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Pandemic Schooling Mode and Student Test Scores: Evidence from US School Districts[†]

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We estimate the impact of district-level schooling mode (in-person versus hybrid or virtual learning) in the 2020–2021 school year on students' pass rates on standardized tests in grades 3–8 across 11 states. Pass rates declined from 2019 to 2021: an average of 12.8 percentage points in math and 6.8 in English language arts (ELA). Focusing on within-state, within–commuting zone variation in schooling mode, we estimate that districts with full in-person learning had significantly smaller declines (13.4 pp in math, 8.3 in ELA). The value to in-person learning was larger for districts with larger populations of Black students. (*JEL* H75, I12, I18, I21, I28, J15)

Over the course of the 2020–2021 school year, students across the United States experienced educational disruptions as schools and districts grappled with how—or if—to limit in-person instruction to mitigate the transmission of coronavirus disease 2019 (COVID-19). Uncertainty about the role of schools in the spread of COVID-19 forced school leaders to make difficult decisions about how to appropriately support both their students and staff (McLeod and Dulsky 2021). School districts thus utilized a range of schooling modes (sometimes called "learning models") throughout the year, including school closures with virtual learning options, full-time in-person instruction, and a combination of these approaches through a "hybrid" schooling mode, which took varying forms (Kaufman and Diliberti 2021; National Forum on Education Statistics 2021).

In this paper, we examine the impact of schooling disruptions over this period on students' pass rates on state standardized assessments. To do so, we combine data on district-level schooling mode with state assessment data for math and ELA in grades 3–8 across 11 states. We begin by documenting overall changes in pass rates during the pandemic and explore how those changes vary across states, schooling

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mode, and student demographics. Across the 11 states in our sample, student pass rates declined by 12.8 percentage points in math and 6.8 percentage points in ELA between 2019 and 2021, on average (spring 2020 assessments were not administered due to the pandemic). These declines varied by state; among the states in our sample, declines were largest in Virginia and smallest in Wyoming. The declines were larger in districts that had less in-person schooling and in districts with more Black students.

We describe how access to in-person schooling varied widely across our sample. What we observe reflects existing findings on variation in schooling mode across the United States (Kaufman and Diliberti 2021). For example, districts in Virginia offered in-person instruction for an average of only 9.7 percent of the school year, compared to 86.5 percent of the school year among districts in Wyoming. We present the distribution of time that districts in each state spent in each schooling mode, on average, in online Appendix Figure A1. In-person schooling both within and across states was more common in more politically conservative areas, as measured by a high Republican vote share in the 2020 presidential election, and in areas with higher community COVID-19 rates. In addition, in-person schooling was more common in districts that had higher baseline pass rates and a lower share of Black and Hispanic students.

Following these overall descriptive comparisons, we turn to isolating causal effects of schooling mode on pass rates. To do this, we exploit the fact that there was significant variation in schooling mode even across small geographic areas. School districts in the same state or county are likely to have had many of the same pandemic experiences—similar case rates, similar pandemic restrictions, and similar economic conditions. These other factors may have played a role in test score changes (Kogan and Lavertu 2021). By estimating models that control for local area, we hope to identify the causal impact of schooling mode on pass rates.

Our main regression specification uses a standard panel data approach, with data at the district-year level, to estimate the impact of the time spent in person or in hybrid learning (instead of virtual) on 2021 pass rates. We estimate these regressions controlling for county-level unemployment rate, time-varying district demographics, time-varying district enrollment, and test participation rates. The latter set of controls is important to capture the possibility of larger changes in enrollment in districts with more virtual schooling and differential changes in test participation across varying schooling modes. In addition, we include (in varying specifications) state-year fixed effects, commuting zone–year fixed effects, and county-year fixed effects.

Our results show that declines in student pass rates are larger in districts with less in-person schooling. The effect sizes are similar across each of our three specifications: offering fully in-person learning, rather than fully virtual learning, reduced pass rate losses by approximately 13–14 percentage points in math and approximately 8 percentage points in ELA between 2019 and 2021. Offering a hybrid model rather than a fully virtual approach reduced these losses by 7 percentage points in math and 5–6 in ELA.

We estimate interactions between schooling mode and district demographics. In math, the interactions between in-person learning and district share of Black students and share of students eligible for free and reduced-price lunch (FRPL) are positive and large (although strongly significant only for Black students). In contrast, there are no significant interactions with the Hispanic student share for math outcomes and no significant interactions across demographics for ELA testing.

Finally, we perform two auxiliary analyses. First, we analyze results by grade and find that the effects are larger, on average, in lower grades. Second, we use nine states that report multiple proficiency levels to estimate whether the effects we observe appear at other parts of the score distribution. These results are noisier than our primary results, but for math, in particular, we see that in-person learning decreases the share of students who are in the lowest proficiency group and increases the share in the highest.

