Student Growth during COVID-19: Grade-Level Readiness Matters

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Curriculum Associates Research Report | February 2022

Executive Summary

Research on the loss of schooling during the start of the COVID-19 pandemic in spring 2020 and the subsequent disruptions to learning has consistently shown, on average, a negative, long-lasting impact on student performance, especially for students who were struggling before the pandemic. Using longitudinal interim assessment data collected using the *i-Ready Diagnostic* from more than two million students spanning three academic years and student-level testing location data as a proxy for in-school or remote learning, we explored differences in academic growth between a cohort of students prior to any impact of COVID-19 and a cohort of students that were learning during COVID-19, differentiated by grade-level placements, school-level demographic and economic characteristics, and school locale. Results from those analyses showed:

- On average, all students in the COVID-19 cohort showed less growth overall when compared to pre-COVID-19 cohort students in both reading and mathematics.
- On average, students in the COVID-19 cohort saw less growth in mathematics than in reading across all grades.
- Overall, on average, there was little difference in growth between students in the COVID-19 cohort who reported being in school only or mostly in school compared to being remote only or mostly remote during COVID-19.
- When disaggregated, however, students who were furthest behind before COVID-19 tended to see the biggest differences in growth during COVID-19 compared to a pre-COVID-19 comparison cohort.
- Students in urban schools with lower percentages of White students and higher percentages of students in households with a less than 200% poverty-to-income ratio had the biggest differences in growth during COVID-19 when compared to similar students in suburban school in both the pre-COVID-19 and COVID-19 cohorts.

Introduction

Current research into the impact of disruptions on student learning due to local, regional, and national policy reactions to COVID-19 can be broken into three different phases: (1) predictions of the impact on student learning outcomes of lost schooling during the early days of the COVID-19 pandemic in spring 2020, (2) reporting on the actual impact as students progressed through the 2021–2022 school year and beyond, and (3) trying to understand how different policy responses related to in-school or remote learning impacted student outcomes.

When COVID-19 hit the United States in early 2020, most public school districts decided to—or were forced to, based on local conditions—move away from in-person learning. While some students were able to take classes remotely, many were unable to access content remotely for various reasons (Chandra, Chang, Day, Fazlullah, Liu, McBride, Mudalige, & Weiss, 2020). In addition, even for schools that tried to move to remote learning, differences remained in both access to digital tools and how students used the tools they were able to access (Curriculum Associates, 2020b). Given all the difficulties outlined in these and many other reports, predictions for the impact on students for the start of the 2020–2021 school year were dire (Allen, Mattern, & Camara, 2020; Dorn, Hancock, Sarakatsannis, & Viruleg, 2020; Kuhfeld & Tarasawa, 2020).

With these predictions driving the national narrative, the ongoing uncertainty about the best way to slow the spread of COVID-19, and the uneven implementation of policy responses across states, schools prepared as best they could. While there were some success stories (Curriculum Associates, 2020a) and plans for additional support to reduce the digital divide (Walton Family Foundation, 2020), there was still much apprehension to start the school year in fall 2020. In general, while the worst predictions didn't necessarily bear out for all students, there was plenty of evidence that students were negatively impacted throughout the 2020–2021 school year in both mathematics and reading (Curriculum Associates, 2021a, 2021b; Dawson, 2021; Lewis & Kuhfeld, 2021; Lewis, Kuhfeld, Ruzek, & McEachin, 2021; Streich, Pan, Ye, & Xia, 2021; West & Lake, 2021), with larger overall negative impacts typically seen in mathematics compared to reading.

A concerning pattern emerged in many studies as well—while a deleterious impact on learning was felt across all student cohorts, students who were already struggling before the pandemic hit, students of color, and students in poverty who were already fighting historical opportunity gaps, seemed to bear the brunt of the impact both academically (Dawson, 2021) and emotionally (Hamilton & Gross, 2021). Both the short- and long-term effects will continue to be followed throughout the 2021–2022 school year and beyond, with more research to be conducted to better understand implications for student learning, in addition to overall academic and social-emotional outcomes.

This report, in contrast, is focused firmly on emerging research exploring how different policy responses impacted student performance, specifically centered on examining differences related to in-school versus remote learning during the 2020–2021 school year. This research adds to recent evidence indicating that students who learned remotely saw larger losses on summative assessments when compared both to students who learned in school or to historical norms for students who took those assessments (Fuchs-Schündeln, Krueger, Kurmann, Lalé, Ludwig, & Popova, 2021; Halloran, Jack, Okun, & Oster, 2021).

Using interim assessment data from the *i-Ready Diagnostic* gathered from more than two million Grades K–8 students between fall 2016 and fall 2021, we examined growth patterns for students who experienced schooling during the full length of the COVID-19 pandemic (i.e., starting with the 2019–2020 school year) against a cohort of students who experienced schooling prior to any impact of the COVID-19 pandemic (i.e., prior to the 2019–2020 school year) as shown in Table 1. Note that there is no "Spring 1" included in these data as many, if not most, districts did not test students in spring 2020, which would have been the first spring for the COVID-19 cohort of students. Thus, Spring 1 scores for both cohorts were left out of the analyses. In Table 1, the testing windows shaded in blue are when COVID-19 would have impacted student learning. In this report, the majority of the analyses focus on student gains between Winter 1 and Fall 3 (i.e., the testing windows in the bolded box in Table 1). More details are provided in the "Methodology" section below.

Table 1: Testing Windows per Cohort

	Fall 1	Winter 1	Spring 1	Fall 2	Winter 2	Spring 2	Fall 3
Pre-COVID-19	Fall 2016	Winter 2017	Spring 2017	Fall 2017	Winter 2018	Spring 2018	Fall 2018
	Fall 2017	Winter 2018	Spring 2018	Fall 2018	Winter 2019	Spring 2019	Fall 2019
COVID-19	Fall 2019	Winter 2020		Fall 2020	Winter 2021	Spring 2021	Fall 2021*

*In-school testers only

Research Question:

The main research question for this study was:

> What were the differences in overall growth between students who reported being in school compared to students who reported being remote during the 2020–2021 school year, as well as compared to historical averages?

Methodology

Sample

Data were collected from Grades K–8 students who took the *i-Ready Diagnostic* on each of seven consecutive testing occasions (i.e., fall, winter, and spring) between fall 2016 and fall 2021, except for spring 2020, in which most schools were closed or did not test. Data from a total of 2,039,367 students who tested in reading and 2,421,643 students who tested in mathematics were used for this study. From this pool of students, two cohorts were constructed—one based on a pooled sample of unique students who took non-rushed assessments during all testing windows from fall 2016 through fall 2018 or students who took assessments during all testing windows from fall 2017 through fall 2019, called the "pre-COVID-19 cohort," and one based on students who tested during all windows starting in fall 2019 through fall 2021, called the "COVID-19 cohort."

