Learning Loss in Reading and Math in U.S. Schools Due to the COVID-19 Pandemic

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Executive Summary

This study investigates students' achievement loss in reading and math due to COVID-19 pandemic school closures. Using a nationally stratified sample from the extensive Istation database across two academic years, we found that students showed learning losses in both reading and math due to the school closures.

Learning loss in reading

Students lost approximately 2 months' learning in reading due to the COVID-19 school closures in addition to the regular 1 month of summer learning loss. Most of this was due to loss of learning gains typically experienced in April and May. Schools implemented remote learning during this time, and it helped students to maintain learning gains they had made from September-March of the 2019-2020 school year.

Learning loss in math

Students typically have greater summer learning losses in math than they do in reading, and these results show that students lost additional months of learning due to the COVID-19 pandemic school closures. Students entering first grade in fall 2020 had higher scores in September than they had in March. When compared with typical summer learning loss in math, students entering second grade lost an extra month, students entering third and fourth grades lost an extra two months, students entering fifth and sixth grades lost an extra three months.

Learning loss varied by type of school

We evaluated the learning losses by the poverty level of each school, categorized as low-, mid-low, mid-high, or high. For students entering first grade in 2020-2021, students enrolled in mid-low and low-poverty schools had larger learning losses as compared to similar students in first grade in 2019-2020, and students in high-poverty schools had less learning loss. In second grade, the biggest differences were in mid-high and mid-low poverty schools, and in third grade the low-poverty schools had the biggest mean differences.

Students in upper elementary school had scores in September 2020 that are lower than in September 2019, with a few exceptions of students in sixth grade in high-poverty schools and seventh grade students in mid-high poverty schools. Sixth and seventh grade students in low-poverty schools had scores that were comparable to students in the previous year's cohort.

Conclusion

- Learning losses were greater in math than in reading.
- Learning losses varied by grade.
- Learning losses varied by poverty status at the school, and typically students enrolled in high or mid-high poverty schools had learning losses that were lower than, or similar to, students enrolled in other types of schools.

Introduction

In March and April of 2020, schools across the country closed their doors and sent their students home in response to concerns about spreading the novel coronavirus, which causes the illness commonly known as the coronavirus disease 2019 (COVID-19). Schools implemented at-home learning using educational technology, conference calls, and increased parental involvement (Malkus, et al., 2020).

From the beginning, there were concerns about student equity and access to technology. Many districts provided students with electronic devices and hot spots for internet access if they did not have access to technology at home. Student engagement in education was mixed during this time. Some students had access to technology and parents who monitored their participation in their learning, while others simply disappeared from schools (Swaby, 2020). Students also lost instructional days as districts and schools extended spring breaks, shortened academic calendars, and spent time implementing remote learning (Malkus, et al., 2020).

Istation, a leading provider of educational software, including progress monitoring and adaptive curriculum, expanded its offerings to include progress monitoring at home for its math and reading assessments, known as Istation's Indicators of Progress (ISIP™). Istation also offered a parent portal, where parents cand track student participation. Istation's school-based curriculum was offered to all participating school districts, as was Ipractice, Istation's at-home curriculum. Istation also made its teacher-directed lessons available to parents to help them with at-home instruction. Istation also offered a series of videos for parents and teachers on how to conduct in-home, remote learning.

When schools opened in fall of 2020, school districts across the country instituted a mixture of in-person learning, remote learning, and a hybrid where students participated some at home and some in the classroom. These learning models were adapted to local conditions and were subject to change if there were COVID-19 outbreaks in the area.

Istation continued to offer progress monitoring at home, and districts had the option to allow progress monitoring at home or only in school, where testing conditions are controlled by the teacher. Schools were advised that if the progress monitoring was conducted at home, the scores could be used to inform instruction, and Istation also advised schools to remind parents not to assist with the assessment, as it was important for the students to work independently.

There is also concern amongst educators and researchers regarding learning loss and whether the pandemic's school closures have created a learning slide that puts students further behind (Dorn, 2020; Kuhfeld, Soland, et al., 2020). Since remote learning at home on a large scale was new, it is unknown how much this might impact student achievement for students of different socioeconomic backgrounds, and if the fall 2020 cohort of students had lower achievement, indicating a greater summer slide.

Researchers from the Northwest Educational Association (NWEA) (Kuhfeld, Soland, et al., 2020; Kuhfeld, Tarasawa, et al., 2020), projected the potential impact of COVID-19 school closures. Their projections were first disseminated in the spring, and they projected students would begin the 2020-2021 school year with 63% to 68% of the learning gains in reading and 37% to 50% of the learning gains in mathematics. Other research using fall 2020 data showed that students had lost 13% of their gains in

reading and 33% of their gains in math. Learning loss was greater in schools that served students of color (Dorn et al., 2020). Similar results were available from Stanford University, which showed that there were differences by state. South Carolina had the largest estimated learning loss, and losses were greater in math than they were in reading (Stanford, 2020).

Summer Learning Loss

To better understand the impact due to the pandemic, it is important to distinguish between losses due to early school closures and remote learning, versus what is typical learning loss over the summer. Research on summer learning loss shows that there are differences between reading and math and differences in grade. Some research indicates that students' achievement scores decline over the summer by 1 month's worth of school-year learning. Students lose their math ability more rapidly than reading, and these losses are greater for students in higher grades (Quinn & Polikoff, 2017). Other research demonstrates that students from all socioeconomic backgrounds forget more of what they learned in math over the summer than the amount they lose in reading skills (Shafer, 2016).

However, students who are lower achieving may experience less loss, and may even experience some gains, as compared to students who are higher achieving, perhaps due to attendance at summer learning programs (Campbell et al., 2019). Many school districts across the country offer summer learning or enrichment programs designed to keep students learning over the summer. These programs are especially common in areas that serve students living in higher-poverty households. Other research shows that students who are high achieving continue to grow over the summer, and average

students will not, and thus high-achieving students' growth, while slower in the summer, still helps them to gain more compared to average or lower-achieving students (Rambo-Hernandez & McCoach, 2015)

This study investigates students' learning loss from COVID-19 school closures using Istation's Indicators of Progress (ISIP™) assessments in reading and math. Istation is an integrated learning system that provides a formative assessment that can be used for either progress monitoring or benchmarking. Over 4 million students have been assessed using ISIP Early Reading (ER), ISIP Advanced Reading (AR), and ISIP Math.

This study has several goals. The first goal is to evaluate whether the students in fall of 2020 had lower achievement than similar students in the fall of 2019, and if those results differed by socioeconomic status at the school level.

This study will specifically address the following research questions:

1. What were the learning losses from March to September of 2020 due to school closures during the pandemic and the institution of remote learning?
2. Did these losses vary by socioeconomic status?

Methodology

Measures

ISIP assessments are web-delivered, computer-adaptive testing (CAT) assessments. ISIP gathers and reports frequent information about student progress in the critical domains throughout and across academic years (Mathes, 2011; Patarapichayatham et al., 2013).

The purpose of ISIP Reading is to measure students' reading ability and identify deficits in critical areas to provide continuous differentiated instruction. ISIP ER is available for prekindergarten through third grade, and ISIP AR is available for fourth through eighth grade. ISIP Math is designed for students in prekindergarten through eighth grade (Istation, 2018).

Methods and Data

We used two separate methods for this analysis, and they are separated by the two research questions. A piecewise analysis was used to determine the learning trajectory of students from September 2019 to September 2020. For the second research question, we used a cohort analysis that compares mean scores from a subset of the sample used in the piecewise analysis.

Piecewise Analysis

For the first research question, we used a piecewise growth model to estimate students' COVID-19 learning loss. It is a type of time series analysis for nonlinear growth with longitudinal data. Growth models examine the development of individuals on one or more outcome variables over time. The outcome variables can be observed or continuous latent variables. A model was fit by grade level using Mplus software. Mplus handles the relationship between the outcome and time by allowing time scores to be parameters in the model so that the growth function can be estimated. This is the approach used in structural equation modeling (Muthén & Muthén, 1998-2017).

In a piecewise growth model, different phases of development are captured by more than one slope growth factor, and it is used when growth is not linear (Muthén & Muthén, 1998-2017). In this study, it allows for multiple slope factors in the model.

COVID-19 school closures occurred in mid-March, and we expected that growth would vary from March to the following September. During April and May growth is harder to predict given that many students did not have scores, and those that did were from at-home progress monitoring. Growth over the summer would also vary depending on student achievement level, grade, and access to resources within the home. Therefore, we expect that students will have greater summer learning loss than expected in typical years, and it might vary by achievement level.