Our paper contributes to a number of strands of literature. First, we add to the research about the characteristics of schooling modes in the United States in the 2020–2021 school year (Fuchs-Schündeln et al. 2021; Kurmann and Lalé 2022). Using cell phone data, Fuchs-Schündeln et al. (2021) find that younger students had more access to in-person instruction as compared to secondary students in 2020–2021, as did students in private schools and students in poorer US counties. Kurmann and Lalé (2022) similarly use cell phone data to track school closures in the United States and find evidence of greater access to in-person instruction in private schools, less affluent areas, and schools with a larger share of White students, which they assert is explained partly by a variety of regional differences. We expand on this work by using comprehensive state-reported schooling mode data to investigate differences across states and also to better understand differences across demographic characteristics.

More broadly, we add to the literature on how students' time out of school impacts their academic achievement (McCombs et al. 2011; Alexander, Pitcock, and Boulay 2016; von Hippel, Workman, and Downey 2018). McCombs et al. (2011) conclude that while all students experience summer learning loss, on average, this is particularly true for low-income students. Other research has focused on learning loss resulting from unplanned school closures or disruptions due to events such as weather emergencies (Pane et al. 2008; Lamb, Gross, and Lewis 2013; Harmey and Moss 2021). These studies generally find disrupted schooling is most harmful to students and schools that have fewer resources before the disruption.

We also contribute to the small but growing literature on the impacts of COVID-19 schooling disruptions on students, which includes, for example, impacts on aspects of students' health (Bacher-Hicks, Goodman, and Mulhern 2021; US Department of Education 2021a; Verlenden et al. 2021) and impacts on public school enrollment (Dee et al. 2021; Musaddiq et al. 2021). With regard to pandemic impacts on academic achievement, initial research provided *projections* of potential learning loss (Kuhfeld and Tarasawa 2020; Wyse et al. 2020), with estimates that impacts would be hardest on our nation's most vulnerable students (Dorn et al. 2020; Kuhfeld et al. 2020; Azevedo et al. 2021). Other research has relied on parent or teacher perspectives of student outcomes based on reported schooling mode (Chen et al. 2021; Verlenden et al. 2021).

Of note are several papers that use test scores to directly study the impact of spring 2020 closures on learning, largely in Europe (Contini et al. 2021; Engzell, Frey, and Verhagen 2021; Maldonado and De Witte 2021; Schult et al. 2022; Tomasik, Helbling, and Moser 2020) but also South Africa (Ardington, Wills, and Kotze 2021). In the US context, assessments in California (Pier et al. 2021) and nationally

(Kuhfeld, Soland, and Lewis 2022) find overall learning losses in both math and reading. A study of one district in the United States found that math and reading outcomes were negatively associated with the proportion of days a student participated in virtual learning (Darling-Aduana et al. 2022), and systematic reviews of the literature tend to find learning losses as a result of limited in-person schooling access (Hammerstein et al. 2021; Storey and Zhang 2021; West and Lake 2021). To date, however, little is known about how US student academic outcomes vary by state-reported schooling mode during the 2020–2021 school year, which is the focus of our study.

From a policy standpoint, our results highlight the educational implications of the pandemic, which may be long lasting. There is significant funding at both the federal and state levels to address these issues; our findings suggest the possibility of targeting certain districts and students in these efforts. These results also may provide a note of caution when considering school closures in the future.

I. Data

Our analyses use three groups of data: district-level schooling mode data from the 2020–2021 school year, district-level state standardized assessment data from spring 2016–2019 and 2021, and additional data including district-level demographic data from the National Center for Education Statistics (NCES) and county-level data for controls. We explain these data sources below.

A. *Schooling Mode Data*

Schooling mode data are drawn from the COVID-19 School Data Hub (CSDH) (COVID-19 School Data Hub 2022a, b). This is a public database, produced by our research team, which uses state-sourced data (typically from state education agencies, or SEAs) to document the schooling modes used by school districts during the 2020–2021 school year. CSDH staff reviewed all state data and either used each state's schooling mode classification or, if more than three categories were provided, collapsed the models into the following three categories for each time period (typically weekly or monthly): "in-person" (all or most students had access to traditional, five-day-per-week, in-person instruction), "virtual" (all or most students received instruction online five days a week), and "hybrid" (schooling modes that did not fall into one of the other two approaches). Note that *access* to in-person instruction indicates that schools were open for full-time in-person attendance, but students may still have had the opportunity to attend virtually. District- and school-level K–12 enrollment totals are sourced from 2020–2021 SEA enrollment counts. We provide additional detail about the schooling mode data used in the analyses in online Appendix Table B3.[1]

We included states in our analyses if the state provided schooling mode data at monthly, biweekly, or weekly intervals during the 2020–2021 school year. Where

[1] More details about the data construction in each state are available from the CSDH at https://www.covidschooldatahub.com/. The CSDH also contains data on student enrollment by schooling mode, if available from SEAs. We do not use those data here.

states provided district-level schooling mode data, we used this in our analyses. Three states (Mississippi, Rhode Island, and Wisconsin) provided only school-level schooling mode. We constructed measures for exposure to each schooling mode by using each time period's schooling mode classification, the length of the time period, and the school or district K–12 enrollment depending on the level of the data file. We then calculated the total number of student days spent in each schooling mode by district for the entire 2020–2021 school year. Finally, we divided the number of district-level student days for each schooling mode by total district-level student days for the full school year to generate shares by schooling mode. We did not include the week of Thanksgiving 2020 or the last two weeks of December 2020 in this calculation even when districts reported a schooling mode for those weeks.