Starting in fall 2020, the *i-Ready Diagnostic* included an item at the start of the testing session that asked students if they were taking their test in the school building. If students required multiple sessions to complete the assessment, the question was asked across all sessions. For the purposes of this study, if a student reported taking the assessment in different locations during multiple sessions within a testing window, they were removed from the sample. In addition, only students with valid, non-rushed test scores and students who took the assessment on the same computer during a given testing window were included in the COVID-19 cohort. Finally, in the COVID-19 cohort we only included students who reported testing in school during fall 2021 to ensure there was no score inflation as was seen for some remote testers during the 2020–2021 school year. In fall 2021, about 92% of all students who took the *i-Ready Diagnostic* reported testing in school (Curriculum Associates, 2021b). All assessments taken by students in the pre-COVID-19 cohort were taken in school.

Having access to testing location data for students in the COVID-19 cohort allows for further disaggregation of that cohort into one of four groups based on where students reported taking their *i-Ready Diagnostic* during the COVID-19 time period testing windows: (1) in school only, (2) mostly in school (remote in fall and then in school the rest of year), (3) mostly remote (remote in the fall and winter and in school in the spring), and (4) remote only. All of the groupings are mutually exclusive. For the purposes of this study, we are using self-reported testing location as a proxy for where instruction took place. While not a perfect indicator, it is reasonable to assume that where students were asked to take these assessments is similar to where the majority of their learning took place. However, we recognize that a student could have, for example, taken their assessment "in school" and then their school went to a remote model due to an outbreak, or students may have been in a hybrid model where they were in school during part of the week and then remote for other days. This limitation should be kept in mind.

Using data from the Common Core of Data (Institute of Education Sciences, 2019), a summary of the school-level demographic characteristics of the sample is shown in Table 2. Note that Table 2 is based on all Grades K–8 students, but for brevity, in the remainder of the report we only show results of analyses for students who started in Grades 2, 4, and 6 and followed them through the start of Grades 4, 6, and 8, respectively (i.e., Grades 2–4, Grades 4–6, and Grades 6–8).

Table 2: Demographic Characteristics of Tested Students

	Reading				**Mathematics**			
	Pre-COVID-19		COVID-19		Pre-COVID-19		COVID-19	
	Count	N %	Count	N %	Count	N %	Count	N %
Less Than 25% White	508,684	41%	268,409	37%	474,225	39%	372,460	33%
25%–49% White	252,342	20%	145,509	20%	243,329	20%	217,472	19%
50%–74% White	261,321	21%	159,414	22%	263,541	22%	254,629	23%
More Than 75% White	220,088	18%	150,691	21%	240,797	20%	271,122	24%
Below 100% Income-to-Poverty Ratio	14,970	1%	8,999	1%	13,746	1%	14,192	1%
100%–199% Income-to-Poverty Ratio	306,381	25%	166,528	23%	292,984	24%	250,066	22%
Greater Than 200% Income-to-Poverty Ratio	921,995	74%	546,596	76%	915,912	75%	848,905	76%
Urban	332,408	27%	192,391	27%	336,903	28%	301,988	27%
Suburban	597,470	48%	338,336	47%	563,727	46%	489,333	44%
Town	116,740	9%	66,345	9%	116,648	10%	120,766	11%
Rural	192,732	16%	124,134	17%	200,049	16%	198,376	18%

The starting scale scores from the first fall Diagnostic for both cohorts were similar. Table 3 shows the differences in starting scale scores (from the first fall Diagnostic) for Reading and Math.

Table 3: Initial Reading and Mathematics Scale Scores for Students in Grades 2, 4, and 6

		Pre-COVID-19				COVID-19			
		Mean	**SD**	**Median**	**Count**	**Mean**	**SD**	**Median**	**Count**
Reading	Grade 2	463	49	467	229,387	458	50	461	137,277
	Grade 4	525	51	529	147,269	525	56	531	84,473
	Grade 6	563	56	569	101,573	568	60	576	48,999
Mathematics	Grade 2	404	23	404	233,776	401	26	402	212,017
	Grade 4	446	28	448	113,095	446	29	449	145,653
	Grade 6	475	31	478	154,048	474	34	478	81,479

Data Analysis

Data were analyzed using a three-level piecewise longitudinal growth model (Bryk & Raudenbush, 1992; Singer & Willett, 2003). This model allows for non-linear growth across a school year (Kuhfeld & Soland, 2021) and follows previous work (Dawson, 2021). While there are multiple ways to model the data, we followed a convention similar to that described by Kuhfeld, Condron, and Downey (2021) to allow us to compare growth rates at different time periods. Details of the model are available in Appendix B.

We note that the results presented in this report are focused on the amount of growth that occurred between two time points. Multiple different analytical approaches were attempted, including using fewer time periods, different covariates, and both quadratic and cubic change models (Singer & Willett, 2003). Further sensitivity analyses revealed similar results across the different analytic models, and the piecewise version was chosen for this report for consistency with previous work and a more intuitive display of scores across relevant time points.

