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COVID-19 and the System Resilience of Public Education: A View from North Carolina

An Essay for the Learning Curve by Thurston Domina, Ayesha Hashim, Caitlin Kearney, Lam Pham, and Cole Smith

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The COVID-19 pandemic has had disparate consequences. The same disease that has killed more than a million people in the United States alone merely comes and goes like a bad flu for some. The story of COVID-19's profound consequences on the American education system is similar. The pandemic roiled every school in America, sidelining traditional in-person schooling in spring 2020 and introducing interruptions that continue to this day.

The best available evidence suggests that the rate of academic achievement fell by as much as half during the pandemic.[1] But, as we demonstrate here using third-grade math test score data from North Carolina public schools, the pandemic's educational consequences vary considerably from school to school and district to district. The pandemic burdened local schools, districts, and communities with the challenging task of sustaining core educational functions, often without clear guidance or support from federal and state authorities. In turn, the pandemic's repercussions varied substantially across communities.

We draw on the concept of system resilience to make sense of this variation. Resilience reflects the collective capacity of schools, districts, and communities to effectively respond to crises and maintain core educational functions when a crisis hits.[2] For example, although some North Carolina school districts were better prepared to transition to remote learning, others struggled to keep in touch with students, much less engage them in learning.[3] Some of these differences can be explained by readily measurable local characteristics, such as student demographics, unemployment rates, school funding,

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[1] Karyn Lewis, Megan Kuhfeld, Erik Ruzek, and Andrew McEachin, "Learning during COVID-19: Reading and Math Achievement in the 2020–21 School Year" (Portland, OR: NWEA Center for School and Student Progress, 2021).

[2] Margaret E. Kruk, Michael Myers, S. Tornorlah Varpilah, and Bernice T. Dahn, "What Is a Resilient Health System? Lessons from Ebola," *The Lancet* 385, no. 9980 (May 2015): 1910–12.

[3] Department of Public Instruction (DPI), *Report to the North Carolina General Assembly: An Impact Analysis of Student Learning during the COVID-19 Pandemic* (Raleigh: North Carolina State Board of Education, DPI, 2022); Thurston Domina, Caitlin Kearney, Ayesha Hashim, Dana Griffin, and Cole Smith, "An Early Look at the Pandemic's Consequences for North Carolina Schools," Carolina Across 100, January 26, 2022, https://carolinaacross100.unc.edu/an-early-look-at-the-pandemics-consequences-for-north-carolina-schools/; and Sarah Crittendon Fuller and Kevin Bastian, "Perspective: Enrollment Declines and Implications for North Carolina's Public Schools," EdNC, April 12, 2021, https://www.ednc.org/perspective-enrollment-declines-and-implications-for-north-carolinas-public-schools/.

and the use of in-person versus online learning. But many of the differences across seemingly similar districts remain unexplained.

Although we cannot make definitive claims about this unexplained variation, we suspect that some portion is the result of unequal distribution of trust, social connection, leadership, organizational coherence and capacity, and other hard-to-measure characteristics of communities that, together, shape a system's resilience in the face of a crisis.

Moving forward, even as we develop strategies to address the pandemic's traumas and get students back on track academically, we need to think about how to strengthen our educational system's resilience. A policy agenda centering resilience will build physical infrastructure, social structures, and organizational conditions that allow educators and communities to work together in challenging conditions. This work will allow schools to provide high-quality educational opportunities for all young people while preparing to buffer young people from future crises.

Student Test Scores Declined Substantially during the Pandemic

Figure 1 reports summary statistics for third-graders in North Carolina public schools. In spring 2019, 65 percent of North Carolina third-graders reached the grade-level proficiency benchmark on end-of-grade tests. The state paused end-of-grade testing in spring 2020 but resumed testing in spring 2021. At that point, after more than a year of pandemic-induced disruptions, just 44 percent of tested third-graders in North Carolina public schools reached the proficiency benchmark in mathematics.[4] We estimate that learning lag in third-grade mathematics is equivalent to an average decline of nearly half a standard deviation, which is approximately a full year of learning based on average annual gains from third-to-fourth-grade math on nationally normed tests.[5]

