TECHNICAL BRIEF

Technical appendix for: The widening achievement divide during COVID-19

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1. Introduction

The purpose of this technical appendix is to share more detailed results and to describe more fully the sample and methods used in the research included in the brief, *The widening achievement divide during COVID-19* (Lewis et al., 2022). We investigated two main research questions in this brief:

1) To what degree have students' reading and math test scores become more variable as a result of the COVID-19 pandemic?
2) How do achievement gains across the pandemic compare to pre-pandemic trends for students who were low- or high-achieving at the start of the pandemic?

2. Data

Sample

The data for this study are from the NWEA anonymized longitudinal student achievement database. We used two separate samples in this study. In our first (cross-sectional) analyses, we compared the spring 2022 test scores for 4.5 million students in grades 3-8 who took MAP® Growth™ to the test scores of 4.9 million students in the same grades who tested in spring 2019. The sample characteristics for this first sample are described in Table 1.

In our second (longitudinal) analyses, we follow cohorts of students from the bottom and top decile of the test score distribution (determined based on the fall 2019 percentile rank) across the most recent three school years (2019-20, 2020-21, 2021-22).[1] The left (dark gray) side of the table below illustrates the grades and years included in our "COVID sample" of students. The right (light gray) side shows the years included for the "pre-COVID" sample which serves as a counterfactual for the achievement gains that may have been expected if the COVID-19 pandemic had not occurred. The cohorts in the pre-COVID sample covered the same grade spans as the COVID sample, but we used fall 2016 test scores to select students who were in the bottom and top decile and then followed these students across the 2016-17 to 2018-19 school years. Descriptive information for the students in the longitudinal analyses are provided in Table 2 by cohort, subject, and pre-COVID/COVID sample.

[1] This parallels analyses included in our prior work (Kuhfeld & Lewis, 2022a) examining overall achievement patterns across the pandemic-affected school years except that here we examine a three-year panel instead of a four-year panel. We did not include the 2018-19 school year so that starting achievement status was as proximal as possible to the start of the pandemic.

	COVID Sample (1 million students in 21K schools)			Pre-COVID Sample (1.3 million students in 21K schools)		
Grade	2019-20	2020-21	2021-22	2016-17	2017-18	2018-19
1-3	1	2	3	1	2	3
2-4	2	3	4	2	3	4
3-5	3	4	5	3	4	5
4-6	4	5	6	4	5	6
5-7	5	6	7	5	6	7
6-8	6	7	8	6	7	8

Measure of achievement

Student test scores from NWEA® MAP® Growth™ reading and math assessments were used in this study. School districts use NWEA MAP Growth assessments to monitor elementary and secondary students' reading and math achievement and gains, with assessments typically administered in the fall (usually between August and November), winter (usually December to March), and spring (late March through June). MAP Growth is a computer adaptive test that precisely measures achievement even for students above or below grade level. The assessment is vertically scaled to allow for the estimation of gains across time and is aligned to state content standards. Test scores are reported on the RIT (Rasch unIT) scale, which is a linear transformation of the logit scale units from the Rasch item response theory model.

3. Methods

RQ1: To what degree have students' reading and math test scores become more variable as a result of the COVID-19 pandemic?

To examine how test score variability changed during the pandemic, we calculated the mean and standard deviation (SD) of MAP Growth test scores for each grade level and subject in spring 2019 (for the pre-COVID sample) and spring 2022 (for the COVID sample). These estimates are presented in Table 3. Table 4 reports the ratio of SDs in the COVID sample relative to the pre-COVID sample (ratios greater than 1 indicate an increase in variability in the COVID sample).

Although not reported in the main brief, we also examined how variability in test scores changed within and between schools. Within-school variability captures how different students in the same school are from one another. Between-school variability captures how different schools are from one another. Although both forms of variability are interesting and important, increases in within-school variability have the most implications for teachers and schools given this would indicate students within the same school have more diverse learning needs now than prior to the pandemic.

To assess changes in within-school variability, we compared within-school SDs in spring of 2019 and spring of 2022. In contrast to the overall SDs we report in Table 3 that reflect the typical distance from average in the overall distribution of students, within-school SDs reflect the typical distance from average within a school. Figure A1 shows the change in within-school variability from spring 2019 and spring 2022 for all subjects/grades. Overall, we see increased within-school variability in spring 2022 both subjects in grades 3-5, but only in reading for grades 6-8. Although we are not able to examine whether this increase in variability is happening at the classroom level, this pattern suggests students within a school are more different from one another now than before the pandemic.

To assess changes in the proportion of variance that is between schools, we compared intraclass correlations (ICC, the percentage of variability that is between schools) in spring of 2019 and spring of 2022. The ICC results are presented in Table 4. We observed slight increases in the percentage of variance that is between schools in grades 3-5, with slightly larger increases in math than reading. However, in grades 6-8 there were either minimal changes or the proportion of between-school variance shrank.

Finally, we explored whether the increased variability was concentrated at the lower end of the test score distribution. To do this we estimated the RIT score corresponding to five selected percentile ranks (10th, 25th, 50th, 75th, and 90th percentile rank) based on the observed test score distribution within each term (spring 2019 and spring 2022 separately). It is important to note that these percentiles are based on the observed distribution of test takers within each grade/term/subject, which is different from the percentiles calculated in the following section based on the NWEA 2020 MAP Growth norms (Thum & Kuhfeld, 2020). The kernel density plots in Figure A2 depict how observed percentiles have shifted over time (in one grade and subject exemplar) and show this change is primarily in the bottom half of the distribution. We also use box plots to show the shifts over time. The full set of these plots is shown in Figure A3.

RQ2: How do achievement gains across the 2021-22 school year compare to pre-pandemic trends for students who were low- or high-achieving at the start of the pandemic?

To address the second research question, we classified students in our COVID sample as being in the bottom or top of the achievement distribution based on the students' fall 2019 achievement percentile ranks calculated using the NWEA 2020 MAP Growth norms (Thum & Kuhfeld, 2020). These norms reflect pre-pandemic achievement trends as they are based on a nationally representative sample of students from the 2015-16, 2016-17, and 2017-18 school years. The NWEA 2020 MAP Growth norms were applied to each term in our data to ensure a consistent normative distribution pre- and post-pandemic. For the COVID sample, students with a percentile rank in fall 2019 less than or equal to the 10th percentile were classified as "bottom decile", while students with a fall 2019 percentile rank greater than or equal to the 90th percentile were classified as "top decile."[2] These students were then tracked longitudinally across three school years (2019-20, 2020-21, and 2021-22). A comparable procedure was done with the pre-COVID sample (with fall 2016 test scores used to classify students). Given the need to classify students based on the first timepoint of the cohort, we required that students have an observed test score in the first fall (fall 2019 for the COVID sample, fall 2016 for the pre-COVID sample).

[2] For these analyses, we exclude students with fall 2019 percentile ranks between the 11th and 89th percentile.

However, we did not exclude students from the sample if they were missing test scores from other timepoints in the analysis.

Within each sample and timepoint, we calculated and plotted the average test score ($\overline{\mathrm{RIT}}_{tgsd}$) in term *t* within cohort *g* (1-3, 2-4, 3-5, 4-6, 5-7, 6-8) for sample *s* (where *s=PC* for the pre-COVID sample and *C* for the COVID sample) and decile *d* (where *d* can equal "top" or "bottom" decile). Line plots connecting the mean RIT scores for each decile group and cohort/subject combination are shown in Figure A4. RIT score means within each term of the COVID sample (2019-20 to 2021-22 school years) are plotted in the darker color (dark orange for the top decile, dark blue for the bottom decile), while the pre-COVID reference line (light orange for the top decile, light blue for the bottom decile) displays the means of the pre-COVID sample (students in the same grade span during the 2016-17 to 2018-19 school years).

Additionally, we calculated the standardized mean difference between average test scores in a grade/term between the pre-COVID and COVID samples. We use the term "achievement gap" to describe the standardized difference between the pre-COVID sample and the COVID sample. For example, the achievement gap (as an effect size) in the final spring term (t=spring 2019 for pre-COVID and t=spring 2022 for the COVID sample) in grade *g* for decile group *d* was calculated as:

$$ES_{tgd} = \frac{\overline{\mathrm{RIT}}_{tgCd} - \overline{\mathrm{RIT}}_{tgPCd}}{\sqrt{\frac{(\mathrm{N}_{tgC} - 1)\mathrm{SD}_{tgC}^2 + (\mathrm{N}_{tgPC} - 1)\mathrm{SD}_{tgPC}^2}{\mathrm{N}_{tgC} + \mathrm{N}_{tgPC} - 2}}},$$

where $\overline{\mathrm{RIT}}_{tgCd}$ is the average COVID sample (spring 2022) test score for decile *d* in grade *g*, $\overline{\mathrm{RIT}}_{tgPCd}$ is the average pre-COVID (spring 2019) test score for decile *d* in grade *g*. In previous reports, we had standardized based on the group-specific standard deviation (SD), but given that each decile group is by definition a restricted range of the distribution, we chose instead to standardize our estimates based on the pooled SD from the overall sample in that term/grade. Specifically, SD_{tgC} and SD_{tgPC} are the SDs for grade *g* from the overall spring 2022 and spring 2019 samples, and N_{tgC} and N_{tgPC} are the observed total sample sizes in grade *g* in spring 2022 and 2019 respectively (see Tables 3 and 4 of the July 2022 technical appendix [Kuhfeld & Lewis, 2022b]). The RIT score means for each decile group, along with the standardized effect sizes, are presented for each cohort/grade/term by each decile group in Table 5 for reading and Table 6 for math.

Finally, to bolster our interpretation of how patterns of gains compare across samples when examining changes in mean test scores across fall and spring test seasons, we also calculated the average raw fall-spring growth[3] within the 2020-21 and 2021-22 school years using the subset of students with observed test scores in the fall and spring of each school year. The average fall-spring growth rate and SD of the growth within each year/subject/cohort/decile group are reported in Table 7. For reference, we presented the average growth rates during the

[3] Note that we use both the term "achievement gains" and "growth" to refer to changes in students' test scores between the fall and spring, but the estimate underlying each term is calculated differently. Achievement gains are calculated by comparing the mean RIT score in the fall with the mean RIT score in the spring, while growth is estimated by averaging each student's fall-spring difference score. Given the number of students tested in each term varies slightly, these estimates will be similar but not equivalent.

corresponding grades per cohort and decile in the pre-COVID sample (2017-18 and 2018-19 school years). The ratio of COVID average growth and pre-COVID growth is also provided.

4. Limitations

There are several important limitations worth noting. It is possible that students who dropped out of the sample during the 2020-21 and 2021-22 school year are systematically different from our observed students in ways that could impact our results. Further, it is possible we may have seen differential attrition at the bottom and top of the distribution, which may lead to an underestimation of the impacts of the pandemic for struggling students. Additionally, we present test score results from three terms (spring 2020, fall 2020, and spring 2021) in which a sizable proportion of students may have tested remotely. While prior research (Kuhfeld et al., 2020) has found that in-person and remote administration resulted in largely equivalent grade 3-8 test score patterns in fall 2020, we note that the trends presented in this report could be affected by shifting proportions of students testing remotely during COVID.

