccnnews.co.kr/news/articleView.html?idxno=201498
9 http://www.ccdailynews.com/news/articleView.html?idxno=2020448
10 https://www.yna.co.kr/view/AKR20201203163951530?input=1195m

In 2020, the proportion of students who received 90 percent and above increased compared to previous years, while students below 60 percent were at their lowest level since 2018. Assuming that the tests' level of difficulty was constant across years, these results imply an absence of learning loss during COVID-19. Indeed, it suggests a learning improvement in the year leading up to the end of 2020 assessment, when most schools in Korea were closed for in-person learning.

The number of students who applied for the 2020 CSAT exam decreased by 10 percent to 493,333, which is the lowest number since the start of CSAT in 1994. In addition, of those registered for the CSAT exam, 13.17 percent did not take the test, compared to 11.7 percent in 2019 (Yonhap News, December 3, 2020). Most of these students declined to take the test because they felt they were not equipped due to the online classes and there was the risk of being infected (Maeil Economy, December 3, 2020). It is consistent with the National Scholastic Achievement Test findings, which showed a modest increase in lower-performing students and a decrease in the number of high performers, resulting in fewer students feeling well equipped to take the test.

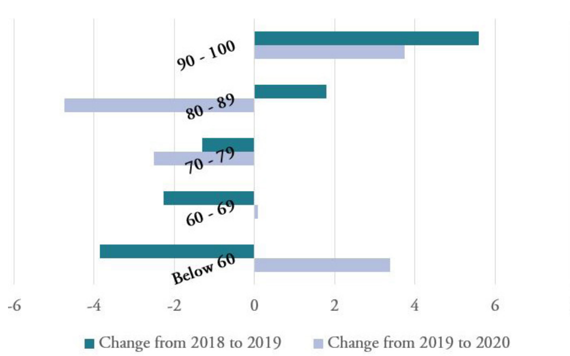
While the 2020 CSAT test appears overall comparable to the 2019 CSAT in difficulty, the number of students taking it declined, which could affect the scores. Therefore, these results should be interpreted with caution. We consider additional sources below to better understand how much learning was lost due to COVID-19 related school closures.

**Seoul middle school student performance using school-level score data.** The Seoul Education Research and Information Institute analyzed the academic achievement of all 8th grade students in middle school in Seoul, representing 15.8 percent of all 8th grade students nationally. They used data from Schoolinfo, the national Education Management Information System (EMIS), to track the performance of two separate cohorts of students in 8th and 9th grade. The first data set is for 73,486 students and their performance in Korean, math, and English in the 1st semester of 8th grade in 2018. The research compares the 1st semester performance of the same student cohort in 2018 (8th grade) and in 2019 when they were in the 9th grade. It then compares the performance of the next cohort of 66,073 students in 8th grade in 2019 to their performance in 9th grade in 2020 when schools were doing hybrid learning because of the pandemic.[11]

Examining the change in the same school between the 2018 and 2019 scores in the pre-COVID period allows us to establish a comparator for the change observed between the 2019 and 2020 scores, when there were widespread school closures and distance learning as a result of the pandemic. We requested individual student-level data, but the Seoul Metropolitan Office of Education responded that data are unavailable as the office only collects school-level data. This restricts our analysis to school-level changes.

The achievement levels were measured using all written and performance tests according to the school's academic plan, which the MOE and the provincial education offices provide to teachers. The test contents and evaluation standards are made public using the EMIS, which is considered consistent and follows the same curriculum and student learning goals for each year. Based on available information, there was no move to make the assessments easier during the period of online instruction considering COVID-19 challenges. The study calculated the average percentage changes in all schools at the school level, and the result shows the learning loss of students from the middle to lower percentile of grades (Figures 6 to 8).

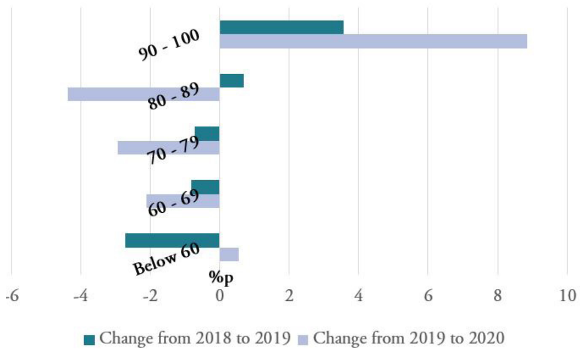
**Figure 6. Percentage change in Korean language scores (8th grade versus 9th grade, two school-level cohorts)**




*Source: Seoul Education Research and Information Institute 2021.*

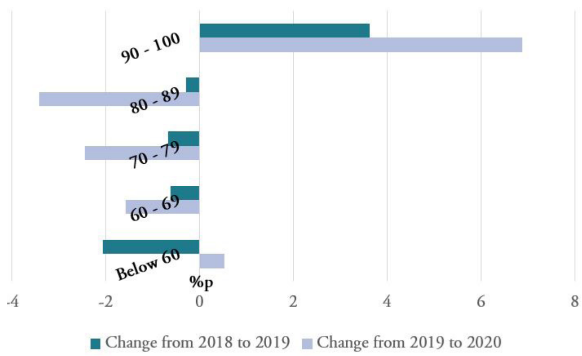
11 Due to the limitation in school and class-level data, there is a possibility of differences in difficulty level across and within cohorts.

**Figure 7. Percentage change in math scores (8th grade versus 9th grade, two school-level cohorts)**




*Source: Seoul Education Research and Information Institute 2021.*

**Figure 8. Percentage change in English scores (8th grade versus 9th grade, two school-level cohorts)**




*Source: Seoul Education Research and Information Institute 2021.*

The results show a small increase in scores below 60 for the 2019–2020 cohort who did online and hybrid learning from April 2020 through the test date as a result of COVID-19. This cohort's proportion of lowest scores (those below 60) increased by an average of 1.49 percent across all three subjects. In comparison, the change in lowest scores for the 2018–2019 cohort was −2.88 percent across all three subjects. The COVID-affected cohort had a larger increase in scores above 90 percent (an average 6.50 percent increase) than for the 2018–2019 cohort, where the average increase across the three subjects was smaller at 4.26 percent. For those in the middle of the score distribution (from 60 to 89), the overall average change was −2.7 percent for 2019–2020, indicating a decrease in the proportion of students achieving in the middle level. The average change for the 2018–2019 cohort was smaller but still negative (−0.46 percent). Across all scores, the simple average change for 2019–2020 was nearly 0 (−0.00067), showing no learning loss on average for students, which indicates there was no learning loss on average for 9th grade students in Seoul during online and hybrid learning using this measure. There was also no change in the average score for the previous 2018–2019 cohort (−0.00133).

Since the 9th grade tests are different from the 8th grade tests, we compare the change in performance of two cohorts moving from 8th to 9th grade. The t-test for change for the student cohort's transition from 8th grade in 2018 to 9th grade in 2019 shows that the average school-level scores of 9th grade students in 2019 increased compared to 2018, and the overall increase was significant at 0.001 level (Table 3). The change for the second cohort's transition from 2019 to 2020 also shows an increase in average scores, with a significance level of 0.05 (Table 4). The fact that the second cohort's scores also increased mean that the temporary closures and online learning did not lead to a significant decrease in achievement levels, rather the increase observed in the earlier cohort was repeated despite the COVID-19 conditions.

The difference in differences (DID) test, which compares the changes in outcomes over time between two groups, was used to compare Group A (change from 2018 to 2019) and Group B (change from 2019 to 2020) for middle school students in the Seoul district. We are comparing two groups of students who changed teachers and classrooms from 8th grade to 9th grade, and we believe the teachers and classrooms were the same for the two cohorts, although there was some standard personnel attrition and transfer. There were no major differences in assessment or instructional policy between the two periods except those associated with COVID-19. The DID comparison shows that the overall change from 2018 to 2019 is larger than the overall change from 2019 to 2020 but with a low significance (Table 5). This means that the differences in results between separate subject-level tests for each class in the cohort, on aggregate, are not significant. This finding supports the interpretation that there were almost no observed impacts on student performance due to school closures and hybrid learning during the COVID period. It would have been helpful to examine individual student level performance over time, but the Korean authorities do not collect them.

**Table 3. Paired t-test for average scores for Korean, English, and math in the 1st semester of 8th graders in 2018 (Average 1) versus 9th graders in 2019 (Average 2) in 380 schools of Seoul**

| Test score | Number of classes and subjects observed | Mean score | Standard error | Standard deviation |
|---|---|---|---|---|
| Average 1 (2018) | 1,140 | 72.7893100 | 0.1609369 | 5.433855 |
| Average 2 (2019) | 1,140 | 73.5528100 | 0.1746410 | 5.896558 |
| Difference | 1,140 | 0.7634921 | 0.1445010 | 4.878917 |

Note: t = 5.2836.
P r(|T| > |t|) = 0.0000.

**Table 4. Paired t-test for average scores for Korean, English, and math in the 1st semester of 8th graders in 2019 (Average 3) versus 9th graders in 2020 (Average 4) in 380 schools of Seoul**

| Variable | Number of classes and subjects observed | Mean score | Standard error | Standard deviation |
|---|---|---|---|---|
| Average 3 | 1,140 | 74.5885100 | 0.1774158 | 5.990248 |
| Average 4 | 1,140 | 75.0372800 | 0.2098143 | 7.084147 |
| Difference | 1,140 | 0.4487719 | 0.1825270 | 6.162822 |

Note: t = 2.4587.
P r(|T| > |t|) = 0.0141.