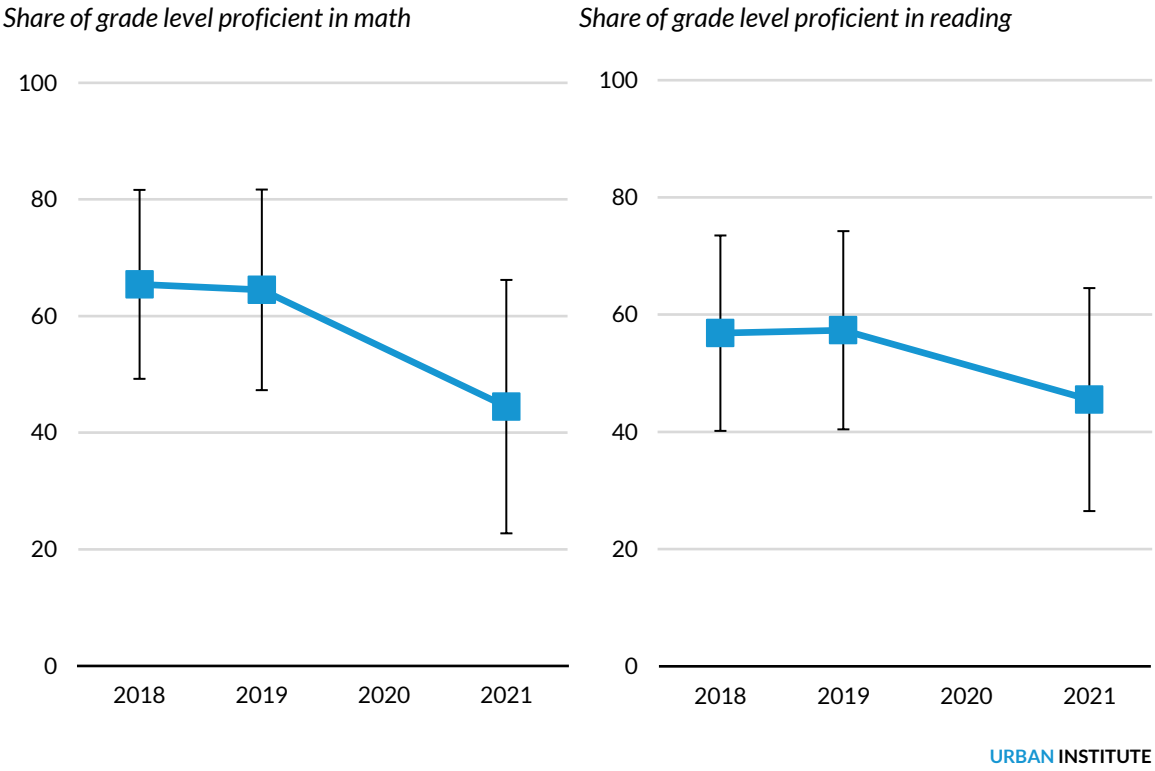
We focus on the large decline in math scores, but figure 1 also shows the substantial pandemic learning lag in third-grade reading.

[4] These data are imperfect. Nearly all third-graders in North Carolina public schools took the tests upon which these figures are based in 2018 and 2019, but less than 10 percent of third-graders opted not to come into their school buildings and take the tests—which were not administered remotely—in 2021. Furthermore, these test data capture only one aspect of student development and provide limited insight into the experiences of students and educators during the pandemic. Students suffered harms and gained strengths during these difficult years that these tests cannot measure. Although the pandemic also disrupted student progress in reading, this disruption appears to be less pronounced. Third-grade proficiency rates in North Carolina public schools fell from 57 percent in 2019 to 46 percent in 2021.

[5] Carolyn J. Hill, Howard S. Bloom, Alison Rebeck Black, and Mark W. Lipsey, "Empirical Benchmarks for Interpreting Effect Sizes in Research," *Child Development Perspectives* 2, no. 3 (December 2008): 172, https://doi.org/10.1111/j.1750-8606.2008.00061.x.

