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The Impact of COVID-19 on Student Math Outcomes

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Technical Report No. 31

acadience® math

Suggested Citation:

Warnock, A. N., Wheeler, C. E., Gray, J. S., & Powell-Smith, K. A. (2021). *The Impact of COVID-19 on Student Math Outcomes* (Technical Report No. 31). Acadience Learning Inc. www.acadiencelearning.org

The Impact of COVID-19 on Student Math Outcomes

Among the many actions aimed at mitigating the spread of COVID-19, one of the most universal was the closure of schools across the United States (Viner et al., 2020). The scale of school closures has led to substantial disruptions in student learning, the effects of which are still occurring. Estimates are that more than 1.5 billion students have missed significant schooling time, which constitutes the largest disruption of schooling in world history (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). There is no precedent for school closures that are this widespread and severe.

The disruption to student learning that occurred in the early spring of 2020 likely resulted in reduced access to instruction for many students. At the schools and districts that implemented remote learning in the spring of 2020, some students may have had difficulty accessing instruction due to a lack of reliable internet access or the technology required to participate in remote instruction. In addition, schools and districts may have opted to review content that had already been covered during the school year through different modalities (e.g., worksheet packets, televised instruction, computerized live remote instruction, computerized asynchronous instruction) instead of introducing new content, effectively ending the school year's instruction several months before school would have typically released. These circumstances, coupled with a continuation of altered learning modalities through the fall of 2020 in many locations, likely compounded any instructional loss caused by the disruption in the spring. Indeed, research examining the effect of the pandemic on student reading skills, as measured by the Acadience Reading K–6 assessment, found that student outcomes were significantly impacted by the disruption to instruction (Gray & Powell-Smith, 2021).

Research into the effects that this disruption has had on student math skills is necessary to help inform both instructional and policy decisions regarding the impact of school closures and remote learning. Perhaps most importantly, this information can help inform educational practices aimed at addressing academic skill gaps resulting from these disruptions to instruction. The present study is aimed at identifying the effects that the COVID-19 pandemic has had on math skills by comparing the Acadience Math scores of students in first through sixth grades from the beginning of the 2020–2021 school year to beginning-of-year scores from the previous 2019–2020 school year.

Method

Research Questions

1. How did student math skills, as measured by the Acadience Math Composite Score (MCS), differ between the beginning of the 2019–2020 school year and the beginning of the 2020–2021 school year?
2. How has the COVID-19 pandemic and subsequent disruption to education impacted students' likelihood of meeting benchmarks?

Participants

Data used for this research consisted of Acadience Math scores for students in grades K–6 collected and entered into Acadience Data Management (ADM; www.acadiencelearning.net) by school personnel during the 2018–2019, 2019–2020, and 2020–2021 school years. Student data were obtained in two cohorts. Cohort 1 consisted of a set of students' middle-of-year MCS from 2018–2019 and beginning-of-year MCS from 2019–2020. Cohort 2 contained a different set of students' middle-of-year MCS from 2019–2020 and beginning-of-year MCS from 2020–2021.

Students' data were selected for inclusion based on two criteria. First, only students who had complete Acadience Math data entered for at least one of the two cohorts (i.e., data entered in both 2018–2019 and 2019–2020 and/or data entered in both 2019–2020 and 2020–2021) were included. Second, schools were matched across cohorts at the grades being analyzed (e.g., kindergarten and first grade, first grade and second grade), meaning that if a school did not have data entered for a specified grade in both cohorts, data from that school were not included. For example, when analyzing beginning-of-year first-grade scores with middle-of-year kindergarten scores from the previous year, data from schools that did not have middle-of-year kindergarten scores entered for both 2018–2019 and 2019–2020 were excluded. Likewise, schools that did not have first-grade scores entered at the beginning of 2019–2020 and the beginning of 2020–2021 were excluded.

Sample sizes by cohort and the pairs of grades for which student data were collected (e.g., kindergarten and first grade, first grade and second grade) are summarized in Table 1. For example, looking at Table 1, we can see that there were 11,236 students in the first cohort who had data collected for kindergarten and first grade. These students had an MCS entered in ADM at the middle of kindergarten in 2018–2019 and an MCS entered at the beginning of first grade in 2019–2020. In the second cohort for kindergarten and first grade, there were 9,647 students. These students had an MCS entered in ADM at the middle of kindergarten in 2019–2020 and an MCS entered at the beginning of first grade in 2020–2021. Across both cohorts, there were 20,883 students with beginning-of-year first-grade data and middle-of-year kindergarten data from the previous year. These students were in schools that collected kindergarten data at the middle of both 2018–2019 and 2019–2020 and in schools that collected first-grade data at the beginning of both 2019–2020 and 2020–2021.

Overall, the sample size is robust, with thousands of students in each cohort. Sample sizes are largest in earlier grades and smallest for fifth and sixth grades. There was also a decrease in the number of students assessed in the second cohort, even after schools were matched. As a percent of the first cohort, the sample sizes for the second cohort range from 80–89%.

Table 1
Sample Sizes by Cohort and Grade

Grades Data Were Collected For	Cohort 1 (2018–2019 & 2019–2020)	Cohort 2 (2019–2020 & 2020–2021)	Total
K & 1	11,236	9,647	20,883
1 & 2	12,860	10,529	23,389
2 & 3	11,819	10,028	21,847
3 & 4	11,288	8,994	20,282
4 & 5	9,582	8,521	18,103
5 & 6	3,092	2,707	5,799

The Acadience Math data in the sample were collected from 389 schools in 191 school districts across the United States and Canada. In the U.S., data were gathered from 386 schools in 188 school districts in 39 states representing every U.S. census region and division (see Table 2). In Canada, data were from three schools in one district in Quebec. Students from these three schools accounted for 0.49% of the total sample size. Of the total participating schools, 23% (90 schools) were private. Demographic information aggregated at the school level from the Institute of Education Sciences' National Center for Education Statistics (NCES) was available for 369 U.S. schools (Broughman et al., 2019; Chen, 2020). This information is summarized by locale in Table 3. Across all schools, approximately half the student population (48%) was reported as female. Thirty-nine percent of students were reported as qualifying for free or reduced-price lunch. Approximately 1% of students were reported as Native American or Alaska Native; 2% as Asian, Native Hawaiian, or Pacific Islander; 11% as Hispanic or Latino; 6% as Black; 75% as White; and 5% as multiracial.

Table 2

Summary of Participating U.S. States and Schools by Census Region and Division

U.S. Census Region: Division	Number of States	Number of Schools (% of Total)
Midwest: East North Central	5	43 (11%)
Midwest: West North Central	6	81 (21%)
Northeast: Middle Atlantic	3	128 (33%)
Northeast: New England	4	17 (4%)
South: East South Central	3	8 (2%)
South: South Atlantic	5	23 (6%)
South: West South Central	3	9 (2%)
West: Mountain	6	51 (13%)
West: Pacific	4	26 (7%)
Total	39	386

Note. Student data from three schools in one province in Canada, not reflected in this table, were also included in the analysis.

Table 3

Available Demographic Information of Participating Schools by Locale

		Average Percentage							
Locale	Number of Schools	Female	FRL Eligible	Native American/ Alaska Native	Asian/Native Hawaiian/ Pacific Islander	Hispanic/ Latino	Black	White	Multiracial
City: Large	12	53%	18%	1%	3%	18%	6%	68%	5%
City: Mid-size	13	49%	33%	<1%	2%	15%	7%	70%	6%
City: Small	14	49%	39%	1%	5%	21%	11%	56%	5%
Suburb: Large	112	48%	31%	<1%	3%	12%	7%	73%	6%
Suburb: Mid-size	11	49%	21%	<1%	6%	7%	3%	76%	7%
Suburb: Small	3	49%	3%	<1%	2%	2%	2%	90%	3%
Town: Fringe	13	50%	39%	<1%	1%	8%	3%	83%	5%
Town: Distant	22	48%	63%	1%	1%	15%	8%	72%	3%
Town: Remote	13	50%	61%	4%	2%	28%	2%	57%	6%
Rural: Fringe	60	49%	42%	1%	1%	8%	6%	80%	4%
Rural: Distant	60	48%	52%	1%	<1%	5%	2%	89%	3%
Rural: Remote	36	48%	54%	16%	<1%	8%	1%	71%	4%
Total	369	48%	39%	1%	2%	11%	6%	75%	5%

Note. Demographic data aggregated at the school level by the U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES) from 2017–2018 (private schools) and 2018–2019 (public schools) (Broughman et al., 2019; Chen, 2020). NCES data were available for 369 of the 389 schools that participated in this research. Of those 369 schools, 71 were private and 298 were public. FRL = Free or reduced-price lunch. FRL Eligible represents students who were eligible for (a) free/reduced-price lunch or (b) for the National School Lunch Program (NSLP) through direct certification. This information is only reported by public schools. Eleven of the 298 public schools did not report FRL eligibility but did report direct certification eligibility. Two schools did not report FRL or direct certification eligibility. FRL percentages were calculated from total student enrollment as reported by NCES across public and private schools. Five of the 71 private schools did not report race/ethnicity information. The five schools were excluded when calculating the percentages for race/ethnicity categories.

Measures

Acadience Math Composite Score (MCS)

The MCS is a combination of scores from multiple Acadience Math measures and provides the best overall estimate of students' math skills (Wheeler et al., 2019). All Acadience Math measures have established reliability and validity. For more information, see the *Acadience Math Technical Adequacy Brief* (Gray, Warnock, et al., 2019), available from www.acadiencelearning.org.

Depending on the grade and time of year, the MCS is calculated from scores on the Early Numeracy, Computation, and/or Concepts & Applications measures. The middle-of-year MCS for kindergarten through fifth grade and the beginning-of-year MCS for first grade through sixth grade were examined in this study. Table 4 reports the components of the MCS for each of these grades and times of year.

Table 4

Components of the Acadience Math Composite Score (MCS)

	Measure						
Times of Year by Grade	BQD	NIF	NNF	AQD	MNF	Comp	C&A
Kindergarten							
Middle of year	X	X	X	—	—	—	—
Grade 1							
Beginning of year	—	X	X	X	X	X	—
Middle of year	—	—	—	X	X	X	—
Grades 2–5							
Beginning of year	—	—	—	—	—	X	X
Middle of year	—	—	—	—	—	X	X
Grade 6							
Beginning of year	—	—	—	—	—	X	X

Note. BQD = Beginning Quantity Discrimination. NIF = Number Identification Fluency. NNF = Next Number Fluency. AQD = Advanced Quantity Discrimination. MNF = Missing Number Fluency. Comp = Computation. C&A = Concepts & Applications. Grades and times of year only included for the scores examined in this research. Dashes indicate the measure is not administered or a component of the MCS at the specified grade and time of year. For more information on the MCS and calculation formulas, see the *Acadience Math Assessment Manual* (Wheeler et al., 2019) at www.acadiencelearning.org.

Acadience Math Benchmarks

One frame of reference for interpreting Acadience Math scores are the criterion-referenced benchmarks and cut points for risk. Acadience Math benchmarks are empirically derived, criterion-referenced target scores that represent adequate math skills for a particular point in time. A benchmark indicates a level of skill at which the student is likely to achieve the next Acadience Math benchmark or math outcome. Benchmarks for Acadience Math are based on research that examines the predictive validity of a score on a measure at a particular point in time, compared to later Acadience Math measures and external-outcome assessments. Students who achieve the benchmark and receive effective, research-based core instruction are likely to achieve later math outcomes.

The cut points for risk indicate a level of skill below which the student is unlikely to achieve subsequent math benchmarks without receiving additional instructional support beyond core instruction. For students who have scores below the cut point for risk, the probability of achieving later math benchmarks is low unless intensive instructional support is provided.

The Acadience Math benchmarks and cut points for risk provide three primary benchmark status categories that describe students' performance: (a) At or Above Benchmark, (b) Below Benchmark, and (c) Well Below Benchmark. These categories are based on the overall likelihood of achieving specified benchmarks on subsequent Acadience Math assessments or external measures of math achievement.

At or Above Benchmark. For students who score at or above the benchmark, the typical overall likelihood of achieving subsequent math benchmarks is approximately 80% to 90%. These students are likely to need effective core instruction to meet subsequent math outcomes. Within this range, the likelihood of achieving subsequent benchmarks is lower for students whose scores are right at the benchmark and increases as scores increase above the benchmark.

To assist in setting ambitious benchmarks for students, the At or Above Benchmark level can be subdivided into *At Benchmark* and *Above Benchmark* levels.

At Benchmark. In the At Benchmark range, the typical overall likelihood of achieving subsequent math benchmarks is 70% to 85%. Some of these students, especially those with scores near the benchmark, may require monitoring and/or strategic support on specific component skills.

Above Benchmark. In the Above Benchmark range, the typical overall likelihood of achieving subsequent math benchmarks is 90% to 99%. While all students with scores in this range will likely benefit from core support, some students with scores in this range may benefit from instruction on more advanced skills.