Table 1. Characteristics for students in cross-sectional analyses (students testing in spring 2019 or spring 2022)

Gr.	Sample	N	Male	Female	White	Black	Hispanic	Asian	AIAN	Multi-Racial	Not Specified
					Reading						
3	Pre-COVID	693,352	0.51	0.49	0.48	0.17	0.19	0.04	0.01	0.04	0.06
4	Pre-COVID	688,839	0.51	0.49	0.49	0.17	0.19	0.04	0.02	0.04	0.06
5	Pre-COVID	696,371	0.51	0.49	0.49	0.17	0.19	0.04	0.02	0.04	0.06
6	Pre-COVID	646,498	0.51	0.49	0.49	0.16	0.19	0.04	0.02	0.04	0.06
7	Pre-COVID	592,696	0.51	0.49	0.50	0.16	0.18	0.04	0.02	0.04	0.06
8	Pre-COVID	546,687	0.51	0.49	0.50	0.16	0.18	0.04	0.02	0.03	0.07
3	COVID	690,713	0.51	0.49	0.48	0.17	0.19	0.04	0.01	0.04	0.06
4	COVID	689,555	0.51	0.49	0.49	0.17	0.18	0.04	0.02	0.04	0.06
5	COVID	697,404	0.51	0.49	0.49	0.17	0.19	0.04	0.02	0.04	0.06
6	COVID	649,248	0.51	0.49	0.50	0.16	0.18	0.04	0.02	0.04	0.06
7	COVID	593,119	0.51	0.49	0.50	0.16	0.18	0.04	0.02	0.04	0.07
8	COVID	523,311	0.51	0.49	0.50	0.16	0.18	0.04	0.02	0.03	0.07
					Math						
3	Pre-COVID	564,945	0.51	0.49	0.49	0.16	0.19	0.05	0.01	0.05	0.06
4	Pre-COVID	569,115	0.51	0.49	0.49	0.15	0.19	0.05	0.01	0.05	0.06
5	Pre-COVID	574,949	0.51	0.49	0.48	0.15	0.20	0.05	0.01	0.05	0.06
6	Pre-COVID	538,938	0.51	0.49	0.50	0.15	0.19	0.04	0.01	0.04	0.06
7	Pre-COVID	533,588	0.51	0.49	0.49	0.15	0.19	0.04	0.01	0.04	0.06
8	Pre-COVID	523,919	0.51	0.49	0.49	0.15	0.19	0.04	0.01	0.04	0.07
3	COVID	563,361	0.51	0.49	0.49	0.15	0.19	0.05	0.01	0.05	0.06
4	COVID	567,643	0.51	0.49	0.49	0.15	0.19	0.05	0.01	0.04	0.06
5	COVID	575,676	0.51	0.49	0.48	0.15	0.19	0.05	0.01	0.05	0.06
6	COVID	538,275	0.51	0.49	0.50	0.15	0.19	0.04	0.01	0.04	0.06
7	COVID	529,077	0.51	0.49	0.49	0.15	0.19	0.04	0.01	0.04	0.06
8	COVID	481,290	0.51	0.49	0.49	0.16	0.19	0.04	0.01	0.04	0.07

Note. AIAN= American Indian or Alaska Native. The pre-COVID sample tested in spring 2019, while the COVID sample tested in spring 2022. As a point of comparison, the projected percentage distribution of students enrolled in public elementary and secondary schools in the 2021-22 school year was 46% White, 15% Black, 28% Hispanic/Latino, 6% Asian, 1% AIAN, and 4% Other Race.

Table 2a. Characteristics for students in longitudinal analyses in reading

Gr.	Sample	N	Male	Female	White	Black	Hispanic	Asian	AIAN	Multi-Racial	Not Specified
					Bottom Decile Group						
3	Pre-COVID	52,702	0.62	0.38	0.30	0.28	0.26	0.04	0.02	0.03	0.06
4	Pre-COVID	84,024	0.61	0.39	0.34	0.25	0.26	0.03	0.02	0.03	0.07
5	Pre-COVID	91,468	0.61	0.39	0.35	0.24	0.26	0.02	0.03	0.03	0.07
6	Pre-COVID	80,034	0.62	0.38	0.33	0.26	0.25	0.02	0.03	0.03	0.06
7	Pre-COVID	78,342	0.63	0.37	0.33	0.27	0.25	0.02	0.03	0.03	0.07
8	Pre-COVID	73,967	0.64	0.36	0.32	0.26	0.25	0.02	0.03	0.03	0.07
3	COVID	58,890	0.61	0.39	0.29	0.26	0.29	0.04	0.02	0.04	0.06
4	COVID	89,391	0.59	0.41	0.33	0.24	0.27	0.03	0.02	0.04	0.06
5	COVID	101,117	0.60	0.40	0.33	0.25	0.28	0.02	0.03	0.04	0.06
6	COVID	89,304	0.61	0.39	0.31	0.26	0.28	0.02	0.03	0.04	0.05
7	COVID	90,363	0.62	0.38	0.30	0.26	0.29	0.02	0.03	0.04	0.05
8	COVID	89,631	0.63	0.37	0.31	0.26	0.29	0.02	0.03	0.04	0.06
					Top Decile Group						
3	Pre-COVID	68,277	0.46	0.54	0.64	0.10	0.08	0.07	0.01	0.04	0.06
4	Pre-COVID	112,432	0.46	0.54	0.64	0.09	0.08	0.07	0.01	0.04	0.07
5	Pre-COVID	90,743	0.47	0.53	0.66	0.07	0.07	0.08	0.01	0.04	0.07
6	Pre-COVID	72,703	0.48	0.52	0.67	0.06	0.07	0.08	0.01	0.04	0.07
7	Pre-COVID	69,297	0.48	0.52	0.68	0.05	0.06	0.08	0.01	0.04	0.07
8	Pre-COVID	56,392	0.47	0.53	0.68	0.05	0.06	0.09	0.01	0.04	0.07
3	COVID	75,559	0.47	0.53	0.63	0.09	0.09	0.08	0.01	0.05	0.06
4	COVID	110,259	0.46	0.54	0.61	0.09	0.09	0.09	0.01	0.05	0.06
5	COVID	95,907	0.46	0.54	0.63	0.07	0.09	0.08	0.01	0.05	0.07
6	COVID	81,967	0.47	0.53	0.64	0.07	0.09	0.09	0.01	0.05	0.06
7	COVID	75,089	0.47	0.53	0.64	0.06	0.09	0.10	0.01	0.05	0.07
8	COVID	69,321	0.47	0.53	0.64	0.06	0.09	0.11	0.01	0.04	0.06

Note. AIAN= American Indian or Alaska Native. The bottom decile group were the students with percentile rank less than or equal to 10th percentile in fall 2019 (fall 2016 for pre-COVID), while the top decile group had a percentile rank greater than or equal to 90th percentile in fall 2016/2019.

Table 2b. Characteristics for students in longitudinal analyses in math

Gr.	Sample	N	Male	Female	White	Black	Hispanic	Asian	AIAN	Multi-Racial	Not Specified
					Bottom Decile Group						
3	Pre-COVID	62,781	0.59	0.41	0.30	0.29	0.26	0.03	0.03	0.03	0.06
4	Pre-COVID	71,869	0.58	0.42	0.33	0.27	0.25	0.02	0.02	0.03	0.06
5	Pre-COVID	74,003	0.56	0.44	0.32	0.27	0.26	0.02	0.03	0.03	0.07
6	Pre-COVID	64,854	0.56	0.44	0.30	0.30	0.25	0.02	0.03	0.03	0.07
7	Pre-COVID	71,163	0.55	0.45	0.30	0.30	0.25	0.02	0.03	0.03	0.07
8	Pre-COVID	71,404	0.56	0.44	0.30	0.29	0.25	0.02	0.03	0.03	0.07
3	COVID	71,144	0.57	0.43	0.28	0.27	0.29	0.03	0.02	0.04	0.06
4	COVID	87,174	0.56	0.44	0.31	0.27	0.27	0.02	0.02	0.04	0.06
5	COVID	88,423	0.54	0.46	0.30	0.28	0.28	0.02	0.03	0.04	0.05
6	COVID	78,199	0.54	0.46	0.28	0.29	0.28	0.02	0.03	0.04	0.05
7	COVID	91,367	0.53	0.47	0.28	0.30	0.28	0.02	0.03	0.04	0.05
8	COVID	88,160	0.55	0.45	0.29	0.30	0.28	0.02	0.03	0.04	0.05
					Top Decile Group						
3	Pre-COVID	59,514	0.56	0.44	0.67	0.07	0.07	0.09	0.01	0.04	0.06
4	Pre-COVID	92,465	0.59	0.41	0.65	0.06	0.08	0.10	0.01	0.04	0.06
5	Pre-COVID	78,752	0.60	0.40	0.66	0.05	0.07	0.11	0.01	0.04	0.07
6	Pre-COVID	78,951	0.60	0.40	0.66	0.04	0.07	0.11	0.01	0.04	0.07
7	Pre-COVID	86,526	0.60	0.40	0.66	0.04	0.07	0.11	0.01	0.04	0.07
8	Pre-COVID	69,398	0.59	0.41	0.67	0.03	0.06	0.12	0.01	0.03	0.07
3	COVID	66,949	0.60	0.40	0.64	0.07	0.08	0.09	0.01	0.05	0.06
4	COVID	99,450	0.61	0.39	0.62	0.06	0.09	0.11	0.01	0.05	0.06
5	COVID	85,849	0.62	0.38	0.63	0.05	0.09	0.12	0.01	0.05	0.06
6	COVID	77,285	0.63	0.37	0.62	0.04	0.09	0.13	0.01	0.04	0.06
7	COVID	92,885	0.62	0.38	0.63	0.04	0.09	0.13	0.01	0.04	0.06
8	COVID	73,344	0.61	0.39	0.62	0.03	0.07	0.15	0.01	0.04	0.07

Note. AIAN= American Indian or Alaska Native. The bottom decile group were the students with percentile rank less than or equal to 10th percentile in fall 2019 (fall 2016 for pre-COVID), while the top decile group had a percentile rank greater than or equal to 90th percentile in fall 2016/2019.

Table 3. Test score characteristics for Pre-COVID & COVID samples of MAP Growth test takers

		Pre-COVID (Spring 2019)				COVID (Spring 2022)			
Subject	Grade	N	N Schools	M	SD	N	N Schools	M	SD
Reading	3	693,352	10,316	197.98	16.25	564,945	9,292	195.99	17.57
Reading	4	688,839	10,093	205.34	15.91	569,115	9,385	203.88	16.94
Reading	5	696,371	9,754	211.02	15.68	574,949	9,219	209.43	16.53
Reading	6	646,498	6,821	214.99	15.68	538,938	7,529	213.49	16.22
Reading	7	592,696	5,607	218.52	15.93	533,588	6,486	216.72	16.57
Reading	8	546,687	5,250	221.65	16.11	523,919	5,820	219.86	16.76
Math	3	690,713	10,303	201.93	14.35	563,361	9,254	199.27	15.80
Math	4	689,555	10,097	211.72	15.72	567,643	9,396	208.62	17.07
Math	5	697,404	9,777	219.76	17.52	575,676	9,248	215.94	18.51
Math	6	649,248	6,857	222.78	17.26	538,275	7,513	219.61	17.58
Math	7	593,119	5,637	227.81	18.57	529,077	6,458	224.09	18.61
Math	8	523,311	5,259	231.67	19.75	481,290	5,781	227.44	19.42

Note. N=number of students, M=mean, SD=standard deviation.

Table 4. Changes in test score variability during the COVID-19 pandemic

		Standard Deviation (SD)			Intraclass Correlation (ICC)		
Subject	Grade	pre-COVID	COVID	Ratio	pre-COVID	COVID	Difference
Reading	3	16.25	17.57	1.08	0.2	0.21	0.01
Reading	4	15.91	16.94	1.06	0.2	0.21	0.01
Reading	5	15.68	16.53	1.05	0.2	0.21	0.01
Reading	6	15.68	16.22	1.03	0.21	0.21	0
Reading	7	15.93	16.57	1.04	0.22	0.2	-0.02
Reading	8	16.11	16.76	1.04	0.21	0.19	-0.02
Math	3	14.35	15.8	1.1	0.23	0.26	0.03
Math	4	15.72	17.07	1.09	0.24	0.28	0.04
Math	5	17.52	18.51	1.06	0.24	0.27	0.03
Math	6	17.26	17.58	1.02	0.26	0.27	0.01
Math	7	18.57	18.61	1	0.25	0.25	0
Math	8	19.75	19.42	0.98	0.26	0.24	-0.01

Note. ICC=% of variability in test scores that is between schools, pre-COVID=spring 2019; COVID=spring 2022.