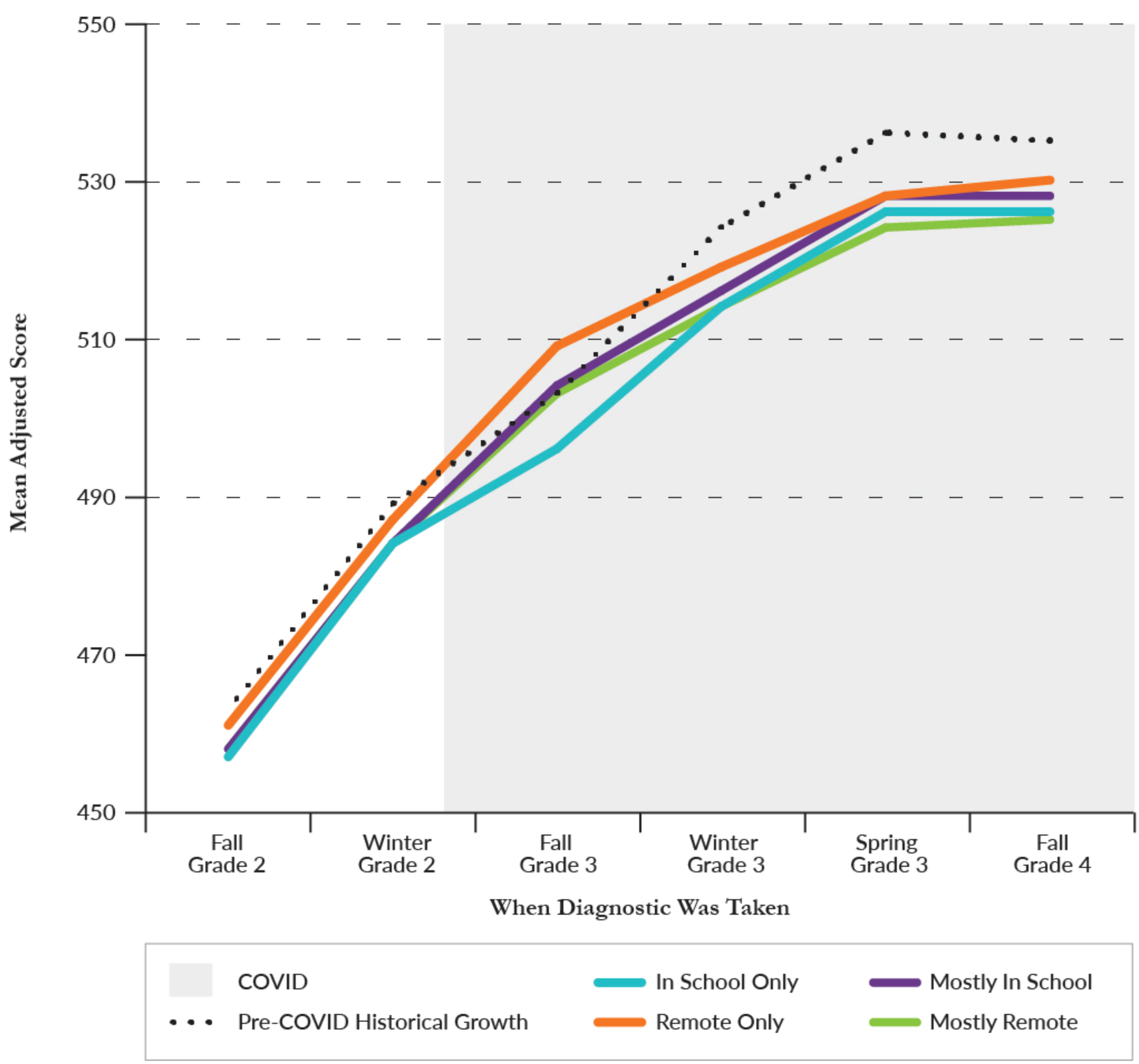
While all of the students in this study have at least three valid *i-Ready Diagnostic* scores based on testing in school regardless of their cohort (e.g., Fall 1, Winter 1, and Fall 3), the majority of the analyses presented next focused on the differences of the adjusted mean scores between a student's first winter Diagnostic (i.e., Winter 1) and their third fall Diagnostic (i.e., Fall 3).

Results/Discussion

Overall Findings

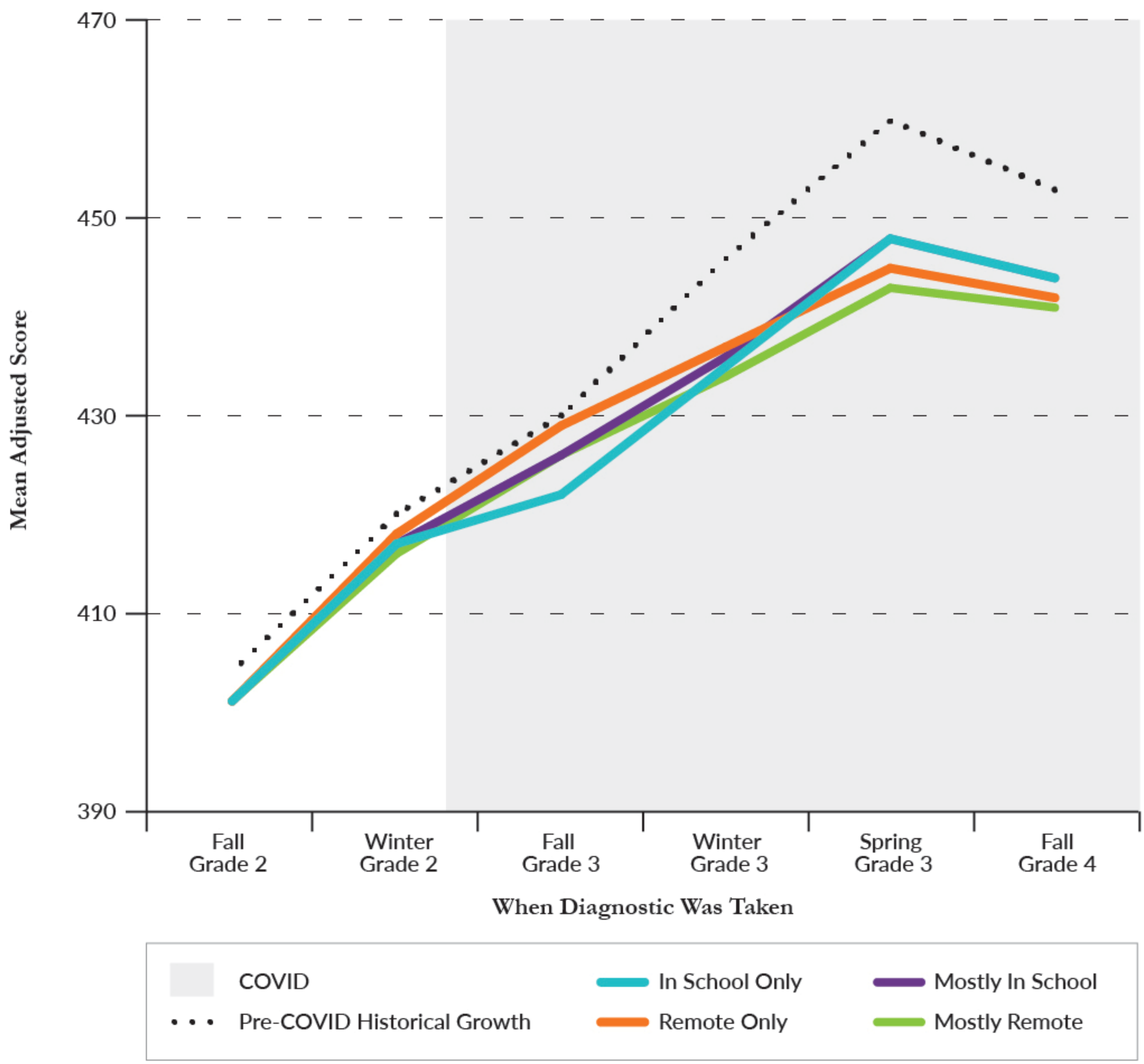
As expected, the differences in growth between students in the pre-COVID-19 cohort (dotted line) and all groups within the COVID-19 cohort that were seen in spring 2021 (Curriculum Associates, 2021b; Dawson, 2021) were maintained into fall 2021. However, differences within the COVID-19 cohort based on reported testing location were less pronounced, as seen in Figure 1 for reading and in Figure 2 for mathematics. That is, while students reported different patterns of in-school and/or remote learning during the 2020–2021 school year, the differences between those groups to start fall 2021 were not as large as compared to differences with the pre-COVID-19 cohort, but they were present. Note that score inflation during the COVID-19 time period can be seen (shaded area in Figures 1–6) for students who reported testing remotely during the fall of Grade 3 for the COVID-19 cohort, which, as reported elsewhere (Dawson, 2021), was more severe in reading than mathematics, especially in the lower elementary grades.