Below Benchmark. Between the benchmark and cut point for risk is a range of scores where students' future performance is more difficult to predict. For students with scores in this range, the typical overall likelihood of achieving subsequent math benchmarks is approximately 40% to 60%. These students are likely to need strategic support to ensure their achievement of future benchmarks. Strategic support generally consists of carefully targeted supplemental support in specific skill areas in which students are having difficulty. To ensure that the greatest number of students achieve later math success, it is best for students with scores in this range to be monitored regularly to ensure that they are making adequate progress and to receive increased or modified support if necessary to achieve subsequent math benchmarks.

Well Below Benchmark. For students who score below the cut point for risk, the typical overall likelihood of achieving subsequent math benchmarks is low, approximately 10% to 20%. These students are identified as likely to need intensive support. Intensive support refers to interventions that incorporate something more or something different from the core curriculum or supplemental support.

Intensive support might entail:

- delivering instruction in a smaller group or individually,
- providing more instructional time or more practice,
- presenting smaller skill steps in the instructional hierarchy,
- providing more explicit modeling and instruction, and/or
- providing greater scaffolding and practice.

Additional information about the MCS and the Acadience Math benchmarks and cut points for risk can be found in the *Acadience Math Assessment Manual* (Wheeler et al., 2019), available for free download from www.acadiencelearning.org.

Analysis

To evaluate the impact of the COVID-19 pandemic on student math outcomes, we compared student performance (as measured by the MCS) at the beginning of the current school year (2020–2021) to student performance at the beginning of the previous school year (2019–2020). However, we did not simply compare beginning-of-year performance between the two school years as it is possible that students who were assessed were not a random sampling of students and differed in some way from those students who were not assessed. To account for these potential differences, we included the middle-of-year MCS from the prior school year as an additional predictor. The middle-of-year MCS was used rather than the end-of-year MCS due to how few students were assessed at the end of the 2019–2020 school year. This approach allowed us to estimate the difference in Acadience Math scores that the typical student exhibited at the beginning of 2020–2021 compared to the beginning of 2019–2020, controlling for previous performance (middle-of-year performance in 2019–2020 and 2018–2019, respectively).

The beginning-of-year MCS for students in grades 1–6 were predicted using multiple linear regression with the following five terms: (a) the middle-of-year MCS from the previous school year, (b) a curvilinear (i.e., quadratic) term of the MCS, (c) school year in which the student received their beginning-of-year benchmark assessment (i.e., 2019–2020 or 2020–2021), (d) an interaction between the MCS and school year, and (e) an interaction between the curvilinear term of the MCS and school year. Because the middle-of-year MCS was used as a predictor and an MCS for preschool students is not currently available, we could not analyze the beginning-of-year MCS in kindergarten. By modeling the interaction between previous performance and year, we were able to assess whether the effect of the pandemic differed based on students' initial level of performance. In other words, did the impact of the pandemic differ for students based on how they scored (low, average, high) at the middle of the previous year? The quadratic term of the MCS was included (a) due to the curvilinear relationship between middle-of-year and beginning-of-year performance on the MCS and (b) to enable us to evaluate a more nuanced relationship between middle-of-year performance and year than a linear term would allow (i.e., a larger effect of the pandemic on beginning-of-year outcomes for students who scored near the average at the middle of the previous year and smaller effects for students who scored at the low or high end).

To evaluate the pandemic's impact on students' likelihood of meeting later benchmarks, we calculated the percentage of students in each benchmark category for the MCS at the beginning of each school year based on their middle-of-year MCS benchmark status and the school year in which they received beginning-of-year benchmark assessment (i.e., 2019–2020 or 2020–2021). This was conducted using three benchmark status categories (Well Below Benchmark, Below Benchmark, and At or Above Benchmark), as well as four (Well Below Benchmark, Below Benchmark, At Benchmark, and Above Benchmark).

Results

Descriptive statistics for the MCS of participating students by cohort and grade span are reported in Table 5. At every grade level, the average middle-of-year MCS were similar between cohorts and were close to or greater than the Above Benchmark level. Students in the second cohort had lower beginning-of-year scores compared to students in the first cohort.

Table 5

Descriptive Statistics for the Middle-of-Year and End-of-Year Math Composite Score (MCS) by Cohort and Grade Span

		Middle-of-Year MCS	Beginning-of-Year MCS
Cohort by Grades	*n*	*M (SD)*	*M (SD)*
Grades K & 1			
Cohort 1	11,236	90.10 (39.53)	142.78 (68.77)
Cohort 2	9,647	90.34 (39.57)	129.02 (72.15)
Grades 1 & 2			
Cohort 1	12,860	52.51 (21.96)	31.33 (19.40)
Cohort 2	10,529	53.11 (22.05)	27.01 (18.17)
Grades 2 & 3			
Cohort 1	11,819	58.11 (28.50)	58.52 (30.41)
Cohort 2	10,028	58.00 (28.50)	50.84 (28.44)
Grades 3 & 4			
Cohort 1	11,288	100.32 (42.77)	88.66 (47.75)
Cohort 2	8,994	102.36 (42.88)	76.42 (42.64)
Grades 4 & 5			
Cohort 1	9,582	107.05 (52.10)	68.49 (38.55)
Cohort 2	8,521	108.65 (52.40)	57.01 (34.26)
Grades 5 & 6			
Cohort 1	3,092	116.95 (51.16)	86.21 (40.86)
Cohort 2	2,707	119.14 (50.46)	70.95 (35.26)

Note. MCS = Math Composite Score. Cohort 1 = Data collected during the 2018–2019 and 2019–2020 school years. Cohort 2 = Data collected during the 2019–2020 and 2020–2021 school years. "Middle-of-year" corresponds to the first grade listed in a grade span. "Beginning-of-year" corresponds to the second grade listed in each grade span.

Results from the multiple linear regression analysis are summarized for grades 1–6 in Table 6. As mentioned previously, a comparison of performance at the beginning of kindergarten could not be made because there is no preschool Acadience Math measure at this time. At all examined grade levels, the effect of year on beginning-of-year MCS was significant, indicating lower overall math performance at the beginning of the 2020–2021 school year. Overall, effects were larger at later grades. The coefficients for "Year" indicate the difference in points students with average scores at the middle of the previous year were expected to score at the beginning of the 2020–2021 school year compared to the beginning of the 2019–2020 school year. For example, the coefficient circled in green indicates that kindergarten students with average middle-of-year scores were expected to score approximately 15 points lower on the MCS at the beginning of first grade in 2020–2021 than students at the beginning of first grade in 2019–2020.

Table 6

Predicting Beginning-of-Year Math Composite Scores (MCS) from Previous Performance and Year

	Grade					
Term	1	2	3	4	5	6
MOY MCS	1.32***	0.62***	0.78***	0.87***	0.56***	0.61***
MOY MCS^2	.00055**	.00314***	.00099***	.00329***	.00079***	.00131***
Year	-15.06***	-4.43***	-7.86***	-13.60***	-13.11***	-15.69***
Year*MOY MCS	.0787***	-.0754***	-0824***	-.1553***	-.1082***	-.1221***
Year*MOY MCS^2	.000627*	-.000507*	.000316	-.000147	.000293**	-.000265
R^2	.599	.520	.552	.619	.591	.579

Note. MOY = middle-of-year. MCS = Math Composite Score. The MOY MCS was centered on the mean. "Grade" corresponds to the grade in which students received their beginning-of-year assessment.
*p < .05. **p < .01. ***p < .001.

As indicated by the interaction terms in Table 6 (i.e., "Year*MOY RCS" and "Year*MOY RCS^2"), the difference in predicted scores between the beginning of the 2019–2020 and 2020–2021 school years was not uniform. The effect of year on students' beginning-of-year scores depended on how students scored at the middle of the previous year. At the beginning of first grade, the difference in beginning-of-year scores was greatest for students with lower middle-of-year scores and narrowed as scores increased. Across grades 2–6, the difference in predicted scores was smallest for students with lower initial scores and widened as students' middle-of-year scores increased.

To help facilitate the interpretation of the results displayed in Table 6, we plotted the regression curves for each grade. The graphs model the beginning-of-year MCS as a function of the MCS at the middle of the previous year and the year in which students received their beginning-of-year benchmark assessment (2019–2020 or 2020–2021). The vertical dashed reference lines indicate the middle-of-year scores corresponding to the cut point for risk, the benchmark, and the Above Benchmark level. A larger gap between the curves indicates a greater difference between performance at the beginning of 2020–2021 compared to the beginning of 2019–2020, and suggests a larger effect of the pandemic on math skills. Results for each grade level are summarized by grade below.

When considering how the pandemic has affected the likelihood of students meeting benchmarks, across all grade levels, students at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark and more likely to score in the Below Benchmark or Well Below Benchmark range compared to students at the beginning of 2019–2020. Stacked bar graphs with accompanying tables listing the percentage of students in each category are presented by grade below.

Grade 1 Results

Figure 1 plots students' first-grade beginning-of-year MCS as a function of their MCS from the middle of kindergarten and the year in which they received their beginning-of-year first-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. Kindergarten students with average middle-of-year scores scored 15.06 points lower on the MCS at the beginning of first grade in 2020–2021 compared to students at the beginning of first grade in 2019–2020. The interaction between year and middle-

of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS increase, the difference in predicted beginning-of-year scores between the two school years narrows. The difference in predicted scores is greatest for students scoring at the lower end on the middle-of-year MCS, somewhat smaller for students scoring in the middle range, and smallest at the higher end. The model accounted for 60% of the total variability in beginning-of-year MCS.

Figures 2 and 3 illustrate first-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in kindergarten and year of first grade (2019–2020 or 2020–2021). Figure 2 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 3 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 7 and 8 list the percentages of students in each category in Figures 2 and 3, respectively.

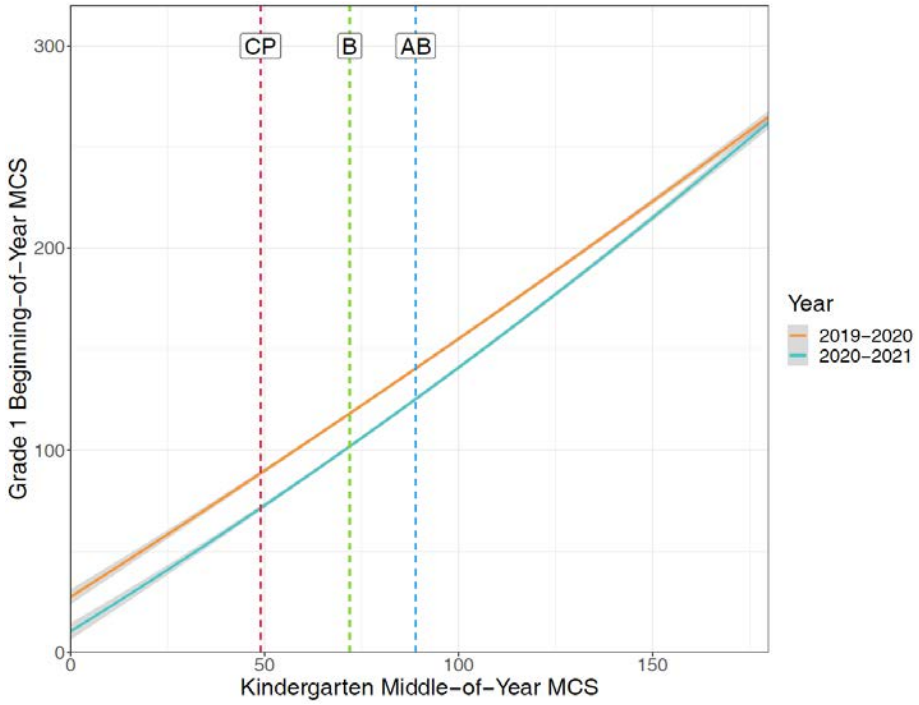
Students entering first grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 2 and Table 7, among students who were At or Above Benchmark at the middle of kindergarten in 2018–2019, 78% were also At or Above Benchmark at the beginning of first grade. For students entering first grade at the beginning of the 2020–2021 school year, this percentage dropped to 68%. This represents an approximate 10% decrease in students meeting later math benchmarks from kindergarten to first grade. Furthermore, while 4% of students who were At or Above Benchmark at the middle of kindergarten in 2018–2019 were Well Below Benchmark at the beginning of first grade in 2019–2020, this percentage increased to 10% for students entering first grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 3 and Table 8) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of kindergarten in 2018–2019, 32% scored Above Benchmark and 22% scored At Benchmark at the beginning of first grade. For students entering first grade at the beginning of the 2020–2021 school year, these percentages dropped to 19% scoring Above Benchmark and 19% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of kindergarten in 2018–2019, 34% were Below Benchmark and 11% were Well Below Benchmark at the beginning of first grade in 2019–2020. These percentages increased to 38% and 24%, respectively, for students entering first grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of kindergarten had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of first grade than students in the At Benchmark range at the middle of kindergarten, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 3 and Table 8, among students who were Above Benchmark at the middle of kindergarten in 2018–2019, 73% scored Above Benchmark and 13% scored At Benchmark at the beginning of first grade. For students entering first grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 64%, with more students (15%) scoring At Benchmark. Furthermore, 12% of students who were Above Benchmark at the middle of kindergarten in 2018–2019 were Below Benchmark at the beginning of first grade in 2019–2020 and only 2% were Well Below Benchmark. For students entering first grade at the beginning of 2020–2021, these percentages increased to 16% and 5%, respectively.