FIGURE 1

Average End-of-Grade Math and Reading Test Results for North Carolina Third-Graders, Spring 2018, 2019, and 2021



Source: Authors' analysis of data from "Accountability Data Sets and Reports," North Carolina Department of Public Instruction, accessed April 25, 2022, https://www.dpi.nc.gov/districts-schools/testing-and-school-accountability/school-accountability-and-reporting/accountability-data-sets-and-reports#2016%E2%80%9317-reports.
Notes: The school-level standard deviations at each point are represented as whiskers. Results are weighted by third-grade enrollment in each district. To estimate scale scores in math and reading, we use heteroskedastic ordered probit models applied to the district-level proficiency rates (see sean f. reardon, Benjamin R. Shear, Katherine E. Castellano, and Andrew D. Ho, "Using Heteroskedastic Ordered Probit Models to Recover Moments of Continuous Test Score Distributions from Coarsened Data," *Journal of Educational and Behavioral Statistics* 42, no. 1 [February 2017]: 3). These models use only North Carolina districts with at least 25 tested third-graders. Math and reading scores are observed in 113 districts.

Learning Lag Varied Widely across Schools and Districts

Figure 2 depicts the pandemic's consequences for third-graders' mathematics achievement and the variation across North Carolina's public school districts. Each blue dot represents a district; districts with larger third-grade enrollments are represented with proportionately larger dots.

The graph on the left compares districts' 2018 third-grade mathematics proficiency rates with their 2019 third-grade mathematics proficiency rates. Because the proportion of third-graders in a district who scored proficient in 2018 typically matched very closely with the proportion of third-graders who scored proficient in 2019, the state's districts line up relatively neatly on the diagonal black line.

But the pandemic interrupted previously stable associations, testing resilience across the state's education system. The graph on the right illustrates that third-grade math proficiency rates fell substantially across North Carolina between spring 2019 and spring 2021. Disruptions to math achievement were nearly universal. Every district in the state except for Surry County Schools falls below the black diagonal line.

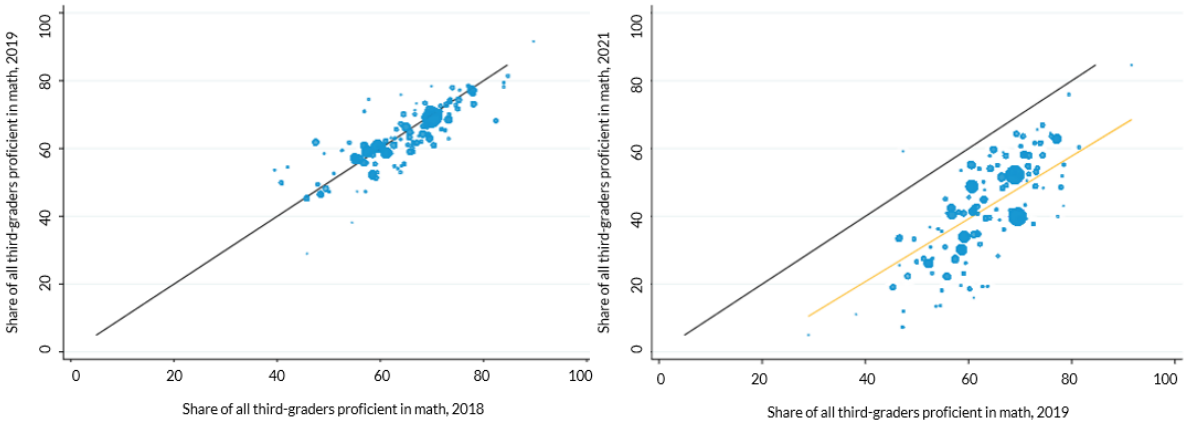
Although the pandemic's educational consequences were broad, they were by no means monolithic. The dispersion of districts around the yellow diagonal line in figure 2 shows the increasing variation between districts during the pandemic's first year and a half (the correlation between current- and prior-year proficiency rates fell from 0.88 to 0.73). We also find that the pandemic increased achievement variation across schools within districts. Statewide, the standard deviation in school-level third-grade mathematics proficiency rates (represented as the whiskers in figure 1) increased from 17 percentage points in 2019 to 21 percentage points in 2021.

We see cross-district and school dispersion in pandemic learning lags as an indication that North Carolina public school districts differed in their resilience during the COVID-19 crisis.