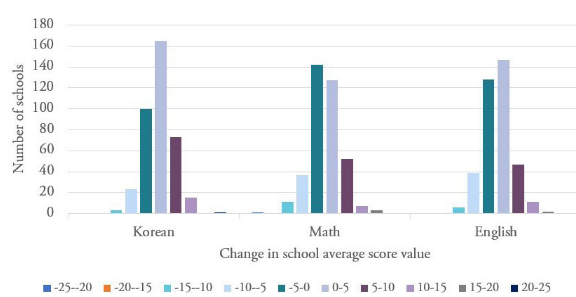
**Table 5. DID: Difference between Average 1 and Average 2 (Cohort 1) versus difference between Average 3 and Average 4 (Cohort 2)**

| Cohort | Number of classes and subjects observed | Mean | Standard error | Standard deviation |
|---|---|---|---|---|
| Cohort 1 | 1,140 | 0.7634921 | 0.1445010 | 4.878917 |
| Cohort 2 | 1,140 | 0.4487719 | 0.1825270 | 6.162822 |
| Difference | - | 0.3147202 | 0.2328018 | - |

Note: t = 1.3519.
P r(|T| > |t|) = 0.1765.

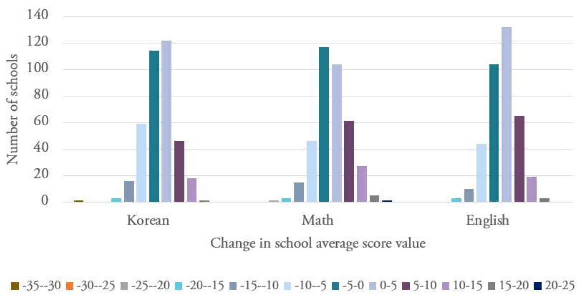
Score changes in most schools are clustered around 0, but more schools had large changes in their average scores under online and hybrid learning conditions. Figure 9 shows histograms of differences between 2018 and 2019 average score values at school levels, counting the number of schools in each value range. The total number of schools is 380. Figure 10 shows the differences in average score values between 2019 and 2020. They indicate most changes are clustered around 0, highlighting minor differences in score values of all three subjects. They also show that there were 21 schools with an average score increase above 10 points for Cohort One (2018–2019) versus 52 schools for Cohort Two (2019–2020), showing almost two and half times greater variability at the positive end of the distribution during the COVID period. Similarly, while there were 211 schools with an average decline of at least five points for Cohort One, there were 626 schools with a decline of five or more points for Cohort Two, showing almost three times greater variability at the negative end of the distribution during the COVID period. This shows overall that the tail ends of the distribution increased during COVID even if average performance did not change much.

**Figure 9. Analysis of differences between 2018 8th and 2019 9th grade score values at the school level in Seoul**




*Source: Author's analysis*

**Figure 10. Analysis of difference between 2019 8th and 2020 9th grade score values at the school level in Seoul**



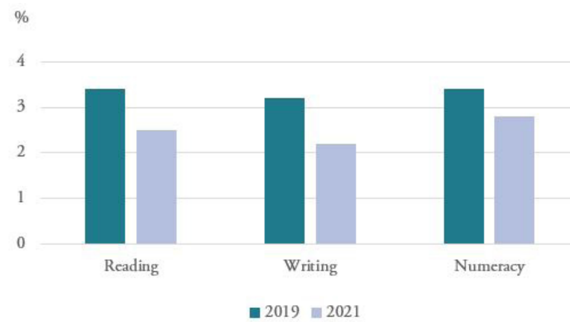

*Source: Author's analysis*

Although the research includes trends from 2018 to 2019 for comparison, the trend analysis on prior years is not publicly available, making it difficult to provide a counterfactual. However, taken together, the results of middle school students in Seoul for Korean, math, and English show modest changes in student performance, specifically a small level of learning loss concentrated among the lower-performing students and some gains in the number of higher-performing students during the period of online and hybrid learning due to COVID (2019–2020). The result was the same for a t-test conducted to compare average scores and student distribution at each achievement level for each subject for 2019–2020. This comparison assumes that teachers kept assessments and grading roughly constant from year to year. If accurate, this shows that Korea was able to largely avoid student learning loss during COVID-19, which required extraordinary resources, planning, and a sustained commitment to investing in EdTech capacity. However, it appears these investments did not protect the lower-performing students from falling further behind their peers, and the higher-performing students from moving even further up.

**Student performance in Gyeongsangnam-do.** A study by the Gyeongsangnam-do Office of Education shows low levels of learning loss during the pandemic with modestly increasing learning inequality for middle and high school students and declining learning inequality for primary students. The Gyeongsangnam-do Office of Education conducted a study for the learning loss of students in all school levels in the province, located in the southeast of the country. Figures 11–13 show the percentage of students in each achievement level. The national diagnostic assessment was used for all 3rd grade students in primary school, representing 7.1 percent of all 3rd graders nationwide.

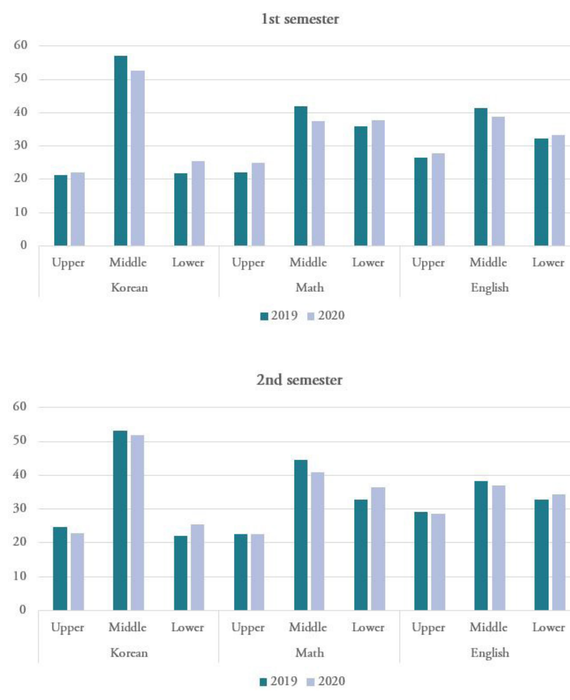
For middle and high schools, the achievement level of Korean, math, and English, measured by tests administered by school teachers, was used to calculate the student percentage in each level for 8th and 10th grade students, representing 6.8 percent and 6.7 percent of all students in these grades nationally, respectively. The student percentages in each grade and semester were compared to the same grade and semester the following year.[12]

**Figure 11. Absolute percentage of 3rd grade students below the basic level of achievement**




*Source: Gyeongsangnam-do Office of Education 2021.*

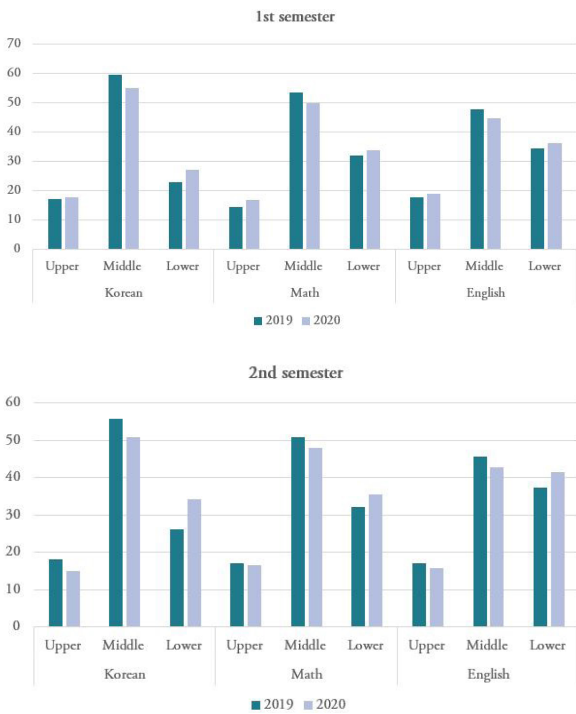
**Figure 12. Student percentage in each achievement level between 2019 and 2020 (8th grade)**




*Source: Gyeongsangnam-do Office of Education 2021.*

12 Data are available at Schoolinfo, but due to the limitation in school and class-level information, there is a possibility of differences in difficulty level across cohorts.

**Figure 13. Student percentage in each achievement level between 2019 and 2020 (10th grade)**




*Source: Gyeongsangnam-do Office of Education 2021.*

According to the Gyeongsangnam-do Office of Education, the decrease in the percentage of primary school students performing below the basic level of achievement in 2020 can be linked to the new local education policy in 2019, which strengthened language and math learning (Gyeongsangnam-do Office of Education 2021). The Office of Education developed and distributed more learning materials for both subjects and provided customized learning in classes from 2019. If accurate, it appears this new policy helped avoid increased learning loss for primary students.