Figure 1

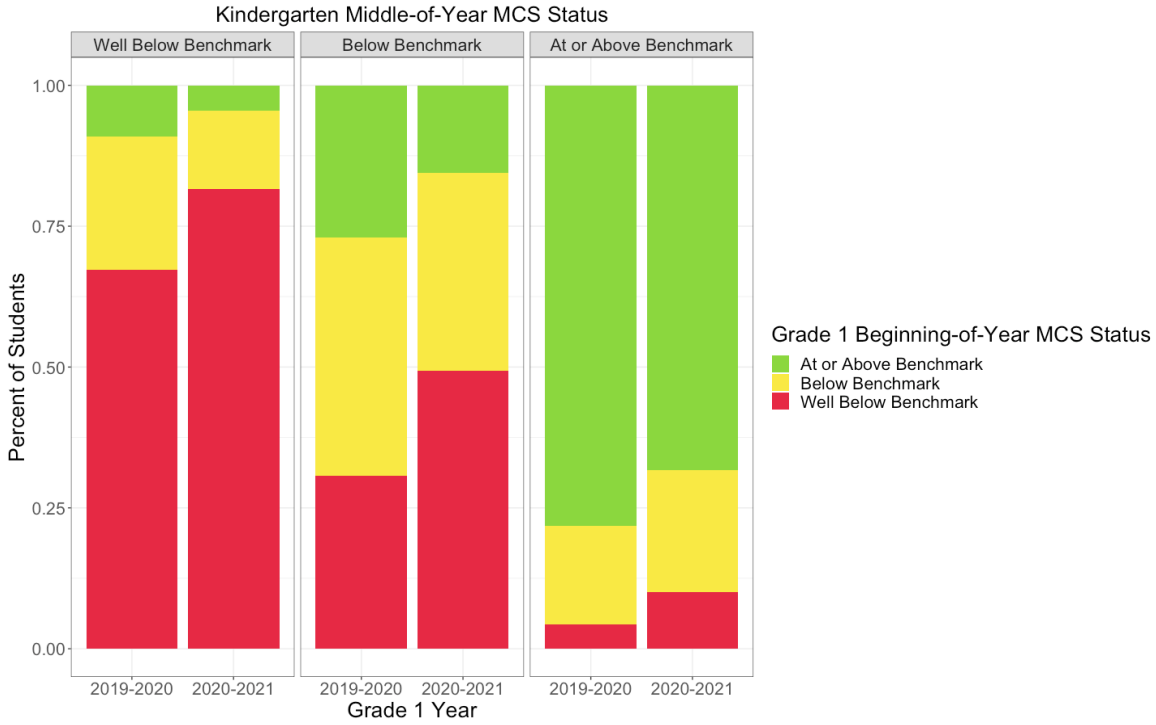
Grade 1 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received first-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of kindergarten. CP = cut point for risk (49). B = benchmark (72). AB = above benchmark (89). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). $N = 20{,}883$.

Figure 2

Likelihood of Meeting the Benchmark at the Beginning of Grade 1



Note. MCS = Math Composite Score. "Grade 1 Year" indicates the school year in which students received first-grade beginning-of-year benchmark assessment. $N = 20{,}883$.

Table 7

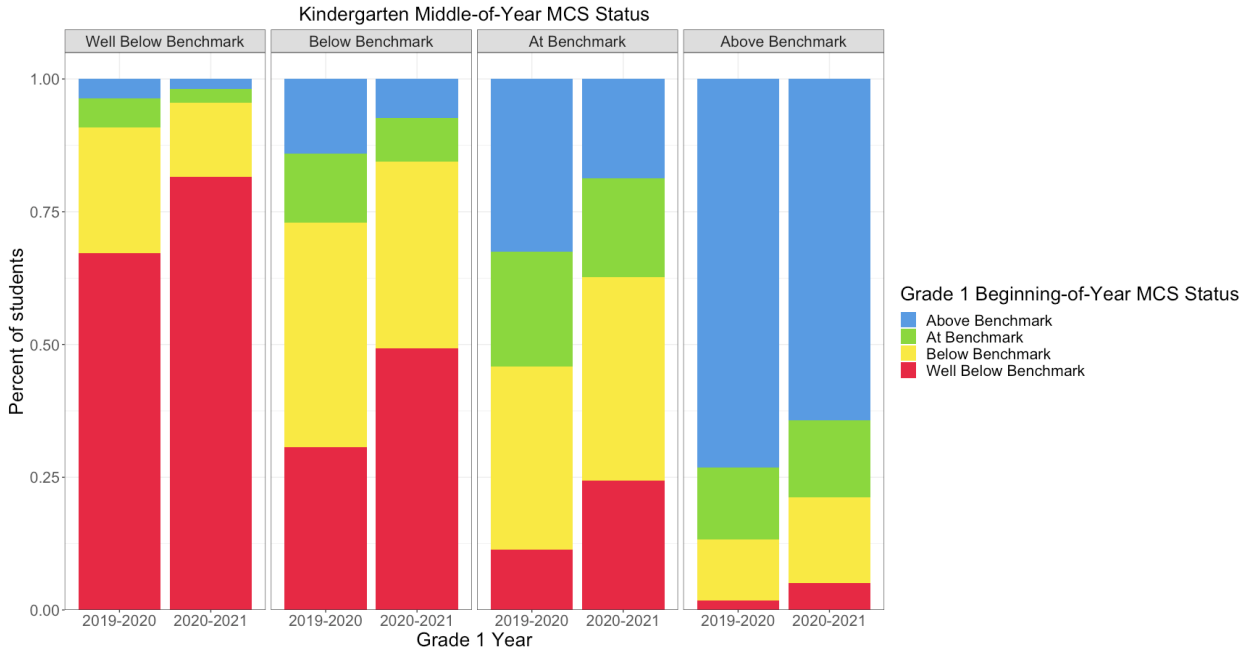
Grade 1 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Kindergarten Status and Year of Grade 1 Assessment

	G1 BOY MCS Benchmark Status and Year		
K MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	78% (68%)	18% (22%)	4% (10%)
Below	27% (16%)	42% (35%)	31% (49%)
Well Below	9% (4%)	24% (14%)	67% (82%)

Note. G1 = Grade 1. BOY = Beginning-of-Year. MCS = Math Composite Score. K = Kindergarten. MOY = Middle-of-Year. $N = 20{,}883$.

Figure 3

Likelihood of Meeting the Benchmark at the Beginning of Grade 1 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 1 Year" indicates the school year in which students received first-grade beginning-of-year benchmark assessment. $N = 20{,}883$.

Table 8

Grade 1 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Kindergarten Status and Year of Grade 1 Assessment

	G1 BOY MCS Benchmark Status and Year			
K MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	73% (64%)	13% (15%)	12% (16%)	2% (5%)
At	32% (19%)	22% (19%)	34% (38%)	11% (24%)
Below	14% (7%)	13% (8%)	42% (35%)	31% (49%)
Well Below	4% (2%)	5% (3%)	24% (14%)	67% (82%)

Note. G1 = Grade 1. BOY = Beginning-of-Year. MCS = Math Composite Score. K = Kindergarten. MOY = Middle-of-Year. $N = 20{,}883$.

Grade 2 Results

Figure 4 plots students' second-grade beginning-of-year MCS as a function of their MCS from the middle of first grade and the year in which they received their beginning-of-year second-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. First-grade students with average middle-of-year scores scored 4.43 points lower on the MCS at the beginning of second grade in 2020–2021 compared to students at the beginning of second grade in 2019–2020. The interaction between year and middle-of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS increased, the difference in predicted beginning-of-year scores between the two school years widened. The gap between predicted scores

is smallest for students with lower middle-of-year MCS and widest for students with higher middle-of year scores. The model accounted for 52% of the total variability in beginning-of-year MCS.

Figures 5 and 6 illustrate second-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in first grade and year of second grade (2019–2020 or 2020–2021). Figure 5 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 6 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 9 and 10 list the percentages of students in each category in Figures 5 and 6, respectively.

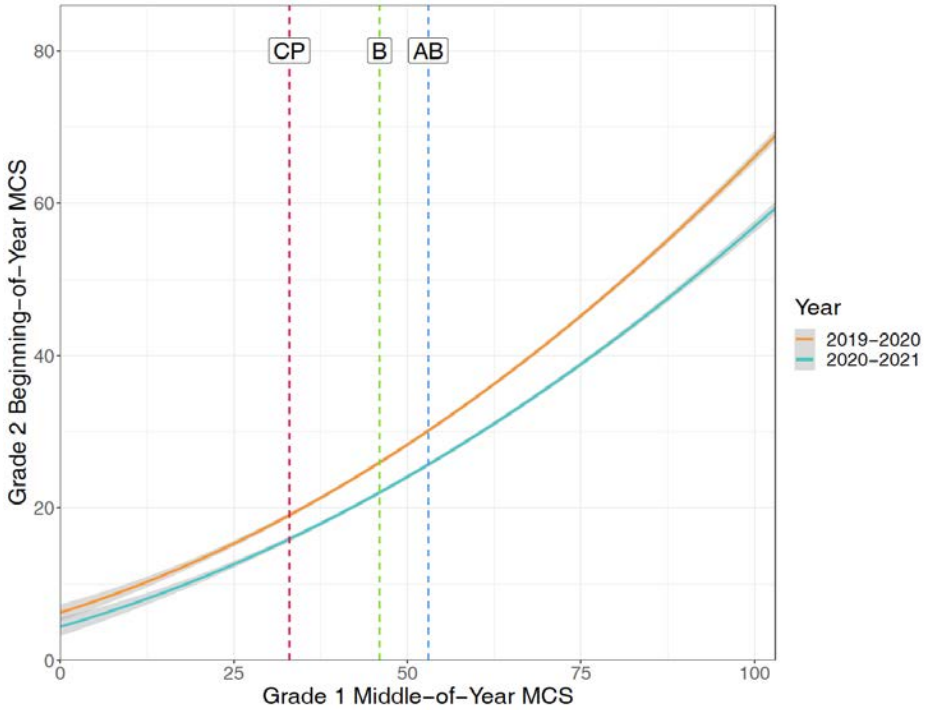
Students entering second grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 5 and Table 9, among students who were At or Above Benchmark at the middle of first grade in 2018–2019, 82% were also At or Above Benchmark at the beginning of second grade. For students entering second grade at the beginning of the 2020–2021 school year, this percentage dropped to 70%. This represents a 12% decrease in students meeting later math benchmarks from first to second grade. Furthermore, 5% of students who were At or Above Benchmark at the middle of first grade in 2018–2019 were Well Below Benchmark at the beginning of second grade in 2019–2020, while this percentage increased to 12% for students entering second grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 6 and Table 10) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of first grade in 2018–2019, 34% scored Above Benchmark and 29% scored At Benchmark at the beginning of second grade. For students entering second grade at the beginning of the 2020–2021 school year, these percentages dropped to 25% scoring Above Benchmark and 24% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of first grade in 2018–2019, 24% were Below Benchmark and 13% were Well Below Benchmark at the beginning of second grade in 2019–2020. These percentages increased to 28% and 24%, respectively, for students entering second grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of first grade had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of second grade than students in the At Benchmark range at the middle of first grade, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 6 and Table 10, among students who were Above Benchmark at the middle of first grade in 2018–2019, 70% scored Above Benchmark and 17% scored At Benchmark at the beginning of second grade in 2019–2020. For students entering second grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 55%, with more students (21%) scoring At Benchmark. Furthermore, 10% of students who were Above Benchmark at the middle of first grade in 2018–2019 were Below Benchmark at the beginning of second grade in 2019–2020 and only 3% were Well Below Benchmark. For students entering second grade at the beginning of 2020–2021, these percentages increased to 15% and 8%, respectively.