Table 5. Student reading RIT score means/SDs by cohort, sample, and decile group

			Pre-COVID Sample		COVID Sample		
Grades	Term	Decile	N	M (SD)	N	M (SD)	Standardized difference between samples
1-3	2S	<10	40237	170.16 (14.45)	33767	166.15 (15.63)	-0.24
1-3	3S	<10	34270	181.32 (16.46)	34050	176.45 (16.52)	-0.29
1-3	2S	>90	54756	206.05 (9.28)	51114	204.53 (10.33)	-0.09
1-3	3S	>90	47460	215.89 (8.85)	49488	215.05 (9.58)	-0.05
2-4	3S	<10	59993	178.10 (15.32)	50482	174.16 (15.87)	-0.24
2-4	4S	<10	53279	186.42 (16.07)	48438	182.76 (16.63)	-0.22
2-4	3S	>90	84486	215.96 (8.33)	71942	215.06 (9.04)	-0.05
2-4	4S	>90	77332	222.14 (8.31)	69913	221.94 (8.64)	-0.01
3-5	4S	<10	64473	182.78 (15.27)	56292	178.84 (15.62)	-0.24
3-5	5S	<10	57944	189.87 (15.74)	55566	186.28 (16.04)	-0.22
3-5	4S	>90	69059	224.45 (7.83)	61632	223.33 (8.26)	-0.07
3-5	5S	>90	62595	229.16 (7.79)	60542	228.54 (8.20)	-0.04
4-6	5S	<10	57323	187.51 (15.33)	50241	183.01 (15.67)	-0.28
4-6	6S	<10	48676	192.78 (14.88)	46508	189.40 (13.90)	-0.21
4-6	5S	>90	55187	231.10 (7.38)	53147	229.51 (7.74)	-0.10
4-6	6S	>90	47417	234.80 (8.12)	49080	233.85 (8.26)	-0.06
5-7	6S	<10	52556	191.37 (15.22)	45505	187.39 (14.53)	-0.25
5-7	7S	<10	45992	195.93 (14.95)	44977	191.71 (14.34)	-0.26
5-7	6S	>90	49245	235.54 (7.68)	45309	234.73 (8.09)	-0.05
5-7	7S	>90	43821	238.93 (8.33)	44215	238.32 (8.26)	-0.04
6-8	7S	<10	48536	194.46 (15.44)	43728	190.08 (15.03)	-0.26
6-8	8S	<10	41965	198.81 (15.23)	43943	194.42 (14.83)	-0.26
6-8	7S	>90	39146	240.48 (7.76)	41347	239.32 (8.13)	-0.07
6-8	8S	>90	34081	243.30 (8.08)	40243	242.29 (8.22)	-0.06

Note. N=number of students, M=mean, SD=standard deviation, 2S=spring of 2nd grade.

Table 6. Student math RIT score means/SDs by cohort, sample, and decile group

			Pre-COVID Sample		COVID Sample		
Grades	Term	Decile	N	M (SD)	N	M (SD)	Standardized difference between samples
1-3	2S	<10	48182	174.61 (13.73)	41650	169.22 (15.42)	-0.38
1-3	3S	<10	39972	185.73 (15.14)	41017	179.03 (16.15)	-0.45
1-3	2S	>90	48759	207.84 (8.48)	46478	204.94 (9.44)	-0.20
1-3	3S	>90	41980	219.52 (9.49)	44339	217.88 (9.67)	-0.11
2-4	3S	<10	50112	183.71 (14.37)	50702	177.38 (15.27)	-0.43
2-4	4S	<10	44402	192.01 (15.51)	48712	185.47 (15.96)	-0.40
2-4	3S	>90	68797	219.76 (9.10)	64645	216.40 (9.43)	-0.23
2-4	4S	>90	63103	231.42 (10.30)	63766	229.14 (10.44)	-0.14
3-5	4S	<10	50684	189.02 (14.50)	50740	182.39 (14.43)	-0.41
3-5	5S	<10	45444	195.38 (15.33)	49507	188.63 (14.72)	-0.38
3-5	4S	>90	59506	233.56 (9.99)	57159	229.24 (10.21)	-0.27
3-5	5S	>90	54578	243.74 (10.81)	55818	240.97 (11.49)	-0.15
4-6	5S	<10	45156	192.61 (14.39)	44667	186.08 (13.85)	-0.37
4-6	6S	<10	38238	196.09 (13.88)	40871	191.87 (12.11)	-0.24
4-6	5S	>90	59507	244.97 (10.07)	52674	241.13 (10.83)	-0.22
4-6	6S	>90	51585	246.62 (9.71)	47785	244.93 (10.45)	-0.10
5-7	6S	<10	46608	195.04 (13.75)	45840	191.80 (12.59)	-0.19
5-7	7S	<10	40826	199.56 (13.87)	45417	195.38 (12.28)	-0.22
5-7	6S	>90	61214	247.07 (9.12)	56909	243.74 (9.91)	-0.19
5-7	7S	>90	52843	253.82 (10.41)	51947	250.85 (10.81)	-0.16
6-8	7S	<10	46074	198.49 (14.33)	43502	194.76 (12.92)	-0.20
6-8	8S	<10	39566	202.74 (14.31)	43162	198.41 (12.60)	-0.22
6-8	7S	>90	46130	256.19 (9.61)	39422	253.30 (10.40)	-0.15
6-8	8S	>90	36531	262.71 (10.59)	31257	259.96 (11.38)	-0.14

Note. N=number of students, M=mean, SD=standard deviation, 2S=spring of 2nd grade.

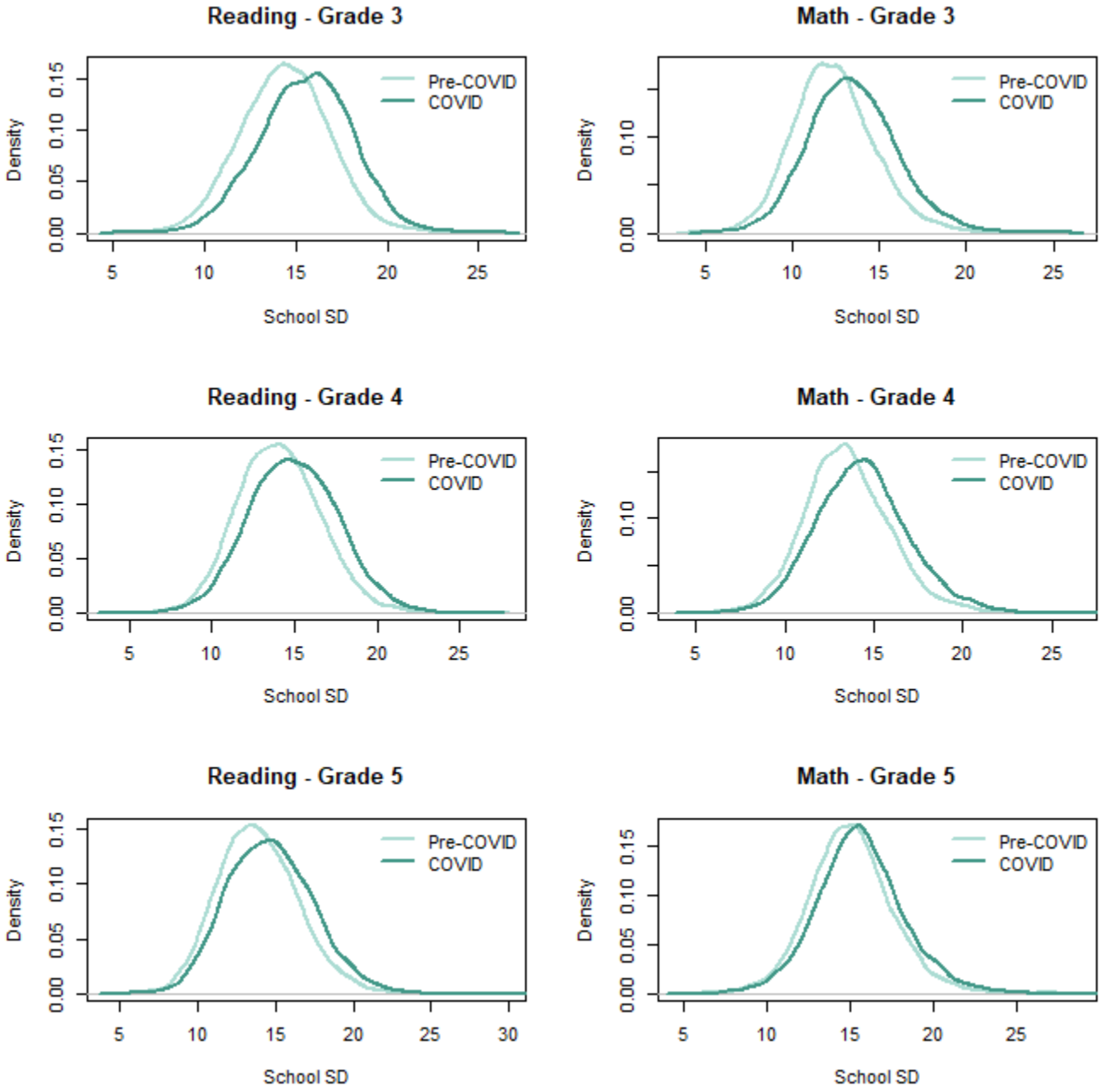
Table 7. Average fall-spring growth rates during the 2020-21 and 2021-22 school year relative to pre-COVID averages gains by decile group