This continuous measure of the shares by schooling mode represents our best attempt at capturing the amount of time that school districts offered in-person, hybrid, or virtual instruction during the 2020–2021 school year. However, changes occurred on a daily basis throughout the year at the district, school, and classroom level due to county-level COVID-19 case rates, state- and district-level quarantine procedures, and parental or community input.

B. *Assessment Data*

To measure changes in students' pass rates in math and ELA, we use state standardized assessment data between spring 2016–2019 and 2021. Spring 2020 assessment data are not included given widespread school closures and cancellations of student testing across the nation. Spring 2021 assessments, however, were required of all but three states (New Jersey, Pennsylvania, and Washington) that received federal waivers to postpone test administration (Pitts and Pillow 2022); these assessments reflect the "pandemic year" of 2020–2021.

We included states in our analysis if they met the following assessment criteria. First, at least two years of prepandemic test data were available. Second, no significant changes to the assessment content occurred over this period, which would have prohibited comparisons. We excluded Alaska, Nevada, and New York due to low assessment participation rates in 2021 (approximately 64 percent overall in Alaska, 40 percent overall in New York, and 61 percent overall in Nevada). We present each state's testing details (assessment names, participation rates, etc.) in online Appendix Table B1.

In spring 2021, the US Department of Education invited states to submit waiver requests if flexibility was needed to administer assessments safely (US Department of Education 2021b). For example, five states in our sample were granted waivers to allow districts to extend their testing window. Of the 11 states in the sample, all but Connecticut and Massachusetts required students to complete the spring 2021 assessments in person. In Massachusetts, the state indicated that while 20 percent of test takers completed the assessment remotely, in-person and remote test takers performed similarly (Massachusetts Department of Elementary and Secondary Education 2021a, b). In Connecticut, 12 percent of test takers participated remotely. While demographic characteristics between remote and in-person test takers were comparable, initial state analyses have found statistically significant differences between these students (Connecticut State Department of Education 2021a). Our results are robust to dropping Connecticut from the analysis. We include more detailed information about state-specific testing protocols due to COVID-19 in online Appendix Table B2.

Our primary outcomes are pass rates for students in grades 3–8 in ELA and math, as measured by the share of students who score proficient or above in ELA or math on state assessments. When possible, we will consider pass rates by grade and consider higher and lower score cutoffs. We draw from district-level participation data across all states to show robustness to variation in participation.

Our final sample includes 11 states: Colorado, Connecticut, Massachusetts, Minnesota, Mississippi, Ohio, Rhode Island, Virginia, West Virginia, Wisconsin, and Wyoming. Several states have also reported learning losses using these raw data (Colorado Department of Education 2021b; Connecticut State Department of Education 2021a; Ohio Department of Education 2021a; Rhode Island Department of Education 2021a).

C. *Additional Data Sources*

In addition to our primary data sources, we use student demographic data from NCES, accessible via the Urban Institute's Education Data Portal (Urban Institute 2022). These data include district-level information on the share of enrolled students by race and ethnicity, English-language-learner (ELL) status, and school-level information on eligibility for FRPL, which we aggregated to the district level. To capture the possible role of variation in COVID-19 case rates in driving district opening decisions, we use county-level COVID-19 case counts from USA Facts (which compiles daily county-level cumulative totals of positive cases from state public health websites) matched with district-level zip codes (COVID-19 School Data Hub 2021). We focus on the average level of COVID-19 cases per 1,000 people between August 2020 and June 2021 in the primary zip code of the school district.

Finally, we use data on the Republican vote share by county in the 2020 presidential election (McGovern 2021), commuting zone data from the US Department of Agriculture, and monthly county-level unemployment data from the US Bureau of Labor Statistics averaged by school year from June to May for 2016–2021.

D. *Summary Statistics and Reopening Determinants*

In Table 1, we present summary statistics by state on the number of districts included in the sample, the average number of years of assessment data in the sample, the average percent of the school year that districts offered each schooling mode, and district demographic characteristics. Of the states in our analyses, in-person learning rates are highest in Wyoming (86.5 percent) and Mississippi (66.7 percent) and lowest in Minnesota (16.2 percent) and Virginia (9.7 percent). Conversely, Virginia and Colorado have the highest share of district time spent in fully virtual learning (38.6 percent and 27.3 percent, respectively). States in the sample vary across demographic characteristics as well, including their share of students who are Black and Hispanic, eligible for FRPL programs, and those who are ELLs.