The result in middle and high schools shows little learning loss during the online and hybrid learning period, but increasing learning inequality. The overall number of students at the upper level of achievement increased for both 8th and 10th grades in the 1st semester, but decreased in the 2nd semester. The number of students in the middle level of achievement decreased, while the number of students with the lowest level of achievement increased in both semesters (Figures 12 and 13). The increase in students at the lower level of achievement was greater than the increase at the upper level in both 8th and 10th grades, indicating an overall decline in performance, though very small (2.1 percent net decrease in 8th grade performance and 3.7 percent net decrease in 10th grade performance from 2019 to 2020). The percent changes in all cases are small (less than 4 percent), indicating low levels of overall learning loss in middle and high school, with increasing levels of learning inequality.

Further analysis of changes in 8th grade Gyeongsangnam-do scores shows that the increases in inequality are somewhat statistically significant. The t-test for change from the 1st semester of 8th grade 2019 to the same semester of 8th grade in 2020 shows a decrease of 1.1 points, significant at 0.05 level (Table 6). The change in the 2nd semester between the two years also shows a decline of 1.9 points, with a significance level of 0.001. The DID, which compares the change in the 1st semester to the 2nd semester, shows a larger decrease in the scores of the 2nd semester but with moderate significance.[13]

**Table 6. Two-sample t-test for average scores for Korean, English, and math in the 1st semester of 8th graders in 2019 (Average 1) versus 8th graders in 2020 (Average 2) in 258 schools of Gyeongsangnam-do**

| Test score | Number of classes and subjects observed | Mean score | Standard error | Standard deviation |
|---|---|---|---|---|
| Average 1 (2019) | 774 | 70.004010 | 0.2629146 | 7.314509 |
| Average 2 (2020) | 774 | 68.888110 | 0.3159816 | 8.790879 |
| Difference | 774 | −1.115891 | 0.4110577 | |

Note: $t = -2.7147$.
$P\ r(|T| > |t|) = 0.0067$.

13 The first semester in Korea is from March to July, while the 2nd semester from September to December. Schools in Korea closed in March 2020 for fully online learning and reopened for hybrid learning in May 2020.

**Table 7. Two-sample t-test for average scores for Korean, English, and math in the 2nd semester of 8th graders in 2019 (Average 3) versus 8th graders in 2020 (Average 4) in 258 schools of Gyeongsangnam-do**

| Test score | Number of classes and subjects observed | Mean score | Standard error | Standard deviation |
|---|---|---|---|---|
| Average 1 (2019) | 774 | 70.577780 | 0.2641239 | 7.348154 |
| Average 2 (2020) | 774 | 68.672350 | 0.2950753 | 8.209247 |
| Difference | 774 | −1.905426 | 0.3960188 | |

Note:t = −4.8115.
P r(|T| > |t|) = 0.0000.

**Table 8. DID: Difference between 8th graders' Average 1 and Average 2 (1st semester) versus difference between 8th graders' Average 3 and Average 4 (2nd semester)**

| Cohort | Number of classes and subjects observed | Mean | Standard error | Standard deviation |
|---|---|---|---|---|
| 1st semester | 1,140 | −1.115891 | 0.3018236 | 8.396991 |
| 2nd semester | 1,140 | −1.905426 | 0.2879544 | 8.011139 |
| Difference | 774 | 0.7895349 | 0.4171514 | |

Note: t = 1.8927.
P r(|T| > |t|) = 0.0586.

Overall, the magnitude of changes is modest, less than two points on a 100 point test scale, equal to about 1/4 of a standard deviation, where the standard deviations range from 7.34 to 8.39. While the DID analysis is close to standard levels of significance, it shows that the larger decrease observed for the 2nd semester (the one most affected by COVID) may have been a result of random chance. The sensitivity of the analysis would be improved with student-level data, but the Gyeongsangnam-do Office of Education only collects school-level data. As with the Seoul scores, we assume the conditions for the two groups of 8th grade students were similar, including the same teachers and classrooms, while there were likely to be some small standard levels of teacher attrition and transfer. This analysis supports the interpretation that little learning was lost by students on average during the COVID period.

**Quantitative estimation of the effects of COVID-19 on student learning.** Below we present results from quantitative estimations on the effects of school closures during the pandemic on student learning. We have data on all middle schools for two provinces, Seoul and Gyeongsangnam-do (380 schools in Seoul and 258 in Gyeongsangnam-do), with assessment results at the school level for three subjects: math, Korean, and English. We observe a school's average score, its standard deviation, the percentage of students falling into each of the five categories: A, B, C, D, and E. For both regions, we observe two cohorts at two points in time, one of the cohorts has been affected by the lockdown in the respective second period. For Seoul, the two periods are the first semesters of 8th and 9th grades from 2018 to 2019 and from 2019 to 2020; for Gyeongsangnam-do, they are the first and second semesters of 8th grade in 2019 and 2020, respectively.

Given that for Gyeongsangnam-do we observe differences over six months, whereas in Seoul it is over one year, the results presented below are not strictly comparable. We will show results for two different exercises: (a) a double differenced regression in time and (b) a distribution of scores for the second time period (that is, grade 9 and 2nd semester, respectively), comparing cohorts right before and during the pandemic. The first exercise consists of a regression of each cohort's average performance in 9th grade on its performance in 8th grade and a binary variable for the second, COVID-affected cohort. The parameters of interest, reported in Table 9, are on the binary variable. The model constitutes a doubly differenced estimation, with both differences taken in the time dimension. It effectively controls for all baseline differences between the two cohorts. However, the average difference in the changes between scores in the two grades levels is largely attributed to the COVID pandemic.

Results are presented for the average assessment score in each subject, its standard deviation, and the percentage of students falling into each of the five categories (A–E). In Seoul, top panel of Table 9, a fairly clear picture emerges. The standard deviation in the assessment scores unambiguously increased with a statistical significance at the 1 percent level in all three subjects. Similarly, the proportion of students scoring in the top category, A, also increased throughout, while the proportions of students scoring at the B and C levels deceased. Again, all these results are significant at the 1 percent level. The percentage scoring in category D also shows negative point estimates but is not significant in all cases. Finally, the proportion in category E increased in all three subjects, but statistical significance is only found for the Korean language assessment. The overall effect on the average score is an increase in math and English and a decrease in Korean.

Results are different in Gyeongsangnam-do. Here, the average assessment scores all decrease, while the standard deviations are largely unchanged. The percentages in categories A and B decrease throughout, but statistical significance is only found for category B in math and category A in Korean. These are met with a statistically significant increase in category E (though for Korean only at the 10 percent level). The results for English are not strong in statistical terms. This, and the overall lower level of statistical significance compared to Seoul, is likely the result of the shorter time for comparison (semesters versus grade levels).

**Table 9. Estimates on the COVID cohort effect**

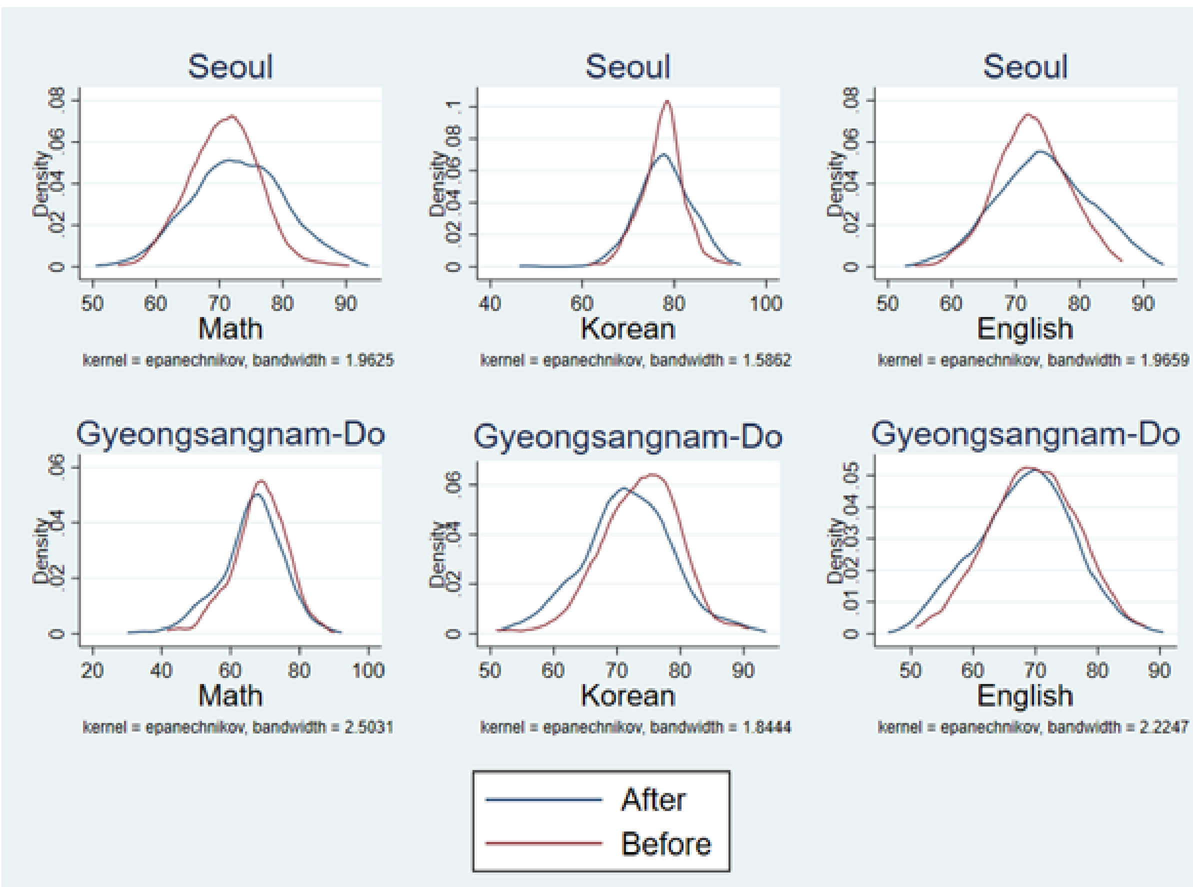
| Average | Standard deviation | A | B | C | D | E |
|---|---|---|---|---|---|---|
| **Seoul** | | | | | | |
| | | | Math | | | |
| 1.21*** | 2.11*** | 9.56*** | −4.77*** | −3.11*** | −2.45*** | 0.77 |
| (0.39) | (0.22) | (0.78) | (0.31) | (0.25) | (0.23) | (0.57) |
| | | | Korean | | | |
| −0.75** | 2.01*** | 4.96*** | −6.10*** | −3.24*** | −0.31 | 4.67*** |
| (0.33) | (0.19) | (0.86) | (0.39) | (0.33) | (0.29) | (0.55) |
| | | | English | | | |
| 0.93*** | 1.49*** | 7.77*** | −3.77*** | −3.03*** | −1.68*** | 0.34 |
| (0.36) | (0.19) | (0.77) | (0.30) | (0.56) | (0.22) | (0.55) |
| **Gyeongsangnam-do** | | | | | | |
| | | | Math | | | |
| −1.72*** | 0.49* | −1.12 | −2.31*** | 0.30 | 0.86 | 2.27** |
| (0.49) | (0.28) | (0.87) | (0.63) | (0.61) | (0.63) | (1.03) |
| | | | Korean | | | |
| −1.01** | −0.01 | −2.02** | 0.51 | −0.29 | 0.20 | 1.60* |
| (0.43) | (0.25) | (0.88) | (0.84) | (0.66) | (0.61) | (0.86) |
| | | | English | | | |
| −0.78* | 0.26 | −0.92 | −0.19 | 0.30 | 0.56 | 0.24 |
| (0.40) | (0.25) | (0.84) | (0.61) | (0.55) | (0.53) | (0.81) |