Figure 4

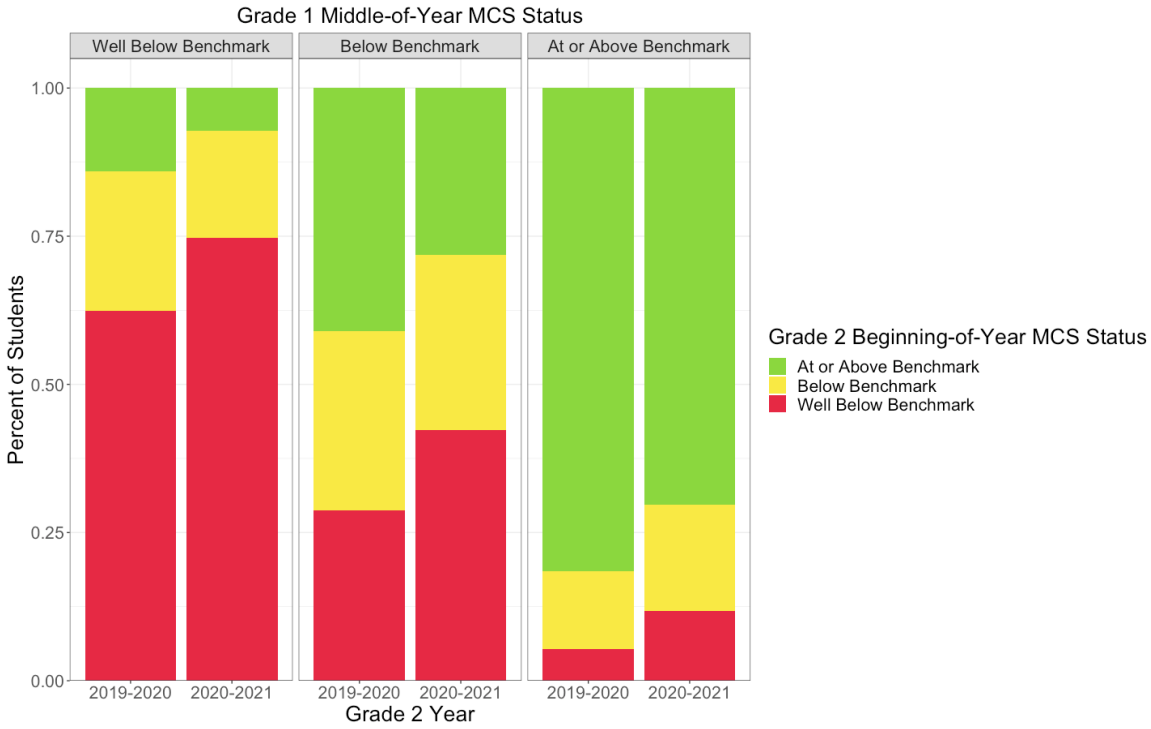
Grade 2 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received second-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of first grade. CP = cut point for risk (33). B = benchmark (46). AB = above benchmark (53). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). $N = 23{,}389$.

Figure 5

Likelihood of Meeting the Benchmark at the Beginning of Grade 2



Note. MCS = Math Composite Score. "Grade 2 Year" indicates the school year in which students received second-grade beginning-of-year benchmark assessment. *N* = 23,389.

Table 9

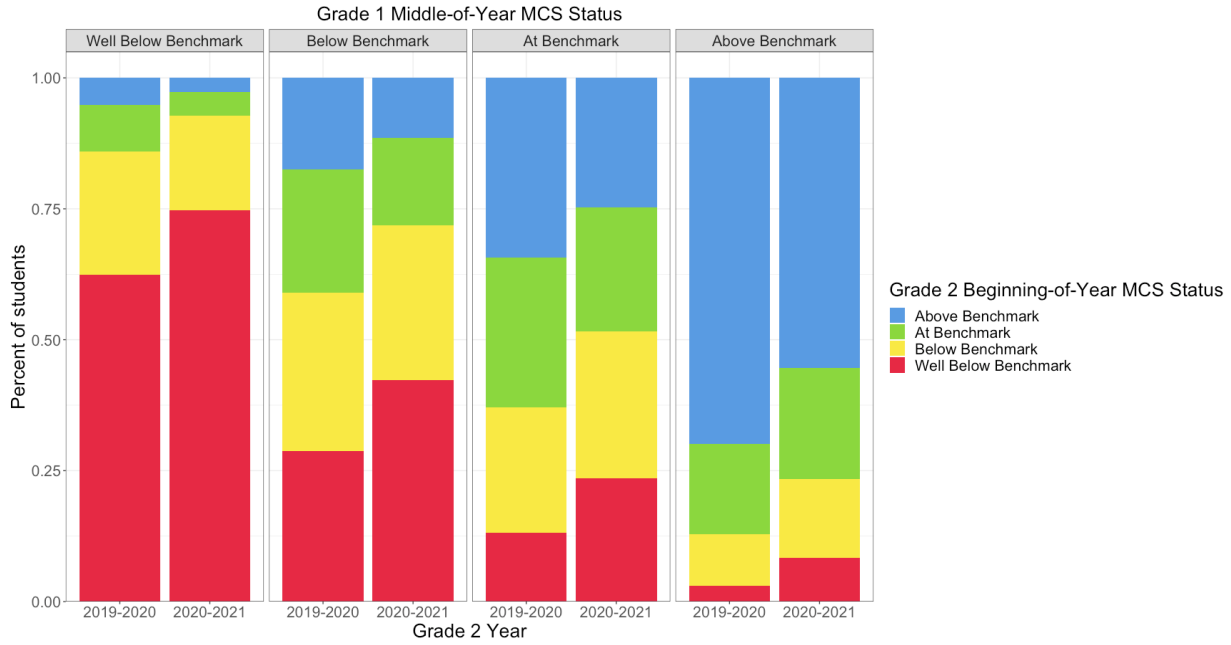
Grade 2 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Grade 1 Status and Year of Grade 2 Assessment

	G2 BOY MCS Benchmark Status and Year		
G1 MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	82% (70%)	13% (18%)	5% (12%)
Below	41% (28%)	30% (30%)	29% (42%)
Well Below	14% (7%)	23% (18%)	62% (75%)

Note. G2 = Grade 2. BOY = Beginning-of-Year. MCS = Math Composite Score. G1 = Grade 1. MOY = Middle-of-Year. *N* = 23,389.

Figure 6

Likelihood of Meeting the Benchmark at the Beginning of Grade 2 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 2 Year" indicates the school year in which students received second-grade beginning-of-year benchmark assessment. $N = 23{,}389$.

Table 10

Grade 2 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Grade 1 Status and Year of Grade 2 Assessment

	G2 BOY MCS Benchmark Status and Year			
G1 MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	70% (55%)	17% (21%)	10% (15%)	3% (8%)
At	34% (25%)	29% (24%)	24% (28%)	13% (24%)
Below	18% (11%)	23% (17%)	30% (30%)	29% (42%)
Well Below	5% (3%)	9% (5%)	23% (18%)	62% (75%)

Note. G2 = Grade 2. BOY = Beginning-of-Year. MCS = Math Composite Score. G1 = Grade 1. MOY = Middle-of-Year. $N = 23{,}389$.

Grade 3 Results

Figure 7 plots students' third-grade beginning-of-year MCS as a function of their MCS from the middle of second grade and the year in which they received their beginning-of-year third-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. Second-grade students with average middle-of-year scores scored 7.86 points lower on the MCS at the beginning of third grade in 2020–2021 compared to students at the beginning of third grade in 2019–2020. The interaction between year and middle-of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS increase, the difference in predicted beginning-of-year scores between the two school years widens. The gap between predicted scores is smallest for students

with lower middle-of-year MCS and widest for students with higher middle-of year scores. The model accounted for 55% of the total variability in beginning-of-year MCS.

Figures 8 and 9 illustrate third-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in second grade and year of third grade (2019–2020 or 2020–2021). Figure 8 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 9 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 11 and 12 list the percentages of students in each category in Figures 8 and 9, respectively.

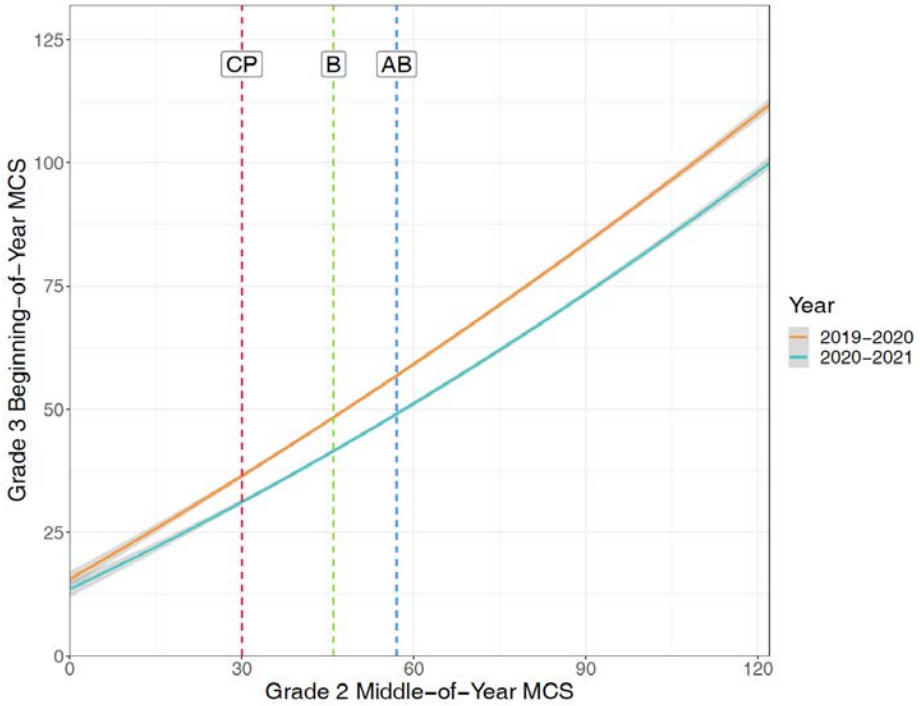
Students entering third grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 8 and Table 11, among students who were At or Above Benchmark at the middle of second grade in 2018–2019, 78% were also At or Above Benchmark at the beginning of third grade. For students entering third grade at the beginning of the 2020–2021 school year, this percentage dropped to 66%. This represents a 12% decrease in students meeting later math benchmarks from second to third grade. Furthermore, 5% of students who were At or Above Benchmark at the middle of second grade in 2018–2019 were Well Below Benchmark at the beginning of third grade in 2019–2020, while this percentage increased to 11% for students entering third grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 9 and Table 12) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of second grade in 2018–2019, 42% scored Above Benchmark and 15% scored At Benchmark at the beginning of third grade. For students entering third grade at the beginning of the 2020–2021 school year, these percentages dropped to 27% scoring Above Benchmark and 13% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of second grade in 2018–2019, 32% were Below Benchmark and 12% were Well Below Benchmark at the beginning of third grade in 2019–2020. These percentages increased to 37% and 23%, respectively, for students entering third grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of second grade had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of third grade than students in the At Benchmark range at the middle of second grade, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 9 and Table 12, among students who were Above Benchmark at the middle of second grade in 2018–2019, 77% scored Above Benchmark and 8% scored At Benchmark at the beginning of third grade in 2019–2020. For students entering third grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 63%, with more students (11%) scoring At Benchmark. Furthermore, 12% of students who were Above Benchmark at the middle of second grade in 2018–2019 were Below Benchmark at the beginning of third grade in 2019–2020 and only 3% were Well Below Benchmark. For students entering third grade at the beginning of 2020–2021, these percentages increased to 18% and 7%, respectively.

Figure 7

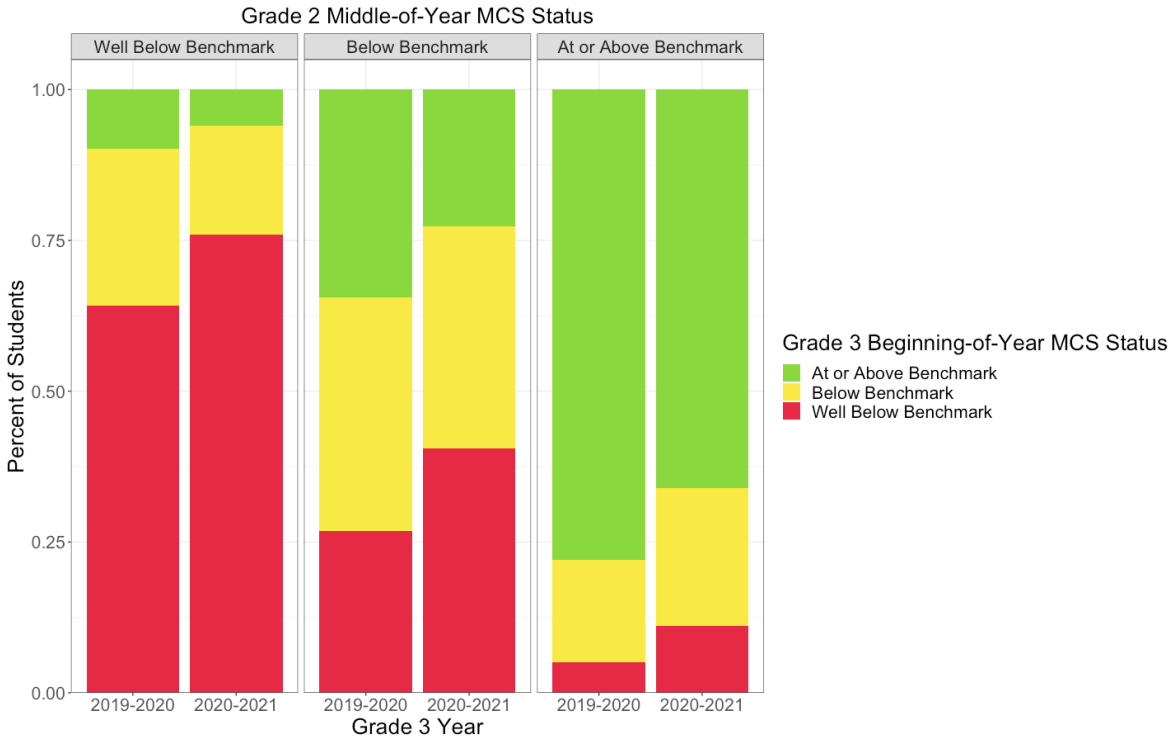
Grade 3 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received third-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of second grade. CP = cut point for risk (30). B = benchmark (46). AB = above benchmark (57). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). $N = 21{,}847$.