FIGURE 2

Prior-Year Third-Grade Math Proficiency Rate Predictiveness on Third-Grade Math Proficiency Rates

2018 versus 2019 *2019 versus 2021*



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Source: Authors' analysis of data from "Accountability Data Sets and Reports," North Carolina Department of Public Instruction, accessed April 25, 2022, https://www.dpi.nc.gov/districts-schools/testing-and-school-accountability/school-accountability-and-reporting/accountability-data-sets-and-reports#2016%E2%80%9317-reports.

Notes: These scatterplots provide a year-by-year comparison of districts' third-grade mathematics proficiency rates. Each blue dot represents a district. If each district's test scores were completely unchanged from one year to the next, each district would line up on the diagonal black line. When a district's proficiency rates improve over the previous year, the district appears above and to the left of the diagonal line; when a district's proficiency rates fall compared with the previous year, the district appears below and to the right of the diagonal line. In comparing the graph from the left (prepandemic) with the one on the right (postpandemic), it is clear that districts had stable year-to-year proficiency rates prepandemic, but districts' proficiency rates declined in the first postpandemic school year (2021) relative to 2019. Moreover, postpandemic, we see more variation in district performance as observed by the dispersion of blue dots along the black line.

Pandemic Learning Lag Was Largest in Marginalized Communities and Communities That Suffered Acute Health and Economic Effects

We use multilevel models to investigate school-, district-, and community-level factors associated with learning lags in third-grade mathematics (figure 3).[6] Our first model compares 2018 and 2019 proficiency rates to establish a prepandemic baseline. Model 2 compares 2019 and 2021 proficiency rates, controlling only for the proportion of tested students. Model 3 adds controls for student demographics, county-level unemployment rates, and total documented COVID-19 case rates between March 2020 and May 2021.

Although these analyses reveal that local conditions such as student demographics, unemployment rates, and COVID case rates explain some of the observed disruptions to student learning, a remarkably large share of the variance in student learning lag remains unexplained at the district level.

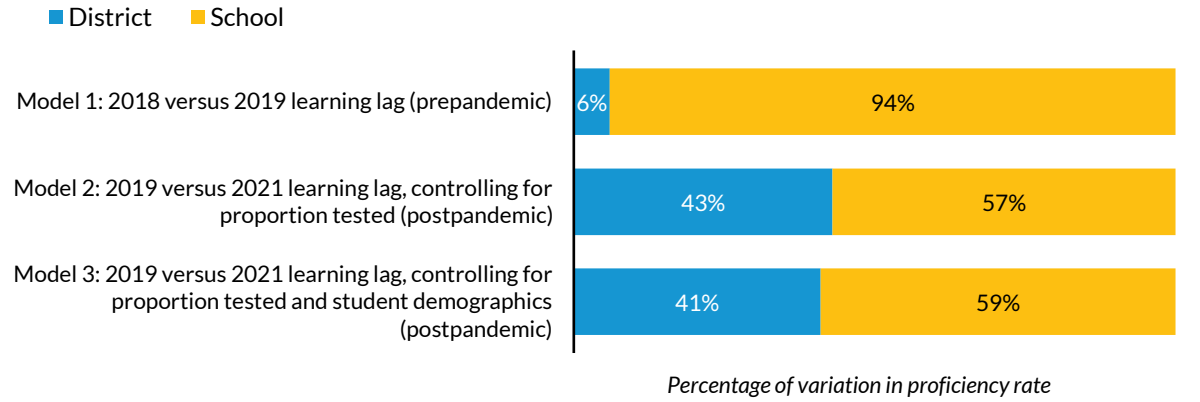
Figure 3 reports findings on district-level clustering in school achievement trajectories. Model 1 reveals that differences across districts account for just 6 percent of the school-level variation in achievement changes between spring 2018 and spring 2019. This finding is consistent with prior analyses that demonstrate that districts account for only a small proportion of variation in student achievement.[7] In contrast, model 2 demonstrates that districts account for 43 percent of the total variation in learning lag between spring 2019 and spring 2021. Model 3 indicates that even after controlling for school demographics and county-level unemployment and COVID-19 case rates, districts account for 41 percent of the remaining variation in 2019–21 changes in third-grade math proficiency rates.