*Note: Results for linear regressions. Estimates are for the parameter on the binary variable denoting the COVID-affected cohort in the second period. Standard errors in parenthesis. Asterisks denote statistical significance at the 10 percent (*), 5 percent (**), and 1 percent (***) levels. The estimations for the percentages in categories A–E use seemingly unrelated regressions (SUR).*

Moving to the visual results, Figure 14 shows kernel density estimates for the average school-level assessment scores in the second period (that is, 9th grade in Seoul and 2nd semester in Gyeongsangnam-do). It needs to be pointed out that unlike the regression results, the kernel estimates would reflect any systematic differences between the two cohorts in the first period as well as in the changes between the two periods. With that caveat in mind, the results reflect the ones found in the regressions. The dispersion has clearly increased in Seoul. Moreover, the shift to the right in math and English shows the higher averages, while there is an increase in both tails for Korean. For Gyeongsangnam-do, the shift to the left, that is, to lower values, is also clearly depicted for math and Korean, and is less pronounced, but still present, for English.

Across these exercises, the different effects in Seoul and Gyeongsangnam-do appear to be driven by an important increase in high-performing students in the former province. One possible explanation is that high-income families, whose parents also have high educational attainment, are more prevalent in Seoul than in Gyeongsangnam-do. These would be the parents who are more heavily engaged in their children's education, are more likely to have appropriate equipment and facilities for online education, and also have the means to arrange for additional support during school closures. The overall effect being that their children improved their performance. Less well-off students, however, suffered learning losses. This last point is more distinct in the results for Gyeongsangnam-do, partly contributed by the regional disparity in access to educational services, which are more concentrated in the Seoul Metropolitan Area.

**Figure 14. Kernel density estimates for the average school-level assessment score in the second period**



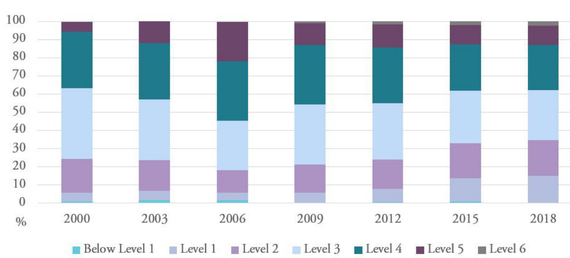
Other pieces of information tell a similar story. For example, the Incheon Metropolitan Office of Education study finds no learning loss in high schools and low levels of loss in middle schools (Incheon Today, May 17, 2021). Further research is needed to confirm the comparability of difficulty and grading between test years as well as student participation. With the currently available evidence, Korea appears to have successfully leveraged its investments in EdTech and teacher skills to protect student learning during the pandemic. If true, it is one of the few countries in the world to do so.

In analyzing these and other assessment scores during the pandemic, Korean media has focused on the increase in 'educational polarization' (학력 격차).[14] Across assessment types and especially in the higher grades, the proportion of students with achievement in the middle of the distribution tends to decrease, while the proportion tends to increase in the upper and lower ends of the distribution. This means that while Korea may have largely avoided learning loss on average, there appears to be some redistribution of learning away from the middle and lower levels toward the top.

Some studies linked the increasing learning inequality to the use of private educational institutes (hagwon) and tutors, which are less accessible to the poor (Seoul Metropolitan Office of Education 2020), while others suggest that low levels of self-directed learning and insufficient parent support of low-performing students help drive this pattern (KERIS 2020a). It is also noticeable that the use of online tutoring has increased during school closures and hybrid learning, which contributed to the large share of sales increase of private educational institutes (Joongang Daily, April 2, 2020). Repeated changes between online and offline classes may also negatively affect student learning outcomes (Chosun Ilbo, July 16, 2021) and could exacerbate the polarization as the emotional and other support to cope with these changes may be less for disadvantaged students.

The polarization or 'shrinking middle' pattern has been present in Korean achievement measures since 2000, though the evidence presented here suggests the pandemic has made it worse. Looking at Programme for International Student Assessment (PISA) reading scores (Figure 15), the proportion of students achieving Level 1 and below has increased from 5.7 percent in 2000 to 15.1 percent in 2018, the last year for which figures are available.[15] The proportion of students achieving Level 5 and above in reading has increased from 5.7 percent to 13.1 percent over the same period. The score trends for math and science are less strong, but in both, the number of students achieving at the lowest levels has increased 5.4 percentage points from 2003 to 2018 (math) and 3 percentage points from 2006 to 2018 (science), while the number of top scorers (Level 6) in science has more than doubled over the same period. There have been concerns about the learning gap between increasing numbers of very high and very low performers, especially the increase in the proportion of students below the basic academic achievement level. One author suggests that in addition to inequitable access to private educational institutes, frequent curriculum revisions that emphasized non-cognitive skills and the Free Semester Program[16] in middle schools may have resulted in less emphasis on basic academic skills. The increased administrative duties of teachers may also compete with the time available to support students performing below basic level (Lee 2021). Increasing educational inequality in Korea did not start with COVID, but it appears that hybrid learning has accelerated the trend.

**Figure 15. Student percentage in each proficiency level for PISA reading test (2000–2018)**




*Source: MOE 2019.*

14 https://www.yna.co.kr/view/AKR20210601163100530?input=1195m, https://www.ytn.co.kr/_ln/0103_202106130521333634

15 Following Azevedeo and Goldemberg 2020 (https://blogs.worldbank.org/education/learning-all-beyond-average-score). The authors would like to thank J. P. Azevedeo and T. Linden for contributions to the conceptualization of this section.

16 An exam-free semester in middle schools which allow students to explore their interest, aspirations, and career options.

## EdTech Policy Development and Implementation

Korea has used a phased approach to adopting EdTech since 1996, following successive ICT Education Master Plans. The plans were updated every four to five years. The initial Master Plans (1996–2010) focused on establishing infrastructure, developing educational content and platforms, and providing teacher training. For example, the government established ICT skills standard and accreditation system for teachers based on an analysis of teachers' digital literacy levels and their responsibilities at schools. These plans were fully financed and implemented over the 15-year period. As a result, all schools in Korea were equipped with ICT infrastructure (MOE and KERIS 2002); an implementing agency (KERIS) was founded; and platforms (NEIS, EDUNET, Cyber Learning System, and others) were established to improve the EdTech service delivery. The recent Master Plans (2011–2018) have been focused on strengthening EdTech equity and quality and supporting more flexible and personalized learning such as the SMART education[17] and digital textbooks.

For policy development and implementation, links between ICT and education policies were promoted by mobilizing different governmental ministries and authority levels, as well as cooperation with the private sector. The government established roles and responsibilities of different stakeholders and their key tasks for implementation. Figure 16 shows the systemic model for implementing EdTech in education policy.