Figure 8

Likelihood of Meeting the Benchmark at the Beginning of Grade 3



Note. MCS = Math Composite Score. "Grade 3 Year" indicates the school year in which students received third-grade beginning-of-year benchmark assessment. $N = 21{,}847$.

Table 11

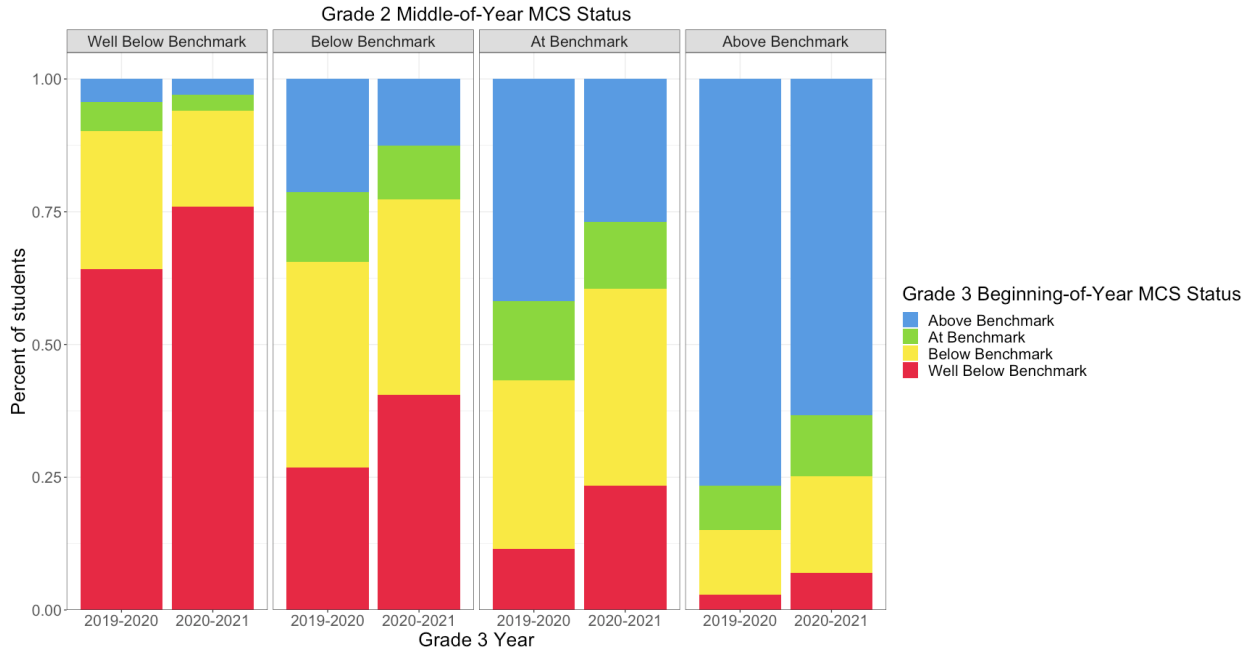
Grade 3 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Grade 2 Status and Year of Grade 3 Assessment

	G3 BOY MCS Benchmark Status and Year		
G2 MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	78% (66%)	17% (23%)	5% (11%)
Below	34% (23%)	39% (37%)	27% (41%)
Well Below	10% (6%)	26% (18%)	64% (76%)

Note. G3 = Grade 3. BOY = Beginning-of-Year. MCS = Math Composite Score. G2 = Grade 2. MOY = Middle-of-Year. $N = 21{,}847$.

Figure 9

Likelihood of Meeting the Benchmark at the Beginning of Grade 3 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 3 Year" indicates the school year in which students received third-grade beginning-of-year benchmark assessment. $N = 21{,}847$.

Table 12

Grade 3 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Grade 2 Status and Year of Grade 3 Assessment

	G3 BOY MCS Benchmark Status and Year			
G2 MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	77% (63%)	8% (11%)	12% (18%)	3% (7%)
At	42% (27%)	15% (13%)	32% (37%)	12% (23%)
Below	21% (13%)	13% (10%)	39% (37%)	27% (41%)
Well Below	4% (3%)	6% (3%)	26% (18%)	64% (76%)

Note. G3 = Grade 3. BOY = Beginning-of-Year. MCS = Math Composite Score. G2 = Grade 2. MOY = Middle-of-Year. $N = 21{,}847$.

Grade 4 Results

Figure 10 plots students' fourth-grade beginning-of-year MCS as a function of their MCS from the middle of third grade and the year in which they received their beginning-of-year fourth-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. Third-grade students with average middle-of-year scores scored 13.60 points lower on the MCS at the beginning of fourth grade in 2020–2021 compared to students at the beginning of fourth grade in 2019–2020. The interaction between year and middle-of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS increase, the difference in predicted beginning-of-year scores between the two school years widens. The gap between predicted scores is smallest for students

with lower middle-of-year MCS and widest for students with higher middle-of year scores. The model accounted for 62% of the total variability in beginning-of-year MCS.

Figures 11 and 12 illustrate fourth-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in third grade and year of fourth grade (2019–2020 or 2020–2021). Figure 11 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 12 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 13 and 14 list the percentages of students in each category in Figures 11 and 12, respectively.

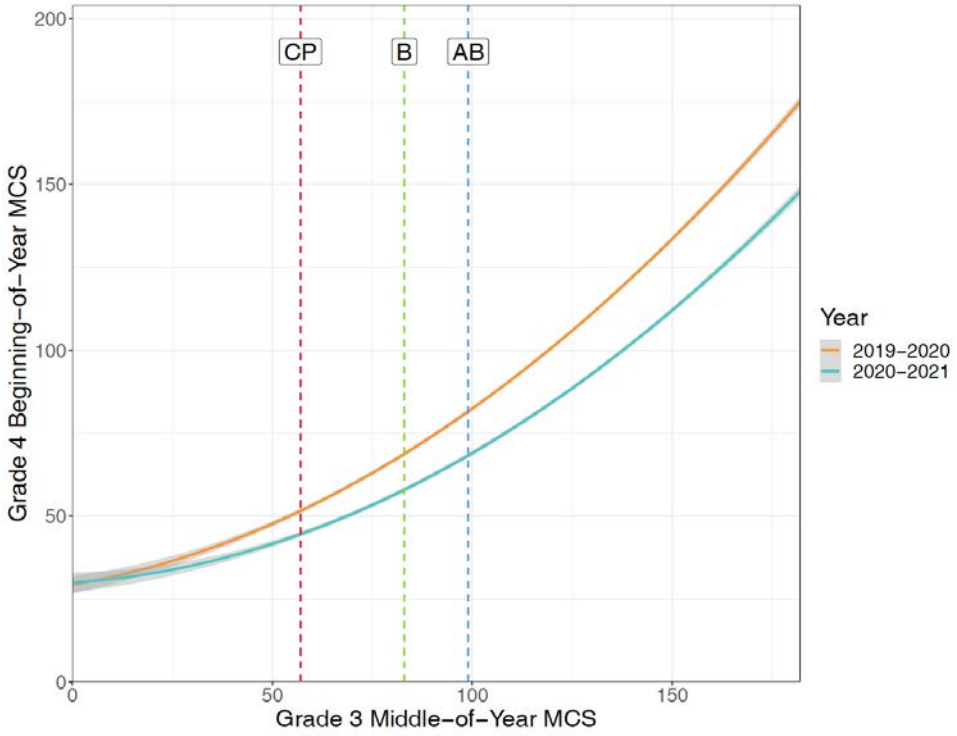
Students entering fourth grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 11 and Table 13, among students who were At or Above Benchmark at the middle of third grade in 2018–2019, 83% were also At or Above Benchmark at the beginning of fourth grade. For students entering fourth grade at the beginning of the 2020–2021 school year, this percentage dropped to 69%. This represents a 14% decrease in students meeting later math benchmarks from third to fourth grade. Furthermore, only 3% of students who were At or Above Benchmark at the middle of third grade in 2018–2019 were Well Below Benchmark at the beginning of fourth grade in 2019–2020, while this percentage increased to 9% for students entering fourth grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 12 and Table 14) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of third grade in 2018–2019, 33% scored Above Benchmark and 25% scored At Benchmark at the beginning of fourth grade. For students entering fourth grade at the beginning of the 2020–2021 school year, these percentages dropped to 19% scoring Above Benchmark and 18% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of third grade in 2018–2019, 31% were Below Benchmark and 11% were Well Below Benchmark at the beginning of fourth grade in 2019–2020. These percentages increased to 40% and 23%, respectively, for students entering fourth grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of third grade had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of fourth grade than students in the At Benchmark range at the middle of third grade, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 12 and Table 14, among students who were Above Benchmark at the middle of third grade in 2018–2019, 78% scored Above Benchmark and 11% scored At Benchmark at the beginning of fourth grade in 2019–2020. For students entering fourth grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 62%, with more students (15%) scoring At Benchmark. Furthermore, 9% of students who were Above Benchmark at the middle of third grade in 2018–2019 were Below Benchmark at the beginning of fourth grade in 2019–2020 and only 2% were Well Below Benchmark. For students entering fourth grade at the beginning of 2020–2021, these percentages increased to 17% and 6%, respectively.

Figure 10

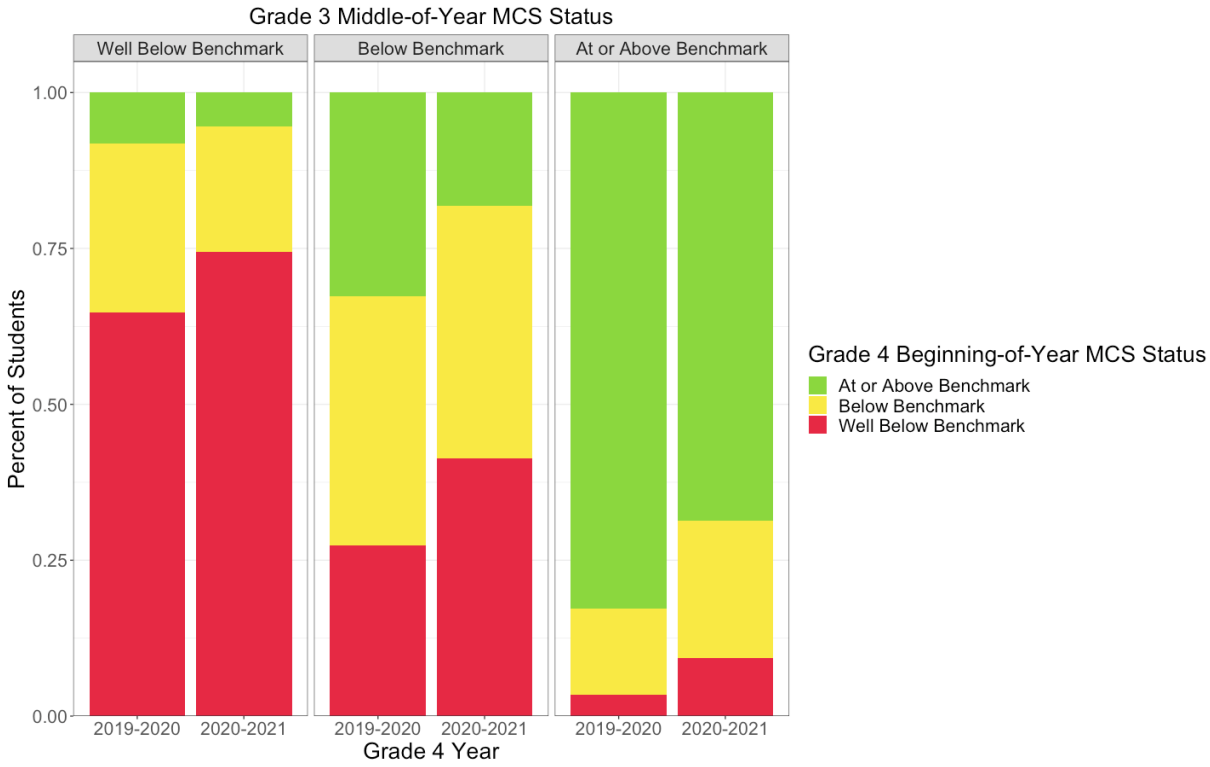
Grade 4 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received fourth-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of third grade. CP = cut point for risk (57). B = benchmark (83). AB = above benchmark (99). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). $N = 20{,}282$.

Figure 11

Likelihood of Meeting the Benchmark at the Beginning of Grade 4



Note. MCS = Math Composite Score. "Grade 4 Year" indicates the school year in which students received fourth-grade beginning-of-year benchmark assessment. *N* = 20,282.