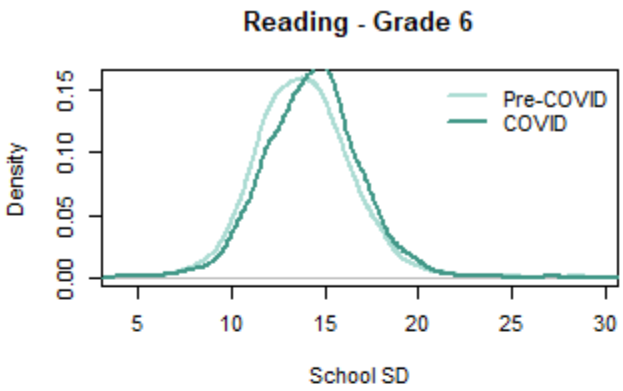
				Pre-COVID Sample		COVID Sample		
Subject	Grade	Year	Decile	N	Mean Gain	N	Mean Gain	Ratio
Reading	3	2020-21	<10	38,424	13.34	28,168	7.59	0.57
Reading	3	2021-22	<10	32,335	11.02	32,049	10.71	0.97
Reading	4	2020-21	<10	56,491	12.64	43,108	7.85	0.62
Reading	4	2021-22	<10	49,552	9.43	45,399	9.05	0.96
Reading	5	2020-21	<10	61,456	10.67	47,245	6.18	0.58
Reading	5	2021-22	<10	54,055	8.28	51,867	7.54	0.91
Reading	6	2020-21	<10	54,700	9.01	42,128	4.84	0.54
Reading	6	2021-22	<10	44,646	6.38	42,036	5.88	0.92
Reading	7	2020-21	<10	49,547	7.07	35,427	2.98	0.42
Reading	7	2021-22	<10	41,285	5.12	40,452	4.15	0.81
Reading	8	2020-21	<10	45,284	5.68	34,267	2.02	0.35
Reading	8	2021-22	<10	37,703	4.09	39,893	3.45	0.84
Reading	3	2020-21	>90	53,032	11.09	45,829	9.56	0.86
Reading	3	2021-22	>90	45,688	8.56	47,387	8.84	1.03
Reading	4	2020-21	>90	80,751	8.37	65,535	6.85	0.82
Reading	4	2021-22	>90	73,193	6.12	66,809	6.29	1.03
Reading	5	2020-21	>90	67,207	6.29	55,343	5.02	0.80
Reading	5	2021-22	>90	60,151	4.72	57,755	4.85	1.03
Reading	6	2020-21	>90	53,676	4.88	47,656	3.78	0.77
Reading	6	2021-22	>90	45,404	3.81	45,605	3.46	0.91
Reading	7	2020-21	>90	47,331	4.10	39,532	2.83	0.69
Reading	7	2021-22	>90	41,465	3.25	41,748	3.13	0.96
Reading	8	2020-21	>90	37,468	3.64	35,894	1.93	0.53
Reading	8	2021-22	>90	32,172	2.47	38,170	2.66	1.08
Math	3	2020-21	<10	45,896	14.60	34,304	8.84	0.61
Math	3	2021-22	<10	37,547	13.05	38,482	12.70	0.97
Math	4	2020-21	<10	47,048	13.19	42,818	8.35	0.63
Math	4	2021-22	<10	41,523	10.57	45,642	10.16	0.96
Math	5	2020-21	<10	48,222	10.44	42,177	6.06	0.58
Math	5	2021-22	<10	42,769	8.59	46,116	7.93	0.92
Math	6	2020-21	<10	43,004	8.41	36,984	4.39	0.52
Math	6	2021-22	<10	35,663	6.39	36,762	6.53	1.02
Math	7	2020-21	<10	44,006	6.23	35,460	4.08	0.65
Math	7	2021-22	<10	37,316	5.17	40,794	4.78	0.92
Math	8	2020-21	<10	42,797	5.43	33,769	3.04	0.56
Math	8	2021-22	<10	36,178	4.40	38,883	4.35	0.99
Math	3	2020-21	>90	47,496	13.25	41,081	12.29	0.93
Math	3	2021-22	>90	40,212	13.24	42,506	13.53	1.02
Math	4	2020-21	>90	65,494	13.10	57,637	12.42	0.95
Math	4	2021-22	>90	59,542	12.67	60,968	13.06	1.03
Math	5	2020-21	>90	57,772	13.25	51,026	11.92	0.90
Math	5	2021-22	>90	52,432	11.93	53,578	12.43	1.04
Math	6	2020-21	>90	57,856	12.53	46,540	10.42	0.83
Math	6	2021-22	>90	49,557	9.50	44,547	10.08	1.06

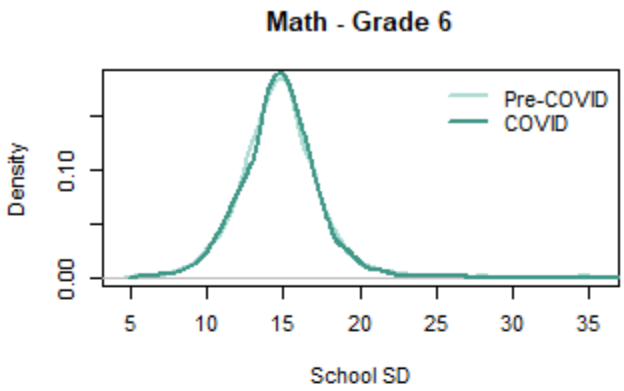
Math	7	2020-21	>90	58,858	9.73	50,061	9.59	0.99
Math	7	2021-22	>90	49,866	7.69	49,229	8.23	1.07
Math	8	2020-21	>90	43,883	7.89	34,183	7.65	0.97
Math	8	2021-22	>90	33,983	7.00	29,645	7.61	1.09

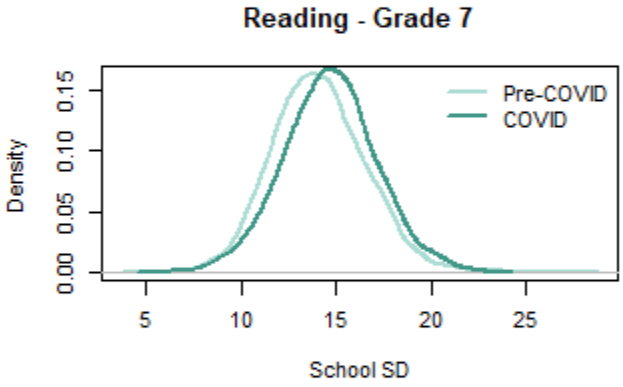
Note. The pre-COVID sample columns show gains from the 2017-18 and 2018-19 school years as a reference to the COVID sample's 2020-21 and 2021-22 fall-spring gains. Gains are calculated as spring RIT minus fall RIT for each grade/subject/year.

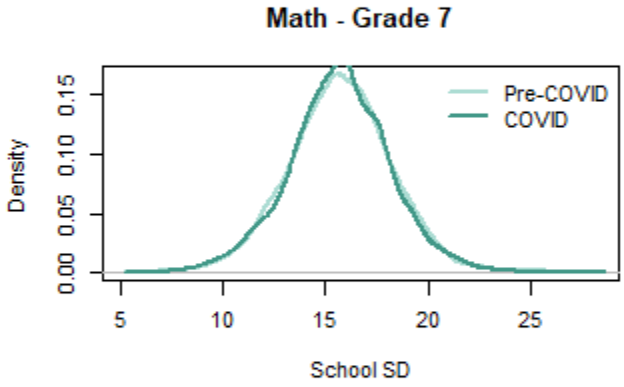
Figure A1. Comparison of within-school variability (school SDs) in spring 2019 (pre-COVID) and spring 2022 (COVID)

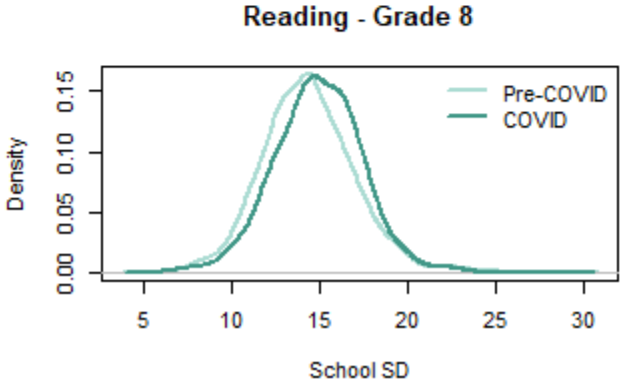



Reading - Grade 6
Pre-COVID
COVID
Density
0.00
0.05
0.10
0.15
5
10
15
20
25
30
School SD


Math - Grade 6
Pre-COVID
COVID
Density
0.00
0.10
5
10
15
20
25
30
35
School SD


Reading - Grade 7
Pre-COVID
COVID
Density
0.00
0.05
0.10
0.15
5
10
15
20
25
School SD


Math - Grade 7
Pre-COVID
COVID
Density
0.00
0.05
0.10
0.15
5
10
15
20
25
School SD


Reading - Grade 8
Pre-COVID
COVID
Density
0.00
0.05
0.10
0.15
5
10
15
20
25
30
School SD

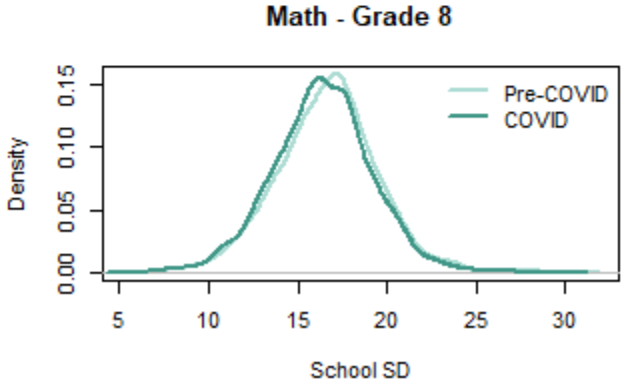

Math - Grade 8
Pre-COVID
COVID
Density
0.00
0.05
0.10
0.15
5
10
15
20
25
30
School SD

Figure A2. Illustration of percentile ranks in spring 2019 and spring 2022 for reading grade 3 test scores