Kamata et al. (2013) demonstrated ways to model nonlinear growth using three testing events. They demonstrated the growth models in the context of curriculum-based measurement with the fall, winter, and spring reading fluency benchmark assessments using various models including a linear growth model, a piecewise growth mixture model, a growth mixture model, and a growth model with an estimated time score model. Their research showed that a piecewise growth mixture model performed well with three test events. Therefore, we applied a piecewise growth model with our longitudinal data with eight test events to estimate an effect of learning loss due to the school closures during the COVID-19 pandemic on students' achievement in reading and math.

Piecewise models were less stable when we attempted to run them on models from each SES separately. Therefore, we used a cohort approach and compared mean differences in September 2020 to assess the differences by grade and socioeconomic status at the school (SES).

The piecewise analyses were completed by grade level for ISIP ER, ISIP AR, and ISIP Math. Figure 1 shows a model in this study. There are eight test events. The model

shows the intercept of the growth factors and the slope for students' learning. The "i" is growth, which includes the first seven test events, which cover their growth before the school closures (SEP 2019, OCT 2019, NOV 2019, DEC 2019, JAN 2020, FEB 2020, and MAR 2020). The "s2" is the slope for the second phase of growth, which has only the September 2020 test event (SEP 2020), when students headed back to school to start their new academic year.

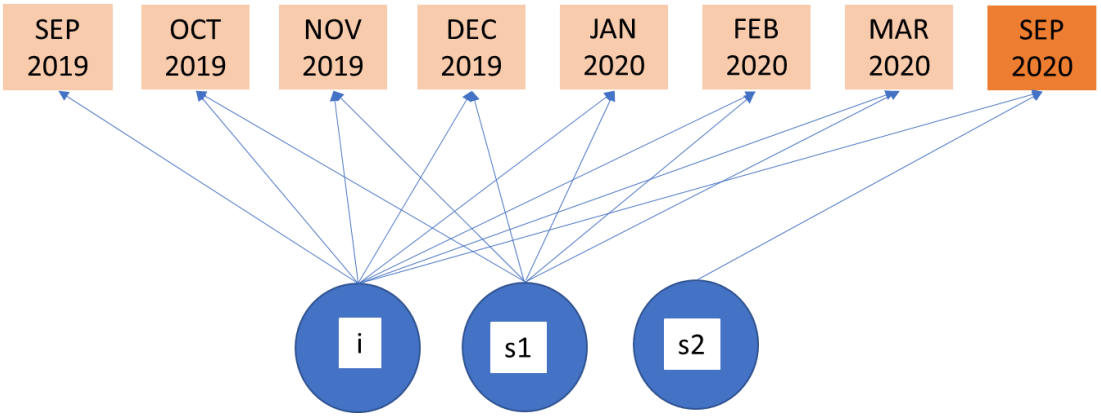

Figure 1: Piecewise growth model

September is considered the beginning-of-the-year assessment month, and May is the end-of-the-year assessment month. April, May, June, July, and August were not included in the analysis. The students' grade level in the 2020-2021 school year is used. In reading, we do not have results for students in fourth grade because of the differences in scale scores, and eighth grade is eliminated due to a convergence issue.

Cohort Analysis

For the second research question, we used a cohort analysis approach and compared the mean scores for September 2019 to September 2020 by grade. For this analysis, we also compared mean scores by type of school to evaluate whether some

schools had greater loss due to the COVID-19 pandemic school closures. We calculated statistical significance and effect sizes, as well as differences in mean percentile ranks.

Data

The data for this study came from the extensive Istation database. Istation serves millions of students with their reading, math, and Spanish-language assessments. We selected students that had data in both the 2019-2020 and 2020-2021 school years. This helped to control for missing data in key assessment months and helped ensure that the sample was equivalent for both academic years.

Since Istation offered home progress monitoring during the pandemic and there may be mean differences in scores between home and school assessments due to a difference in the testing environment, we only selected students who had progress monitoring at school in September 2020. This helped to control for the possible effects of the testing environment.

While the Istation database is extensive, we did not use all available students as this may introduce some selection bias into the results. Typically, students from higher socioeconomic status households have higher achievement than students from lower socioeconomic status households. Since the Istation database is slightly skewed toward schools that have higher percentages of students receiving free or reduced priced lunch (FRPL, which is a measure used to indicate SES), and this may impact the results, we selected a stratified sample according to the school SES.

To do this, we created four categories for SES, using the categories from the National Center for Education Statistics. SES 1 consists of schools that have 75% or

more of their students enrolled in the FRPL program. SES 2 schools have 50% to 74.9% enrolled in FRPL, and SES 3 schools have 25% to 49.9% of students enrolled in FRPL. SES 4 schools have less than 25% of students enrolled in FRPL. Next, we calculated the percentage of students that were enrolled in each of the four SES school types according to enrollment data available from NCES for public and public charter schools and used this information to create sample targets.

For the piecewise models, we created code in *R* statistical software to conduct sampling with replacement at all grade levels. In grades 1-5, we used a sample size of 10,000–10,100 students per grade. In grades 6 and 7, we had lower numbers of students at some SES levels and used a smaller sample size to limit the sampling with replacement. This was accomplished by using code in *R* statistical software to select a sample that matched enrollment percentages. For the cohort analysis, we selected cases that had both September 2019 and September 2020 scores; they were a subset of the piecewise sample. A description of the sample is available in Table 1.

Table 1. Description of the ISIP Reading and ISIP Math Analytical Samples

Piecewise Models						
Assessment	Grade as of September 2020	Sample Size	SES 1	SES 2	SES 3	SES 4
Reading	1	10,090	36%	16%	20%	28%
	2	10,090	36%	16%	20%	28%
	3	10,090	36%	16%	20%	28%
	4	10,065	36%	16%	20%	28%
	5	10,087	36%	16%	20%	28%
	6	4,037	29%	18%	24%	30%
	7	1,515	29%	18%	24%	30%
Piecewise Analytic Sample Grades 1-5			*36.3%*	*16.1%*	*19.4%*	*28.2%*
NCES Enrollment Grades 1-5			*36.2%*	*16.1%*	*19.5%*	*28.2%*

Piecewise Analytic Sample Grades 6 and 7			*28.9%*	*17.8%*	*23.7%*	*29.7%*
NCES Enrollment Grades 6 and 7			*28.9%*	*17.7%*	*23.7%*	*29.7%*
Math	1	10,090	36%	16%	20%	28%
	2	10,090	36%	16%	20%	28%
	3	10,090	36%	16%	20%	28%
	4	10,090	36%	16%	20%	28%
	5	10,090	36%	16%	20%	28%
	6	4,039	29%	18%	24%	30%
	7	1,515	29%	18%	24%	30%
Piecewise Analytic Sample Grades 1-5			*36.3%*	*16.1%*	*19.4%*	*28.2%*
NCES Enrollment Grades 1-5			*36.2%*	*16.1%*	*19.5%*	*28.2%*
Piecewise Analytic Sample Grades 6 and 7			*28.9%*	*17.8%*	*23.7%*	*29.7%*
NCES Enrollment Grades 6 and 7			*28.9%*	*17.7%*	*23.7%*	*29.7%*

Cohort Analysis

Assessment	Grade as of September 2020	Sample Size	SES 1	SES 2	SES 3	SES 4
Reading	1	7,427	33%	16%	21%	30%
	2	8,233	34%	16%	20%	30%
	3	8,302	33%	17%	20%	30%
	4	7,658	35%	17%	21%	27%
	5	7,790	34%	17%	20%	29%
	6	3,258	28.6%	18.1%	24.7%	28.5%
	7	1,153	29.2%	18.6%	22.5%	29.7%
Cohort Analytic Sample Grades 1-5			*33.9%*	*16.7%*	*20.4%*	*29.0%*
NCES Enrollment Grades 1-5			*36.2%*	*16.1%*	*19.5%*	*28.2%*
Cohort Analytic Sample Grades 6 and 7			*28.1%*	*18.6%*	*24.6%*	*28.7%*
NCES Enrollment Grades 6 and 7			*28.9%*	*17.7%*	*23.7%*	*29.7%*
Math	1	7,097	37.6%	15.4%	19.7%	27.3%
	2	7,201	37.7%	16.8%	19.4%	26.1%
	3	7,401	36.8%	16.6%	19.4%	26.1%
	4	7,561	35.6%	16.6%	19.1%	27.5%
	5	7,668	34.7%	15.9%	20.1%	29.3%
	6	3,398	26.9%	17.5%	23.1%	32.5%
	7	1,344	26.8%	17.9%	23.3%	32.0%
Cohort Analytic Sample Grades 1-5			*36.5%*	*16.4%*	*19.7%*	*27.4%*
NCES Enrollment Grades 1-5			*36.2%*	*16.1%*	*19.5%*	*28.2%*

Cohort Analytic Sample Grades 6 and 7	*27.0%*	*17.5%*	*23.1%*	*32.4%*
NCES Enrollment Grades 6 and 7	*28.9%*	*17.7%*	*23.7%*	*29.7%*

In the 2019-2020 school year data, students had ISIP scores from the September assessment month through March. Students with some missing data were included in the analysis. Some students had home progress monitoring scores in April and May during the pandemic. Most students had ISIP scores up to the March assessment month, some students had scores up to April, and some students had scores up to May 2020. Because there were large amounts of missing data in April and May, and the potential for sample bias due to access to technology or a conducive home environment, the April and May scores are dropped from this study. Using information from the students' growth trajectories, we projected the expected growth for April and May, which will be described in the methods section.