In Table 2, we illustrate the pairwise correlations between the demographic and pandemic variables and in-person learning. We explore these correlations in the

Table 1—Summary Statistics by State and Overall

	Demographic characteristics and schooling mode							
	Districts	Avg. years	% in-person	% hybrid	% virtual	% Black or Hispanic	% FRPL	% ELL
CO	136	4.7	28.9	43.8	27.3	37.8	41.4	11.5
CT	160	5.0	47.4	36.3	9.1	35.1	37.4	6.7
MA	284	4.0	27.4	54.4	18.2	26.9	–	9.1
MN	340	4.9	16.2	69.1	14.7	17.6	36.4	7.5
MS	134	4.9	66.7	18.4	14.9	51.5	73.9	2.3
OH	606	5.0	50.0	32.1	17.1	19.0	43.7	3.1
RI	37	2.9	44.5	41.8	8.2	31.5	44.7	8.8
VA	132	5.0	9.7	51.8	38.6	37.4	40.4	8.7
WI	396	5.0	51.5	22.1	18.4	19.9	39.1	5.4
WV	55	5.0	37.6	41.4	17.4	6.1	49.2	1.1
WY	48	3.0	86.5	6.2	0.7	14.7	37.0	3.0
Overall	2,328	4.8	35.4	41.9	20.9	27.7	42.9	6.7

Notes: This table shows summary statistics for the 11 states included in the sample. "Districts" represents the number of school districts included in the sample due to available data. "Avg. years" represents the average number of years of assessment data for districts in the state. Schooling mode variables ("% in-person," "% hybrid," "% virtual") are drawn from the CSDH and represent the average percent of the school year that the state's school districts offered each schooling mode. Demographic variables include the share of students who are Black or Hispanic (based on NCES 2020–2021 data), the share of students who are eligible for FRPL (based on NCES 2019–2020 data due to changes in reporting requirements in 2020–2021; Massachusetts does not report FRPL and is excluded here), and the share of ELLs (based on NCES 2018–2019 data, the most recent data available).

sample overall and then within state and within commuting zone. In all specifications, we observe more in-person learning in districts with higher baseline pass rates, fewer Black and Hispanic students, and smaller populations of students who are ELLs or FRPL eligible. Put differently, the overall picture suggests that districts with more historically underserved students were less likely to offer in-person schooling.

Table 2 also shows that districts with a greater Republican vote share in 2020 were also more likely to have in-person learning than districts with lower Republican vote shares. In addition, districts with higher COVID-19 rates showed greater in-person schooling. Much has been written on the possible role of schools in driving COVID-19 cases, most of which suggests that schools were not significant drivers of COVID-19 (UNICEF 2020; Goldhaber et al. 2021; Harris, Ziedan, and Hassig 2021). The positive correlation here likely reflects differences in other pandemic restrictions that were correlated with schooling mode choice and influenced COVID-19 rates.

II. Results

A. *Changes in Pass Rates in Spring* 2021

In Figure 1, we illustrate the year-on-year average percentage point changes in pass rates in math and ELA between spring 2016–2019 and spring 2021 overall, by state, by the share of districts offering in-person instruction, and by demographic group. We represent prior year-on-year changes in pass rates with light circles to

Table 2—Pairwise Correlations between In-Person Learning on District Demographic and Pandemic Variables

	Correlation (no fixed effects)		Correlation (state fixed effects)		Correlation (commute zone fixed effects)	
Previous pass rate	0.440	(0.066)	0.611	(0.062)	0.598	(0.053)
Share Black	−0.465	(0.039)	−0.752	(0.043)	−0.757	(0.041)
Share Hispanic	−0.442	(0.067)	−0.328	(0.063)	−0.296	(0.061)
Share FRPL	−0.160	(0.048)	−0.255	(0.048)	−0.365	(0.046)
Share ELL	−1.290	(0.121)	−0.879	(0.104)	−0.764	(0.099)
Avg. case rate	0.803	(0.199)	0.367	(0.107)	0.115	(0.051)
Repub. vote share	0.010	(0.000)	0.010	(0.000)	0.009	(0.001)

Notes: This table shows the pairwise correlations of the share of days in person during the 2020–2021 school year with district demographic and pandemic characteristics. We present the correlations of the sample overall, without fixed effects included (“no fixed effects”), with state-year fixed effects (“state fixed effects”), and with commuting zone fixed effects (“commute zone fixed effects”). The share in person measures the share of time during the 2020–2021 school year that the district offered full-time in-person instruction (rather than hybrid or virtual instruction). “Previous pass rate” represents the average pass rate on state standardized assessments for students in grades 3–8 between 2016 and 2019 for districts in each state. Demographic variables include the share of students who are Black (based on NCES 2020–2021 data), the share of students who are Hispanic (based on NCES 2020–2021 data), the share of students who are eligible for FRPL (based on NCES 2019–2020 data due to changes in reporting requirements in 2020–2021; Massachusetts does not report FRPL and is excluded here), and the share of ELLs (based on NCES 2018–2019 data, the most recent data available). “Avg. case rate” represents average district-level COVID-19 case counts per 1,000 people between August 2020 and June 2021 (COVID-19 School Data Hub 2021). “Repub. vote share” represents the Republican vote share in 2020 national elections (McGovern 2021). Each cell represents a separate regression, weighted by district enrollment. Robust standard errors are reported in parentheses.

give a sense of the general pattern of variation in the prepandemic period, while the year-on-year change from spring 2019 to 2021 is represented with dark circles.