Table 13

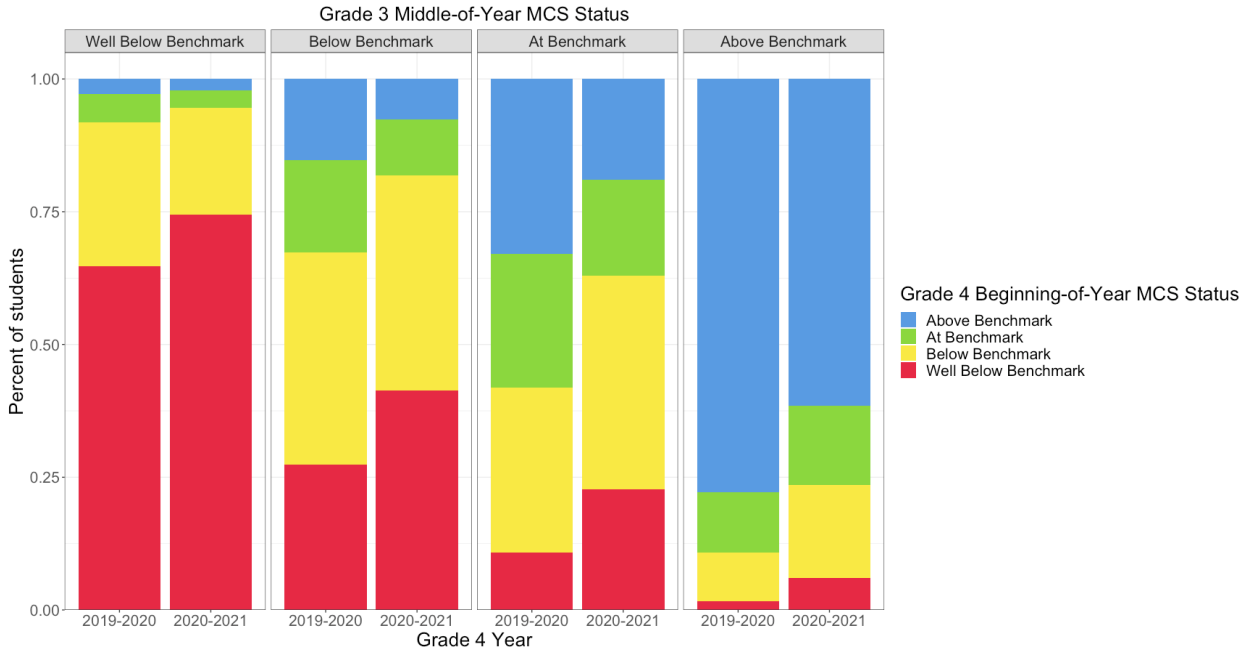
Grade 4 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Grade 3 Status and Year of Grade 4 Assessment

	G4 BOY MCS Benchmark Status and Year		
G3 MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	83% (69%)	14% (22%)	3% (9%)
Below	33% (18%)	40% (40%)	27% (41%)
Well Below	8% (5%)	27% (20%)	65% (74%)

Note. G4 = Grade 4. BOY = Beginning-of-Year. MCS = Math Composite Score. G3 = Grade 3. MOY = Middle-of-Year. *N* = 20,282.

Figure 12

Likelihood of Meeting the Benchmark at the Beginning of Grade 4 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 4 Year" indicates the school year in which students received fourth-grade beginning-of-year benchmark assessment. $N = 20{,}282$.

Table 14

Grade 4 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Grade 3 Status and Year of Grade 4 Assessment

	G4 BOY MCS Benchmark Status and Year			
G3 MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	78% (62%)	11% (15%)	9% (17%)	2% (6%)
At	33% (19%)	25% (18%)	31% (40%)	11% (23%)
Below	15% (8%)	17% (11%)	40% (40%)	27% (41%)
Well Below	3% (2%)	5% (3%)	27% (20%)	65% (74%)

Note. G4 = Grade 4. BOY = Beginning-of-Year. MCS = Math Composite Score. G3 = Grade 3. MOY = Middle-of-Year. $N = 20{,}282$.

Grade 5 Results

Figure 13 plots students' fifth-grade beginning-of-year MCS as a function of their MCS from the middle of fourth grade and the year in which they received their beginning-of-year fifth-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. Fourth-grade students with average middle-of-year scores scored 13.11 points lower on the MCS at the beginning of fifth grade in 2020–2021 compared to students at the beginning of fifth grade in 2019–2020. The interaction between year and middle-of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS increase, the difference in predicted beginning-of-year scores between the two school years widens. The gap between predicted scores is smallest for students

with lower middle-of-year MCS and widest for students with higher middle-of year scores. The model accounted for 59% of the total variability in beginning-of-year MCS.

Figures 14 and 15 illustrate fifth-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in fourth grade and year of fifth grade (2019–2020 or 2020–2021). Figure 14 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 15 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 15 and 16 list the percentages of students in each category in Figures 14 and 15, respectively.

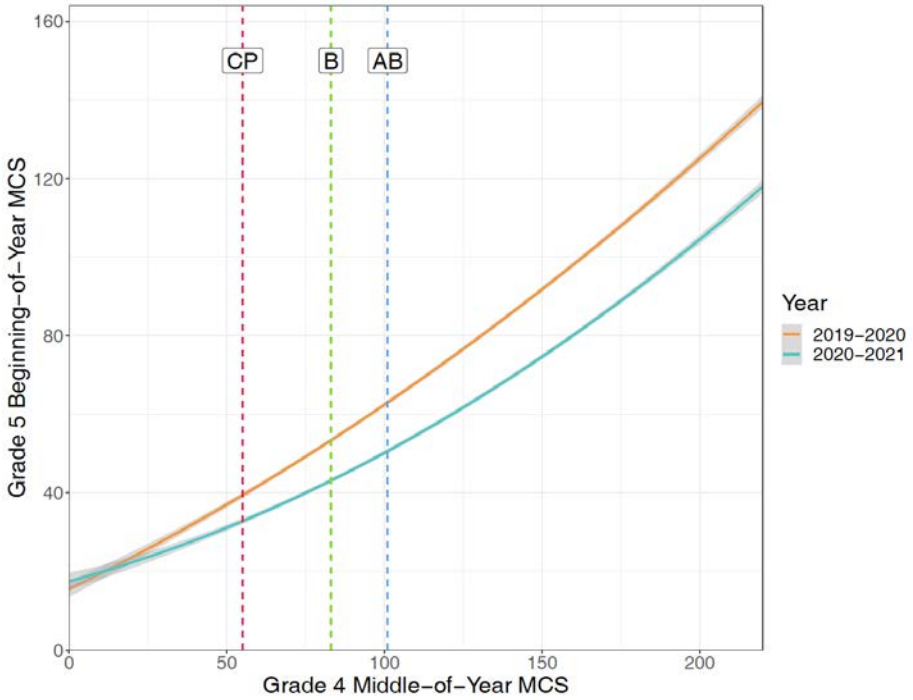
Students entering fifth grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 14 and Table 15, among students who were At or Above Benchmark at the middle of fourth grade in 2018–2019, 81% were also At or Above Benchmark at the beginning of fifth grade. For students entering fifth grade at the beginning of the 2020–2021 school year, this percentage dropped to 65%. This represents a 16% decrease in students meeting later math benchmarks from fourth to fifth grade. Furthermore, just 5% of students who were At or Above Benchmark at the middle of fourth grade in 2018–2019 were Well Below Benchmark at the beginning of fifth grade in 2019–2020. This percentage increased to 12% for students entering fifth grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 15 and Table 16) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of fourth grade in 2018–2019, 37% scored Above Benchmark and 20% scored At Benchmark at the beginning of fifth grade. For students entering fifth grade at the beginning of the 2020–2021 school year, these percentages dropped to 18% scoring Above Benchmark and 16% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of fourth grade in 2018–2019, 30% were Below Benchmark and 13% were Well Below Benchmark at the beginning of fifth grade in 2019–2020. These percentages increased to 41% and 25%, respectively, for students entering fifth grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of fourth grade had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of fifth grade than students in the At Benchmark range at the middle of fourth grade, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 15 and Table 16, among students who were Above Benchmark at the middle of fourth grade in 2018–2019, 76% scored Above Benchmark and 11% scored At Benchmark at the beginning of fifth grade in 2019–2020. For students entering fifth grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 56%, with more students (16%) scoring At Benchmark. Furthermore, 10% of students who were Above Benchmark at the middle of fourth grade in 2018–2019 were Below Benchmark at the beginning of fifth grade in 2019–2020 and only 3% were Well Below Benchmark. For students entering fifth grade at the beginning of 2020–2021, these percentages increased to 19% and 8%, respectively.

Figure 13

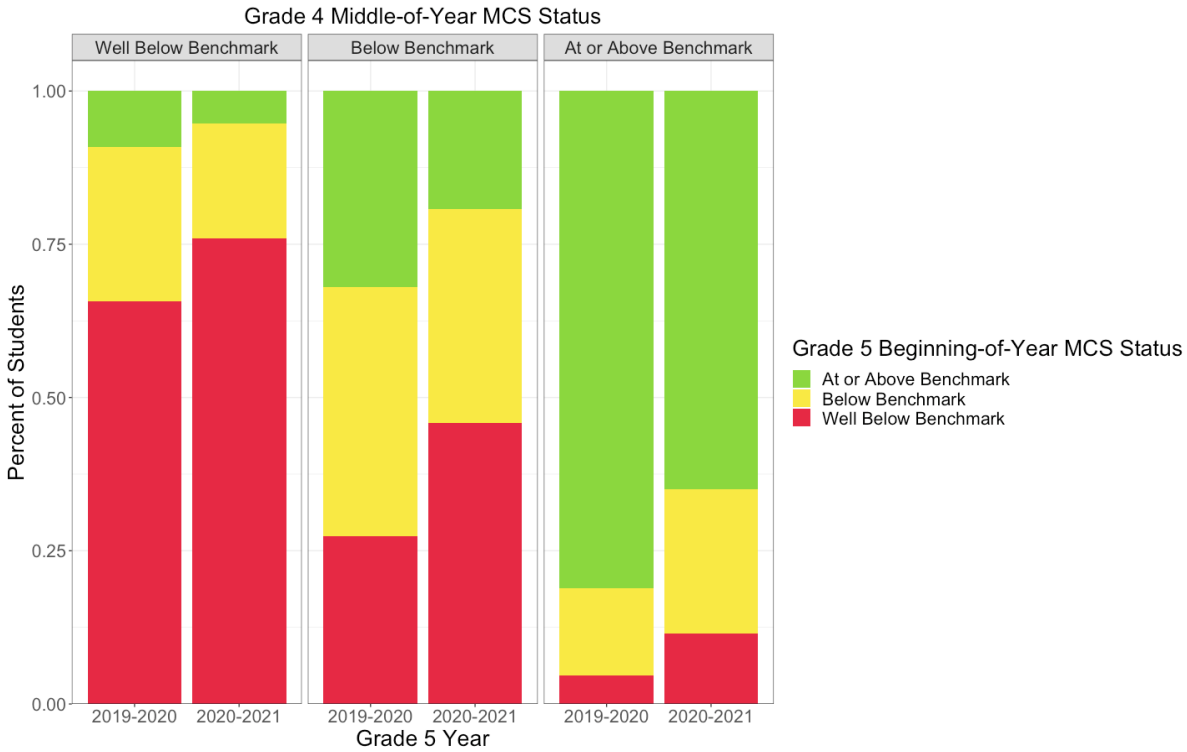
Grade 5 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received fifth-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of fourth grade. CP = cut point for risk (55). B = benchmark (83). AB = above benchmark (101). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). N = 18,103.

Figure 14

Likelihood of Meeting the Benchmark at the Beginning of Grade 5



Note. MCS = Math Composite Score. "Grade 5 Year" indicates the school year in which students received fifth-grade beginning-of-year benchmark assessment. *N* = 18,103.