[6] These regression models acknowledge that schools in the same district operate in a shared context and make it possible to systematically study the way outcomes align across schools within the same district. We use random intercept models where schools (level 1) are nested within districts (level 2). We estimate null models and models that include both school- and district-level covariates (which we list below).

[7] Matthew M. Chingos, Grover J. Whitehurst, and Michael R. Gallagher, "School Districts and Student Achievement," *Education Finance and Policy* 10, no. 3 (July 2015): 378.

FIGURE 3

Intraclass Correlations Showing Percentage of Variation at the District and Schools Levels before and after the Pandemic Began



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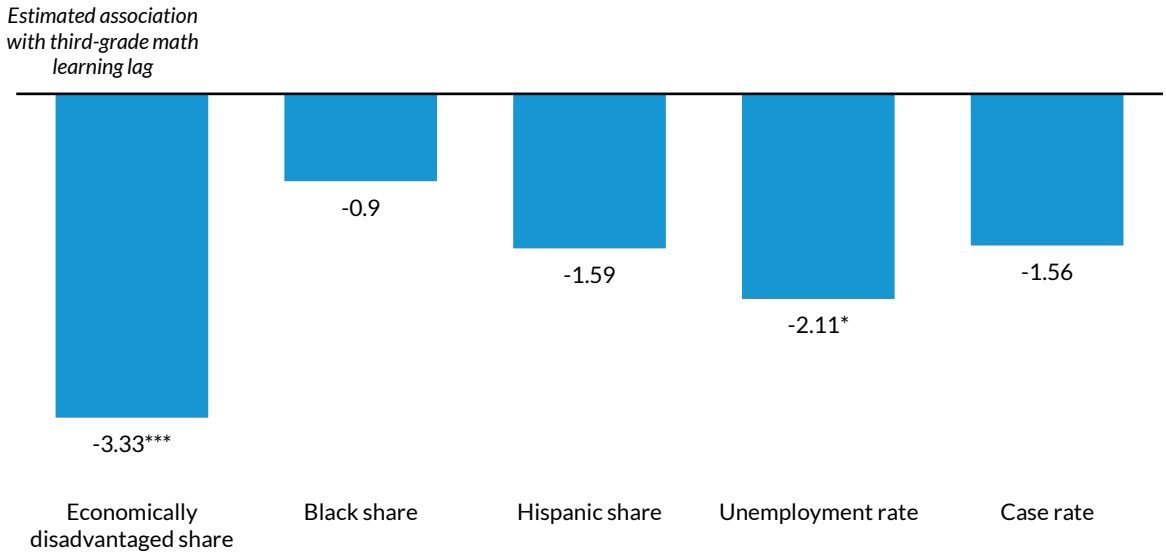
Source: Authors' analysis of data from "Accountability Data Sets and Reports," North Carolina Department of Public Instruction, accessed April 25, 2022, https://www.dpi.nc.gov/districts-schools/testing-and-school-accountability/school-accountability-and-reporting/accountability-data-sets-and-reports#2016%E2%80%9317-reports. Model 3 adds data from the American Community Survey, the Common Core of Data (https://usafacts.org), and the US Department of Agriculture's local area unemployment statistics program.

This does not mean school and community characteristics are unrelated to learning lag. Indeed, schools with relatively large concentrations of economically disadvantaged students experienced substantially larger declines in third-grade mathematics proficiency between 2019 and 2021 than more affluent schools (figure 4). Although not statistically significant, our models also suggest relatively large learning lags in schools with higher proportions of Black and Hispanic students. These findings are consistent with prior research indicating that the pandemic's consequences were most acute in previously marginalized communities.[8]

[8] Benjamin W. Domingue, Madison Bell, David Lang, Rebecca Silverman, Jason Yeatman, and Heather Hough, "The Effect of COVID on Oral Reading Fluency during the 2020–2021 Academic Year" (Stanford, CA: Stanford University Graduate School of Education, forthcoming); and Libby Pier, Heather J. Hough, Michael Christian, Noah Bookman, Britt Wilkenfeld, and Rick Miller, "COVID-19 and the Education Equity Crisis: Evidence on Learning Loss from the CORE Data Collaborative," Stanford University, Policy Analysis for California Education, January 25, 2021, https://edpolicyinca.org/newsroom/covid-19-and-educational-equity-crisis.