There are consistent declines in pass rates across all areas and groups in spring 2021. Overall, enrollment-weighted average pass rates declined by 12.8 percentage points between 2019 and 2021 in math and 6.8 in ELA, with considerable variation across states in these declines. In both math and ELA, the largest declines were seen in Virginia (34.1 and 10.1 percentage points, respectively), with the smallest declines in Wyoming (3.7 and 3.1 percentage points, respectively).

We also observe that pass rate losses are larger in districts that offered less in-person learning, grouping districts based on the share of student days that they offered full-time in-person learning (0–25 percent, 25–50 percent, 50–75 percent, and 75–100 percent, lower bound included). Examining pass rate changes across demographic groups, we observe that districts with a larger share of Black students had larger declines in pass rates in spring 2021. There was more limited variation in pass rate changes across the share of Hispanic, FRPL-eligible, or ELL students.

Prior to the pandemic, we saw limited movement in pass rates across any of these groups. The pandemic school year of 2020–2021 stands out starkly for the large changes. We also consistently see across all groups that changes in pass rates for math are considerably larger than the changes in pass rates for ELA. This is consistent with NWEA’s finding that students experienced greater achievement declines in math as compared to ELA in spring 2021 (Lewis et al. 2021) and aligns with a larger

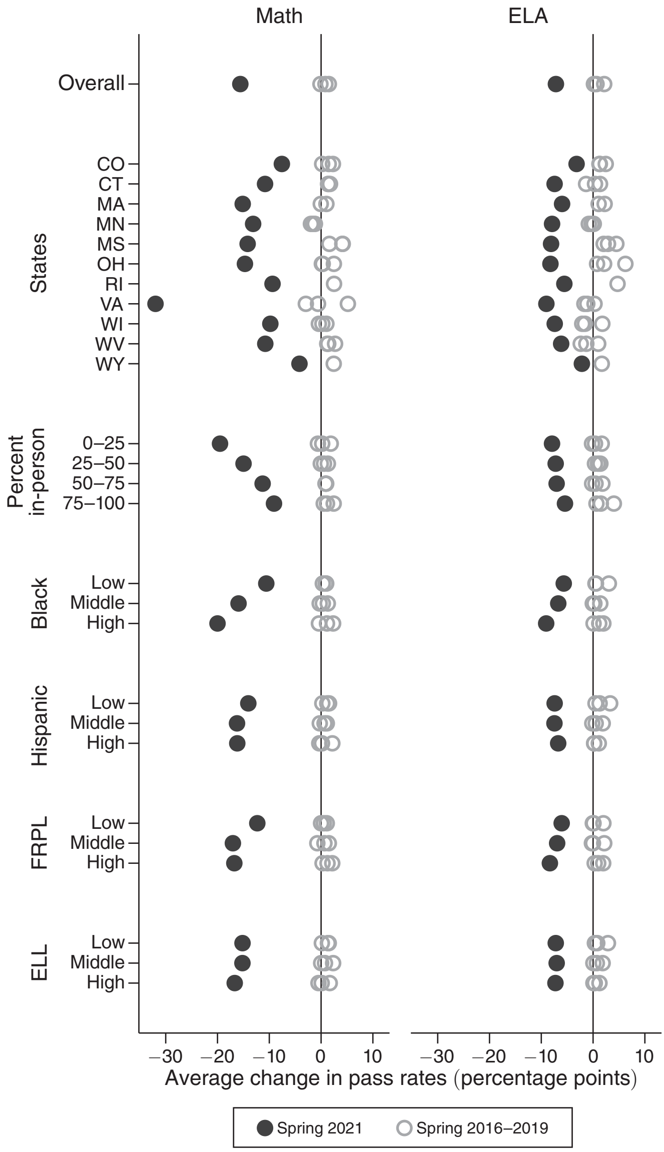

Figure 1. Average Change in Pass Rates on State Standardized Assessments in Spring 2021 versus Spring 2016–2019

Notes: This figure shows the average percentage point change in pass rates in math (left) and ELA (right) for students in grades 3–8 on state standardized assessments from the previous testing year, weighted by enrollment. Spring 2021 is calculated as the change between 2021 pass rates and 2019 pass rates (dark circles); additional data points represent 2019 versus 2018, 2018 versus 2017, and 2017 versus 2016 (light circles). Pass rates are measured by the number of students achieving proficiency or above in each subject area. Comparisons are presented for all students in the sample (overall), by state, by the percent of in-person instruction offered by districts over the 2020–2021 school year, by the share of students who are Black or Hispanic (based on NCES 2020–2021 data), by the share of students who are eligible for FRPL (based on NCES 2019–2020 data due to changes in reporting requirements in 2020–2021; Massachusetts does not report FRPL and is excluded here), and by the share of ELLs (based on NCES 2018–2019 data, the most recent data available). Schooling mode data are from the CSDH. Ranges for "Percent in-person" groups include the lower bound of each range.

literature that shows that math scores are more responsive to schooling differences (Betts and Tang 2011; Angrist, Pathak, and Walters 2013).