Figure 1: Growth in Reading from Fall of Grade 2 to Fall of Grade 4



For mathematics, a pattern similar to that in reading occurred, with clear differences between the pre-COVID-19 and COVID-19 cohorts for the last testing period (to start Grade 4), but smaller or no differences within the COVID-19 cohort groups. Figure 2 shows the changes over time for students starting in Grade 2 and following them through the start of Grade 4. Interestingly, the COVID-19 cohort of students also showed less summer learning loss between the spring of Grade 3 and fall of Grade 4 (a loss of two to four scale score points on average) when compared to the pre-COVID-19 cohort (a loss of about seven points on average). That difference was not seen between the spring of Grade 5 and fall of Grade 6 nor the spring of Grade 7 and the fall of Grade 8. Further investigation will be done to explore why this may be.

Figure 2: Growth in Mathematics from Fall of Grade 2 to Fall of Grade 4



For students learning during COVID-19, those who reported being fully remote showed less growth in mathematics when compared to students who reported being in school only or mostly in school, while the same cannot be said for reading (Table 4). Given the numbers shown in Table 4, on average, students who were able to be in school all year or for both the winter and spring testing windows (all or mostly in school) saw negligible differences—or in some cases lower growth—in reading compared to remote-only students and students who were remote in the fall and winter (all or mostly remote) and slightly larger differences in mathematics. The somewhat counterintuitive finding in reading is further explored below.

Table 4: Differences in Growth by Cohort and Grade

Cohort	COVID-19 Growth*					
	Reading			Mathematics		
	Grades 2–4	Grades 4–6	Grades 6–8	Grades 2–4	Grades 4–6	Grades 6–8
Pre-COVID-19	46	31	24	33	20	13
In School Only	43	25	16	27	16	9
Mostly In School	44	26	17	27	15	8
Mostly Remote	42	25	17	24	13	8
Remote Only	43	25	19	24	13	9

*Based on assessments taken during the testing windows in the gray shaded area in Figures 1–6

Differences by Initial Placement Status

One of the advantages of using data from the *i-Ready Diagnostic* is that it reports student scores both in relation to how a student's score compared to their peers in the same grade (i.e., norm-referenced score) and how that score reflects the demonstrated knowledge and skills required for proficiency at a given grade level (i.e., criterion-referenced score). Thus, a student's placement level reveals a student's performance against grade-level content standards, not just other students' scores. Why does this matter? A placement level based on standardized criteria allows educators to have more information about how a student is performing in relation to a reference point based on content, not other scores. While student scores can change from year to year for numerous reasons outside of the control of schools, which impacts a student's percentile rank, content standards and their related cut scores do not change. Given that, we use a student's placement based on their initial fall assessment to further disaggregate the data to examine patterns based on important student and school characteristics.

While looking at the average scores and gains for each cohort is of interest, examining the data by a student's initial placement level reveals some interesting dynamics, continuing a pattern seen in earlier work (Dawson, 2021). For example, focusing on students from Grade 2 to Grade 4 in reading (Figure 3), there was less of a difference in growth between students who were close to or were performing on grade level to start Grade 2 in the pre-COVID-19 cohort compared to students who were close to or were performing on grade level to start Grade 2 across all groups within the COVID-19 cohort. Unfortunately, there were clear differences for students who began Grade 2 performing two or more grade levels below their chronological grade when comparing the pre-COVID-19 and COVID-19 cohorts, as well as looking at groups within the COVID-19 cohort. In mathematics, however, the differences between groups were more consistent regardless of starting placement, although students who started two or more grade levels below saw the largest differences (Figure 4) when compared to pre-COVID-19 cohort students.

Figure 3: Differences in Growth in Reading by Cohort and Initial Placement Fall of Grade 2 to Fall of Grade 4