Table 15

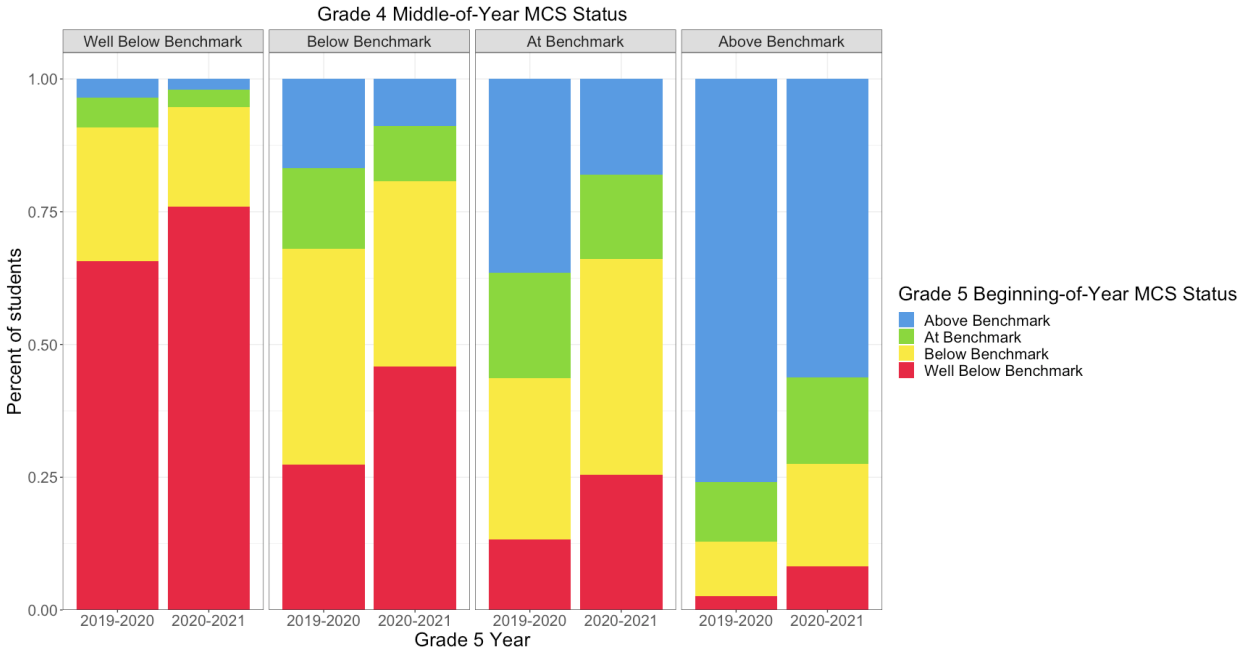
Grade 5 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Grade 4 Status and Year of Grade 5 Assessment

	G5 BOY MCS Benchmark Status and Year		
G4 MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	81% (65%)	14% (23%)	5% (12%)
Below	32% (19%)	41% (35%)	27% (46%)
Well Below	9% (5%)	25% (19%)	66% (76%)

Note. G5 = Grade 5. BOY = Beginning-of-Year. MCS = Math Composite Score. G4 = Grade 4. MOY = Middle-of-Year. *N* = 18,103.

Figure 15

Likelihood of Meeting the Benchmark at the Beginning of Grade 5 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 4 Year" indicates the school year in which students received fourth-grade beginning-of-year benchmark assessment. *N* = 18,103.

Table 16

Grade 5 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Grade 4 Status and Year of Grade 5 Assessment

	G5 BOY MCS Benchmark Status and Year			
G4 MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	76% (56%)	11% (16%)	10% (19%)	3% (8%)
At	37% (18%)	20% (16%)	30% (41%)	13% (25%)
Below	17% (9%)	15% (10%)	41% (35%)	27% (46%)
Well Below	4% (2%)	6% (3%)	25% (19%)	66% (76%)

Note. G5 = Grade 5. BOY = Beginning-of-Year. MCS = Math Composite Score. G4 = Grade 4. MOY = Middle-of-Year. *N* = 18,103.

Grade 6 Results

Figure 16 plots students' sixth-grade beginning-of-year MCS as a function of their MCS from the middle of fifth grade and the year in which they received their beginning-of-year sixth-grade benchmark assessment (2019–2020 or 2020–2021). The effect of year was statistically significant. Fifth-grade students with average middle-of-year scores scored 15.69 points lower on the MCS at the beginning of sixth grade in 2020–2021 compared to students at the beginning of sixth grade in 2019–2020. The interaction between year and middle-of-year MCS was also significant, meaning that the difference in predicted scores between years depended on students' middle-of-year performance. As middle-of-year MCS Scores increase, the difference in predicted beginning-of-year scores between the two school years widens. The gap between predicted scores is smallest

for students with lower middle-of-year MCS and widest for students with higher middle-of year scores. The model accounted for 58% of the total variability in beginning-of-year MCS.

Figures 17 and 18 illustrate sixth-grade students' beginning-of-year MCS benchmark status based on their middle-of-year MCS in fifth grade and year of sixth grade (2019–2020 or 2020–2021). Figure 17 reports three categories for benchmark status (Well Below Benchmark, Below Benchmark, and At or Above Benchmark). Figure 18 subdivides the At or Above Benchmark category into At Benchmark and Above Benchmark. Tables 17 and 18 list the percentages of students in each category in Figures 17 and 18, respectively.

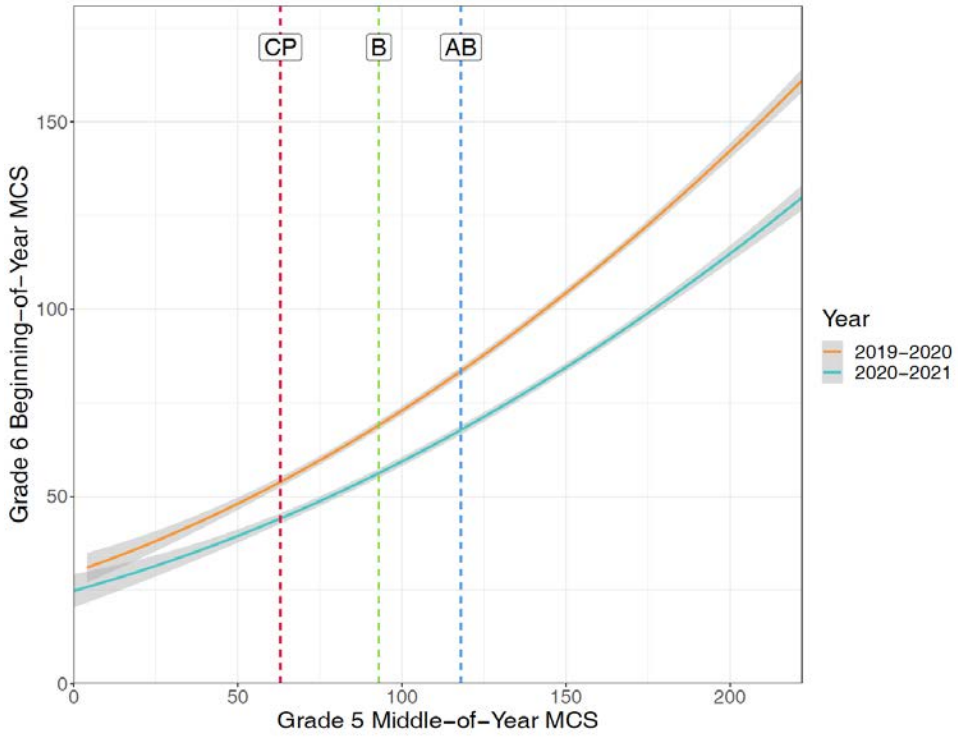
Students entering sixth grade at the beginning of the 2020–2021 school year were less likely to meet the MCS benchmark. As seen in Figure 17 and Table 17, among students who were At or Above Benchmark at the middle of fifth grade in 2018–2019, 78% were also At or Above Benchmark at the beginning of sixth grade. For students entering sixth grade at the beginning of the 2020–2021 school year, this percentage dropped to 56%. This represents a 22% decrease in students meeting later math benchmarks from fifth to sixth grade. Furthermore, only 3% of students who were At or Above Benchmark at the middle of fifth grade in 2018–2019 were Well Below Benchmark at the beginning of sixth grade in 2019–2020. This percentage increased to 9% for students entering sixth grade at the beginning of 2020–2021.

Subdividing the At or Above Benchmark category into the At Benchmark and Above Benchmark categories (Figure 18 and Table 18) allowed for a more detailed look into students' likelihood of achieving subsequent benchmarks at the upper end of the performance range. Among students who were At Benchmark at the middle of fifth grade in 2018–2019, 33% scored Above Benchmark and 21% scored At Benchmark at the beginning of sixth grade. For students entering sixth grade at the beginning of the 2020–2021 school year, these percentages dropped to 11% scoring Above Benchmark and 13% scoring At Benchmark. Furthermore, of students who scored At Benchmark at the middle of fifth grade in 2018–2019, 38% were Below Benchmark and 8% were Well Below Benchmark at the beginning of sixth grade in 2019–2020. These percentages increased to 57% and 19%, respectively, for students entering sixth grade at the beginning of 2020–2021.

Students scoring in the Above Benchmark range at the middle of fifth grade had a higher likelihood of scoring Above Benchmark or At Benchmark at the beginning of sixth grade than students in the At Benchmark range at the middle of fifth grade, but the likelihood decreased for students assessed at the beginning of the 2020–2021 school year. Again, looking at Figure 18 and Table 18, among students who were Above Benchmark at the middle of fifth grade in 2018–2019, 75% scored Above Benchmark and 12% scored At Benchmark at the beginning of sixth grade in 2019–2020. For students entering sixth grade at the beginning of the 2020–2021 school year, the percentage of students who scored Above Benchmark dropped to 52%, with more students (15%) scoring At Benchmark. Furthermore, 12% of students who were Above Benchmark at the middle of fifth grade in 2018–2019 were Below Benchmark at the beginning of sixth grade in 2019–2020 and just 1% were Well Below Benchmark. For students entering sixth grade at the beginning of 2020–2021, these percentages increased to 28% and 5%, respectively.

Figure 16

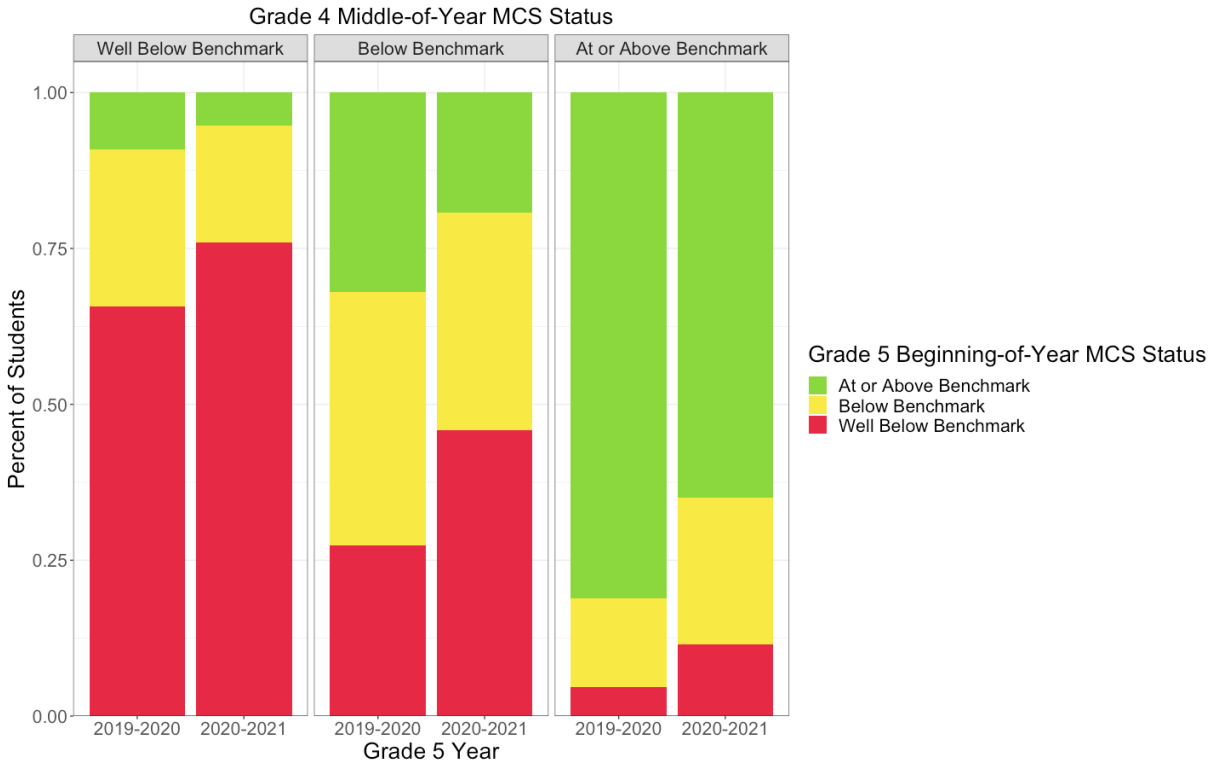
Grade 6 Beginning-of-Year Math Composite Score (MCS) Predicted by Previous Performance and Year



Note. MCS = Math Composite Score. "Year" indicates the school year in which students received sixth-grade beginning-of-year benchmark assessment. Vertical dashed reference lines correspond to the following MCS at middle of fifth grade. CP = cut point for risk (63). B = benchmark (93). AB = above benchmark (118). Range of x-axis is restricted to the MCS corresponding to the 99th percentile on the 2016–2017 Acadience Math National Norms (Gray, Wheeler, & Good, 2019). $N = 5{,}799$.

Figure 17

Likelihood of Meeting the Benchmark at the Beginning of Grade 6



Note. MCS = Math Composite Score. "Grade 6 Year" indicates the school year in which students received sixth-grade beginning-of-year benchmark assessment. $N = 5{,}799$.