We used the students' grade level in the 2020-2021 school year to compute the longitudinal growth. For example, a fifth grade student means that the student was in the fourth grade in the 2019-2020 school year and in fifth grade in the 2020-2021 school year. In reading, fourth grade students were excluded from this study because of a scaling issue between ISIP ER and ISIP AR. ISIP ER has a different scale than ISIP AR, and fourth grade students who took ISIP ER in the 2019-2020 school year when they were in third grade and also took ISIP AR in the 2020-2021 school year had scores from two different scales.

ISIP Math was renormed for the 2020-2021 school year with a new vertical scale. For this study, we converted the old scale scores to the new scale scores for this analysis. Due to a smaller sample in eighth grade that would require heavier sampling with

replacement in some SES categories, this grade was dropped from analysis for both reading and math.

Results

Piecewise Model

Table 2 shows the observed mean score by month. Table 3 shows the estimated intercepts, estimated slope 1, and estimated slope 2. The estimated intercept is a cut point on the y-axis, with the ISIP scores on the x-axis. The intercept shows the estimated scale scores in September 2019. Estimated slopes are the students' growth trajectories in each segment in the growth model. The estimated intercepts and estimated slopes in Table 3 are used to derive the estimated mean scores for each assessment month using the formula $\hat{y}_i = \mathrm{i} + s_1 * (time1)_i + s_2 * (time2)_i$ and the results are shown in Table 4. Observed mean scores and estimated mean scores were comparable across grades in both reading and math, indicating reasonable results from a piecewise growth model.

Table 2: Observed Scale Scores of Each Assessment Month

Assessment	Grade as of September 2020	SEP 2019	OCT 2019	NOV 2019	DEC 2019	JAN 2020	FEB 2020	MAR 2020	SEP 2020
Reading	1	179	185	189	192	194	196	198	199
	2	202	205	208	211	213	215	217	221
	3	224	226	228	230	231	233	234	236
	5	1851	1866	1889	1902	1917	1894	1923	1930
	6	1956	1966	1995	2002	2021	1980	2004	1956
	7	2030	2041	2063	2066	2083	2030	2044	2072
Math	1	304	318	335	349	357	366	374	391
	2	394	410	424	435	443	451	459	450
	3	454	462	470	476	479	481	482	476
	4	478	483	491	496	499	506	510	497
	5	505	510	515	519	523	526	530	504
	6	510	511	517	522	531	531	536	526
	7	542	539	544	548	561	548	549	542

Table 3: Estimated Intercept, Estimated Slope 1, and Estimated Slope 2

Assessment	Grade as of September 2020	Estimated Intercept	Estimated Slope 1	Estimated Slope 2
Reading	1	180.626	3.153	-0.680
	2	202.132	2.535	3.048
	3	223.101	1.986	1.270
	5	1849.769	12.775	0.366
	6	1962.396	9.737	-2.516
	7	2035.408	7.166	-8.867
Math	1	306.455	11.610	14.582
	2	397.712	10.400	-10.406
	3	458.181	4.329	-8.542
	4	477.857	5.222	-12.130
	5	505.009	4.208	-26.270
	6	509.759	4.522	-11.218
	7	539.940	3.514	-19.309

Table 4. Piecewise Scaled Scores for Each Assessment Month

Assessment	Grade as of September 2020	SEP 2019	OCT 2019	NOV 2019	DEC 2019	JAN 2020	FEB 2020	MAR 2020	SEP 2020
Reading	1	181	184	187	190	193	196	200	199
	2	202	205	207	210	212	215	217	220
	3	223	225	227	229	231	233	235	236
	5	1850	1863	1875	1888	1901	1914	1926	1927
	6	1962	1972	1982	1992	2001	2011	2021	2018
	7	2035	2043	2050	2057	2064	2071	2078	2070
Math	1	306	318	330	341	353	365	376	391
	2	398	408	419	429	439	450	460	450
	3	458	463	467	471	475	480	484	476
	4	478	483	488	494	499	504	509	497
	5	505	509	513	518	522	526	530	504
	6	510	514	519	523	528	532	537	526
	7	540	543	547	550	554	558	561	542

Reading

In reading, students grew consistently from September 2019 through March 2020, as expected. To determine the growth for April and May, we looked at the mean score and its percentile rank for each month from September through March. Most months had the same mean percentile rank, which might vary by a point or two. We took the average of the percentiles across the months and used that percentile to project what growth would have been in April and May. We also projected the typical learning loss in the summer of 2020 by using the incoming scores in September of the 2019-2020 school year. This may not completely capture the full learning loss, as some students may have taken their May assessment at the beginning of the month and school ended four to six weeks later. Students also began school in August, and therefore there may be

a month or more of instruction that the learning loss method described here does not fully capture.

The growth and the learning loss that the students experienced varied by grade. Kindergarten students entering first grade had scores (199) that were between the average of the previous year's scores in February (196) and March (200), indicating 3 and a half months of learning loss. Students entering second grade had a mean of 220, which showed a slight learning gain from the previous March (217), indicating they grew slightly some over the spring, but their scores were lower than the projected scores (221), indicating a loss of one month. Students entering third grade had scores (236) that were higher than March (235), and lower than the projected scores of 238.

Students in the upper grades experienced the pandemic differently than students in early elementary. Students entering fifth grade had scores in September 2020 (1927) similar to the average in March (1926), and students entering sixth grade had September 2020 scores (2018) that were between the averages for February (2011) and March (2021). Students entering seventh grade had September 2020 scores (2070) that were similar to those in February (2071).

When comparing September 2019 and September 2020 scores, incoming students performed lower when compared to similar students in the previous year. Students entering first or second grade in September 2020 had scores that were 3 points less than students from the previous cohort, indicating that they came in approximately 2 months behind the previous cohort. Students entering third grade had a mean ISIP score that was 6 points less than the previous cohort. Students in upper elementary also had lower scores than students from the previous cohort.

Across the grades, the means in September 2020 were approximately equivalent to their mean scores around March or April in their prior year, with the exceptions noted above. This indicates that once schools closed in March, students did not have increased gains, with the possible exception of students entering second grade.

Although some students may have been able to maintain their reading ability until the end of the school year, the majority of students did not continue to grow in April and May. The remote learning may have helped them maintain the growth they experienced through March.

Typical summer learning loss in reading is one month when using the ISIP reading scores. This study demonstrates that in reading, the COVID-19 school closures contribute approximately 1 to 3 months' loss in reading in addition to the typical summer loss. These results are consistent with many studies on COVID-19 learning loss as well as summer learning loss in reading (Kuhfeld, Soland, et al., 2020; Kuhfeld, Tarasawa, et al., 2020; Lewis et al., 2020; Patarapichayatham et al., 2021; Quinn and Polikoff, 2017). Figures 2 and 3 show the difference between the expected summer learning loss and the actual COVID-19 learning loss by grade for ISIP ER, and Figure 4 shows the learning loss for students assessed with ISIP AR. These graphs show that the biggest loss was that student learning did not progress in April and May and that for the most part, students picked up in September where they left off in March of 2020.

