Understanding changes in academic achievement and online learning application use in Pittsburgh Public Schools during the COVID-19 pandemic: Methodology memo

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This memo describes the data, samples, and analysis methods for the Regional Educational Laboratory (REL) Mid-Atlantic study with Pittsburgh Public Schools (PPS) titled *Understanding changes in academic achievement and online learning application use in Pittsburgh Public Schools during the COVID-19 pandemic*. This study has two main research questions, split by topic:

1. Changes in academic achievement:
    a. During the 2019/20 to 2020/21 school years, was there a change in the proportion of students (1) taking the NWEA math and reading tests and (2) receiving grades; and if there was a notable change in the proportion, did the demographic characteristics of included students change?
    b. How has academic achievement, as measured by test scores and grades, changed during the pandemic? How do changes in academic achievement vary across grades and demographic groups?
2. Online learning application use:
    a. How much and in what ways did students access and use online learning applications while learning remotely? How does access and usage vary across grades and demographic groups? How does access and usage vary over time in the 2020-21 school year? Is there more variation between schools, between teachers in a school, or between students with the same teacher?
    b. How are logins and measures of activity in the learning management system related to grades and absences?

Data

The key data sources for this study are PPS's student administrative records, including enrollment records, demographics, grades, test scores, and online learning applications.

Enrollment and demographics. The student administrative data files have information for all PPS students enrolled in 2019/20 and 2020/21. The data include basic demographic information, such as gender, special education status, free or reduced-price lunch status, and race/ethnicity, as shown in table 1. They also include enrollment information, such as school and grade level, for all schools and grades a student was enrolled in during the year, along with dates of enrollment. We assigned students to schools and grade levels based on their school and grade level in the enrollment records during the NWEA Measures of Academic Progress (MAP) assessment windows. For all students we used the following reference dates to determine their school and grade level during each assessment window, as these were near the midpoint of the assessment window:

- Fall: October 1
- Winter: December 15 for 2019/20 and January 15 for 2020/21
- Spring: March 1

For any students who were enrolled at any point during the assessment window for a given test but not enrolled on the reference date, we determined the school and grade level using the enrollment day that was closest to the reference date. For example, if a student entered the district during the fall assessment window on October 3, we assigned them a school and grade level for the fall assessment window based on their October 3 enrollment.

Course/subject grades. The student grade files included information about students' quarterly and semester grades. Our study focuses on grades from the first semester (quarter 1 and quarter 2) for 2019/20 and 2020/21, because the first semester of 2019/20 occurred before PPS switched to remote learning. To identify student grades in each course for the first semester, we used the semester grade for a course first. If the semester grade

was not available for a course, we took an average of the quarter 1 and quarter 2 grades, after converting letter grades to a numeric scale (A=4.0, B=3.0, C=2.0, D=1.0, E=0.0). In less than 3 percent of student–course–quarters, a student had multiple grades in a quarter. In these cases, we took the highest grade. We ignored grades for citizenship (i.e., class behavior), quarter credit, and final exams, as well as grades the district overrode. After these steps, 99.7 percent of all courses in the grade data for the first semester of 2019/20 or 2020/21 had a valid semester letter grade (A, B, C, D, or E).

To calculate first semester grade point average (GPA), we took the average numeric grade across all subjects for each student to calculate each student's GPA. To identify course failures, we created an indicator variable to identify all cases in which a student received a grade of "E" for a course in the first semester (PPS uses "E" to indicate a failing grade). We calculated GPA for students in grades 1–12, as these students received letter grades A–E. We did not include kindergarteners in any of our grade outcomes because most kindergarteners only received citizenship grades. For students enrolled in grades 1–12, only 1.7 percent received no semester grade in first semester 2019/20 and 2.3 percent in first semester 2020/21.

NWEA MAP test scores. The NWEA MAP test score files include test scores for math and reading in grade levels K–12. NWEA MAP tests are offered in fall, winter, and spring in PPS. At the time the data were collected in early spring 2021, we received fall, winter, and spring test scores for 2019/20 and fall and winter scores for 2020/21.

Because the NWEA MAP tests are vertically aligned, students across grades receive scores on the same scale. We used these scale scores for some analyses to identify how much students have grown in terms of scale score points over the last year. We also calculated standardized scale scores, standardizing within subject, grade level, and year relative to the national means and standard deviations reported by NWEA from a norming study conducted before the pandemic (Thum & Kuhfeld, 2020). Standardizing scores in each year relative to the same pre-pandemic benchmark allows us to examine changes in student achievement relative to pre-pandemic national norms.

We also used the standardized scores to create indicator variables to assign students to quartiles of the national distribution using the fall 2019/20 math and reading scores. These indicators identify student subgroups based on baseline test scores.