After the outbreak of COVID-19 and three postponements in starting the new school year (from March to April 2020), the government decided to move education completely online in April 2020. Online learning was implemented progressively by grade level, starting with students in the last years of senior secondary and middle school (Hankyoreh, April 1, 2020). By the end of April 2020, 99 percent of 5.34 million students of elementary, middle, and high schools participated in full-scale online classes. About 470,000 online classrooms were created on the public e-learning platforms, and on average, 3.97 million users accessed them daily (MOE 2020a). Public platforms provided by KERIS and Education Broadcasting System (EBS) were utilized mainly for giving student feedback and assigning homework. Two-way videoconferencing tools such as Zoom (59.2 percent of teachers) and Google Hangout/Meet (14.2 percent of teachers) were mainly utilized for the online classes (KERIS 2020b).

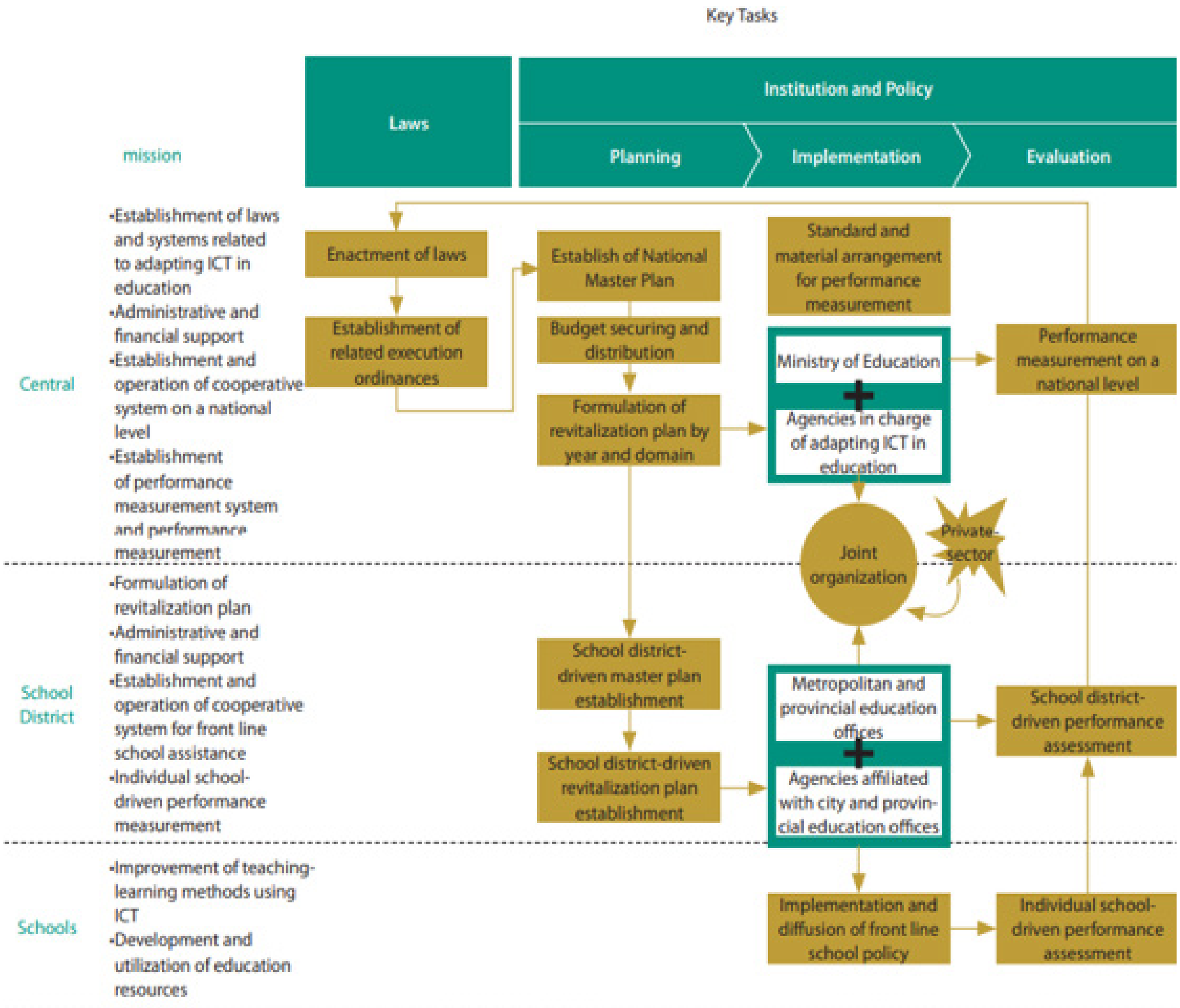
The MOE worked with other government ministries and stakeholders to support all students during this exceptional period. For example, the MOE cooperated with the Ministry of Science and ICT, Statistics Korea, and provincial education offices along with private companies to provide digital devices and subsidize internet subscriptions fees (MOE 2020b). The MOE also carried out an emergency child care program cooperating with the Ministry of Gender Equality and Family and the Ministry of Employment and Labor to support students and families during online classes (Box 2).

**Box 2. Emergency child care program to support online classes**

Emergency child care was provided in Korea to all families affected by the COVID-19 outbreak. In cooperation with relevant government ministries, the MOE bolstered support for families with the start of the online classes from April 2020. Parents could send their children to kindergartens and schools running emergency child care during school closure. Children in each class were limited to a maximum of 10, and the government recruited and compensated the emergency staff. For children who could not go to school, the Ministry of Gender Equality and Family organized home visits dispatching caregivers to households. The Ministry of Health and Welfare and the Ministry of Gender Equality and Family also opened the community centers previously closed during the pandemic to provide extra space for emergency child care, and the Ministry of Employment and Labor provided temporary financial support to parents taking unpaid family leaves (World Bank 2020a).

17 The education policy introduced in 2012, facilitating 'Self-directed, Motivated, Adaptive, Resource enriched, Technology embedded (SMART)' education to promote students' self-learning using data and technology, according to their personal needs and learning levels.

**Figure 16. Operations model for the EdTech policy in Korea**




*Source: KERIS 2016a.*

## Staff Training

Teacher training is a central pillar of the Korean EdTech initiative and key to its success. The training program is developed by KERIS and the provincial education offices designated ICT training centers to provide training. Teachers who received high scores from training are rewarded with a 'teacher ICT skills certificate' and additional credit points in promotions or transfers. At least 30 percent of teachers have been receiving the EdTech training at least once a year.

In 2002, 46.1 percent of elementary school teachers, 44.3 percent of middle school teachers, and 30.2 percent of high school teachers received training (Sanchez, Salinas, and Harris 2011), and according to the KERIS's estimate, almost 100 percent of teachers were trained in 2020.[18] The ICT Skills Standards for Teachers (ISST) were used in the ICT skills certificate system. Table 10 shows the required competency of teachers.

Teacher training focuses on specific software utilization and promotes the 'SMART education' practice by enhancing teaching, communication, and information utilization skills. Diverse and flexible training methods are used, including online/offline training, class consultation, EdTech pilot schools, and EdTech contests for teachers. In addition, training and training providers are evaluated annually for quality management. The ICT operational staff in schools also receive periodic training to update school infrastructure, digitize the school system, and strengthen information security.

18 Communication from KERIS, June 15, 2021.

**Table 10. Required competency of teachers in ISST**

| Categories | ICT skills standards |
|---|---|
| Data collection | • Accessing and collecting information<br>• Saving and managing information |
| Data process and analysis | • Using a word processor, spreadsheets, multimedia materials, presentation materials, web pages, and National Education Information System (NEIS) |
| Deliver and exchange information | • Providing information through TV and printer<br>• Searching for information via educational software<br>• Using email and messenger services to communicate |
| Cybersecurity and ethics | • Understanding and protecting copyright<br>• Managing personal information and respecting online etiquette |

During online classes under COVID-19, the MOE and provincial education offices used multiple channels to provide teacher training on EdTech. For example, the MOE created a teacher training website, and the Seoul Metropolitan Office of Education used its YouTube channel to provide training and issued the certificate (World Bank 2020b). Teachers also voluntarily created community platforms (Teacher-On and the Community of 10,000 Representative Teachers) to share their online teaching experience and provide real-time consulting services using phone calls and remote access to devices. Teacher-On provides teacher-made manuals for creating online classrooms, making lecture videos, and managing online classes. With the development of teacher's digital skills, they were encouraged to design and lead the training themselves according to the schools and students' needs.

## Infrastructure

The initial EdTech Master Plans focused on building the EdTech Infrastructure, including networks and equipment, digital devices, information security system, and human resources. Their construction, especially for networks and security, is a constantly moving target, and their investments are both large and recurring. The government secured budgets for the stages of infrastructure expansion, following the Master Plans and more detailed action plans. These investments meant that by 2000, Korean schools had an average of 166 computers and 1.4 multimedia classrooms (KERIS 2021). The initiative was expanded through private-public cooperation, especially on devices and internet access. The provincial education offices also established the maintenance department to update devices and internet service. Cybersecurity was also part of the approach. The government established comprehensive security systems and operations centers (Education Cybersecurity Center, the Education Public Key Infrastructure Center, and Business Continuity Planning and Disaster Recovery Center) to manage and protect information (KERIS 2017).