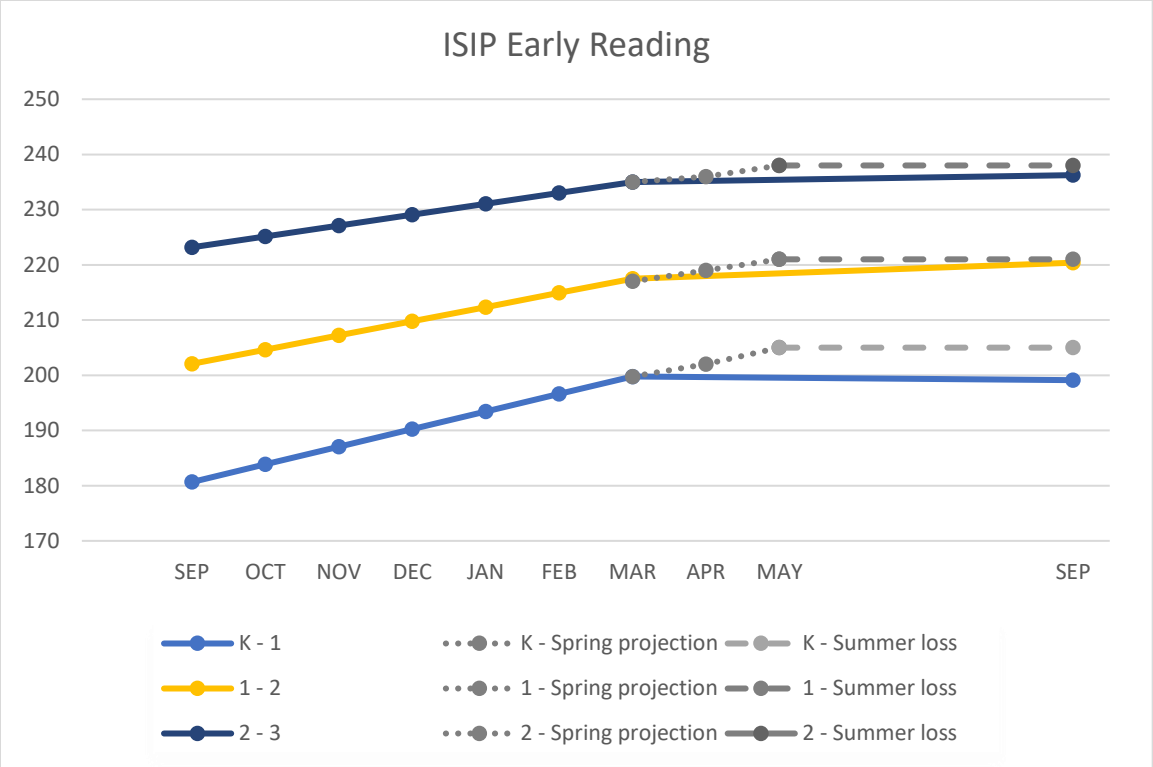

Figure 2. Typical summer loss and COVID-19 learning loss in reading: grades 1-3.

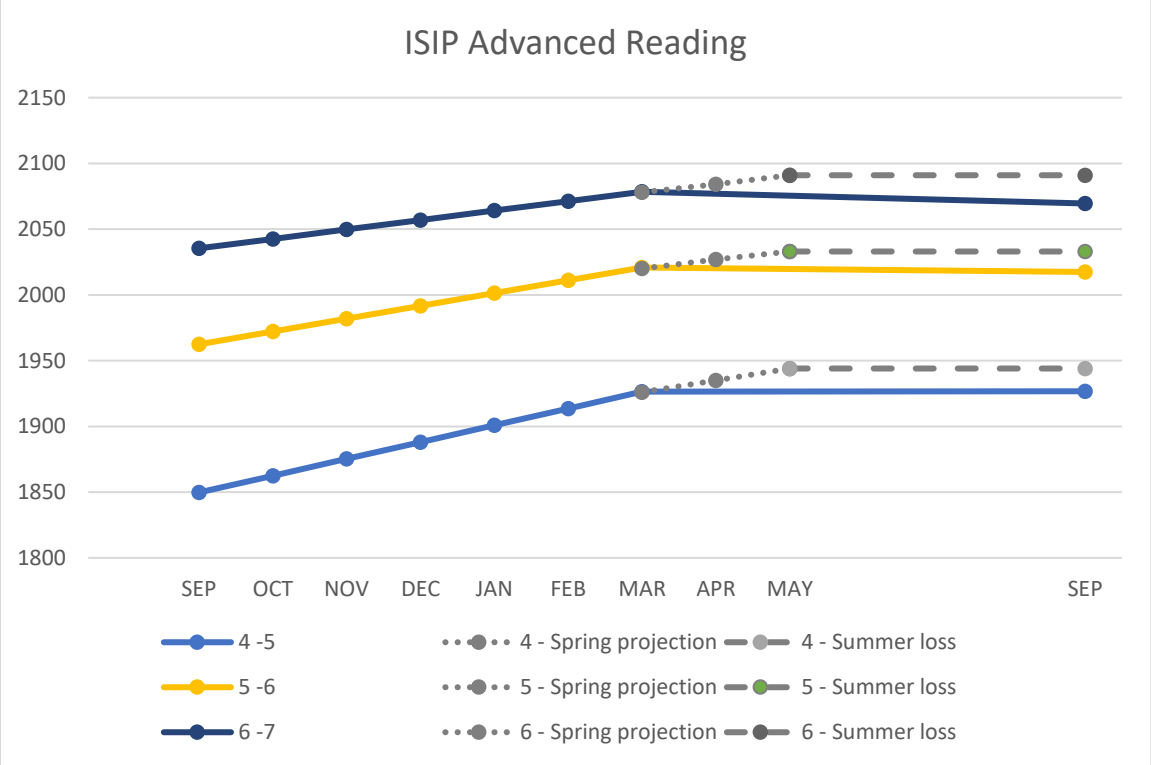

Figure 3. Typical summer loss and COVID-19 learning loss in reading: grades 5-7.

Math

The results for math demonstrate that while students in the early grades had less learning loss, the learning loss was greater in math than in reading. Students entering first grade had September 2020 scores (391) that were higher than March (376) but lower than the projected scores (395). After that, students showed greater learning loss in math. We note that summer learning losses are greater in math than they are in reading, so for the remaining grades, we will report the losses in comparison not with the March scores, but rather with the typical summer learning losses.

Students entering second grade would typically have 2 months of summer learning loss, and in this research, they had 3 months of learning loss in math. Students entering third or fourth grade would typically have 3 months of summer loss, and the learning loss from the pandemic was 5 months. Students entering fifth grade would have 5 months of loss, and in this research, they have 8 months of learning loss — almost an entire year. Students entering sixth grade would have 3 months of loss, and in this research, they had 5 and a half months of learning loss. Figures 5-7 show the projected gains, typical summer learning loss, and the actual loss in math.

Similar to ISIP ER and ISIP AR students, ISIP Math students showed increased COVID-19 learning loss when comparing their September 2020 performance scores to their previous assessment performance scores. They also had mean math scores in September that were lower than the previous cohort. Students entering first grade had ISIP Math scores that were 7 points lower than students in the prior year. Students entering second grade had ISIP Math scores that were 8 points lower, third graders had

scores that were 2 points lower, and fourth and fifth graders had scores that were 8 and 6 points lower, respectively. Students entering sixth grade had scores that were 14 points lower than the previous cohort.

Understanding the ISIP Math norms is important to put these results in context. The norms assume that the learning gains are greater in the fall and winter months, and then they taper in the spring. They use a parabola method that mirrors the learning gains expected during the year, and they also assume the greater learning loss over the summer that was present in the norming data. While the learning losses were greater from the pandemic closures and greater than expected summer learning losses, it is typical that students will lose more in math than they will in reading, and that the losses will be greater in the upper elementary years when the curriculum is more difficult to learn and easier to forget if the skills are not practiced.