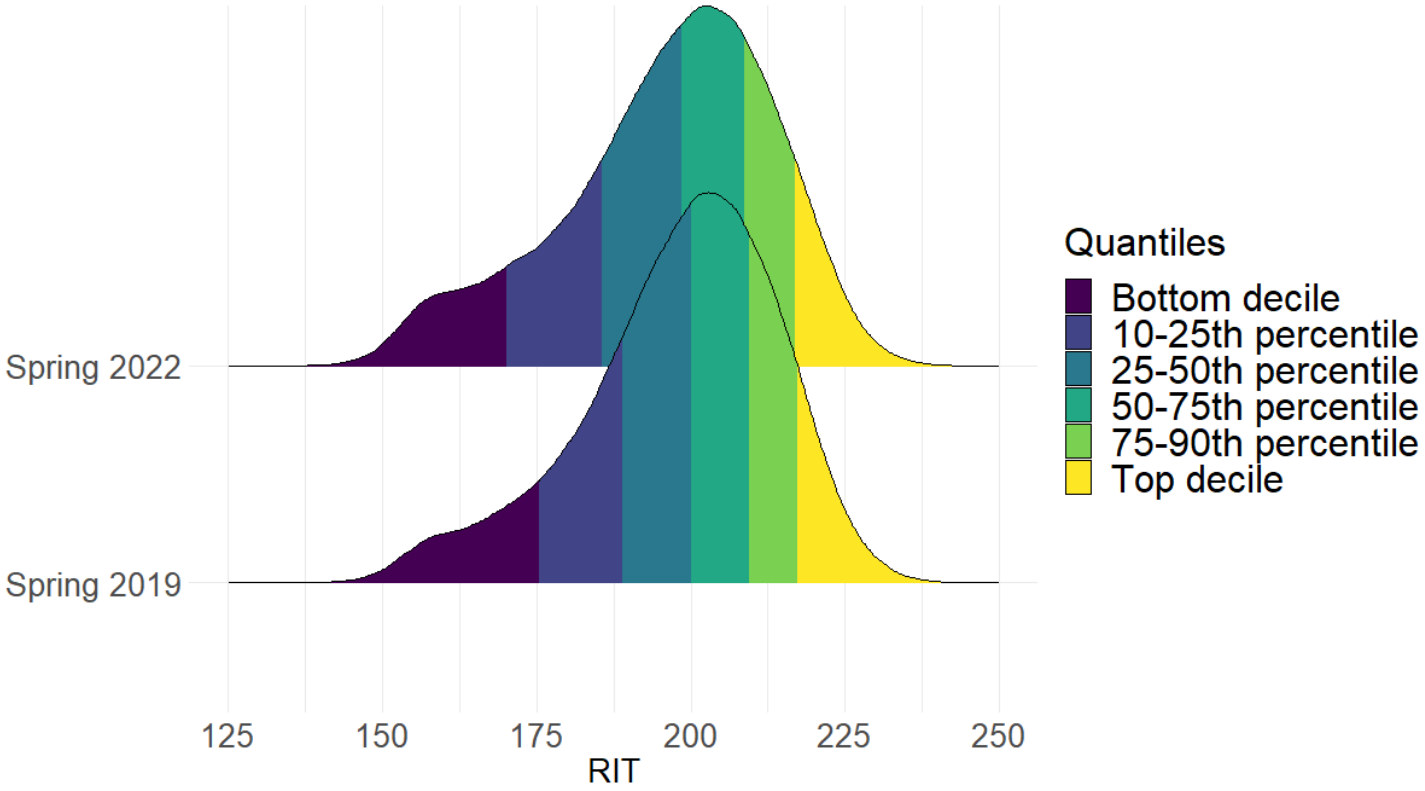
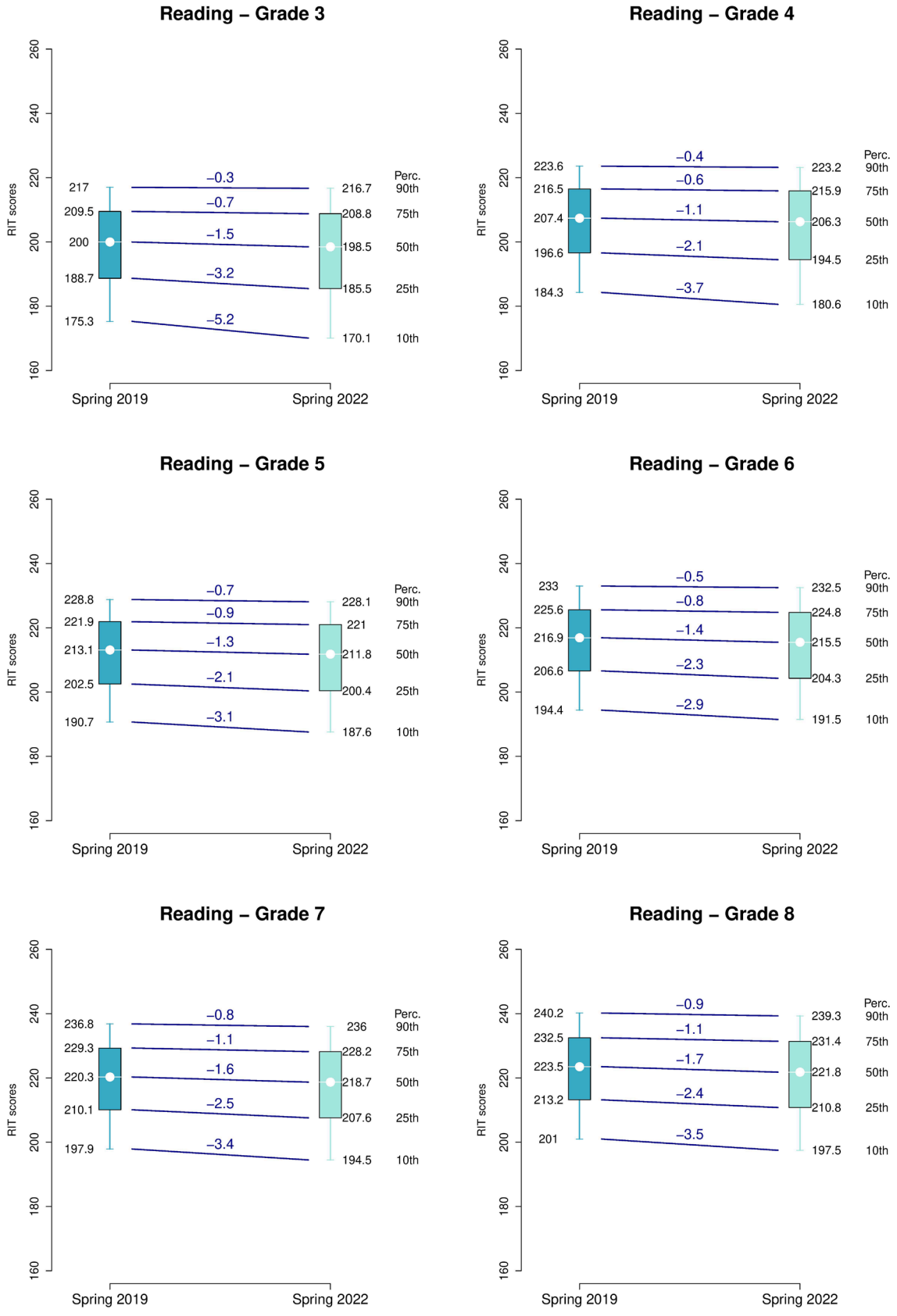
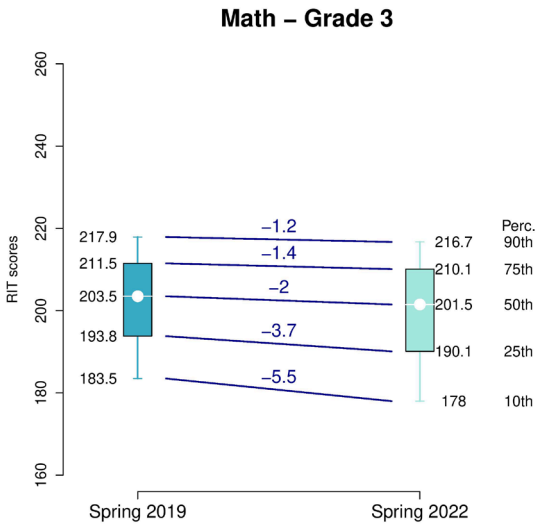
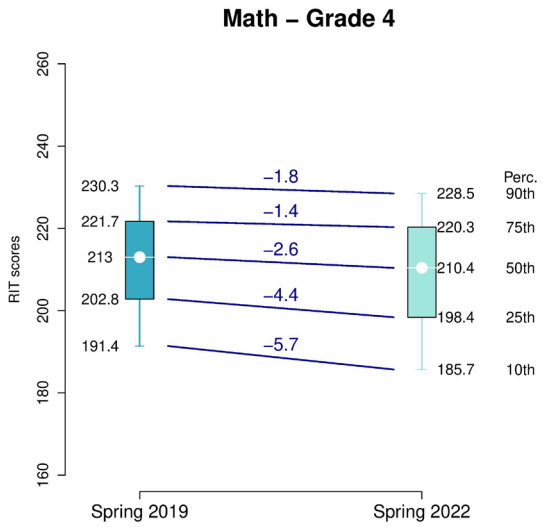
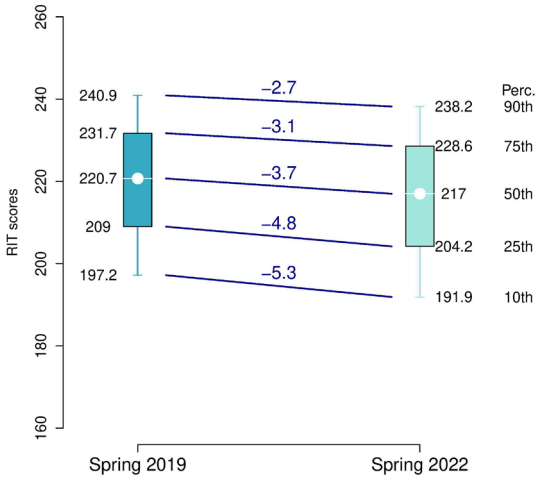


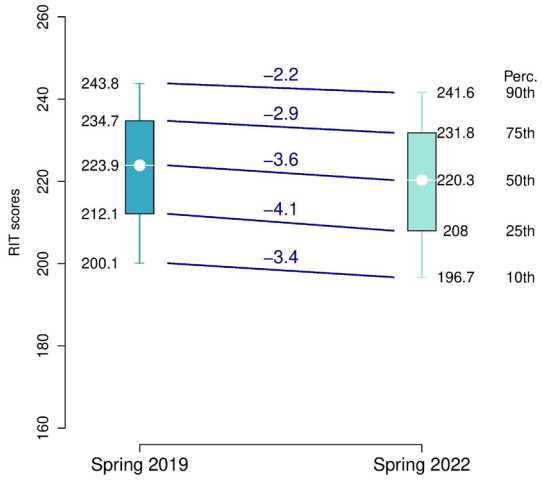
Figure A3. Average MAP Growth achievement across four school years for all cohorts and subjects.

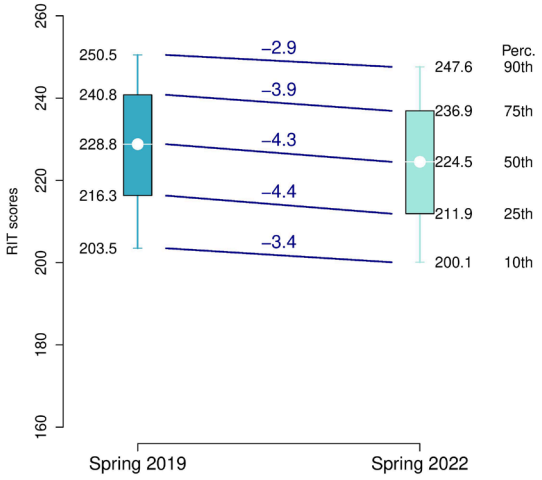



Math – Grade 3
RIT scores
160
180
200
220
240
260
217.9
211.5
203.5
193.8
183.5
−1.2
−1.4
−2
−3.7
−5.5
216.7
210.1
201.5
190.1
178
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022


Math – Grade 4
RIT scores
160
180
200
220
240
260
230.3
221.7
213
202.8
191.4
−1.8
−1.4
−2.6
−4.4
−5.7
228.5
220.3
210.4
198.4
185.7
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022


Math – Grade 5
RIT scores
160
180
200
220
240
260
240.9
231.7
220.7
209
197.2
−2.7
−3.1
−3.7
−4.8
−5.3
238.2
228.6
217
204.2
191.9
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022


Math – Grade 6
RIT scores
160
180
200
220
240
260
243.8
234.7
223.9
212.1
200.1
−2.2
−2.9
−3.6
−4.1
−3.4
241.6
231.8
220.3
208
196.7
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022


Math – Grade 7
RIT scores
160
180
200
220
240
260
250.5
240.8
228.8
216.3
203.5
−2.9
−3.9
−4.3
−4.4
−3.4
247.6
236.9
224.5
211.9
200.1
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022