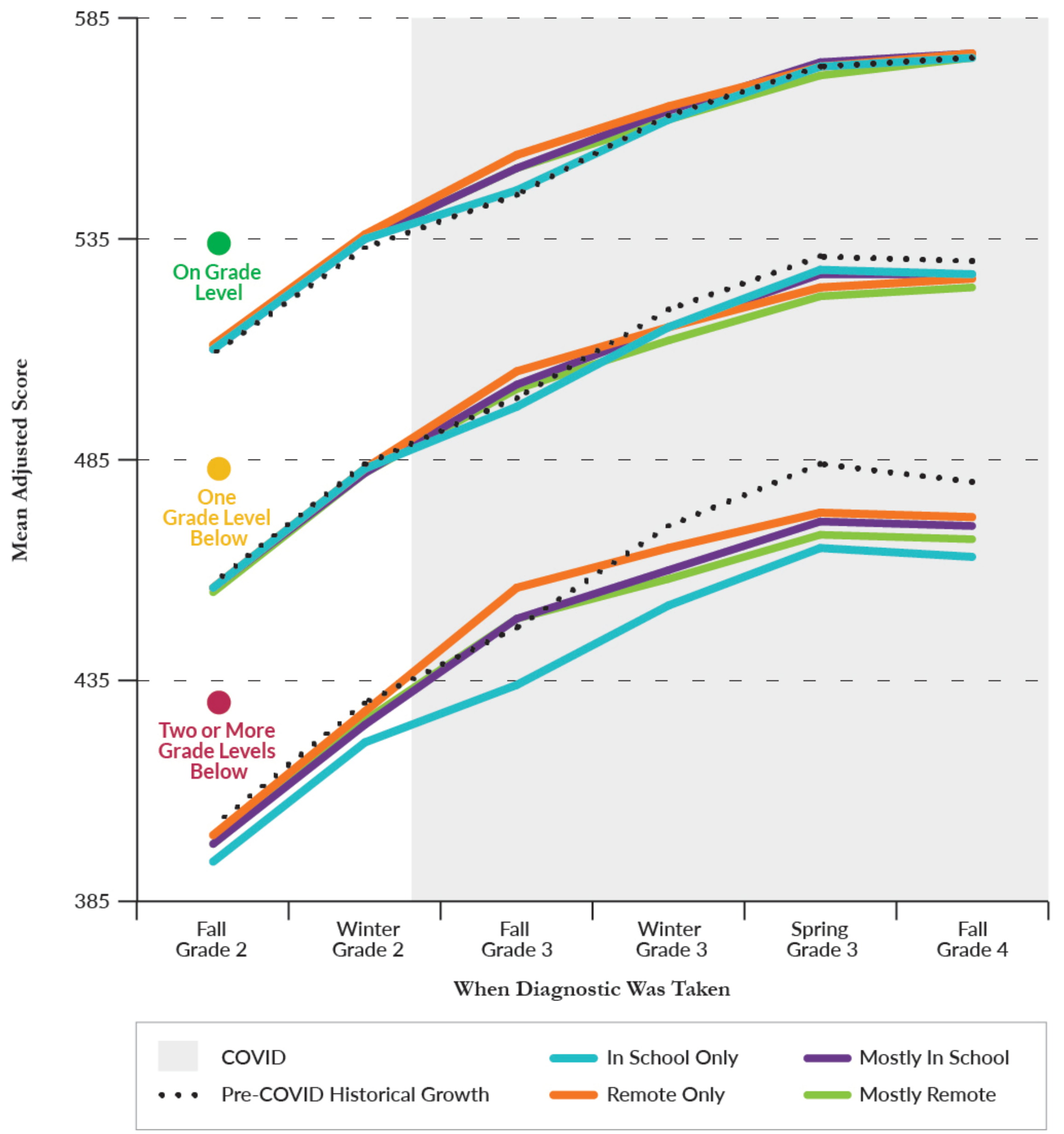
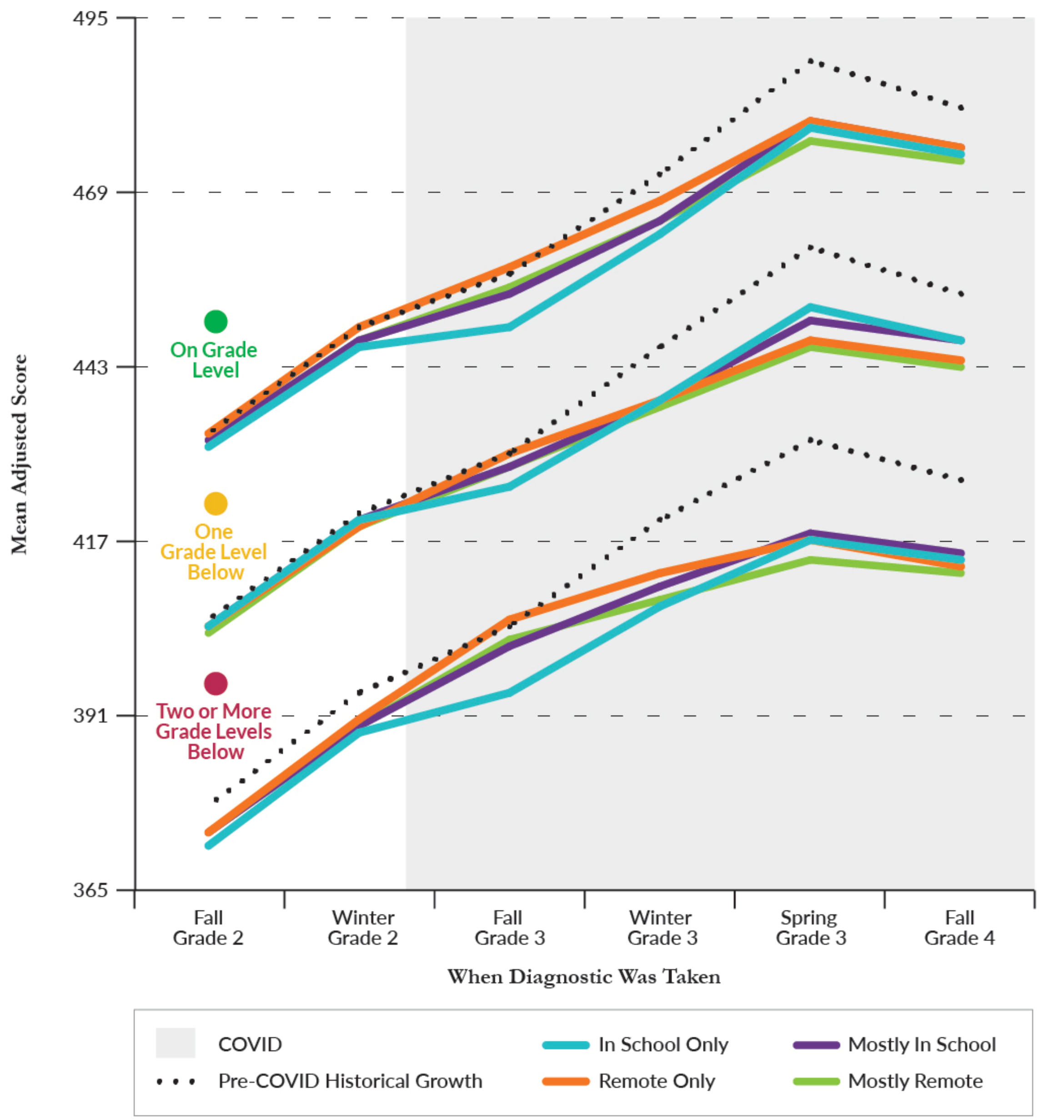


Figure 4: Differences in Growth in Mathematics by Cohort and Initial Placement Fall of Grade 2 to Fall of Grade 4



Digging more deeply into the data across additional grades (Table 5), we see how students who started two or more grade levels below saw the least, or close to the least, amount of growth across reading and mathematics. During a typical school year, it is not unexpected that the kids furthest behind gain the most because they usually are getting extra support as they have the most ground to make up to get to a proficient level. What is especially troubling, then, is that because these already struggling students are not gaining at the usual rate (i.e., as the pre-COVID-19 cohort), they are falling even further behind. While all students struggled to some extent, or at least struggled to make up losses from the initial loss of schooling in spring 2020, the students who could least afford to fall further behind appear to have done just that.