FIGURE 4

Estimated Relationship with Third-Grade Math Proficiency Learning Lags, Using Multilevel Models with Controls for School- and County-Level Characteristics



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Source: Authors' analysis of data from "Accountability Data Sets and Reports," North Carolina Department of Public Instruction, accessed April 25, 2022, https://www.dpi.nc.gov/districts-schools/testing-and-school-accountability/school-accountability-and-reporting/accountability-data-sets-and-reports#2016%E2%80%9317-reports; the American Community Survey, Common Core of Data (https://usafacts.org); and the US Department of Agriculture's local area unemployment statistics program.
Notes: ICC = 0.41. All variables are z-score standardized so that the coefficient represents the expected shift in proficiency associated with a 1 standard-deviation difference in the predictor. These results are from model 3, which compares 2019 and 2021 proficiency rates and controls for the proportion of tested students, student demographics, county-level unemployment, and documented COVID-19 case rates.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

We further find that schools in communities suffering more from the pandemic's economic and health effects experienced a greater degree of learning lag. Model 3 indicates that a 1 standard-deviation (approximately 1 percentage-point) increase in the community unemployment rate was associated with a 2 percentage-point decline in third-grade math proficiency rates, net of controls. Although not statistically significant in all models, the results also point to a similar negative association between local COVID-19 case rates and learning lag.

Remote Learning Is Only Part of the Story

What, then, accounts for the way pandemic achievement trajectories cluster at the district level? A great deal of recent discussion about the shortcomings of remote instruction suggests district decisions about mode of instruction as a potential explanation.

Research indicates that students who received fully remote instruction for most of the 2020–21 school year received less instructional time and were more likely to be absent and to receive a failing

grade than their peers who attended class in person.[9] Using comprehensive data on district-level instructional modality and standardized test scores across 12 states, Halloran and colleagues find significantly large test score declines—with magnitudes of 10.1 percentage points in math and 3.2 percentage points in English language arts—in districts offering fully hybrid or virtual instruction relative to districts offering in-person instruction.[10]

Our analyses of North Carolina instructional modality data align with this finding.[11] Even after controlling for school and community characteristics, we find a significant negative relationship between the proportion of the 2020–21 academic year that schools spent offering remote-only instruction and third-grade math proficiency rates. This relationship, which is more pronounced than the relationship between the concentration of economically disadvantaged students and proficiency rates, is consistent with previous research on remote-only instruction. Specifically, we find that a 1 standard-deviation increase in days of fully remote instruction is associated with a 4.5 percentage-point decline in third-grade math proficiency rates.

Interestingly, however, cross-district differences in mode of instruction account for only a fraction of the district-level variation in learning lag we observe. Put differently, although remote-only districts experienced more learning lag than mostly in-person districts, an enormous amount of variation exists among districts in each of these categories. To understand this cross-district variation, we need to better understand the challenges and resources that different communities brought to the pandemic and the ways different communities mobilized to provide high-quality instruction to students throughout the pandemic, whether in person or remotely.

Figure 5 provides a visual representation. In this figure, we graph the change in third-grade math proficiency rates between 2019 and 2021 against the proportion of the 2020–21 academic year each North Carolina public school district spent offering exclusively remote instruction. Consistent with the regression results above, the black line in figure 5 shows that districts that spent more of the academic year remote experienced more learning lag.

More striking, however, is the remarkable degree of district dispersion around that black line. Some districts that offered primarily in-person or hybrid instruction throughout the 2020–21 academic year (far left of figure 5) experienced negligible lags in the third-grade mathematics proficiency rate, while others experienced substantial learning lags. This variation in performance among districts offering

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[9] Julia H. Kaufman and Melissa Kay Dilberti, "Divergent and Inequitable Teaching and Learning Pathways during (and Perhaps Beyond) the Pandemic: Key Findings from the American Educator Panels Spring 2021 COVID-19 Surveys" (Santa Monica, CA: Rand Corporation, 2021).