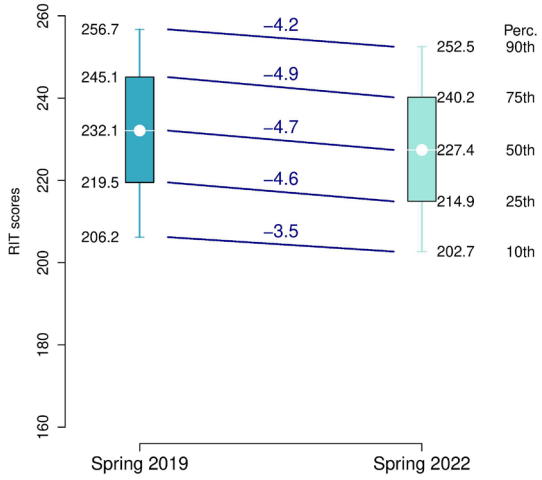
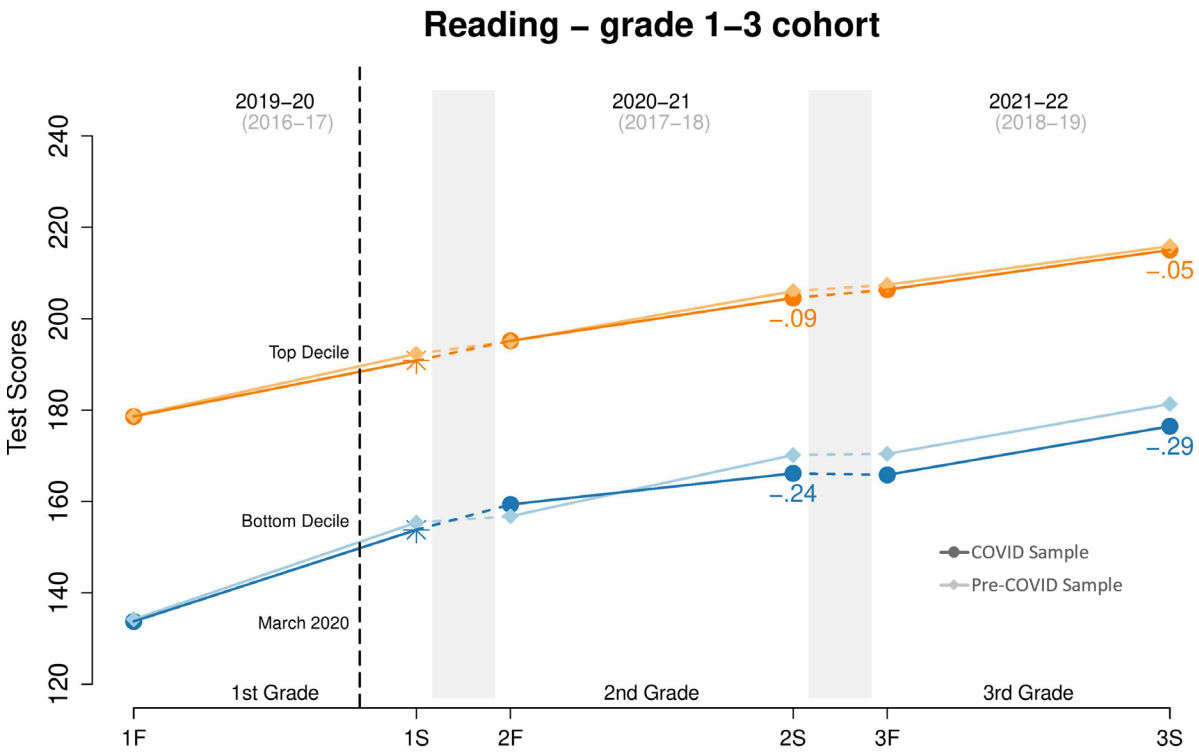
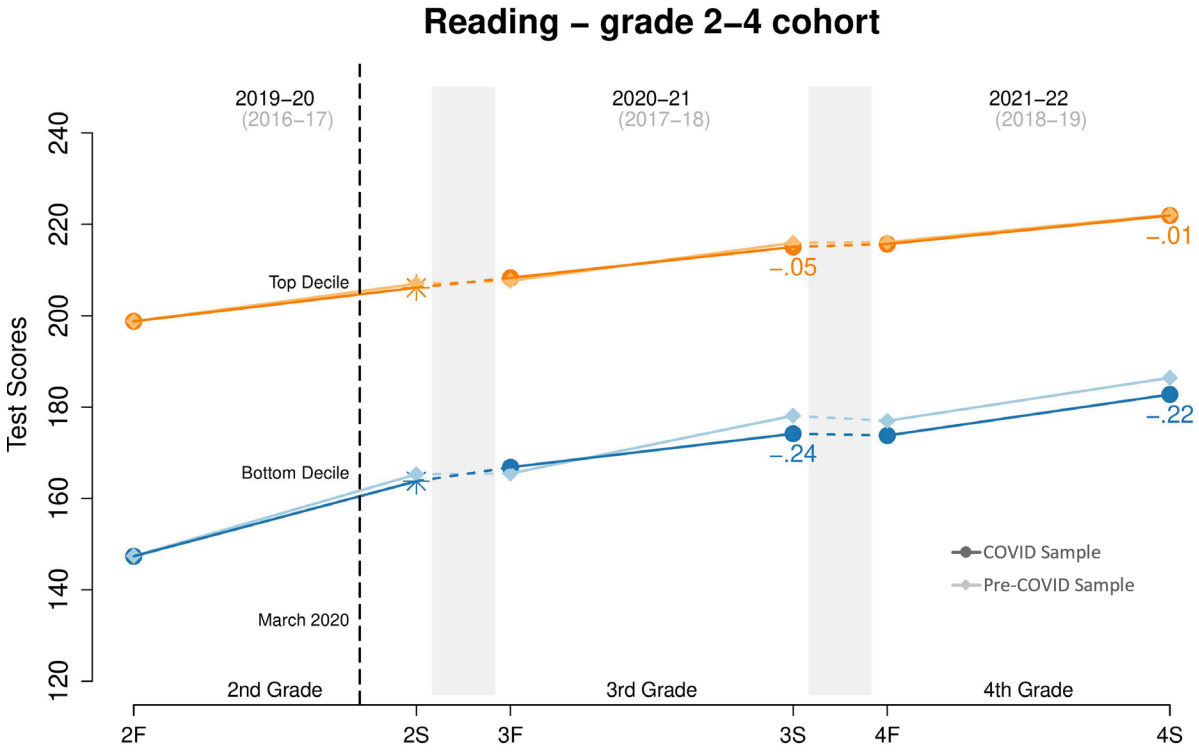
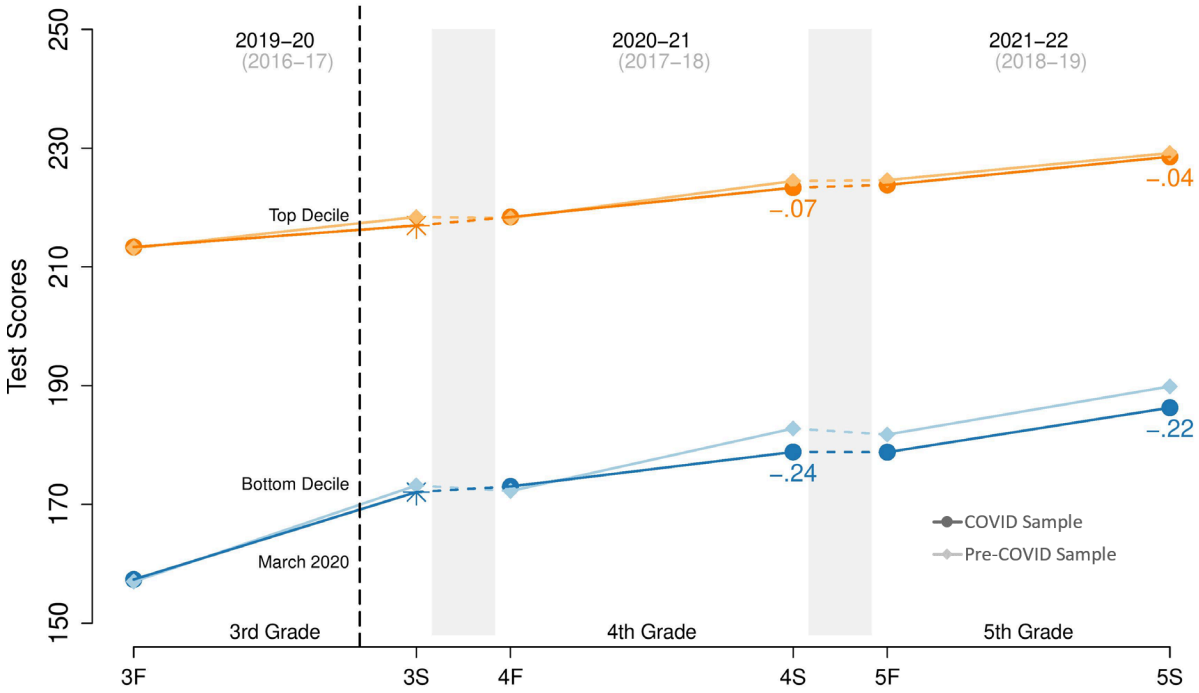

Math – Grade 8
RIT scores
160
180
200
220
240
260
256.7
245.1
232.1
219.5
206.2
−4.2
−4.9
−4.7
−4.6
−3.5
252.5
240.2
227.4
214.9
202.7
Perc.
90th
75th
50th
25th
10th
Spring 2019
Spring 2022

Figure A4. Average MAP Growth achievement across three school years for students in bottom and top deciles