Table 5: Differences in Growth by Cohort and Initial Placement

Student Starting Placement	Cohort	COVID-19 Growth*					
		Reading			Mathematics		
		Grades 2–4	Grades 4–6	Grades 6–8	Grades 2–4	Grades 4–6	Grades 6–8
Two or More Grade Levels Below at Start	Pre-COVID-19	50	33	26	32	18	11
	In School Only	42	24	17	26	13	6
	Mostly In School	45	27	18	26	12	6
	Mostly Remote	42	25	19	22	10	5
	Remote Only	44	25	21	23	9	6
One Grade Level Below at Start	Pre-COVID-19	46	31	23	33	20	12
	In School Only	44	24	15	28	16	9
	Mostly In School	45	25	17	27	15	8
	Mostly Remote	42	24	17	24	13	8
	Remote Only	42	25	19	24	12	9
On Grade Level at Start	Pre-COVID-19	43	31	22	33	21	16
	In School Only	41	25	15	29	19	12
	Mostly In School	42	26	16	29	18	13
	Mostly Remote	41	25	16	27	17	12
	Remote Only	41	26	18	28	17	13

*Based on assessments taken during the testing windows in the gray shaded area in Figures 1–6

Differences by School-Level Demographic Characteristics

While looking at the data broken out by where students started is enlightening, there is more to the picture. If we focus on students who tested two or more grade levels below their chronological grade, we see that there are differences between students based on school location and the demographic and economic situations for students in those schools. For example, Figures 5 and 6 show the changes in scale scores for students who started the Grade 2 testing below grade level and who were either in suburban, low-poverty, high-percentage-White schools or from urban, high-poverty, low-percentage-White schools. The graphs not only highlight the historical disparities between the cohorts at the start of Grade 2 before any impact of COVID-19 (gray shaded area), but they also show how, in reading at least, Grade 2 students who were in school during COVID-19 seemed to grow the least in reading, even when compared to remote-only students. In fact, students who were below grade level in reading at the start of Grade 2 from suburban, low-poverty, high-percentage-White schools but were remote only during COVID-19 had, on average, score gains that were slightly higher than the historical gains of their pre-COVID-19 peers (Figure 5). The same pattern is not seen in mathematics (Figure 6).

Figure 5: Differences in Growth in Reading by Cohort and Demographic Characteristics with an Initial Placement of Two or More Grades Below from the Fall of Grade 2 to Fall of Grade 4

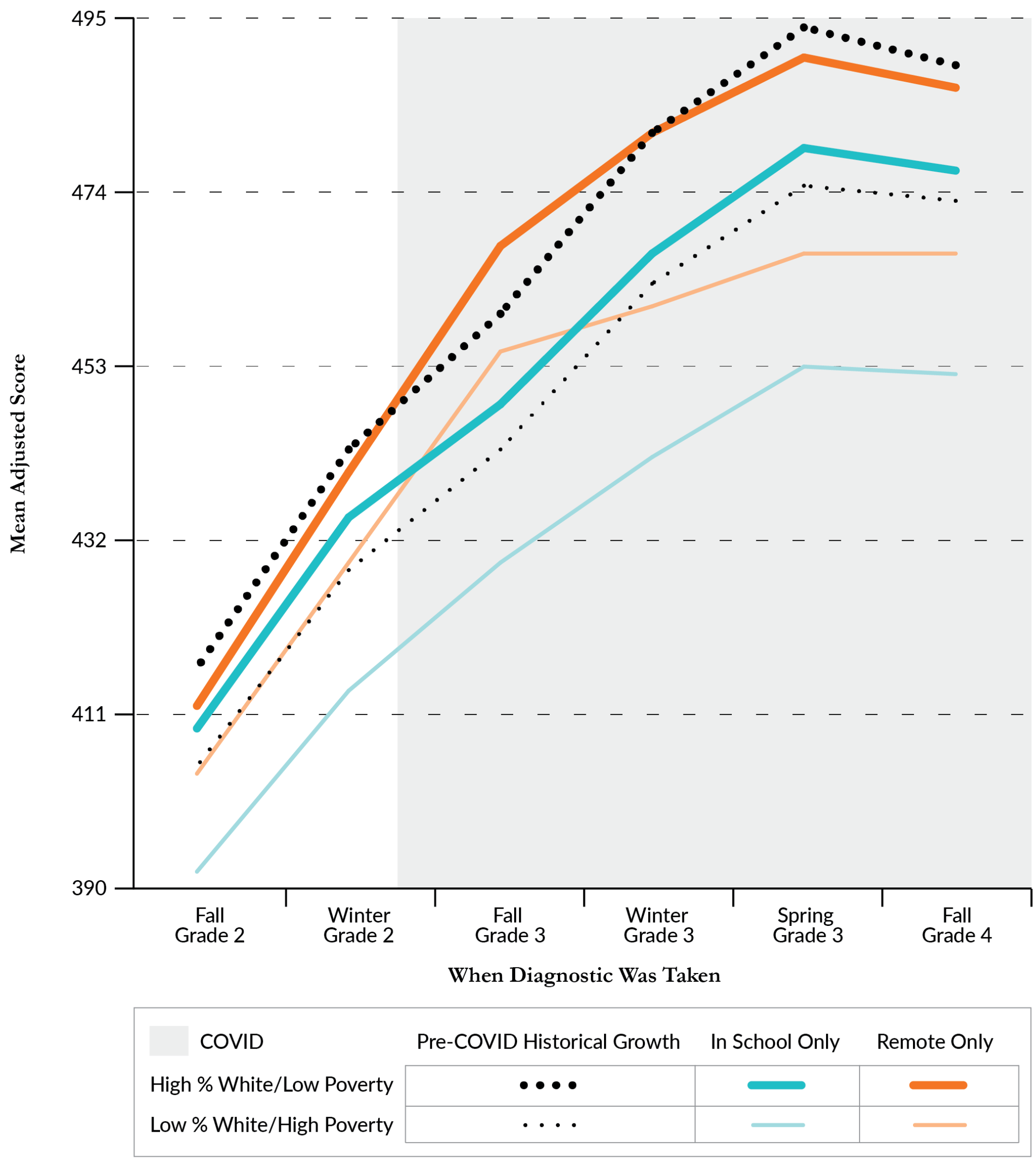
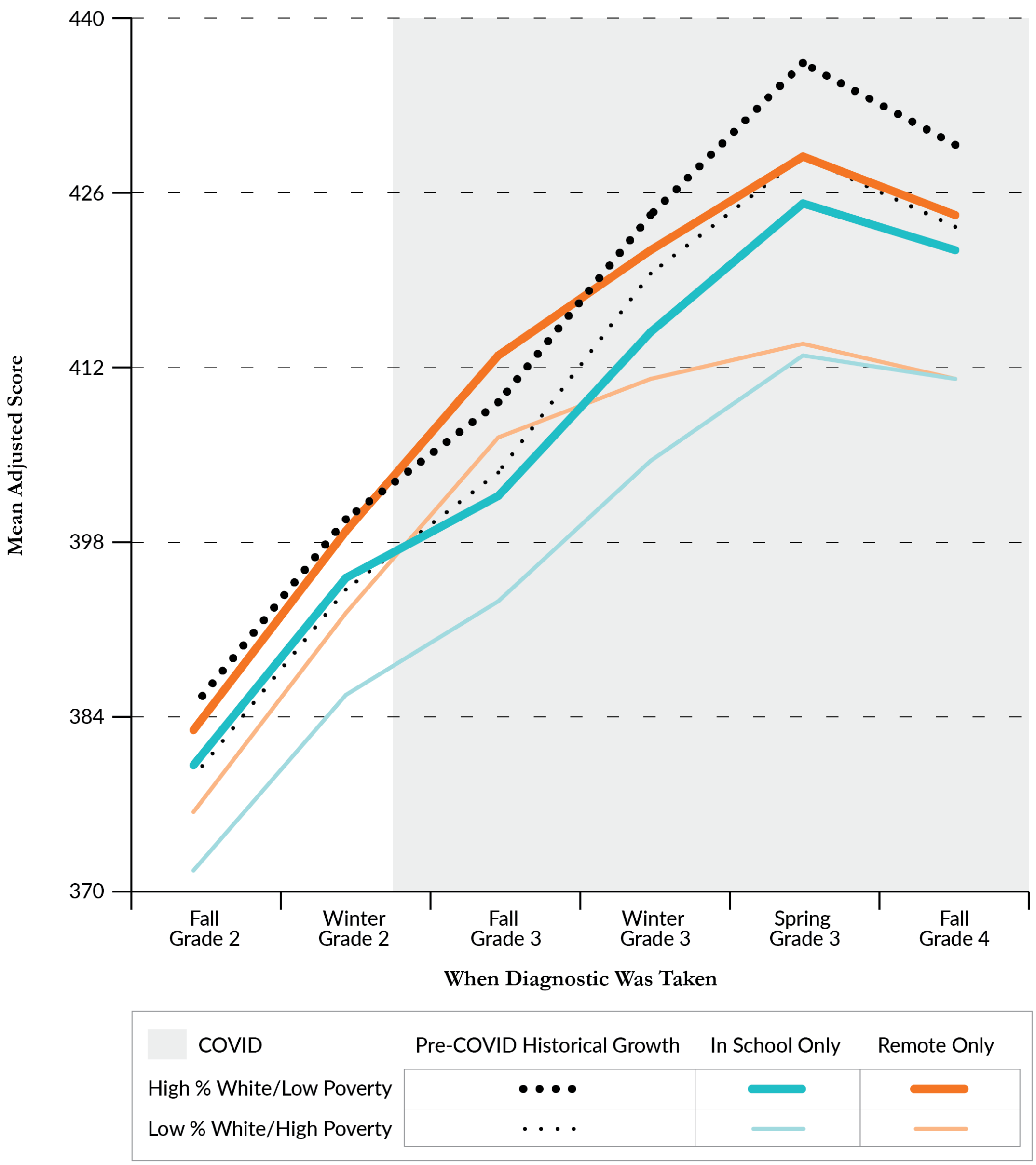