B. *Impacts of Schooling Mode on Pass Rates*

Our focus here is isolating the impact of schooling mode on pass rates. Our primary treatments are the share of student days that districts offered full-time in-person learning options or hybrid learning options. These are estimated relative to the share of student days where school was fully virtual.

Empirical Strategy.—We estimate a standard panel regression at the district-year level. The independent variables of interest are the in-person and hybrid shares; the outcome is the average pass rate in math or ELA over grades 3–8. All regressions include district and year fixed effects, and standard errors are clustered by district.

There are two key concerns to consider with this analysis. The first is the possibility that results are driven by other differences across areas in the pandemic experience. This could include differences in COVID-19 rates or political leanings, for example. Perhaps most relevant is that areas with greater school closures may have also experienced more restrictions related to commerce, travel, and general access to public spaces, as well as more labor market disruptions. To the extent that adult unemployment affects student school performance (Kogan and Lavertu 2021), this could drive part of the impacts we observe. The second key concern is that changes in enrollment or participation in testing could bias our results.

We address the first concern to the extent possible by focusing our analysis on variations in schooling mode within geographies that had otherwise similar pandemic experiences. In particular, we consider regressions that include either state-year fixed effects, commuting zone–year fixed effects, or county-year fixed effects.

The estimating equation is below.

$$(1) \qquad pass_{ict} = \alpha + \beta_1(\%InPerson_{it}) + \beta_2(\%Hybrid_{it}) + \gamma_{ct} + \delta_t + \eta_i + \Pi X_{ict} + \epsilon_{ict}.$$

In this equation, $pass_{ict}$ is the pass rate for district i in location c in year t. The location is either state, commuting zone, or county. The coefficients of interest are β_1 and β_2, the impacts of the percent of time spent in person or hybrid (instead of virtual). Note that in years prior to 2021, all school districts are coded as fully in person. The regression includes district fixed effects (η_i), year fixed effects (δ_t), location-year fixed effects (γ_{ct}), and time-varying district-level controls (X_{ict}). Given the inclusion of year and district fixed effects, our effects are identified off of variation in the 2021 year schooling experience.

Our second concern is that variation in enrollment or participation in testing could bias the results. On enrollment: during the pandemic, some students left the US public school system and therefore may not appear in the testing pool at all (this could have been due to homeschool or private school enrollment, delayed kindergarten enrollment, or dropping out of school, for example (Dee et al. 2021)). To the extent that these declines are larger in areas with more virtual learning, and to the extent that the group that left the system has systematically higher or lower test scores, this could bias our results. Dee et al. (2021) show relatively small drops in enrollment in the grades we consider here. However, in official NCES enrollment data for our particular states for the 2020–2021 school year, we find larger declines (3 to 6 percentage points overall, relative to 2019). Since we observe enrollment directly, we include it in the regression to address the possible bias.

In addition to enrollment declines, many states experienced lower test participation rates in the 2020–2021 school year (Pitts and Pillow 2022). This was at least in part due to a waiver of accountability requirements by the US Department of Education (US Department of Education 2021b). In our data, we observe that the 2021 participation rate drops are typically larger in districts with more virtual learning. Our baseline estimates will be accurate for the overall population if test takers are drawn randomly from the population. If those who opt in to the test are likely to perform *better*, then our estimates will understate the losses. If those who opt in are likely to perform worse, then our estimates will overstate them.

Based on state reports, participation declines during the pandemic appear to be larger among historically underserved student groups, such as students of color, students of lower socioeconomic status (SES) backgrounds, and students receiving special education services, among other student subgroups (Colorado Department of Education 2021b; Ohio Department of Education 2021a; Rhode Island Department of Education 2021a). Participation among ELLs also declined nationally by approximately 30 percentage points (Sahakyan and Cook 2021). Assessment scores for these students typically lag behind other student subgroups, such as their White peers, higher-SES students, or students who are English proficient (Carnoy and García 2017). For these reasons, failing to adjust for participation differences is likely to bias us against finding a positive impact of in-person learning.

As with enrollment, however, we observe participation directly and are able to control for it in all of our regressions. All regressions we consider include both enrollment counts and participation rates in the time-varying controls (in X_{ict} in equation (1)).

Primary Results.—We present our results in Table 3. Columns 1–3 show the results for math, columns 4–6 for ELA. Moving across columns within subjects, we add area-year fixed effects for progressively smaller areas.

The coefficients are quite stable across specifications and highly significant in all of them. In terms of magnitude, these regressions suggest that moving a district from fully virtual to 100 percent access to in-person learning would have reduced pass rate losses in spring 2021 by 13–14 percentage points in math and about 8 percentage points in ELA. Moving from fully virtual to fully hybrid would have reduced pass rate losses by about 7 percentage points in math and 5–6 percentage points in ELA. Focusing on within-state, within–commuting zone variation in schooling mode, we estimate that districts with full in-person learning had an average decline of 13.4 percentage points less in math and 8.3 percentage points less in ELA.

These results suggest that even within relatively small geographic areas, differences in schooling access correlate with differences in pass rates. Schooling mode isn't random, of course, and it is difficult to fully rule out all possible confounds.