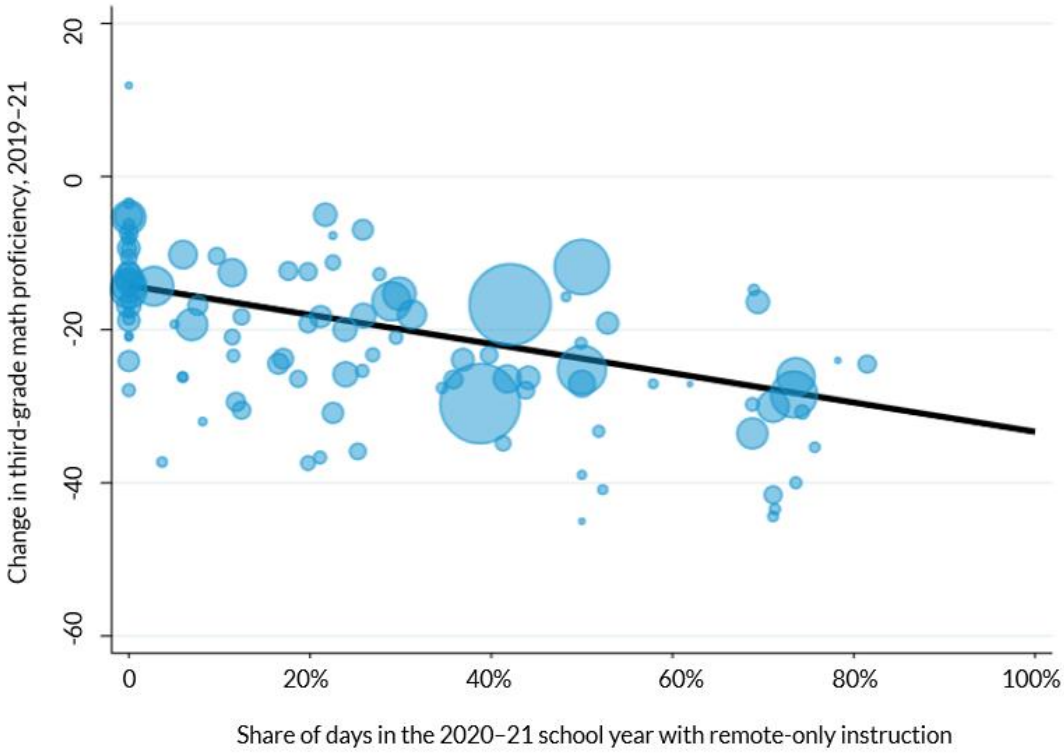
[10] Clare Halloran, Rebecca Jack, James C. Okin, and Emily Oster, *Pandemic School Mode and Student Test Scores: Evidence from US States* (working paper, National Bureau of Economic Research, Cambridge, Massachusetts, 2021).

[11] North Carolina instructional modality data are based solely on publicly available data provided by district websites and social media outlets. Our team explored every district's website, relying on district communication provided by news updates, school board minutes, and linked Facebook and Twitter posts. Varying by district capacity, school boards approved official plans to shift modality but ultimately did not implement these shifts, based on a multitude of factors, such as COVID-19 community spread, family and staff input, and facility safety. Our team captured the date of the actual implementation of modality shifts for third-grade students as best we could based on public communication via districts' varying platforms.

primarily in-person or hybrid instruction indicates that choice in instructional modality was just one of a broad array of pandemic-induced conditions that tested educational system resilience. Similarly, figure 5 suggests that some primarily remote districts (far right) sustained third-grade math proficiency rate declines over the pandemic period that were smaller than the state average, while other primarily remote districts sustained larger setbacks. We again see this variation in learning lag among the primarily remote districts as an indicator of variability among North Carolina districts in their ability to redesign instructional processes and sustain student achievement in a remote-only instructional format while responding to other adverse local conditions.

FIGURE 5

Third-Grade Mathematics Learning Lag, by the Proportion of Remote-Only Instruction in the 2020–21 School Year for North Carolina Public School Districts



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Source: Authors' analysis of data from "Accountability Data Sets and Reports," North Carolina Department of Public Instruction, accessed April 25, 2022, https://www.dpi.nc.gov/districts-schools/testing-and-school-accountability/school-accountability-and-reporting/accountability-data-sets-and-reports#2016%E2%80%9317-reports merged with district-level instructional modality data described in footnote 11.