Figure 6: Differences in Growth in Mathematics by Cohort and Demographic Characteristics with an Initial Placement of Two or More Grades Below from the Fall of Grade 2 to Fall of Grade 4



It is difficult to know if the phenomenon seen in reading for students starting in Grade 2 is limited to our sample of students, especially because it was not replicated in students in Grades 4 and 6 and was not seen in any group in mathematics (Table 6). An optimistic view would be that learning reading skills remotely, presumably with the help of a parent and access to the right tools, was very beneficial for many struggling students. Unfortunately, remote students in poorer communities didn't see the same gains in reading in the early grades, which could point to disparities related to the digital divide (Rome & Lay, 2022), among other things.

Regardless, when seeing the overall differences in growth for students who were already at risk but attending schools in different locales and with different student body characteristics and knowing that learning foundational reading skills in early elementary school is critical, these numbers are startling. Similar issues appear in mathematics, where students in poorer, less-White schools grew less, and those who learned remotely seemed to grow the least compared to the other students in their respective groups.

Table 6: Differences in Growth by Cohort and School Characteristics for Students Below Grade Level

Cohort	School Race/Ethnicity	Neighborhood Poverty	School Locale	Student Starting Placement	COVID-19 Growth*					
					Reading			Mathematics		
					Grades 2–4	Grades 4–6	Grades 6–8	Grades 2–4	Grades 4–6	Grades 6–8
Pre-COVID-19	>75% White	>200% Income-to-Poverty Ratio	Suburban	Two or More Grade Levels Below at Start	51	33	23	32	19	10
In School Only	>75% White	>200% Income-to-Poverty Ratio	Suburban	Two or More Grade Levels Below at Start	46	27	18	28	15	6
Remote Only	>75% White	>200% Income-to-Poverty Ratio	Suburban	Two or More Grade Levels Below at Start	52	26	19	27	12	7
Pre-COVID-19	<25% White	<200% Income-to-Poverty Ratio	Urban	Two or More Grade Levels Below at Start	49	36	29	31	18	13
In School Only	<25% White	<200% Income-to-Poverty Ratio	Urban	Two or More Grade Levels Below at Start	43	25	20	26	11	6
Remote Only	<25% White	<200% Income-to-Poverty Ratio	Urban	Two or More Grade Levels Below at Start	41	24	22	20	7	7

*Based on assessments taken during the testing windows in the gray shaded area in Figures 1–6

Sadly, these differences were also seen for students who were already performing at grade-level expectations before COVID-19 (Table 7). In general, students in urban, high-poverty, low-percentage-White schools showed the least amount of growth, both in scale score points and in relation to how much similar students grew before COVID-19. The interaction of already existing historical differences and the impact of COVID-19 were clearly evident, and the gaps that existed before COVID-19 continued to grow even for the highest-performing students. Put another way: While almost all students struggled, some struggled more along distressingly predictable pathways.

Table 7: Differences in Growth by Cohort and School Characteristics for On Grade Level Students

Cohort	School Race/Ethnicity	Neighborhood Poverty	School Locale	Student Starting Placement	COVID-19 Growth*					
					Reading			Mathematics		
					Grades 2–4	Grades 4–6	Grades 6–8	Grades 2–4	Grades 4–6	Grades 6–8
Pre-COVID-19	>75% White	>200% Income-to-Poverty Ratio	Suburban	On Grade	43	31	21	33	22	16
In School Only	>75% White	>200% Income-to-Poverty Ratio	Suburban	On Grade	43	27	15	30	21	13
Remote Only	>75% White	>200% Income-to-Poverty Ratio	Suburban	On Grade	45	27	16	29	19	13
Pre-COVID-19	<25% White	<200% Income-to-Poverty Ratio	Urban	On Grade	42	33	25	32	20	18
In School Only	<25% White	<200% Income-to-Poverty Ratio	Urban	On Grade	39	27	17	29	16	13
Remote Only	<25% White	<200% Income-to-Poverty Ratio	Urban	On Grade	35	25	19	22	12	13

*Based on assessments taken during the testing windows in the gray shaded area in Figures 1–6

Summary

The current study focused on examining the growth among students during the parts of their academic life impacted by the COVID-19 pandemic and looked at differences broken out by a proxy for their learning environment (in school versus remote), as well as by initial grade-level placement and important demographic characteristics. Like previous reports, almost all groups of students were negatively impacted by the loss of schooling during the initial phase of the pandemic and the continued disruption in learning throughout the 2020–2021 school year. On average, however, the overall impacts seem smaller than originally predicted but still represent a significant increase in unfinished learning for most students.