TABLE 3—SCHOOLING MODE AND CHANGES IN PASS RATES

	Math			ELA		
	(1)	(2)	(3)	(4)	(5)	(6)
	Pass rate	Pass rate	Pass rate	Pass rate	Pass rate	Pass rate
Panel A. Main specifications						
% in-person	0.140	0.134	0.128	0.0813	0.0828	0.0872
	(0.0137)	(0.0147)	(0.0156)	(0.0102)	(0.0105)	(0.0105)
% hybrid	0.0776	0.0722	0.0743	0.0608	0.0537	0.0637
	(0.0143)	(0.0148)	(0.0161)	(0.0116)	(0.00949)	(0.00994)
Observations	11,041	11,041	11,041	11,064	11,064	11,064
Commute zone × year	No	Yes	No	No	Yes	No
County × year	No	No	Yes	No	No	Yes
Panel B. Demographic interactions						
% in-person × 2021	0.0960	0.156	0.0872	0.0686	0.0784	0.0729
	(0.0174)	(0.0196)	(0.0388)	(0.0138)	(0.0123)	(0.0276)
% hybrid × 2021	0.0379	0.0907	0.0280	0.0381	0.0409	0.0360
	(0.0169)	(0.0205)	(0.0388)	(0.0129)	(0.0123)	(0.0279)
% Black × % in-person × 2021	0.0943			0.0193		
	(0.0398)			(0.0240)		
% Black × % hybrid × 2021	0.0855			0.0508		
	(0.0472)			(0.0279)		
% Hispanic × % in-person × 2021		−0.135			−0.0178	
		(0.0680)			(0.0482)	
% Hispanic × % hybrid × 2021		−0.0664			0.0247	
		(0.0734)			(0.0421)	
% FRPL × % in-person × 2021			0.0810			0.000259
			(0.0582)			(0.0371)
% FRPL × % hybrid × 2021			0.0689			0.0153
			(0.0605)			(0.0380)
Observations	11,041	11,041	9,620	11,064	11,064	9,643
Commute zone × year	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the relationship between district in-person share, hybrid share, and pass rates in math and ELA on state standardized assessments for students in grades 3–8. Virtual share is the reference group. In panel A, we present our results for state-year fixed effects in columns 1 and 4 for math and ELA, respectively, for commuting zone–year fixed effects in columns 2 and 5, and for county-year fixed effects in columns 3 and 6. All regressions are weighted by district enrollment and include district fixed effects, year fixed effects, state-year fixed effects, demographic controls (race/ethnicity shares, share of students eligible for FRPL, and share of ELLs), county-level unemployment rates from the US Bureau of Labor Statistics averaged by school year from June through May for 2016–2021, district enrollment, and test participation controls. Smaller commuting zone–year fixed effects and county-year fixed effects are included in some columns (as noted in the table). In panel B, we allow effects of race to vary by in-person shares in earlier years. Standard errors are clustered by district and reported in parentheses. Details on assessment data for each state are provided in online Appendix B.

However, these analyses give us additional confidence that the effects we see on pass rates are primarily driven by school experience.

Demographic Variation.—To explore demographic variation in the effect of in-person learning, we estimate regressions with interactions between demographics and schooling mode. In these regressions, we include interactions between race and ethnicity or FRPL shares and the in-person and hybrid variables. We include, as well, baseline interactions between demographic variables and later schooling mode. This allows for the possibility that districts that differed in their schooling mode choice might have been trending differently for other reasons.

The results are shown in Table 3, panel B. We focus here on the commuting zone fixed effects model, since this isolates a relatively small area but avoids the issue that many districts overlap fully with counties. As seen in panel A, all three models are very similar. The coefficient on the interaction with the share of Black students is positive and significant for math, suggesting that the impacts of in-person learning are about twice as large for a district with 100 percent Black students versus 0 percent Black students. In terms of point estimates, we see a similar result for FRPL share, although not significant. We do not find the same result for either Hispanic share or ELA testing.

This finding suggests amplification of the disparate impact of the pandemic schooling disruptions on Black students in particular. Districts with more Black students were less likely to have access to in-person schooling in the first place; thus, even if the impact of less access to in-person instruction were the same across districts, this group would be more impacted overall. The finding here shows that these districts *also* had the largest impact of the alterations in schooling mode.

Additional Analyses.—We consider two additional analyses: effects by grade and effects for different academic proficiency levels. As with the demographic variation, we focus on the commuting zone fixed effect specification, as shown in columns 2 and 5 of Table 3.

In Table 4, panel A, we provide estimates of the impact of in-person and hybrid learning by grade. This is relevant for two reasons. First, we may be interested in whether there are variations in the value of in-person learning by age group. Second, to the extent that there are changes in the size of these grades as a result of the pandemic, it is possible that these changes could be driving the overall impact (this would be a form of Simpson's paradox).