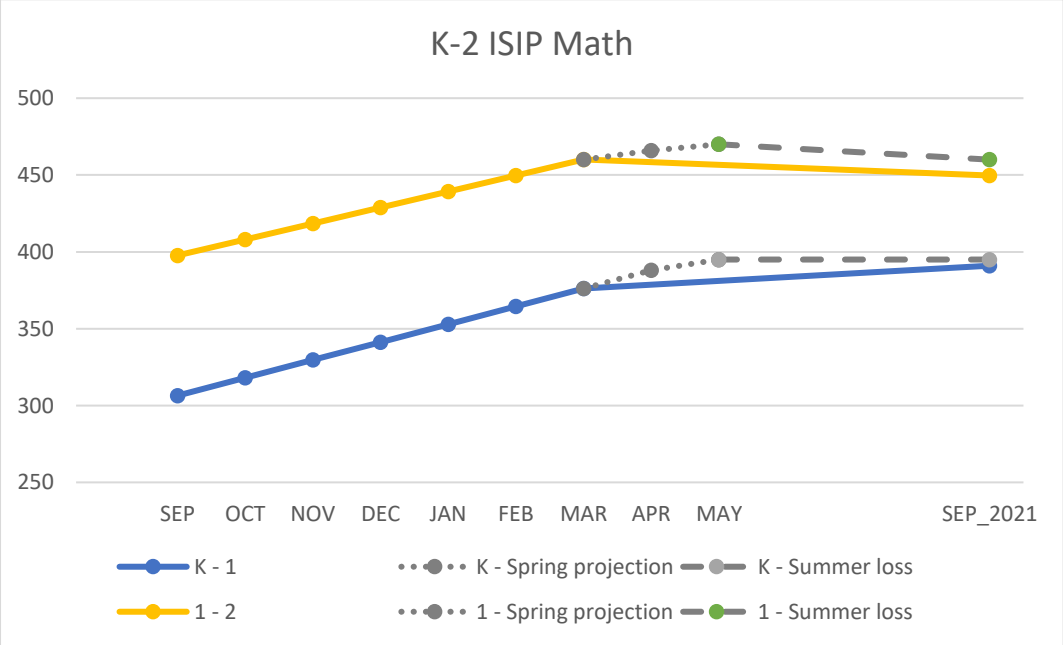

Figure 5. Typical summer loss and COVID-19 learning loss in math: grades 1 and 2.

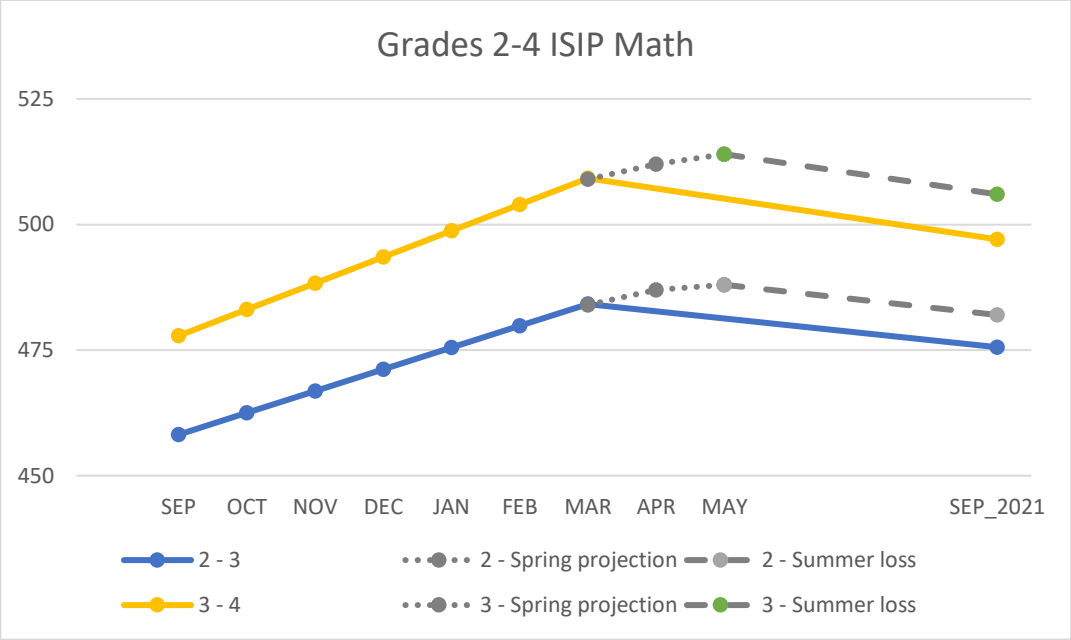

Figure 6. Typical summer loss and COVID-19 learning loss in math: grades 2 and 3.

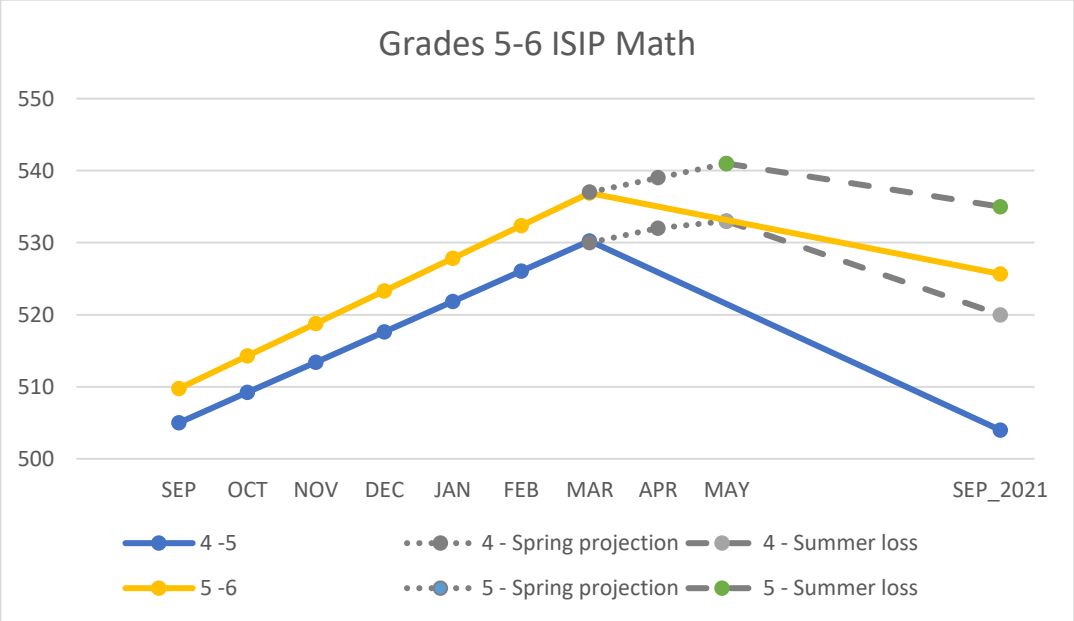

Figure 7. Typical summer loss and COVID-19 learning loss in math: grades 4-6.

Our results are consistent with many studies on COVID-19 learning loss and summer learning loss in reading and math (Kuhfeld, Soland, et al., 2020; Kuhfeld, Tarasawa, et al., 2020; Lewis et al., 2020; Patarapichayatham et al., 2021; Quinn & Polikoff, 2017; Shafer, 2016; Dorn, 2020). In summary, our findings show that in reading, students' growth trajectories kept going up until they finished their 2019-2020 school year. Once they headed back to school in September 2020, their scores dropped, especially in the upper grades. Learning losses were greater in math than they were in reading, and the students entering fifth grade had steep losses in their math ability as compared to their previous year's achievement.

Cohort Analysis

To answer the second research question, we compared the differences among mean scores in reading and math for students in September 2020 versus the previous cohort, by grade and SES level at the school, using the same categories as described in the sample selection process. All differences were statistically significant, and therefore we calculated effect sizes using Hedges's g to better see the magnitude of the difference. Most effect sizes were moderate or small. The results are available in Table 5.

Table 5. Cohort comparisons for students ISIP Reading

	SES	Sept. 2019	Sept. 2020	Difference in Scale Score Points	Effect Size	Difference in Percentile Points
Grade 1	SES1	198	195	-3	-0.21	-7
	SES2	200	197	-3	-0.22	-7
	SES3	204	200	-4	-0.28	-9
	SES4	208	205	-3	-0.21	-8
	All	202	199	-3	-0.19	-7
Grade 2	SES1	218	216	-2	-0.11	-4
	SES2	222	218	-4	-0.22	-7
	SES3	226	222	-4	-0.25	-7
	SES4	230	227	-3	-0.18	-6
	All	224	221	-3	-0.16	-6
Grade 3	SES1	232	231	-1	-0.09	-2
	SES2	237	235	-2	-0.14	-5
	SES3	241	239	-2	-0.13	-5
	SES4	246	243	-3	-0.17	-7
	All	239	236	-3	-0.12	-7
Grade 4	SES1	1786	1754	-32	-0.18	-7
	SES2	1831	1793	-38	-0.21	-6
	SES3	1872	1835	-37	-0.22	-9
	SES4	1925	1883	-42	-0.25	-9
	All	1850	1813	-37	-0.20	-9

	SES	Sept. 2019	Sept. 2020	Difference in Scale Score Points	Effect Size	Difference in Percentile Points
Grade 5	SES1	1893	1861	-32	-0.16	-7
	SES2	1917	1912	-5	-0.03	-1
	SES3	1979	1954	-25	-0.13	-6
	SES4	2024	2009	-15	-0.09	-3
	All	1955	1930	-25	-0.20	-6
Grade 6	SES1	1950	1965	+15	0.08	+3
	SES2	2022	1978	-44	-0.23	-10
	SES3	2057	2038	-19	-0.10	-4
	SES4	2097	2086	-11	-0.06	-2
	All	2030	2021	-9	-0.05	-2
Grade 7	SES1	2005	1980	-25	-0.12	-4
	SES2	2034	2043	9	0.04	+2
	SES3	2144	2097	-47	-0.24	-10
	SES4	2150	2156	6	0.03	+1
	All	2088	2072	-16	-0.08	-3

For ISIP Early Reading, the cohort of students in the 2020-2021 school year is behind the 2019-2020 school year cohort of students in all grades and SES levels with a few exceptions. In first through third grades, the students have lower scores in September 2020 in all SES levels. In grade 1, the schools that are SES 3 and SES 4 have the greatest difference in mean percentile points, and in grade 2, the biggest differences in mean percentile points are with SES 2 and SES 3 schools. In grade 3, the SES 4

schools have the biggest mean differences in percentile points. These results are depicted in Figure 8.