Table 17

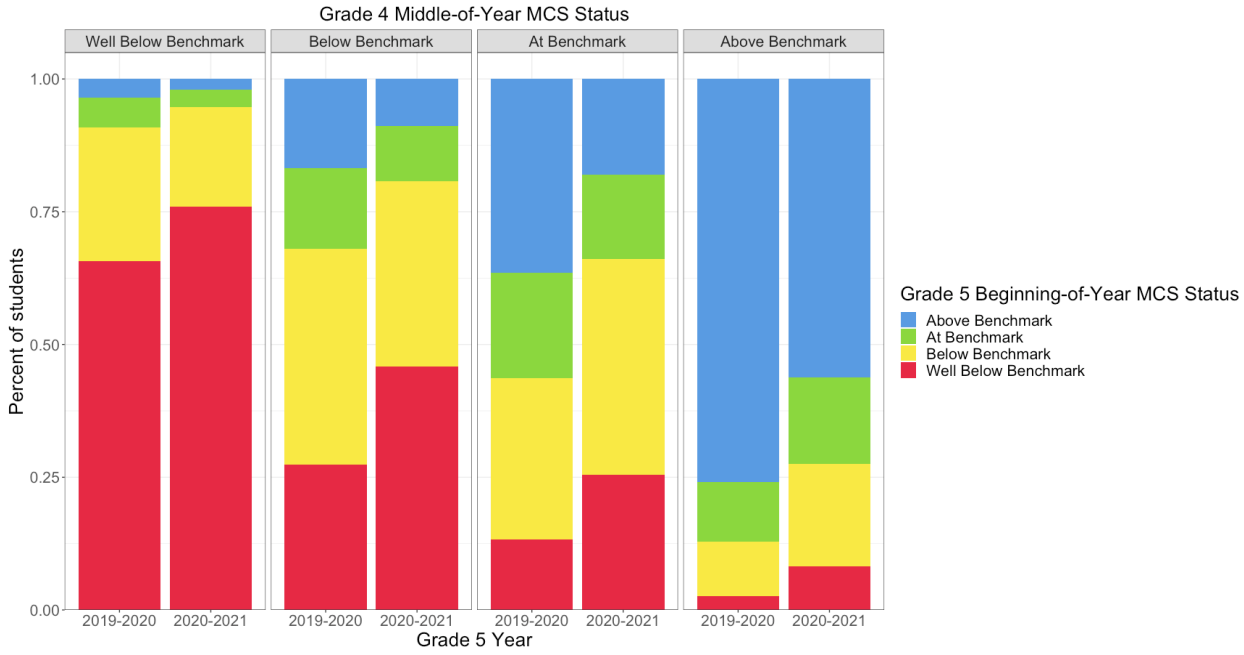
Grade 6 Beginning-of-Year Math Composite Score (MCS) Benchmark Status by Middle-of-Year Grade 5 Status and Year of Grade 6 Assessment

	G6 BOY MCS Benchmark Status and Year		
G5 MOY MCS Status	At or Above 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
At or Above	78% (56%)	19% (35%)	3% (9%)
Below	29% (14%)	49% (44%)	22% (41%)
Well Below	9% (3%)	36% (26%)	55% (72%)

Note. G6 = Grade 6. BOY = Beginning-of-Year. MCS = Math Composite Score. G5 = Grade 5. MOY = Middle-of-Year. $N = 5{,}799$.

Figure 18

Likelihood of Meeting the Benchmark at the Beginning of Grade 6 with Four Benchmark Categories



Note. MCS = Math Composite Score. "Grade 6 Year" indicates the school year in which students received sixth-grade beginning-of-year benchmark assessment. $N = 5{,}799$.

Table 18

Grade 6 Beginning-of-Year Math Composite Score (MCS) Benchmark Status, Including the Above Benchmark Category, by Middle-of-Year Grade 5 Status and Year of Grade 6 Assessment

	G6 BOY MCS Benchmark Status and Year			
G5 MOY MCS Status	Above 19–20 (20–21)	At 19–20 (20–21)	Below 19–20 (20–21)	Well Below 19–20 (20–21)
Above	75% (52%)	12% (15%)	12% (28%)	1% (5%)
At	33% (11%)	21% (13%)	38% (57%)	8% (19%)
Below	16% (7%)	13% (8%)	49% (44%)	22% (41%)
Well Below	2% (1%)	6% (2%)	36% (26%)	55% (72%)

Note. G6 = Grade 6. BOY = Beginning-of-Year. MCS = Math Composite Score. G5 = Grade 5. MOY = Middle-of-Year. $N = 5{,}799$.

Discussion

This study examined the initial effects of the COVID-19 pandemic on the math skills of student in first through sixth grade. We investigated the impacts that school closures and modified instruction had starting at the end of the 2019–2020 school year through the beginning of the 2020–2021 school year. Overall, our results indicate that students performed significantly lower on Acadience Math measures at the beginning of 2020–2021 compared to the previous school year at all grades. In first grade, the difference between the MCS was greatest for students with initial scores at the lower end of the performance spectrum. However, in second through sixth grade, the gap between scores was largest at the higher end of the performance spectrum and smallest at the lower end. The impact of the disruption to learning was also observed in the percentage of students meeting math benchmarks. At every grade, students were less likely to be At or Above Benchmark

and more likely to be Below or Well Below Benchmark at the beginning of the 2020–2021 school year compared to students at the beginning of the 2019–2020 school year, regardless of previous benchmark status.

Mathematics skills continuously build upon earlier learned material. New content is introduced at each grade level, meaning that the disruption to schooling would have created an impact across all grade levels. The data from this study not only indicates significant effects at each grade level, but that the impacts were larger at the upper grade levels. As grade levels increase, the mathematical content becomes increasingly difficult, and it is possible that students in second through sixth grade were not taught all of the material they would have typically been taught or would have learned during the end of the 2019–2020 school year. Additionally, with the differences observed at the higher end of the performance spectrum, it is possible that during the last months of 2019–2020, schools were not able to provide supplemental instruction for out-of-grade level math skills that they may have otherwise provided to challenge higher-performing students. Schools may have instead focused their efforts on providing instruction targeting the skills necessary for students scoring at the lower end of the performance spectrum.

The difference in results between first grade and second through sixth grade could be due to the nature of the skills assessed on the measures. In kindergarten and first grade, there is a strong emphasis on early numeracy skills, with the addition of basic computation in first grade. At the beginning of first grade, two of the four Early Numeracy measures, Number Identification Fluency and Next Number Fluency, are considered a "check-in" to ensure students have acquired number identification and strategic counting skills to a point that is sufficient for meeting later goals. For the students who were in first grade during the 2020–2021 school year, the school closures and modified instruction at the end of their kindergarten year may have represented as much as a quarter to a third of their overall educational experience at the time. It is possible that the greater impact observed for students with lower middle-of-year kindergarten scores indicated that they did not have the opportunity to master the early numeracy skills assessed in first grade before the end of the school year. The students scoring at the higher end of the performance spectrum may have been proficient with those skills before instruction was disrupted.

Implications for Practice

As educators, it is important to address the academic needs of students systematically. In the spring of 2020, the system of education changed when schools closed due to the COVID-19 pandemic and a variety of modalities of instruction emerged. Some schools and districts shut down, offering review for students, some schools and districts offered asynchronous learning through a variety of educational applications or pre-recorded learning segments, and some schools and districts provided live, remote instruction. This study examined the impact of the disruptions to the system of education that took place from the end of the 2019–2020 school year to the beginning of the 2020–2021 school year. As educators look toward the future, the academic gaps resulting from the pandemic should first be examined and addressed at the systems level before moving to addressing them at the individual student level.

The primary question facing educators is determining what they can focus on as students continue their education. Using a prevention-oriented, problem-solving approach focused on outcomes, called the Outcomes-Driven Model (ODM; Kaminski et al., 2008; Good et al, 2018), educators can ensure that students who are on track to become proficient in math continue to make adequate progress. Using the ODM, educators can also ensure those students who are not on track receive the support they need to become proficient in math.

The ODM is comprised of five steps: (a) identify the need for support, (b) validate need for support, (c) plan support, (d) evaluate support, and (e) review outcomes. Each step is aligned to a set of questions for which educators use data (i.e., universal screening and progress monitoring data) to answer with respect to the system (e.g., classroom, school, or district) or individual students. This approach is consistent with a Multi-Tiered System of Support (MTSS) model of service delivery. The ODM provides a prevention-oriented framework for addressing students' academic gaps in the acquisition of math skills and ensures step-by-step progress toward outcomes of established, adequate math achievement.

Through the ODM, educators can also determine what changes to instruction may be necessary to meet the varying needs of students. It will be important to consider which components of instruction may be altered along with the instructional context in which they exist. The current instructional context is very different than it was prior to the spring of 2020. Even as more schools are returning to hybrid or in-person instruction, barriers to instructional access will still exist and instructional gaps will be greater than what educators saw prior to the spring of 2020.

To address the instructional gaps, we recommend a multipronged approach consisting of Tier 1 (core instruction) adjustments and small group intervention. In instances where large percentages of students are Below or Well Below Benchmark, adjustments and enhancements to Tier 1 instruction is the most practical and resource-efficient target of opportunity. Additionally, noting student response patterns after administering the Early Numeracy measures or conducting a response pattern analysis after scoring the Computation or Concepts & Applications measures provides valuable information about how the student performed on specific items and what types of errors were made. This information is useful for planning instruction and identifying overarching educational needs at each grade level. Targeted intensive support should be provided only for those students with the greatest needs. Instructional elements that are alterable and may be adjusted include the following: (a) grouping; (b) materials; (c) motivational strategies; (d) pacing; (e) personnel; and (f) time allocated, including both frequency of instructional opportunities and duration.

Limitations and Future Directions for Research

One substantial advantage of the present study was that schools were matched between cohorts. The purpose of matching schools was to attempt to ensure relatively similar sample characteristics, such as student demographics, school- and district-level factors, and geographic location and setting, between cohorts. Although the sample sizes were robust and schools were matched, there was still attrition between the first and second cohorts. This attrition could be due to a variety of factors, including (a) fewer students enrolled at participating schools during the 2020–2021 school year; (b) an increase in parents or guardians opting students out of assessment (e.g., if learning occurred remotely and testing was conducted in person); (c) inequitable access to the technology resources required for remote assessment; or (d) attendance issues. A future study should examine the characteristics of schools that collected data in prior years but did not collect data at the beginning of the 2020–2021 school year, as well as the characteristics of students who received assessment in the past but were not assessed at the beginning of 2020–2021.

Another limitation was the diversity of the sample. Although the data were gathered from hundreds of schools across a broad and diverse geographic area, data from NCES indicated that a majority of the students at participating schools were White. Additionally, the students in this study were overall high performing, as indicated by their average middle-of-year scores. The data collected from the sample of schools may not be representative of national school demographics and performance. Both of these factors potentially limit the

generalizability of the results. Future research could address this by examining student-level demographics in order to assess disproportionate outcomes and by utilizing a more diverse sample in terms of demographics and range of student performance.

Another limitation is that this study did not address the nested structure that exists within our education system. Students are taught within a classroom, that is in a school, that is in a district, that is in a state. Each layer may have a differing impact on student learning. A further complicating factor is that because this study examined several years of data, the nesting at the classroom level may be convoluted. For example, two students in the same classroom during the 2020–2021 school year may not have had the same teacher during the 2019–2020 school year. Despite the challenges that examining the nested structure of the data may pose, it would be worthwhile to do so in order to tease apart the different factors that may have impacted learning.

The current study did not differentiate the mode of assessment for scores collected at the beginning of the 2020–20201 school year. Acadience Math is designed to be given in person. At the beginning of the pandemic, Acadience Learning provided guidelines to adapt the assessment for remote administration. Even with following these guidelines, it is possible there may be differences in scores solely based on the mode of assessment. Future research should examine the relationship between student performance on Acadience Math and how the measures were administered (i.e., remote or in-person).

Lastly, to gain better insight into the impact of the pandemic on student math skills, it will be critical to examine data from the middle of the 2020–2021 school year. The current study examined the impact that the efforts to lessen the spread of COVID-19 has had on student math skills, as measured at the beginning of the 2020–2021 school year. Extending the current study to include middle-of-year data will allow us to see if the gaps observed at the beginning of the school year have continued to widen or if the systemic changes that have been implemented have been sufficient in closing the gap.

Conclusion

At the time of writing this technical report, the COVID-19 pandemic has disrupted nearly every of aspect of life for more than a year across the globe. This study highlighted the impact that the disruption in education has had on the math skills of students in first through sixth grade. Our research found that evidence of instructional loss was present for both the MCS and students' likelihood of meeting later benchmarks.

Gaps in skills will exist when students start the 2021–2022 school year. Instructional gaps existed prior to the pandemic as well, but now educators are faced with addressing them on an unprecedented scale. However, as schools begin to slowly reopen and navigate the challenges of hybrid or in-person learning, the method in which gaps should be tackled remains the same. It will be ever more important to use a systematic approach, like the Outcomes-Driven Model, gather data using a reliable and valid assessment, like Acadience Math, and analyze that data both at a systems level and at the student level in order to identify gaps in skills and develop a plan for addressing them. Once the gaps are identified, it will be important to use research-based practices to help teachers and educators meet the needs of their students. Data will only be one key piece in executing this nation's educational recovery.

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[1] The DIBELS® registered trademark was sold by Acadience Learning Inc. to the University of Oregon (UO) and is now owned by the UO.