The effects estimated by grade are noisier but largely significant across most grades and subjects. In general, we see higher impacts in younger grades. This is especially true for in-person learning. This may reflect a greater benefit of consistent in-person time for younger students, although based on these data alone, it is difficult to fully elucidate mechanisms. Reports suggest that in-person learning is particularly important for students in grades K–3 given that they are "still developing the skills needed to regulate their own behavior and emotions, maintain attention, and monitor their own learning" (National Academies of Sciences, Engineering, and Medicine 2020, 30), which are each critical aspects of virtual learning.

As noted, our primary outcome is pass rates, defined as the share of students who receive a score that the state defines as sufficient to indicate mastery of that grade-level material. One concern about this single cutoff is that it may be less responsive to learning changes in some districts than others. In a high-performing district where nearly all students perform well above the pass rate level, declines in learning may not reflect in this "pass" outcome. To the extent that these higher-performing districts are more likely to have in-person learning, this could bias the results.

As a final robustness check, therefore, we present the impact of schooling mode on two other metrics in Table 4, panel B. The first is the share of students in the lowest academic proficiency category (as defined by each state); the second is the

Table 4—Robustness by Grade Level and Alternative Pass Rate Cutoffs

	Math				ELA			
	In-person		Hybrid		In-person		Hybrid	
Panel A. By grade								
All	0.167	(0.019)	0.101	(0.020)	0.084	(0.012)	0.054	(0.012)
Grade 3	0.233	(0.020)	0.182	(0.022)	0.107	(0.014)	0.087	(0.013)
Grade 4	0.241	(0.022)	0.181	(0.024)	0.138	(0.015)	0.095	(0.015)
Grade 5	0.217	(0.025)	0.157	(0.028)	0.088	(0.015)	0.061	(0.014)
Grade 6	0.139	(0.038)	0.061	(0.041)	0.092	(0.015)	0.055	(0.016)
Grade 7	0.057	(0.028)	−0.016	(0.033)	0.049	(0.017)	0.017	(0.019)
Grade 8	0.122	(0.036)	0.044	(0.040)	0.080	(0.018)	0.051	(0.018)
Panel B. Alternative cutoffs								
All	0.127	(0.019)	0.064	(0.017)	0.068	(0.014)	0.045	(0.011)
Below pass	−0.101	(0.027)	−0.113	(0.022)	−0.022	(0.019)	−0.043	(0.016)
Advanced pass	0.024	(0.007)	−0.007	(0.007)	0.014	(0.006)	−0.002	(0.006)

Notes: This table shows robustness analyses. All regressions follow the form of column 2 in Table 3 and include commuting zone fixed effects. Panel A estimates the impacts of in-person learning on student pass rates on state standardized assessments by grade. These grade-level data are missing for Massachusetts, so the first row estimates the overall impact for the subset of states with data. Panel B estimates the impact on alternative pass rate cutoffs (we are missing data from Ohio and Virginia). "Below pass" is the lowest cutoff in the state, and "Advanced pass" is the highest. Standard errors are clustered by district.

share of students in the highest category. By examining the lowest and highest categories, we are able to see whether there are impacts of schooling mode on the lower- and higher-performing parts of the distribution. Eight states in our sample have four academic proficiency categories, with passing scores defined as being in one of the top two groups (Colorado, Connecticut, Massachusetts, Minnesota, Rhode Island, Wisconsin, West Virginia, and Wyoming), one state has five categories (Mississippi), and we do not have these measures for two states (Ohio and Virginia). We find that more in-person learning seems to decrease the share of students in the lowest proficiency category and increase the share in the highest category. These results suggest that in-person learning matters across the distribution. We provide more detail on each state's proficiency levels in online Appendix Table B1.

III. Conclusion

This paper analyzes the relationship between in-person schooling mode and pass rate changes on state standardized assessments during the COVID-19 pandemic of the 2020–2021 school year. Overall, we find considerable declines in math and ELA pass rates for students in grades 3–8 in spring 2021, and these declines were larger in school districts with less in-person instruction. Pass rate declines were larger in districts serving a higher population of Black students, due in part to less access to in-person learning and perhaps also in part to a greater positive impact of in-person learning on Black students.

Test scores are only one measure of student learning during the 2020–2021 school year. This paper cannot capture ways that students learned that were not reflected on such assessments; we also cannot account for pandemic-related changes in students' lives beyond schooling mode. We acknowledge the significant variation at the district level in terms of how districts chose to structure their virtual and hybrid learning approaches as well as students' access to digital devices and the internet, which was particularly a challenge for virtual education in high-poverty schools (Diliberti and Kaufman 2020). These schooling mode data cannot capture such variation, nor can they provide a measure of instructional *quality*. However, it is likely that learning losses varied by the quality of virtual instruction (Dorn et al. 2020), which would be an important area for future research.

Taken together, however, these results can serve as a starting point for education leaders and policymakers as they weigh where to target funding moving forward in order to support student learning. Specifically, our analyses suggest that a focus on areas that had less in-person learning over the 2020–2021 school year would be critical. More generally, our analyses demonstrate that hybrid or virtual schooling modes cannot support student learning in the same way as fully in-person instruction, at least during this elementary and middle school period. As such, educational impacts of schooling mode on students' learning outcomes should be a critical factor in policy responses to future pandemics or other large-scale schooling disruptions.

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