To narrow the digital gap during COVID-19, the MOE provided digital devices to all students from low-income families, families with multiple children, single parent, and in which primary caregivers are grandparents. The government mobilized private companies in donating devices and providing technical assistance in networks and information systems. As of April 2020, 280,000 students rented digital devices, which is 5.3 percent of all students (MOE 2020a). In addition, the zero-rating policy (providing internet access without financial cost for educational uses), in cooperation with the Ministry of Science and ICT and three major telecommunications companies, allowed all students, teachers, and parents to access the public education websites without internet and mobile charges. The telecommunications companies also newly opened a free educational channel at their Internet Protocol Television (IPTV) to provide learning content.

At the regional level, each provincial office of education provided alternative channels for continued learning. Gyeongsangnam-do Office of Education instructed schools to use social media and text messages to continue the communication within the class in case the Learning Management System (LMS) does not work (World Bank 2020b). Several schools also offered a 'drive-through' distribution of textbooks at the beginning of the new semester to avoid personal contact between students and teachers.

## Educational Content

Once the EdTech infrastructure was established, the government focused on developing online educational content and platforms to ensure their quality and link to the specific curricular objectives. Content was developed and disseminated in four general phases: (a) planning and research, (b) development, (c) diffusion and adoption, and (d) evaluation (KERIS 2016b). In the diffusion and adoption stage, the purchase fee for online content from private companies was subsidized by the MOE and provincial education offices, and KERIS developed online tools to allow teachers to create and utilize content and digital textbooks. Evaluation and monitoring are the responsibility of provincial education offices.

During online classes under COVID-19, about 50,000 online learning content items such as video lectures, audio textbooks, and e-books were added to public education platforms. A lot of free content has also been developed under public-private partnerships (MOE 2020a). According to the MOE's teachers survey in April 2020, teacher-developed materials are most frequently used in online classes (58.4 percent), followed by private content such as YouTube (43.3 percent), EBS lectures (42.1 percent), and digital textbooks (17.2 percent) (Yonhap News, May 4, 2020). In cooperation with the Ministry of Culture, Sports and Tourism which is in charge of copyrights, copyrights have been temporarily relaxed to give teachers broad access to online resources to create their teaching materials.

The content was mostly distributed on the public educational platforms, which used the cloud systems run by the private sector. These private firms joined the government's 'Online School Reopening Task Force' and customized and strengthened the platforms to accommodate growth in users from 40,000 to 3,000,000, a 7,500 percent increase from pre-pandemic levels. KERIS also collaborated with private firms to enhance the cybersecurity system to prevent increased cyberattack such as Distributed Denial of Service (DDoS) and address privacy concerns (Aju Business Daily, May 6, 2020).

The rapid expansion of EdTech also brought adverse effects such as cyberbullying, technology misuse, overuse, and addiction. Due to the nature of online classes, which lacks face-to-face interaction, and the increased use of the internet and mobile devices, cyberbullying cases have increased in Korean schools since many classes transitioned online. Box 3 shows cyberbullying at schools and prevention measures by the government.

The targeted support was also provided for students with different disabilities during online classes. Table 11 shows support at the national, provincial, and school levels to meet their specific needs.

**Box 3. Increased cyberbullying in online classes**

According to the Foundation for Preventing Youth Violence, a Korean nongovernmental organization (NGO), the number of students who experienced school violence has decreased due to school closure, but the cases of cyberbullying have increased. About 6.7 percent of all primary, middle, and high school students experienced school violence in 2020, which decreased from 11.2 percent in 2019, but students who experienced cyberbullying increased to 16.3 percent, threefold of 2019. There is an alarming increase in female victims, and online verbal abuse was the most common form of cyberbullying (22.5 percent), followed by defamation (15.7 percent) and bullying in groups (8.3 percent). The experts analyzed that the increase in cyberbullying is mostly because of school violence in Korea moving from physical violence toward social and emotional assault online (Kyunghyang News, April 20, 2021). The online classes amplified the trend toward social and emotional assault, as the online platform is suitable with its anonymity and responsive nature. The bullying cases happen most frequently on KakaoTalk, the country's leading mobile messenger service, as well as on Facebook and TikTok (Moon 2021). The MOE formed an intergovernmental committee to prevent and respond to cyber violence, mobilizing government ministries and relevant policy institutes to develop the response measures and guidelines (MOE 2021a). For example, the committee supports cyberbullying prevention education at schools by developing and distributing education materials and promoting the 'cyberbullying prevention week' to encourage relevant courses and campaigns.

**Table 11. Targeted support for students with physical and mental impairment during COVID-19**

| Types of impairment | Support measures | Relevant resources |
|---|---|---|
| Students with visual impairment | • The online learning content from the public education platforms were developed in braille. For example, students can download digital braille files from the EBS website to use in their braille information instrument and computer interface. | • Braille learning content in EBS: https://www.ebs.co.kr/free/textbook/primary |
| Students with hearing impairment | • The learning content of Eduable, the online educational portal, supports students with disabilities, and EBS provides sign language and closed captions.<br>• The Special Education Support Center under each provincial education office provides sign language and stenography services. The centers dispatch special education teachers to home to support online classes, and the center's stenographers provide the real-time stenography service during the classes. | • Learning content with closed captions at EBS: https://www.ebs.co.kr/free/subtitles/elementary<br>• Learning content with sign language at EBS: https://www.ebs.co.kr/free/signlanguage/lifelong/onair<br>• Learning content with closed captions and sign language at Eduable: http://www.nise.go.kr/boardCnts/list.do?boardID=521&s=eduable&m=110102#contents<br>• Support services provided by the Special Education Support Center: http://www.sen.go.kr/sedu/sedu/index.do |
| Students with physical impairments | • The provincial education offices help students to borrow learning devices and assistive technology devices. The Special Education Support Center's website offers a list of devices, and students can apply through schools. | • The list of learning devices provided by the Special Education Support Center under the Daegu Dalseong Office of Education: http://www.dgdse.go.kr/dgdse/cm/cntnts/cntntsView.do?mi=5342&cntntsId=3131 |
| Students with developmental impairments | • The e-learning site of the Korea National Institute for Special Education (KNISE) provides the learning content for activity-based online classes composed of various visual aids.<br>• Students can apply for a teacher's home visit at the Special Education Support Centers, and teachers provide the weekly learning plans and materials. | • Learning materials from the KNISE's e-learning site: https://www.nise.go.kr/jsp/onlineedu/onlineedu.jsp |

## Curriculum

The Korean government designed or redesigned the curriculum for all grades from primary to senior secondary starting in the early 2000s to integrate digital skills and the effective use of technology. The new curriculum focuses on implementing full-scale computer education and utilizing ICT to make learning more compelling and efficient. In the revised and most recent 2015 curriculum, the schools were encouraged to apply EdTech in at least 10 percent of all classes, and software education was included as a required course for all levels of education. The newly introduced digital skills classes and ways of learning served as a foundation for a swift transition to online learning during COVID-19. In addition, from 2021, AI education will be newly introduced at all high schools (MOE 2020c).

After the COVID-19 outbreak, the MOE provided curriculum reorganization examples and guidelines, including integrating the learning content and changing the evaluation criteria, for schools to adopt them flexibly. The provincial education offices organized relevant training, in which almost all teachers participated.[19] Online performance-based evaluation for students was advanced, which was later combined with the paper-based exams after schools reopened. For example, teachers could evaluate students' online debates and discussions and their recorded videos of physical activities or musical performances. LMS was also used to track students' attendance through students' login history and to monitor their learning progress (MOE 2020a).

19 Communication from KERIS, June 15, 2021

## Putting the Korean Experience in a Global Context

COVID-19 has challenged students, parents, and education systems around the world. The World Bank and other international organizations have estimated large increases in global learning poverty despite major efforts by many governments to support distance learning through TV, radio, and online (World Bank 2020c, 2020d). Other high-income countries such as Switzerland, Germany, the Netherlands, and the United States experienced concerning levels of student learning loss during COVID-related online or hybrid instruction, but not all students suffer learning loss, and the learning loss is unequally distributed. Patrinos and Donnelly (2021) find that students in early grades are likely more vulnerable to learning loss than secondary students because of their inability to seek learning on their own, due to the differences in developmental and cognitive abilities. Of the eight studies they examined, four found instances of inequality in learning loss, with certain demographics of students experiencing losses more significant than others. For example, in Belgium, Maldonado and De Witte (2020) observed inequality within schools rise by 17 percent for math and 20 percent for Dutch. Engzell et al. (2021) determined that losses were up to 60 percent larger among students from uneducated homes in the Netherlands. In Germany, Schult et al. (2021) found losses in math among grade 5 students to be more severe in low achieving students (see Box 4 for further discussion).