Students in upper elementary school who took the ISIP Advanced Reading assessment have a more variable pattern of results, and the differences between SES levels are more pronounced. These results can be seen in Figure 9. The scores have more of a sawtooth pattern, where students in fifth grade in SES 1 schools have scores similar to students in fourth grade in SES 3 schools, and fifth grade students in SES 2 schools have scores similar to fourth grade students in SES 4 schools. A similar pattern is evident in sixth and seventh grades. The scores in September 2019 are higher than in September 2020, with the exception of students in sixth grade in SES 1 schools, seventh grade in SES 2 schools, and SES 4 schools in sixth and seventh grade, where scores were comparable to the prior year.

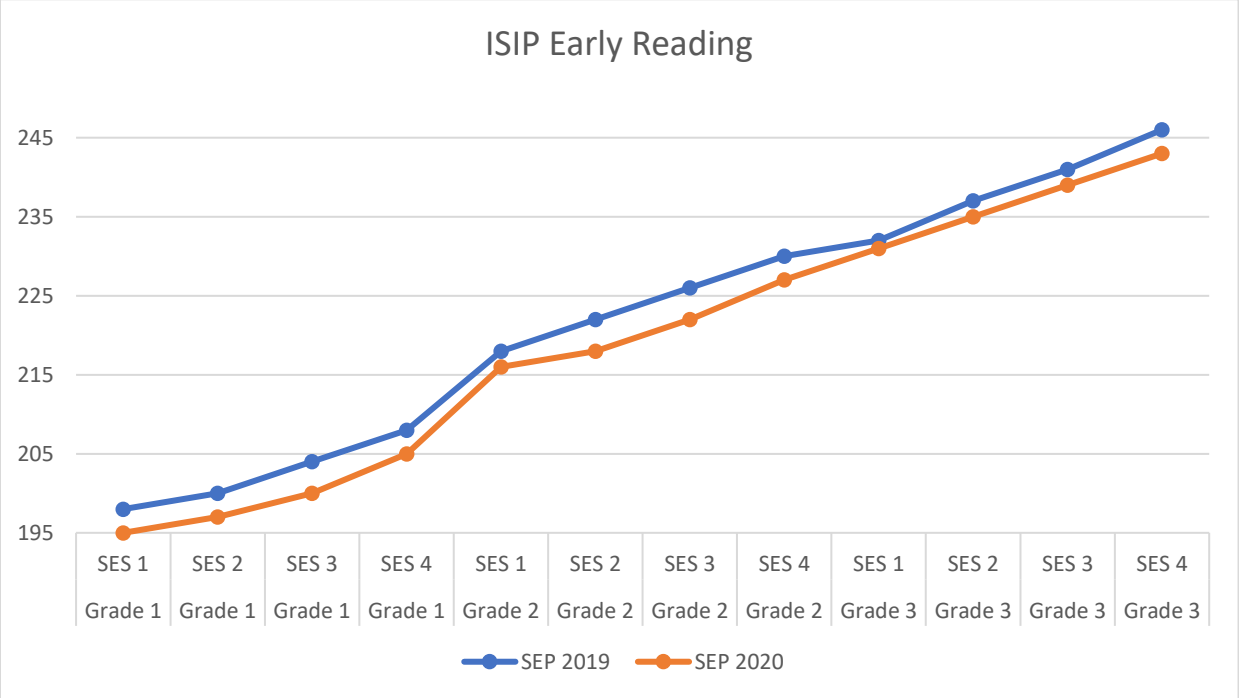

Figure 8. Differences in cohort performance by school SES in reading, grades 1-3.

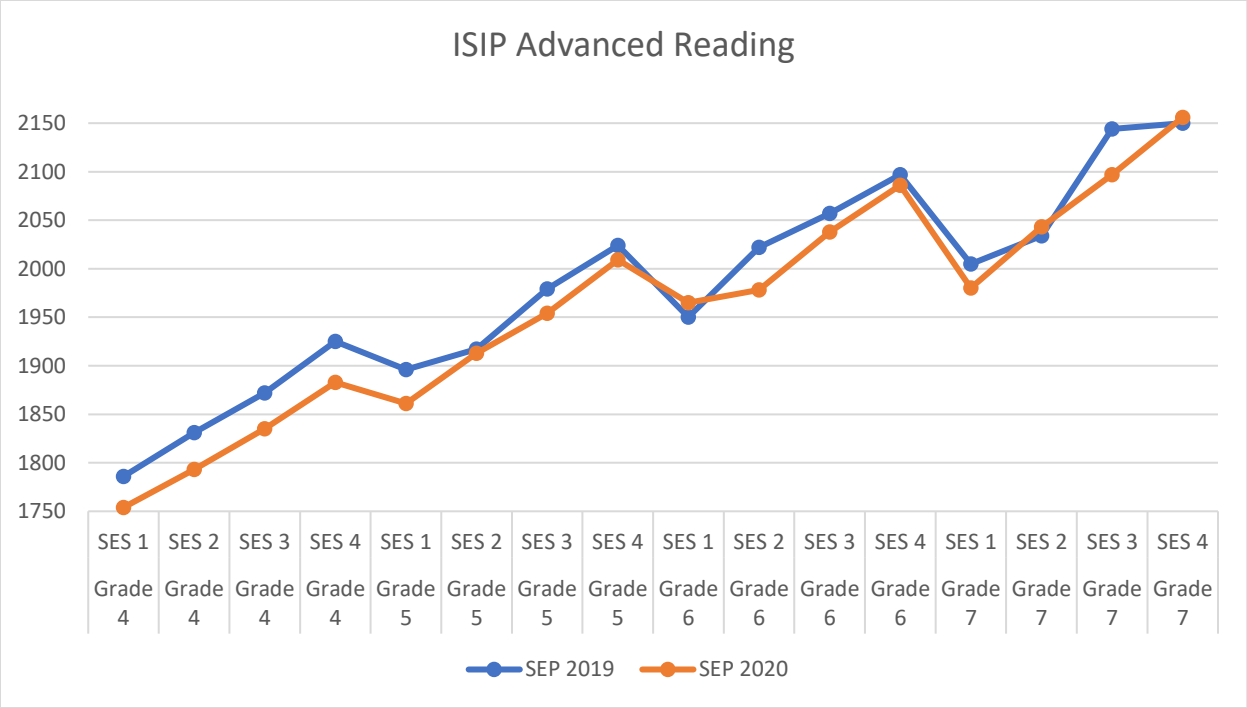

Figure 9. Differences in cohort performance by school SES in reading, grades 4-7.

For ISIP Math, the cohort of students in the 2020-2021 school year scored lower than students in the 2019-2020 school year cohort of students in all grades and SES levels, and the differences in the mean percentile points has a wide range. These results are available in Table 6. Students in first grade in SES 1 schools have scores that are similar to each other in September of 2019 and September 2020. SES 2 schools have the biggest gap of 9 scale points, which is equivalent to 7 percentile points. Students in SES 3 and SES 4 schools also had lower scores in September 2020 than in September 2019. In second grade, students in SES 4 schools had the biggest drop in ISIP Math scores, particularly in the number of percentile points.