Unfortunately, when examining the data further, it becomes clear that some students fared much worse than others, and simply looking at averages across all students masked some important differences. By disaggregating the data by important student and school characteristics, this report continues to highlight the fact that the students who could least afford to fall further behind suffered the most. The interplay of both prior performance, school locale, and demographic and economic makeup of students in those schools should not be surprising, however, as these results seem to be a logical outcome following additional work done by Curriculum Associates showing that students in urban, high-poverty, low-percentage-White schools were more likely to test remotely (Rome & Cançado, 2021) and that there are the continued differences in usage rates of supplemental instruction for these students (Rome & Lay, 2022). Getting these students back on track will require a dramatic increase in the rate of their learning growth, beyond even what is "expected," as even matching historical growth for these students means they will never have a chance to get to where the deserve to be.

Limitations

As with all research, the results presented in this report should be interpreted with the limitations of the sample and the choices made for the data analysis.

The sample for this paper is not representative of all students in public schools in the United States but is pulled from a population of students who have taken the *i-Ready Diagnostic*. In addition, given the longitudinal nature of this project, the sample only includes students who had valid assessment data across all testing windows during the time period of interest. Note that there were seven possible testing windows across three academic years, but for the COVID-19 cohort, there was not a valid assessment for their first spring assessment as this would have been during spring 2020 when many districts chose not to administer the *i-Ready Diagnostic* because they did not have the remote testing capabilities to do so and were concerned about the validity of data gathered from non-proctored tests given remotely. Regardless, the analyses done for this paper did not include any scores from the first spring testing window for any cohort of students. In addition, some students only test in the fall and spring, but those students would have been removed from this sample as well. In general, we do not believe the choices made for the sample are systematically biased, but there is always the possibility that different inclusion criteria would change the results.

Using testing location as a proxy for where learning takes place can be misleading. It is impossible to know whether students who reported taking their *i-Ready Diagnostic* in school or remotely were also attending classes in the same format. It is possible, for example, that even if some students may have reported taking their assessment in school, that conditions on the ground changed a short time later and those students started learning remotely. While we cannot account for all possible scenarios, we believe these deviations occurred at random and do not bias the sample in one direction or another.

Finally, the current analysis assumes that summer learning loss between spring 2021 and fall 2021 is like historical norms, and student access and/or use of summer school was similar to historical norms. We have seen anecdotal evidence that a greater number of students attended summer school during summer 2021 than usual, and some districts required additional learning over the summer to try and make up for losses the previous year. We did not account for that possibility in our analyses but assume that any differences were small enough to not bias the results. Further study would have to be done to test this assumption.

Appendix A: Sample Characteristics

Table A1: Starting Relative Grade-Level Placements for Reading

		Two or More Grade Levels Below	One Grade Level Below	On Grade Level
Grade 2	Pre-COVID-19	20%	48%	32%
	COVID-19	22%	49%	29%
Grade 4	Pre-COVID-19	25%	46%	28%
	COVID-19	26%	43%	31%
Grade 6	Pre-COVID-19	48%	24%	29%
	COVID-19	42%	23%	35%

Table A2: Starting Relative Grade-Level Placements for Mathematics

		Two or More Grade Levels Below	One Grade Level Below	On Grade Level
Grade 2	Pre-COVID-19	21%	63%	16%
	COVID-19	25%	60%	15%
Grade 4	Pre-COVID-19	29%	45%	26%
	COVID-19	27%	48%	25%
Grade 6	Pre-COVID-19	33%	39%	28%
	COVID-19	36%	34%	30%

Appendix B: Model

To examine the weekly growth rates for each student across different time periods, the Level-1 model was of the following form:

$$DIAGSCOR_{tij} = \pi_{0ij} + \pi_{1ij}*(TWK1_{tij}) + \pi_{2ij}*(TWK2_{tij}) + \pi_{3ij}*(TWK3_{tij}) +$$

$$\pi_{4ij}*(TWK4_{tij}) + \pi_{5ij}*(TWK5_{tij})\ e_{tij} \qquad [1]$$

where

DIAGSCOR*tij* is the Diagnostic score at time *t* for child *i* in school *j*;
π_{0ij} is the initial expected score of child *ij* on the first fall Diagnostic assessment
π_{1ij} is the learning rate for child ij during the first time period (Fall 1 to Winter 1)
π_{2ij} is the learning rate for child ij during the second time period (Winter 1 to Fall 2)
π_{3ij} is the learning rate for child ij during the third time period (Fall 2 to Winter 2)
π_{4ij} is the learning rate for child ij during the fourth time period (Winter 2 to Spring 2)
π_{5ij} is the learning rate for child ij during the fifth time period (Spring 2 to Fall 3)
TWKXtij is the number of weeks between Diagnostics across each of the five different time periods

To examine the differences in weekly growth rates between the two different cohorts of students (TESTGROU) within schools, the Level-2 model took the following form:

$$\begin{aligned}
\pi_{0ij} &= \beta_{00j} + \beta_{01j}*(TESTGROU_{ij}) + r_{0ij}\\
\pi_{1ij} &= \beta_{10j} + \beta_{11j}*(TESTGROU_{ij}) + r_{1ij}\\
\pi_{2ij} &= \beta_{20j} + \beta_{21j}*(TESTGROU_{ij}) + r_{2ij} \qquad [2]\\
\pi_{3ij} &= \beta_{30j} + \beta_{31j}*(TESTGROU_{ij}) + r_{3ij}\\
\pi_{4ij} &= \beta_{40j} + \beta_{41j}*(TESTGROU_{ij}) + r_{4ij}
\end{aligned}$$

Finally, variation between schools accounting for school-level demographic characteristics such as the percentage of White students (PCT_WHIT), the neighborhood poverty estimate of the school (IPR_EST), and the National Center for Education Statistics (NCES) locale code (L_TOWN, L_RURAL, L_URBAN) was modeled at Level-3. Note that both the percentage of White students and child poverty estimates were grand mean centered, and the NCES locale categories were dummy coded, with suburban being the reference category.

$$\beta_{pqj} = \gamma_{pq0} + \gamma_{001}(PCT\_WHIT_j) + \gamma_{002}(IPR\_EST_j) + \gamma_{003}(L\_TOWN_j) + \gamma_{004}(L\_RURAL_j) +$$

$$\gamma_{005}(L\_URBAN_j) + u_{pqj} \qquad [3]$$

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