When the available evidence for Korea is taken together, the 2020 National Scholastic Achievement Test, the CSAT scores, student scores from 8th and 9th grade students in Seoul in three subjects, as well as the student scores for primary, 8th, and 10th grades in Gyeongsangnam-do and Incheon, low levels of average student learning loss are observed. This is true across grades, performance levels, and areas of the country, though it appears that students in the middle and lower performance percentiles tend to be more vulnerable to the negative impacts of school closure, particularly in the higher grades. The numbers of those performing at the lowest ends of the learning distribution have increased, along with those at the top end, leaving a shrinking middle and increasing levels of learning inequality. This trend was observed before the pandemic, as shown in Korea's PISA results, and it appears that school closure and hybrid learning may have exacerbated them. The evidence reviewed in this report also shows greater levels of loss among students at the lower end of the performance spectrum than those at the top. Further research is needed to confirm the comparability of assessments and scoring across the different measures reviewed here, preferably using individual student scores. The overall picture with the available evidence is of a country that avoided major learning loss during the pandemic and implemented a successful shift to hybrid online and in-person learning, though with increased learning inequality.

While there is evidence that EdTech can partially replace face-to-face instruction, there is no evidence that online learning is better on average than face-to-face instruction. There are increasing amounts of global evidence on how EdTech can support student learning as compared to face-to-face instruction. Some high-quality evaluations show positive student learning gains, no learning gains, or in some cases, student learning losses when compared with face-to-face instruction or other interventions (see Escueta et al. 2020 for a review). Recent evidence from China shows that students with access to high-quality online resources during COVID learned more than those with access to lower-quality resources or no resources at all (Clark et al. 2021). There is some evidence of earlier gains in student learning linked to EdTech in Korea, but with mixed effects. For example, a study using pre- and post-tests for 15,072 students from 160 elementary and middle schools found learning gains associated with the introduction of digital textbooks, but the introduction was also associated with increased smartphone addiction for students who spent considerable time using the digital textbooks (KERIS 2014).

Within-country variation also appears to play an important in determining overall learning. While the average student in Korea may have learned as much, or almost as much, during online and then hybrid instruction as fully in-person instruction, it appears some students learned more than in-person and others significantly less. These differences were likely either minimized or maximized by parental and family interventions, including private tutoring (Afkar and Yarrow 2021). This shift to online learning and dependence on parents and families for support appears to have amplified the disparities in student learning outcomes in Korea that existed before COVID-19.

The technological 'Law of Amplification' is that technology's primary effect is to amplify human forces (Toyama 2015). The premise is that technologies by themselves do not have fixed effects; whether the effects are good, bad, or neutral depend on who is using them, how, and in what context. The implication is that good tech can help high-quality education systems improve student learning faster than without good tech. Conversely, good tech can help low-quality education systems not improve student learning faster, by providing a distraction to teachers and a sink for financial resources that could have gone to other essential inputs. Bad or inappropriate tech, such as those with highly complex student interfaces, culturally irrelevant or age and ability-level inappropriate content, are unlikely to help any system improve. This amplification tendency of EdTech is a threat for all countries who are increasingly using technology, both in a response to COVID and as part of the increased role of technology in all parts of our lives. It is a threat to Korea and other countries, since the use of tech in the absence of special measures and support for low-performing schools and students is likely to make an inequal system more unequal, faster.

**Box 4. EdTech and growth in learning inequality**

Inequity in student learning outcomes is often exacerbated by EdTech and the transition to online learning. Evidence from Germany indicates that as schooling went online last year, students reduced their average daily learning time. Students previously identified as low achievers reduced learning time more than those identified as high achievers (4.1 hours reduction versus 3.7 hours reduction; Grewenig et al. 2020). Similarly, a study of COVID-19 learning loss of 350,000 students in the Netherlands found up to 60 percent higher losses among students from less educated households. Using data from 25 US states, students of color showed greater levels of learning loss than their white peers when tested in the fall of 2020 after several months of pandemic school closures (Dorn et al. 2020). A study in Switzerland found increasing heterogeneity in learning among primary school students doing distance learning after schools closed abruptly (Tomasik, Helbling, and Moser 2020; see also Donnelly and Patrinos 2020 and Patrinos and Donnelly 2021). In China, students with access to a computer at home rather than only a smartphone benefited 60–75 percent more from online instruction during COVID school closures (Clark et al. 2021). The links between economic inequalities, learning inequalities, and EdTech is not just a Korean challenge, it is a global one.

The 'Matthew effect' of educational technology was well established before COVID-19 and has contributed to increasing learning inequality during the pandemic. The Matthew effect is that those most likely to benefit from the use of new technologies in educational settings are those who already enjoy many privileges related to wealth, existing levels of education, and prior exposure to technology (Trucano 2013; World Bank 2018). Students from higher socioeconomic backgrounds score significantly higher on computer and information literacy assessments than pupils from lower socioeconomic backgrounds (European Commission 2018), so while many other factors are at play, it is not surprising that the more privileged should be able to use EdTech more effectively to learn.

This tendency of technology to reproduce or expand existing inequalities works at lower levels of tech as well. Among students with access to educational TV in Bangladesh, 45 percent of those in the highest economic quartile reported watching TV, but it is only 36 percent for the lowest economic quartile. During the COVID-19 school closure, students from the top quartile also received more academic support from family members (39 versus 62 percent; Biswas et al. 2020). In another study in China, students who had access to tablets and iPads for distance learning during COVID-based school closures learned more than students who only had access to phones (Clark et al. 2021).

Based on the available evidence, differential impacts of the transition to online learning and EdTech use should be expected, and these transitions are likely to lead to greater polarization of student learning results unless a set of complementary measures are explored. A COVID-related study in Nepal using mobile phone text and voice connections found greater impacts on math learning for students from the poorest and lowest parent literacy backgrounds (Radhakrishnan et al. 2021). It may be that when developers and implementers of EdTech interventions understand the specific needs of the communities they intend to serve, they can give the greatest advantage to the groups with the greatest needs (Reich 2020).

*Note: We are grateful to Michael Trucano, Inaki Sanchez, and Cristobal Cobo for their comments and observations which helped inform this section.*

## Lessons Learned from EdTech in COVID Korea

**Korea's recent experience highlights the possible education system level resilience supported by EdTech.** With large and continued investments in developing staff and student capacities, a country's education system can mitigate current learning losses and be resilient and inclusive for future threats. However, as the data from Korea show, even high-income countries with high-performing education systems are susceptible to rising inequality in education outcomes. Just as lower-income and vulnerable students experienced greater levels of learning loss, middle- and low-income countries likely experienced greater levels of learning loss during school closures and distance learning. There are also impacts on health, nutrition, violence, and other key areas of development, overall having large negative impacts on human capital (Levinson, Geller, and Allen 2021; Patrinos and Donnelly 2021; World Bank 2020c).

**EdTech is likely to become more important with the acceleration of the fourth industrial revolution and an increase in the frequency of school closures due to disasters and emergencies, many linked to a warming climate.** While more evidence is needed to be conclusive, it appears Korea suffered low levels of learning loss due to COVID-19 school disruptions, while learning inequality increased. The following are the key elements that could apply in other country settings and additional steps Korea and other countries can take to support student learning and reduce inequality.

- **Somewhat counterintuitively, human infrastructure should be the primary focus of EdTech strategies.** In Korea's case, teachers' digital skills supported by the digital leadership of government were key contributors to successful virtual learning, alongside digital infrastructure and software as part of a broader system. Any digital strategy should supplement investments in technology with digital capability initiatives that invest in human capital, especially education (Hawkins et al. 2021; Melhem and Jacobsen 2021).
- **EdTech training should target all educational staff using ICT in schools and be linked to explicit ICT teacher standards as part of teacher accreditation and continuous professional development**, along with close monitoring of the EdTech training program's quality and impact. In addition to Korea's example, countries may refer to the standards developed by the International Society for Technology in Education (https://www.iste.org/standards/iste-standards-for-teachers) and the pedagogy and people-centric approach of Uruguay's Plan Ceibal (Mateo-Berganza Díaz et al. 2020). Without people adequately skilled to use them, investments in EdTech can be expected to fail to deliver improved student learning outcomes and even cause a lowering of student achievement levels (see Escueta et al. 2020 for a review).
- **Special attention should be paid to differences in student achievement, with a focus on the poorest and those at the bottom of the learning curve.** While there are multiple long-term drivers, Korea's apparent 'shrinking middle' or educational polarization is likely exacerbated by the tendency of EdTech to increase existing inequalities. EdTech itself can potentially be a way to address the gaps in learning equity, but most often it increases them (Hawkins et al. 2021; Reich 2020). Korea and other East Asia and Pacific countries could lead the way in discovering EdTech design and deployment strategies to preferentially support low-income, vulnerable students and those with low levels of academic achievement, as this is an area where the current evidence base is thin.
- **The need for equipment and networking infrastructure tends to increase over time, so long-term financing strategies that include input from teachers and other stakeholders rather than one-off procurements decided by a small number of stakeholders are helpful.** Due to the investment size and its recurrence, in an optimal situation, annual budget allocations will be aligned with multi-year EdTech plans, resources permitting. There are multiple stakeholders in this process, with different perspectives; a US study found principals are dissatisfied with how teachers are involved in procurement decision-making for EdTech, while technology directors are dissatisfied with the credibility of evidence provided by technology companies and district superintendents report funding as the key challenge to EdTech procurement (Martin 2014). Formal assessment of learner's

needs can help inform the procurement and prioritization process.