Table 6. Cohort comparisons for students, ISIP Math

	SES	Sept. 2019	Sept. 2020	Difference Scale Score Points	Effect Size	Difference Percentile Points
Grade 1	SES1	384	383	-1	-0.02	-1
	SES2	394	385	-9	-0.20	-7
	SES3	398	394	-4	-0.09	-3
	SES4	406	401	-5	-0.16	-4
	All	394	391	-3	-0.06	-2
Grade 2	SES1	446	444	-2	-0.06	-1
	SES2	453	448	-5	-0.16	-5
	SES3	455	452	-3	-0.09	-4
	SES4	464	457	-7	-0.20	-8
	All	454	450	-4	-0.12	-4
Grade 3	SES1	471	468	-3	-0.10	-3
	SES2	475	473	-2	-0.07	-2
	SES3	481	479	-2	-0.07	-3
	SES4	486	484	-2	-0.07	-2
	All	478	476	-2	-0.07	-2
Grade 4	SES1	497	488	-9	-0.29	-10
	SES2	502	494	-8	-0.26	-9
	SES3	507	501	-6	-0.18	-7
	SES4	515	508	-7	-0.24	-8
	All	505	497	-8	-0.25	-9

	SES	Sept. 2019	Sept. 2020	Difference Scale Score Points	Effect Size	Difference Percentile Points
Grade 5	SES1	499	494	-5	-0.16	-4
	SES2	509	502	-7	-0.21	-7
	SES3	506	508	2	0.06	-2
	SES4	522	515	-7	-0.20	-6
	All	510	504	-6	-0.17	-6
Grade 6	SES1	527	513	-14	-0.36	-11
	SES2	538	523	-15	-0.37	-16
	SES3	542	526	-16	-0.39	-17
	SES4	556	539	-17	-0.49	-15
	All	542	526	-16	-0.40	-17
Grade 7	SES1	518	527	9	0.26	-8
	SES2	535	538	3	0.07	-3
	SES3	550	545	-5	a-0.12	-4
	SES4	568	555	-13	-0.30	-10
	All	545	542	-3	-0.07	-3

In third grade the drops in mean scores and percentile points were comparable across all types of schools. In fourth grade, the biggest drop in mean scores and percentile points was in SES 1 and SES 2 schools. In contrast, students in fifth grade had bigger drops in SES 2 and SES 4 schools, and slight gains in SES 3 schools.

Students entering sixth grade showed the largest drop in scores across all grades and SES, and the drops in mean scores and difference in percentile ranks were large, with effect sizes between –.49 and –.39. These results show that students in all types of schools came to school in September 2020 with scores that were substantially lower

than their September 2019 counterparts, indicating that teachers would need to spend time catching students up on what they forgot since school closures were instituted in March 2020. Students entering seventh grade had a mixed pattern of results, with students in SES 1 and SES 2 schools having higher scores, and students in SES 3 and SES 4 schools having lower scores.

These results are not surprising given the results from the piecewise models that showed these students had the greatest learning loss. Figures 10, 11, and 12 depict these results. With the exception of students entering seventh grade, the gaps between September 2019 and September 2020 scores were greater in the upper grades than in the lower grades.

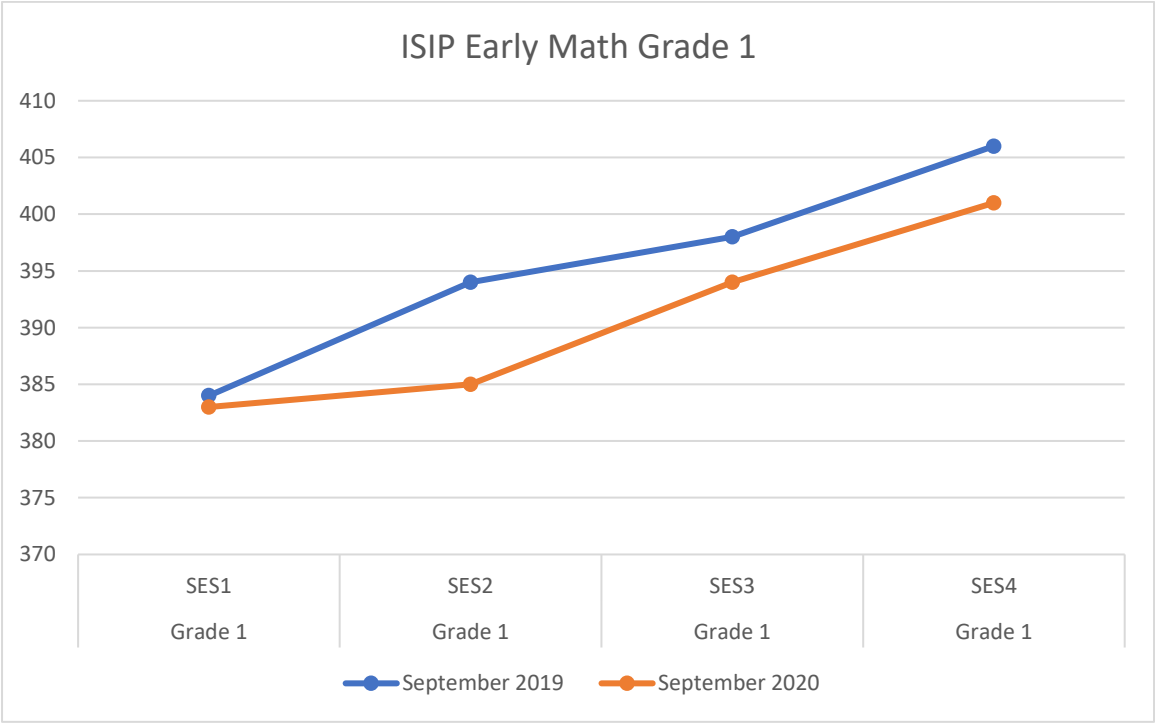

Figure 10. Differences in cohort performance by school SES in reading, grade 1.

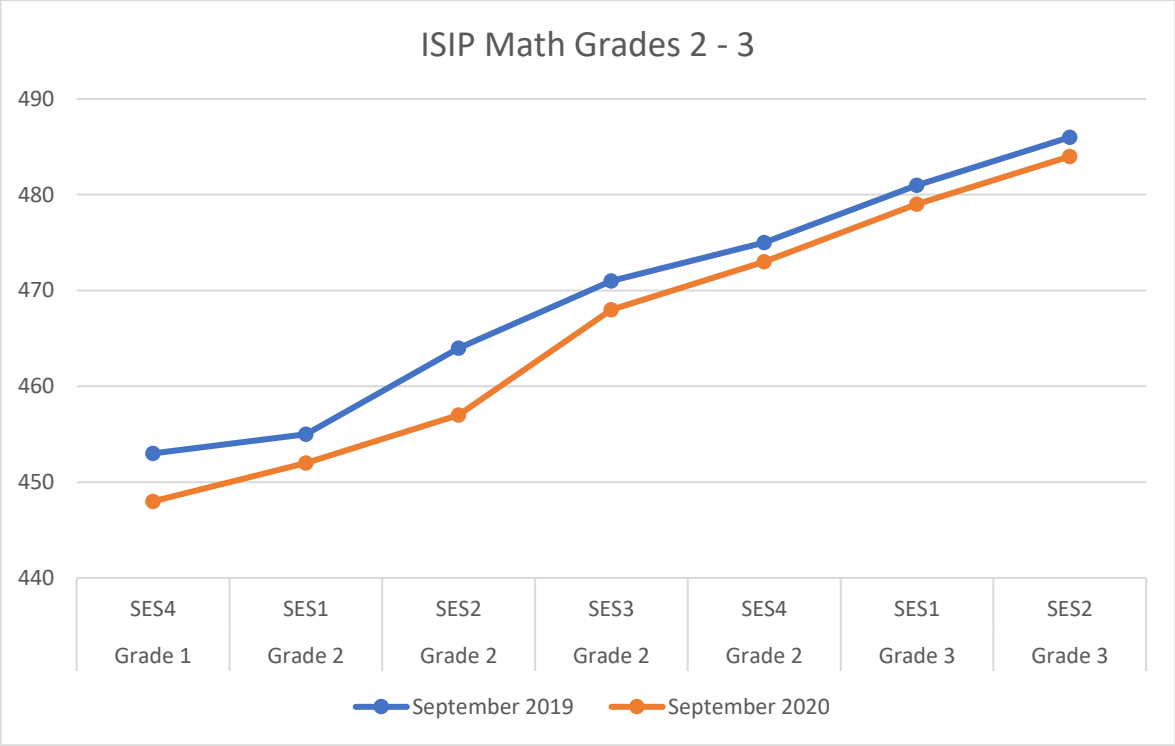

Figure 11. Differences in cohort performance by school SES in reading, grades 2 and 3.