Notes: This scatterplot represents districts' pandemic learning lag in third-grade mathematics (or the difference between the share of third-graders who scored proficient in mathematics in 2021 and the share of third-graders who scored proficient in mathematics in 2019) on the *y* axis against the proportion of days in the 2020–21 school year in which districts offered remote-only instruction. Each blue dot represents a district. If district test scores were completely unchanged from one year to the next, each district would line up in a horizontal line at zero. Districts that offered primarily remote instruction experienced a larger decline in year-to-year proficiency rates than districts that offered primarily in-person instruction. But we see variation in district

performance as observed by the dispersion of dots along the trendline, suggesting that districts in both instructional modalities were tested in resilience and that instructional modality is not the sole explanatory factor.

Additional analyses suggest that the achievement costs of remote schooling were particularly pronounced for schools that began the pandemic with relatively low third-grade math proficiency. If we interpret baseline proficiency rates as a proxy for the existing skills and resources that students can bring into schools, these results suggest that primarily remote districts serving students with greater academic needs faced the largest challenges to educational resilience.

Building Resilience in Education

Our analyses of third-grade mathematics achievement trajectories in North Carolina public schools suggest that although the COVID-19 crisis severely and negatively affected student learning across the state, schools, districts, and their surrounding communities varied substantially in their resilience to pandemic-induced disruptions. Notably, although there has been much empirical attention on the adverse effects of remote instruction on student achievement, we show that instructional modality explains only a fraction of the pandemic's adverse consequences for student learning. For example, our findings show that certain fully remote school districts demonstrated better test score performance relative to the state average, while certain in-person school districts underperformed relative to other districts.

We see these findings as a starting point for a discussion about the work needed to bolster the resilience of the American education system. To understand COVID-19 learning lags and build a brighter future for American schools, scholars, policymakers, and educators must move beyond contentious debates about remote learning. To build a system that can better educate children through the next crisis, we need to do more than build programs to ameliorate COVID-19 skills gaps.

What policies, structures, and resources might help build a more resilient educational system? Infrastructure investments might be a good place to start. For decades, the US has been underinvesting in school facilities. As a result, schools across the country are crumbling. If the US had invested a generation ago to improve air quality in our K–12 schools, we might not have had to close schools to prevent viral transmission. If we had made a national broadband system that was available to all families, the transition to remote schooling might have been more successful.

But social infrastructure may be every bit as important. To build a resilient education system, we must build the trust that students, educators, families, and community members have in one another. Resilience requires that people across the education system be empowered to speak up about their experiences and feel confident they will be heard. When open and empathetic dialogue exists, systems can learn to see problems as they emerge and can build the capacity to adapt and iteratively develop new strategies.

Education leaders should also develop organizational conditions in districts and schools that can support student learning during crises. Although our results identify districts that were the least and

most severely affected by the pandemic, we cannot observe the organizational conditions within districts that supported educational resilience. Future research on districts that are outliers may shed light on resilient organizational structures, policies, practices, and routines. This research should include studying outlier districts across instructional modalities, as we find that instructional modality may be a symptom of the tests to educational resilience faced by local communities rather than the sole or primary driver for learning lags. Policymakers at the local and state level can partner with researchers in these endeavors to identify and disseminate knowledge on organizational conditions that support educational resilience.

Finally, although we have observed the resilience of North Carolina's public education systems in terms of district and school test score performance, we recognize there are other core functions of schooling beyond reading and math instruction, such as supporting student mental health, supporting social and emotional well-being, and facilitating access to social services. We encourage future studies to focus on these additional processes and outcomes. Indeed, understanding how these additional core processes relate to student learning and test score performance would deepen our understanding of the resilience of education systems in crisis.

Thurston Domina is the Robert W. Eaves Sr. distinguished professor in educational leadership at the University of North Carolina at Chapel Hill, Ayesha Hashim is an assistant professor of educational policy and organizational leadership at the University of North Carolina at Chapel Hill, Caitlin Kearney is a PhD student studying K–12 education policy at the University of North Carolina at Chapel Hill; Lam Pham is an assistant professor in the Department of Educational Leadership, Policy, and Human Development at North Carolina State University; and Cole Smith is a PhD student studying educational policy and school improvement at the University of North Carolina at Chapel Hill.

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500 L'Enfant Plaza SW
Washington, DC 20024

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