- **Governments and school districts can request and support the generation of high-quality evidence on the usefulness of EdTech investments.** Purchasing decisions based on data and evidence are preferable to those based on hope or referral networks. Without incentives, the private sector is unlikely to provide rigorous evidence on its own. Without support and direction, academics and civil society may not provide the kind of evidence needed for decision-making by school systems about EdTech investments. While prior investments in EdTech contributed to Korea's mitigation of learning loss during the pandemic, surprisingly little evidence was generated in the previous decade that these investments increased student learning.

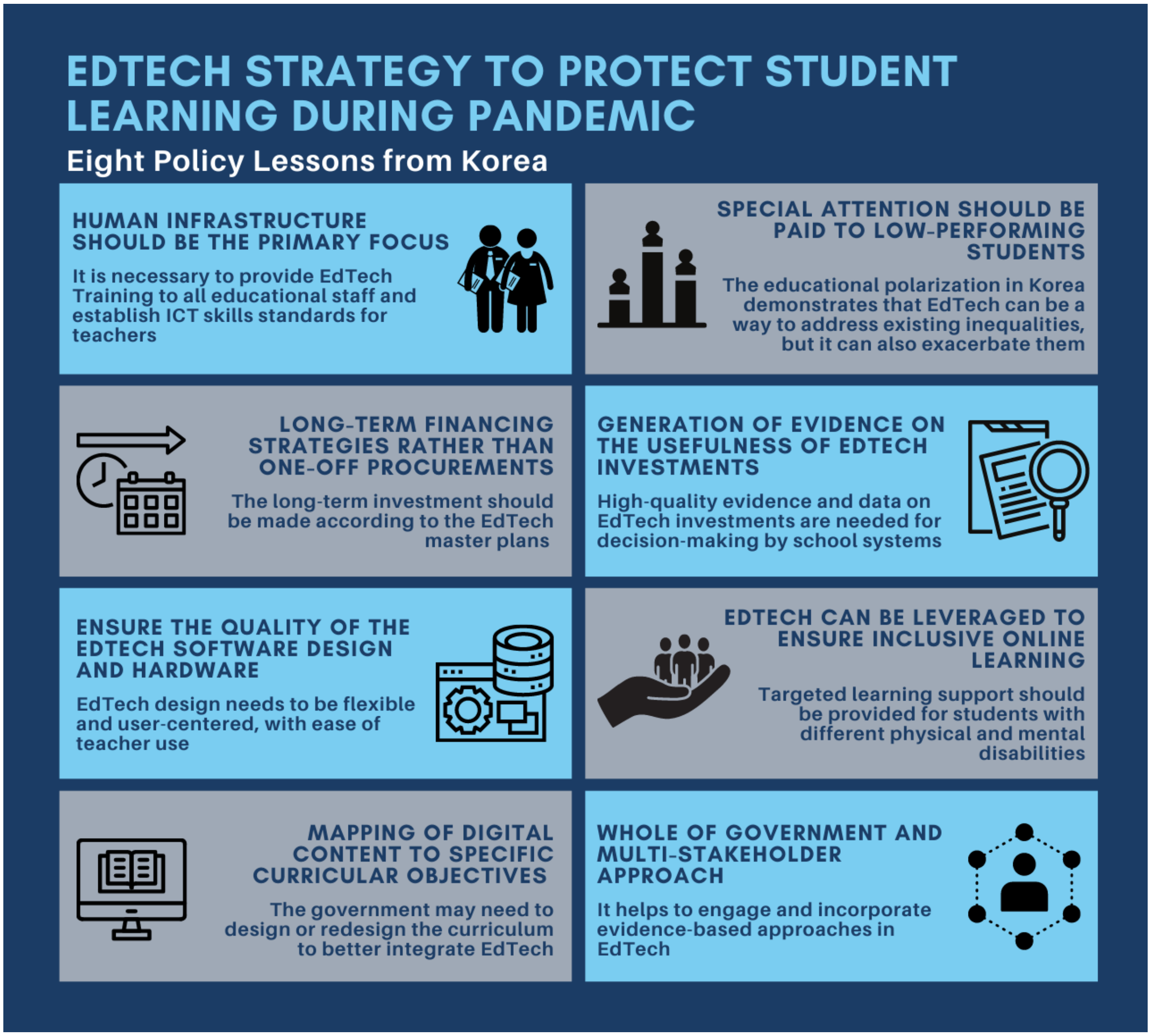
- **The quality of the EdTech software design and content, as well as the hardware, is key to supporting student learning and ease of teacher use.** EdTech design needs to be flexible and user centered and provide quality learning opportunities for all students (Hawkins et al. 2021). Governments and school districts can encourage private sector development and innovation by being clear about their priorities and their learner's needs, rather than simply waiting to see what providers have to offer.

- **EdTech can be leveraged to ensure inclusive remote learning for students with different physical and mental disabilities, as they may need specific support and teaching tools that are not available in distance learning.** In addition to work in this area during the pandemic, Korea's Master Plans Two (2001–2005) and Three (2006–2010) included goals of supporting marginalized populations (Mateo-Berganza Díaz et al. 2020). KNISE, which is in charge of EdTech in special education, led the EdTech content development based on students' types and levels of disabilities. They also created educational portals such as Eduable (www.eduable.net) to support their learning (Hwang, Yang, and Kim 2010). Following Korea's example, governments can also consider information security, privacy, and the risk of cyber violence to protect and support students and teachers in online settings.

- **The mapping of digital content to specific curricular objectives gains importance over time.** The government may need to design or redesign the curriculum to better integrate EdTech into classroom teaching and support student learning. The curriculum and methods should detail its scale, applicability, and practicality to support the local government and schools' adaptation based on the local e-readiness and capacity of ICT infrastructure. The Korean example shows that governments can create guidelines and standards for educational content and establish a quality management system. This helps ensure that all EdTech supports for teachers and students are high quality and avoids duplication and interoperability issues across applications and platforms.

- **Whole-of-government and multi-stakeholder approach to engage and incorporate evidence-based approaches in EdTech and develop broader policies promote long-term economic development.** The Korean government consistently promoted strong links between ICT and education policies, as well as the clear roles and responsibilities of different government ministries and stakeholders for effective policy implementation.

**Figure 17. Policy lessons from Korea on EdTech strategy to protect student learning**



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## Annex 1. Average number of school days for face-to-face classes in 2020

Unit: Days

| Region | Primary school | | | Middle school | | | High school | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1st semester | 2nd semester | Total | 1st semester | 2nd semester | Total | 1st semester | 2nd semester | Total |
| Seoul | 11.6 | 30.8 | 42.4 | 18.6 | 26.6 | 45.2 | 42.3 | 42.6 | 84.9 |
| Busan | 42.6 | 60.1 | 102.7 | 42.4 | 47.3 | 89.7 | 55.4 | 56.3 | 111.7 |
| Daegu | 36.1 | 64.8 | 100.9 | 34.8 | 66.6 | 101.4 | 48.4 | 63.7 | 112.1 |
| Incheon | 18.1 | 33.0 | 51.1 | 20.8 | 32.8 | 53.6 | 41.7 | 42.0 | 83.7 |
| Gwangju | 28.9 | 52.1 | 81.0 | 30.6 | 43.7 | 74.3 | 43.3 | 52.1 | 95.4 |
| Daejeon | 30.8 | 51.1 | 81.9 | 29.7 | 51.6 | 81.3 | 48.1 | 63.3 | 111.4 |
| Ulsan | 48.8 | 48.8 | 97.6 | 46.3 | 48.0 | 94.3 | 58.1 | 58.3 | 116.4 |
| Sejong | 39.0 | 68.0 | 107 | 37.8 | 62.2 | 100.0 | 53.7 | 63.4 | 117.1 |
| Gyeonggi-do | 17.0 | 33.0 | 50.0 | 22.5 | 30.0 | 52.5 | 42.2 | 41.7 | 83.9 |
| Gangwon-do | 53.3 | 63.5 | 116.8 | 49.7 | 61.2 | 110.9 | 56.5 | 59.3 | 115.8 |
| Chungcheongbuk-do | 50.6 | 61.7 | 112.3 | 42.6 | 63.6 | 106.2 | 44.7 | 61.3 | 106.0 |
| Chungcheongnam-do | 54.4 | 72.4 | 126.8 | 45.9 | 63.6 | 109.5 | 55.1 | 59.1 | 114.2 |
| Jeollabuk-do | 51.8 | 81.2 | 133.0 | 52.6 | 73.9 | 126.5 | 55.4 | 74.5 | 129.9 |
| Jeollanam-do | 57.9 | 78.8 | 136.7 | 55.3 | 78.1 | 133.4 | 58.3 | 75.7 | 134.0 |
| Gyeongsangbuk-do | 55.5 | 63.4 | 118.9 | 50.2 | 68.7 | 118.9 | 55.8 | 64.3 | 120.1 |
| Gyeongsangnam-do | 46.6 | 71.3 | 117.9 | 54.5 | 48.9 | 103.4 | 49.1 | 67.1 | 116.2 |
| Jeju | 54.0 | 62.0 | 116.0 | 49.6 | 60.1 | 109.7 | 56.0 | 50.1 | 106.1 |
| National Average | 37.3 | 55.0 | 92.3 | 37.7 | 50.4 | 88.1 | 48.8 | 55.3 | 104.1 |

*Source: Yonhap News, March 16, 2020.*