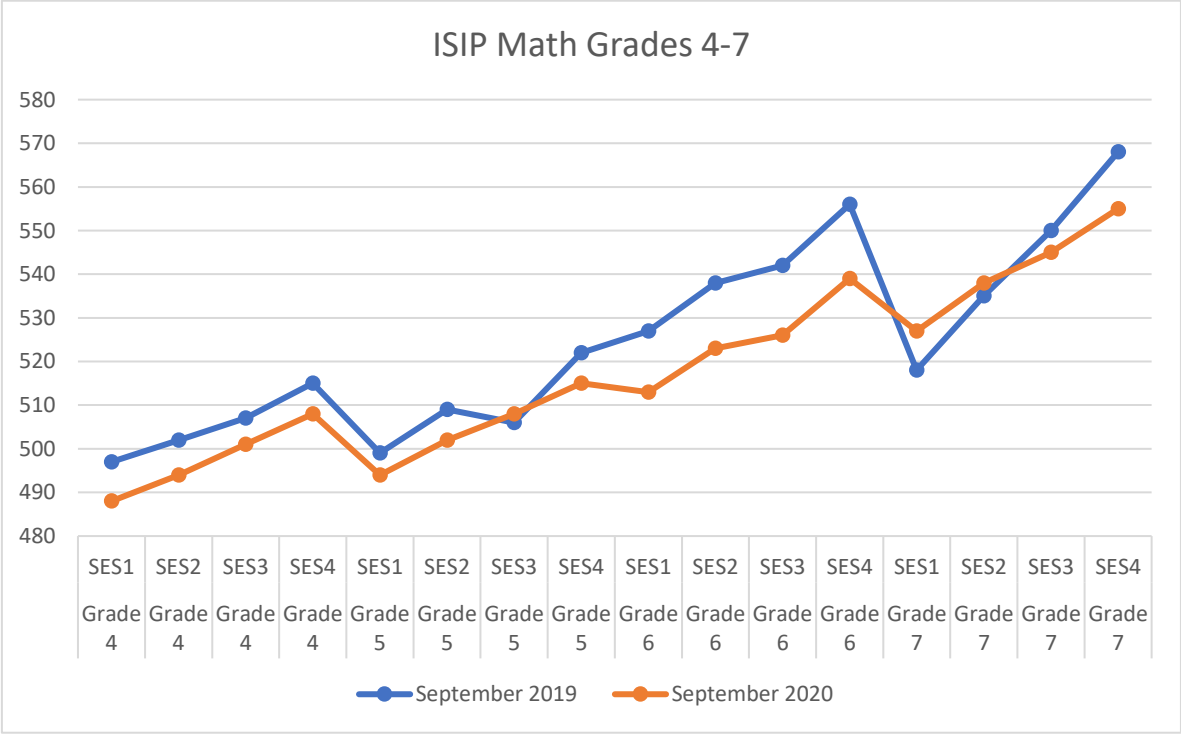

Figure 12. Differences in cohort performance by school SES in reading, grades 4-7.

Discussion

Our findings in both reading and math are consistent with previous research that found differences in learning gains and losses in reading and math during the COVID-19 pandemic (Kuhfeld, Soland, et al., 2020; Dorn, 2020; Huff, 2020; Patarapichayatham et al., 2021). Students made learning gains through March in the 2019-2020 school year, but they did not make the typical gains in April and May. In reading, students held on to their learning gains through March, but for the most part missed out on the learning gains they would have achieved in April and May had schools been open. The results varied by the SES level of the school, and students in higher-poverty SES 1 schools did not have learning losses that were substantially greater than other students. Our research is also similar to Quinn & Polikoff (2017) which found that students' achievement scores declined over the summer by one month's worth of school-year learning, and students in higher grades had more loss than the lower grades.

The situation in math is somewhat different. Students entering first and second grade appear to have held on to their gains through March from the previous year, and first grade students gained a bit during the pandemic. However, as the students' grade increased — and thus the complexity of the math concepts increased — they had a harder time maintaining their gains. While students in the elementary grades typically lose more months in math than they do in reading when looking at typical summer loss, the losses were more substantial due to the school closures from the pandemic. Losses were the greatest for students in sixth grade across all SES levels, indicating that students entering sixth grade came in further behind with more substantial learning losses than other grades.

Research from Lewis et al. (2020) showed that students in lower SES schools who engaged in online learning for reading narrowed the achievement gap compared to students in higher SES schools. It is likely that online learning helped to stave off some of the anticipated learning losses from the pandemic closures for those who were able to obtain the needed resources to do so.

The patterns of learning loss follow what we know about summer loss in a typical school year. Shafer (2016) found that students had greater summer learning loss in reading than they did in math. The loss from the pandemic was greater in math than it was in reading. This may be because there are greater opportunities for a student to use their reading skills when they are not in the classroom, especially if reading is part of a family's daily life. Many parents will read to their children and ask questions about what they read, and it is likely that fewer parents help their children practice math skills when school is out. This may be especially true with older students, since parents may have forgotten parts of the math curriculum. As a result, when the school year ends, students may have very few opportunities to engage in any type of mathematical thinking.

Recommendations

Our results indicate that students fell behind in their learning in both reading and math, with greater learning loss in math. This will put a burden on teachers and parents to help students get caught up so that there are not lifelong repercussions for the students. First, while remote learning may have helped stave off some of the losses when schools closed in the spring (Lewis et al., 2020), this research indicates that it was not as effective as in-person learning. Students did not make learning gains in April and May like they would have in a normal year. In reading, teachers will need to review basic

concepts and teach some of the more advanced concepts from the previous year to help students catch up. Parents may also want to emphasize literacy in the home, such as by reading to their children and checking out books from the library if possible. Many libraries have apps that patrons can download and check out books to read on a device, and schools across the country have provided devices to students during the pandemic so that students can participate in remote learning. Educational technology can also help students with their learning growth, including lower-achieving students (Sutter, et al., 2019).

The situation will be more urgent in math, especially in the upper grades, when the concepts are more difficult and students may have a greater tendency to forget the concepts of decimals, fractions, number lines, graphing, and other more complex and abstract concepts. Teachers across grades may need to strategize on which concepts to review more extensively and how to keep students engaged in math concepts. In addition, teachers should reach out to parents to help them incorporate math skills at home so that students have time to practice their math skills as well as their reading skills.

Long-Term Implications of COVID-19 Learning Loss

Unknown is the longer-term impact of COVID-19 learning loss since the pandemic has continued through the 2020-2021 school year. Some states and districts have returned to in-person learning, and others have remained closed, with students only participating remotely. Still others have maintained a hybrid model where some students are remote and others are attending in person on different days, so as to minimize class sizes and exposure. Likely there will be long-term impacts for students,

especially if states and districts do not implement recovery learning strategies for their students such as expanding summer school.

Learning losses from five to nine months could occur by June 2021 (Dorn et al., 2020). In research conducted by McKinsey & Company, they recommended that districts work with teachers to make remote learning engaging and structured and eliminate the digital divide. Acceleration plans using evidence-based programs and formative assessments to identify students who are falling behind may help students catch up academically (Dorn et al., 2020). Another approach may be to expand learning time during the day and consider in-person summer programs after the pandemic has waned.

The question of whether to implement state-level summative assessment in spring of 2021 has been controversial. Having a year-end summative assessment may be helpful for states and districts to determine the extent, if any, of the learning loss and whether there are differences by type of instruction received in the 2020-20201 school year. These results could be helpful for instructional planning for the following school year in the event the districts may need to implement plans to help students catch up. Some high-accountability states such as Texas have opted to go forward with the summative assessment but not use it to grade teachers, schools, and districts on student performance. Others, such as California have opted to replace the summative assessment with a shorter version, and others have sought waivers to cancel all standardized testing. Georgia and Colorado will reduce the number of summative assessments, and Massachusetts required districts to develop academic recovery plans

(Olneck-Brown, 2021). The results from these tests, if administered, should be interpreted with caution, especially if the assessments are administered at home.

Limitations and Future Directions

This study shows the impact of the COVID-19 pandemic's school closures on students' achievement in reading and math with a nationally representative sample of students in the US that use Istation and the ISIP assessments. This study focused on students who took the assessment in school in September 2020.

Our results indicate that students lost their math ability more rapidly, and while remote learning may have helped students retain their progress in reading, it was not the same for math. More research needs to investigate how remote learning is different in math than in reading and what can be done to help students maintain their math ability as well as their reading ability.

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