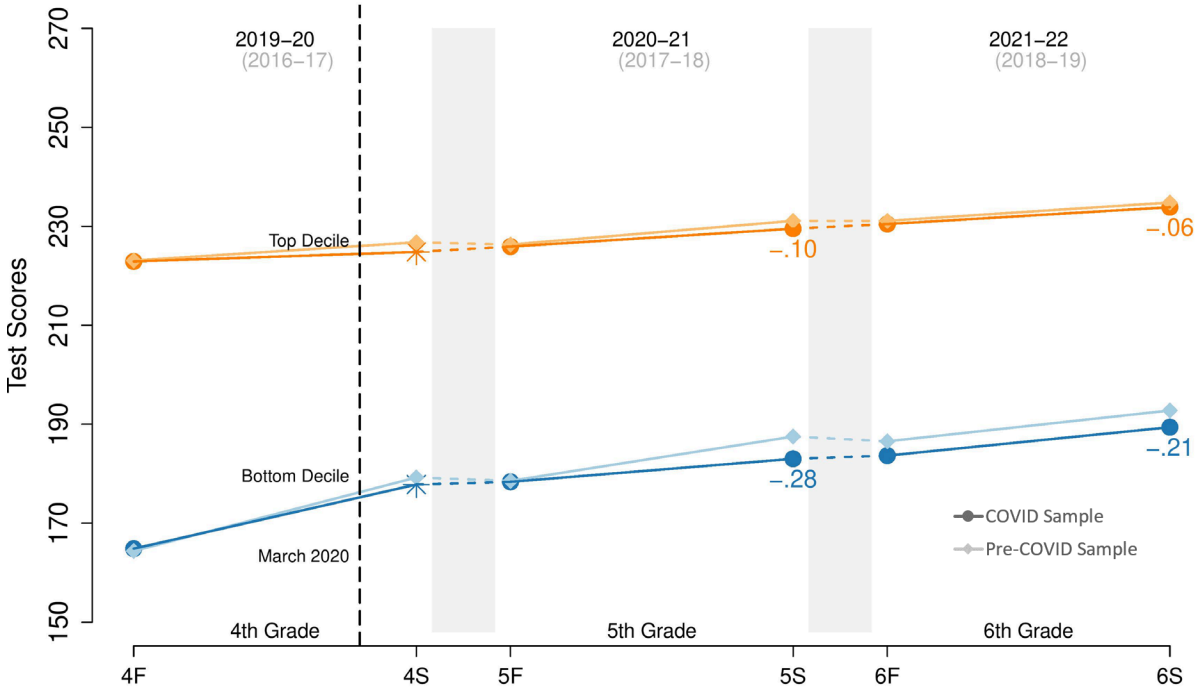




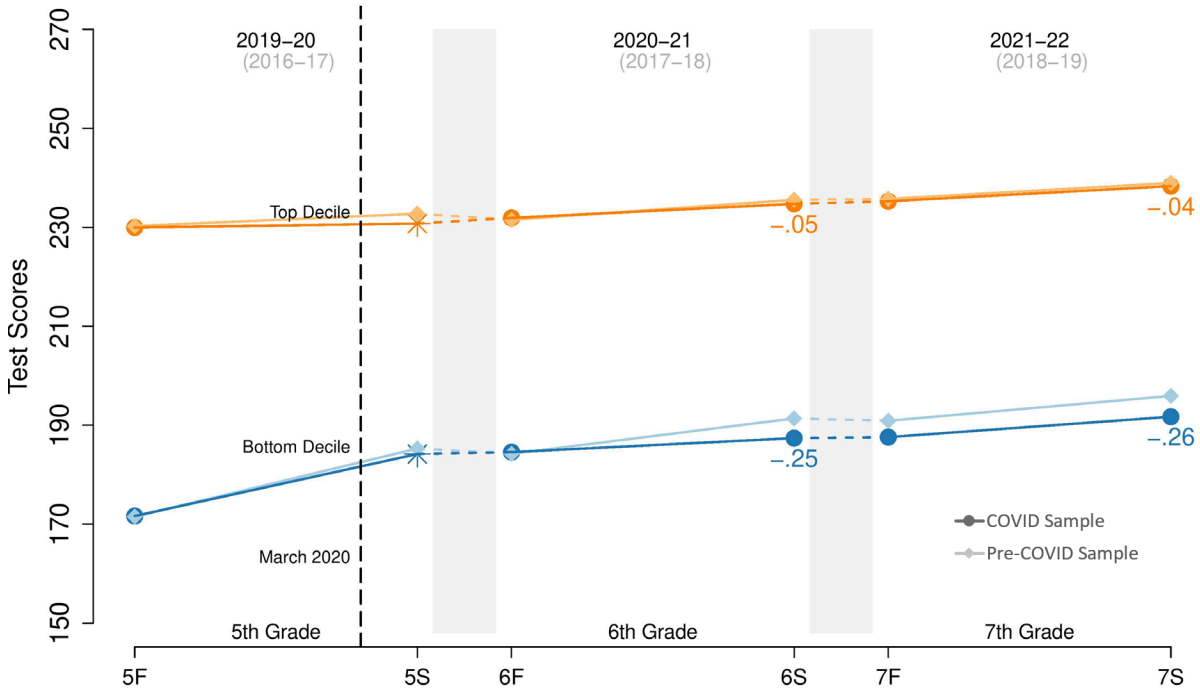
Reading – grade 3–5 cohort



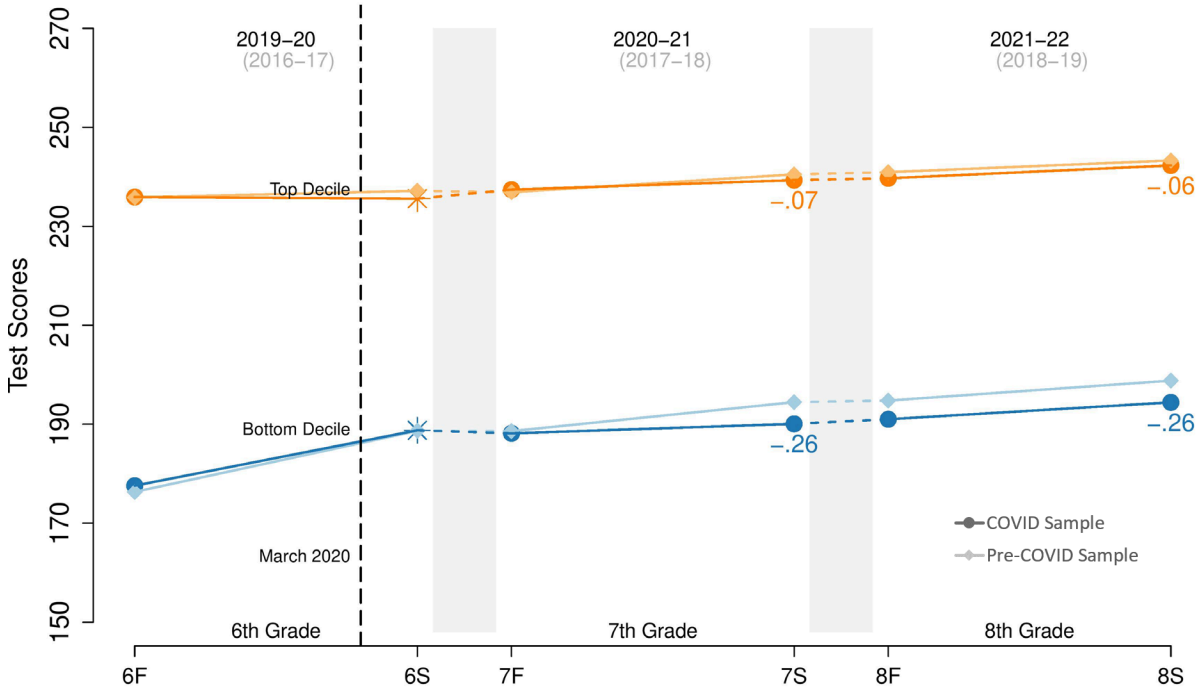
Reading – grade 4–6 cohort

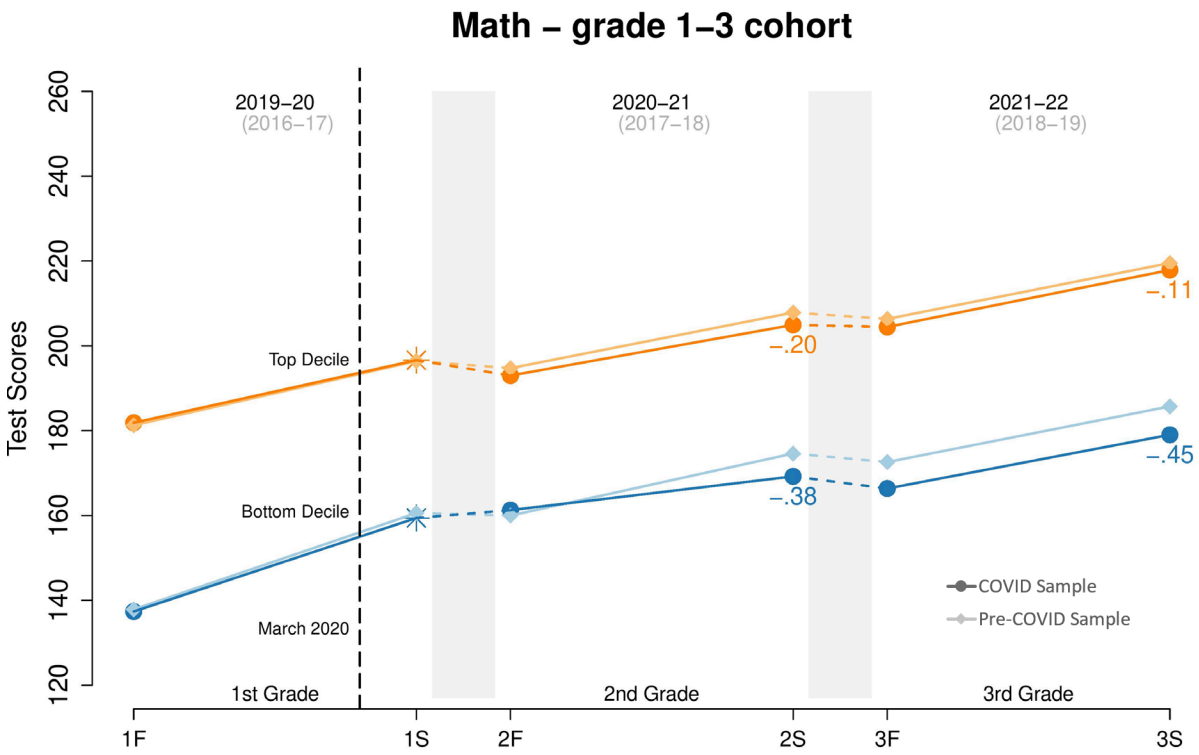


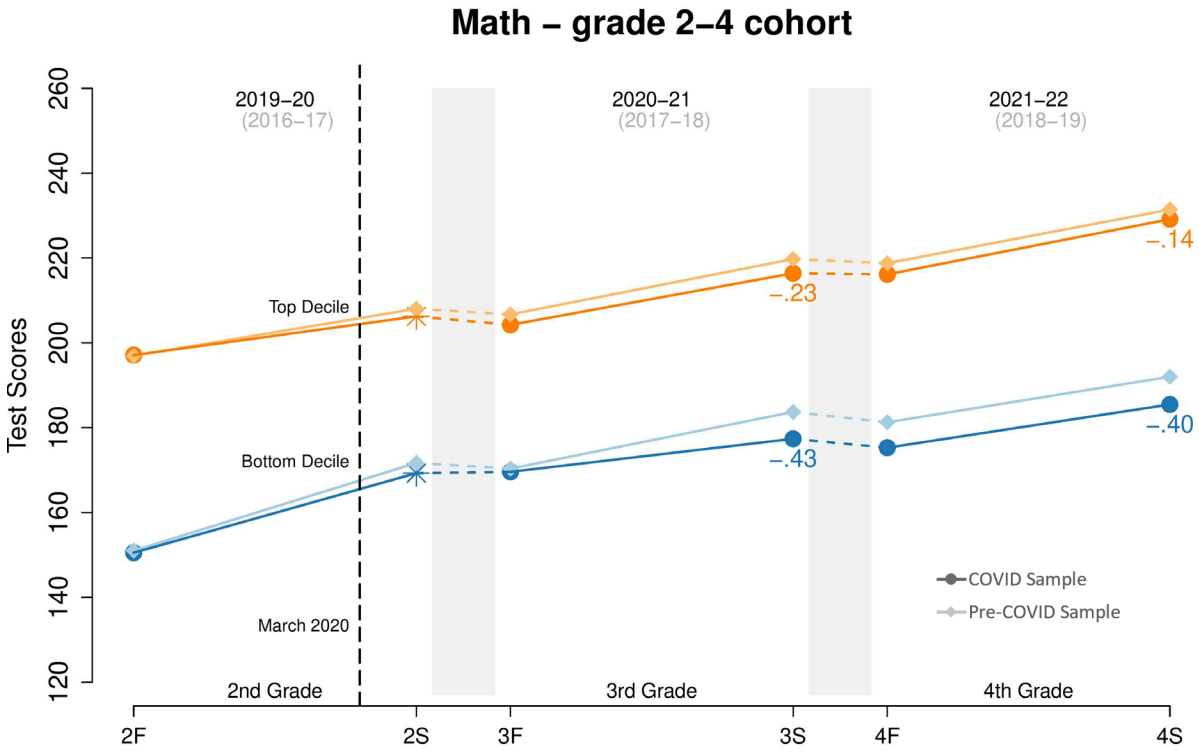
Reading – grade 5–7 cohort

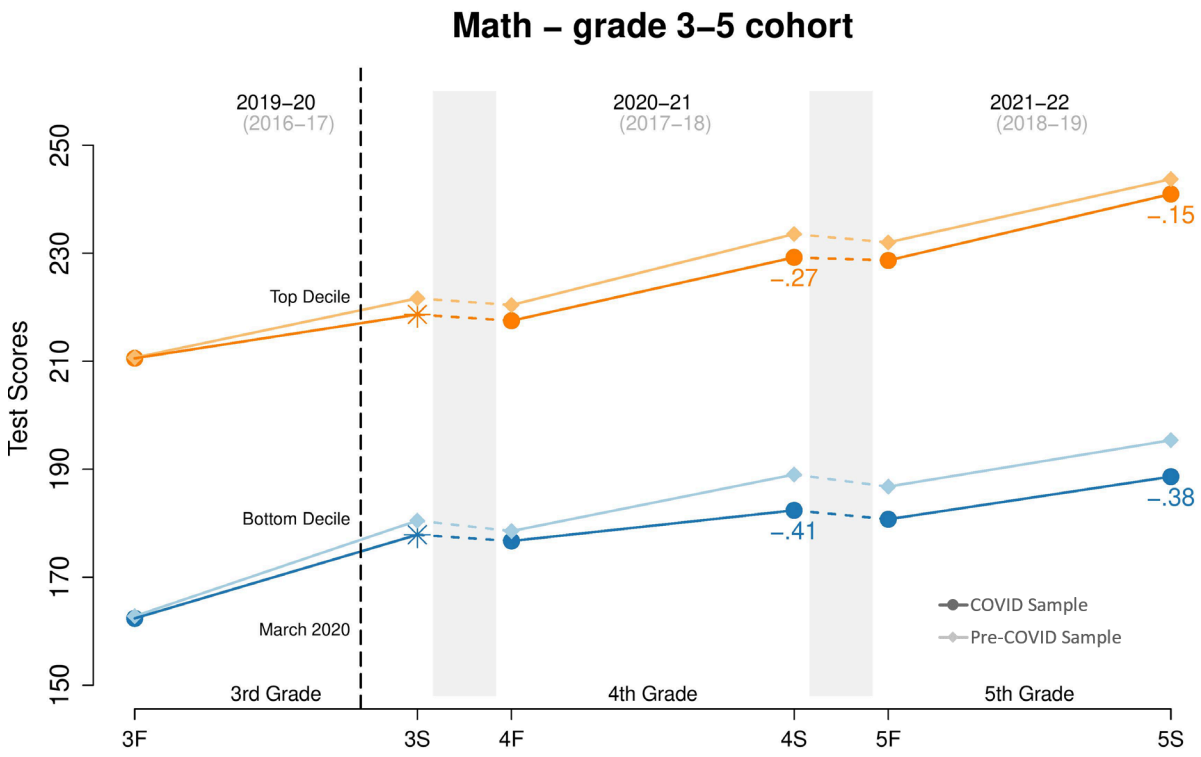


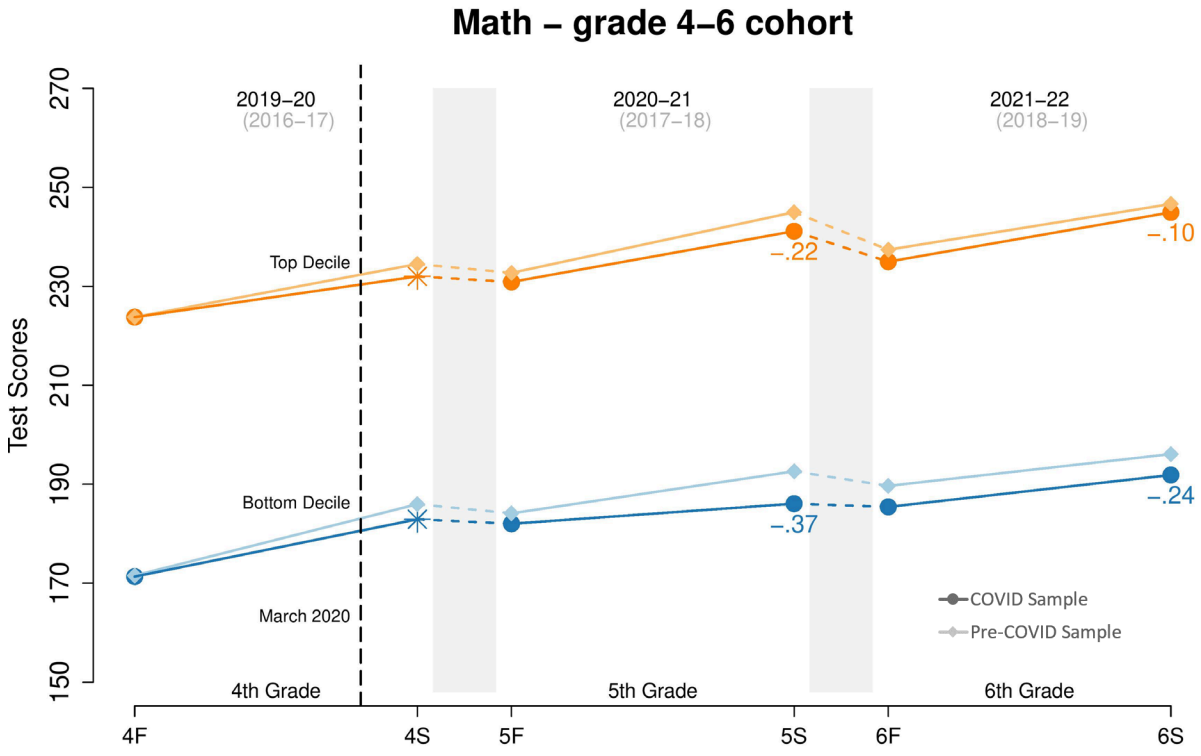
Reading – grade 6–8 cohort

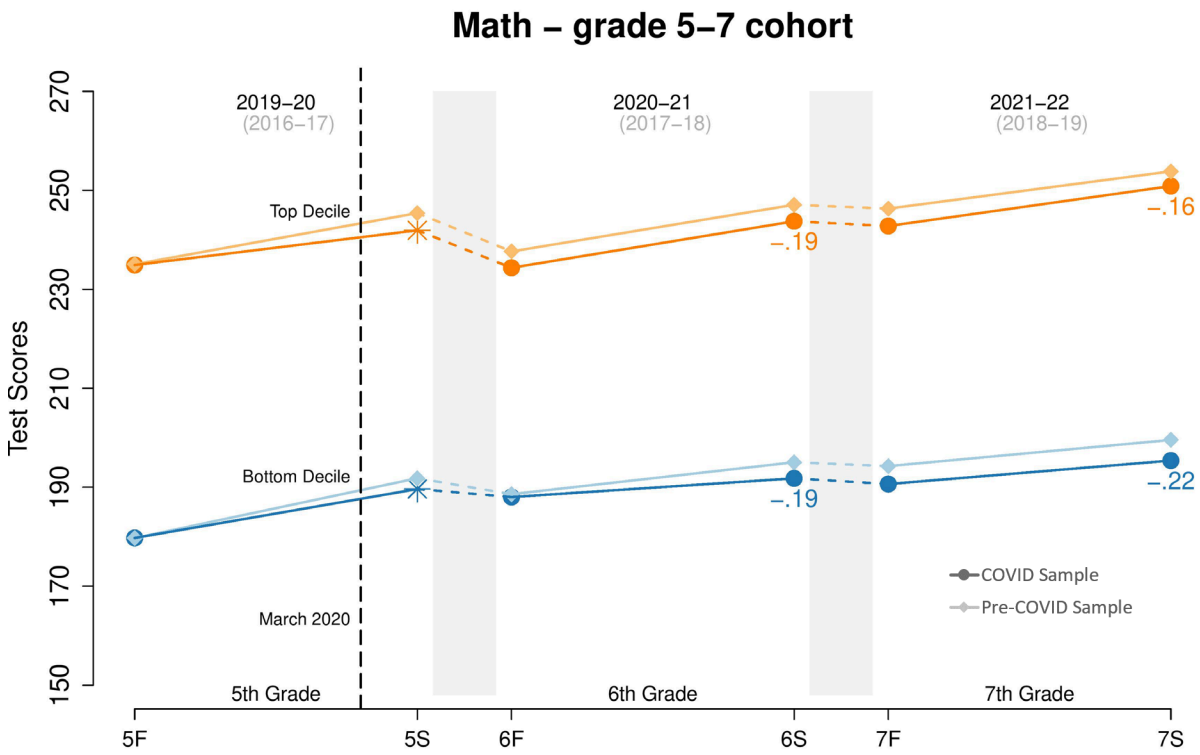


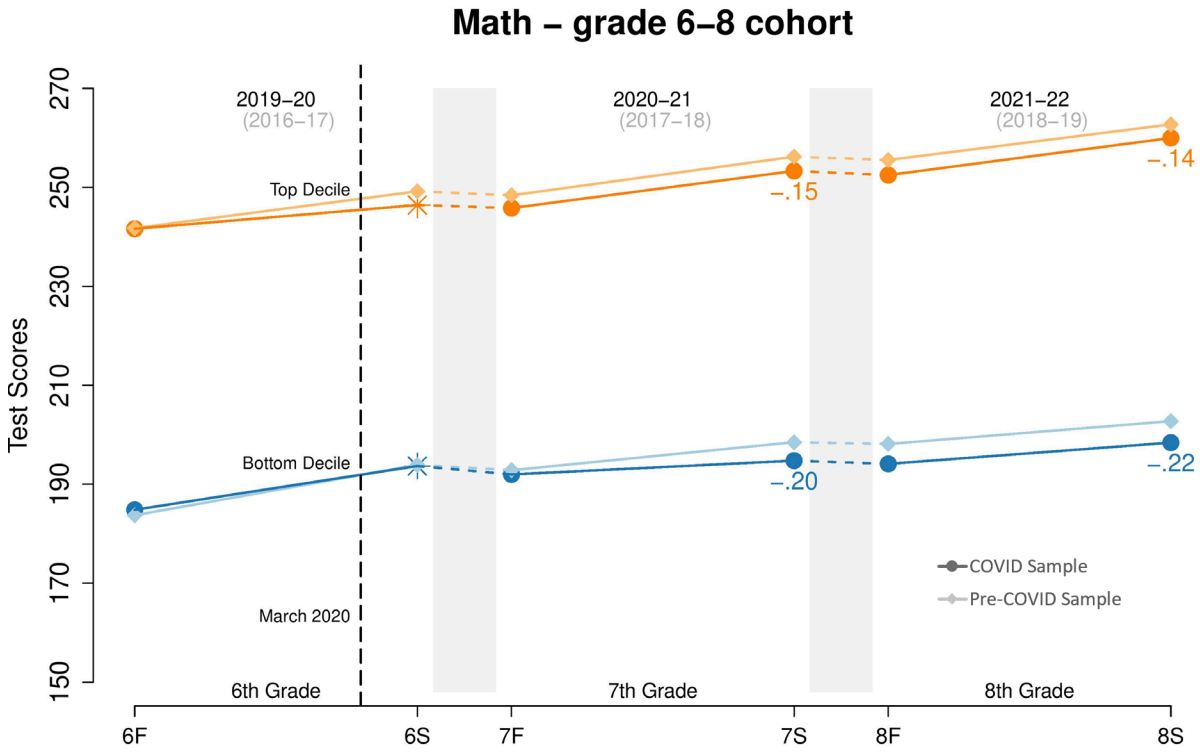

Math – grade 1–3 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Test Scores
120
140
160
180
200
220
240
260
Top Decile
Bottom Decile
March 2020
–.20
–.38
–.11
–.45
COVID Sample
Pre-COVID Sample
1st Grade
2nd Grade
3rd Grade
1F
1S
2F
2S
3F
3S


Math – grade 2–4 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Test Scores
120
140
160
180
200
220
240
260
Top Decile
Bottom Decile
March 2020
–.23
–.43
–.14
–.40
COVID Sample
Pre-COVID Sample
2nd Grade
3rd Grade
4th Grade
2F
2S
3F
3S
4F
4S


Math – grade 3–5 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Test Scores
250
230
210
190
170
150
Top Decile
Bottom Decile
March 2020
–.27
–.15
–.41
–.38
COVID Sample
Pre-COVID Sample
3rd Grade
4th Grade
5th Grade
3F
3S
4F
4S
5F
5S


Math – grade 4–6 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Test Scores
270
250
230
210
190
170
150
Top Decile
Bottom Decile
March 2020
–.22
–.10
–.37
–.24
COVID Sample
Pre-COVID Sample
4th Grade
5th Grade
6th Grade
4F
4S
5F
5S
6F
6S


Math – grade 5–7 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Top Decile
Bottom Decile
−.19
−.16
−.19
−.22
March 2020
COVID Sample
Pre-COVID Sample
Test Scores
150
170
190
210
230
250
270
5th Grade
6th Grade
7th Grade
5F
5S
6F
6S
7F
7S


Math – grade 6–8 cohort
2019–20
(2016–17)
2020–21
(2017–18)
2021–22
(2018–19)
Top Decile
Bottom Decile
−.15
−.14
−.20
−.22
March 2020
COVID Sample
Pre-COVID Sample
Test Scores
150
170
190
210
230
250
270
6th Grade
7th Grade
8th Grade
6F
6S
7F
7S
8F
8S

5. References

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