Online learning application data: Schoology. Schoology is PPS's learning management system. Through Schoology, teachers make announcements, share course materials (e.g., videos, reading materials), give assignments, give quizzes and tests, and post discussion boards for students. Students use Schoology to view course materials and announcements and submit assignments, assessments, and discussion posts. [1] The vast majority of courses with more than 10 students enrolled in them during 2020/21 have at least one course action in Schoology (79 percent of courses in grades K–5, 91 percent in grades 6–8, and 94 percent in grades 9–12).

The Schoology data file contains a record for every action a user takes in the learning management system from the start of the school year on September 8, 2020, through April 5, 2021. Although users include students, teachers, and other staff, we only use student data. Actions include logging into the system and interacting with course material, such as opening course materials or submitting any materials, including assignments, assessments, and discussion posts.

Any action that involves opening or submitting course materials has a course code associated with it that we can link to PPS's course enrollment data. Within PPS course enrollment data, we linked students to the courses they were enrolled in as of October 1, 2020, for the fall semester and March 1, 2021, for the spring semester. (Choosing a date several weeks into the semester allows students time to settle into their courses.) We dropped any courses in Schoology that are not in the PPS course data. For all remaining course actions, we calculated summary

[1] Pittsburgh Public Schools. (n.d.) E-Learning resources and instructional videos. https://www.pghschools.org/Page/5410.

measures for each student describing their actions for any course and for their math, English, science, and social studies courses. See table 1 for the measures we report.

To identify a student's math, English, science, and social studies courses, we used department codes from PPS's administrative data. In elementary grades, we combined reading, handwriting, and spelling classes under the English category. In core subjects (math, science, English, and social studies), 87 percent of courses students are enrolled in in the first semester of 2020/21 have Schoology usage. In grades 6–12, 97 percent of core subject classes that students are enrolled in in the first semester of 2020/21 have Schoology usage, while only 72 percent of elementary core classes do.

Online learning application data: Clever. Clever is a single sign-on service that allows students to enter their user name and password once to gain access to all district-approved online resources. Students can use Clever to access Microsoft Teams (the conferencing software used for synchronous classes), Schoology, Edmentum, and other resources. Although all students in all grades are encouraged to use Clever to log in to any online learning resources, students can also log in directly to resources without going through Clever.

The Clever data files include daily records for each student on the number of logins to Clever and the number of resources accessed. They also include daily records for each student on the specific resources students accessed via Clever. The date range for the daily records we used is from September 8, 2020, through March 26, 2021. From the resource list, we identified all supplemental math or reading products, excluding online textbook resources. The purpose of separating these resources was to understand how use of supplemental math and reading products might substitute for use of Edmentum (discussed in the next section). See table 1 for the measures we report.

Online learning application data: Edmentum (Exact Path). Edmentum's Exact Path is an online supplemental math and reading product that provides individualized learning. The product uses diagnostic assessments to provide self-paced, targeted instruction and practice. Students can move forward to new content when they master a skill. Students struggling with a skill will receive remediation to help them master content.[2] For 2020/21, Pittsburgh intended all students to use Exact Path for math for approximately 45 minutes per week.

The Edmentum Exact Path data came in two data files: (1) daily cumulative counts of logins, activities completed, skills mastered, and time on activities, each by subject, and (2) year-to-date progress in several activities toward mastery of a skill, also by subject. The first file describes the intensity with which a student practices skills in a subject, while the second shows the unique activities and skills the student worked on.

For the daily usage file, we reset usage measures to zero where we observed negative progress from one day to the next, which affected 0.2 percent of student-day-subject level records. Another challenge with the daily usage file was that the district appeared to not receive any data on 33 percent of instructional days, especially early in the academic year. The flow of data during this time was concentrated on some days, likely because multiple days' worth of usage was being downloaded on a single day to catch up for days in which no data were downloaded. As a result, we focused on constructing and reporting year-to-date measures, as shown in table 1.

The year-to-date progress file is cumulative through April 19, 2021, two weeks after PPS resumed in-person learning, and does not allow us to limit to progress during the remote learning period alone. We note in the slides and table 1 where our measures include these additional weeks.

Online learning application data: Edmentum (Study Island). Edmentum's Study Island is an online supplemental math and reading product that assesses students' mastery of state standards and provides targeted practice on

[2] Edmentum. (2019). *Unpacking Exact Path: What does the learning path experience look like?* https://blog.edmentum.com/unpacking-exact-path-what-does-learning-path-experience-look.

specific standards students are struggling with. Pittsburgh uses Study Island as an intervention for specific students based on their needs.

The Edmentum Study Island data came in two data files. The first file covers all students who ever use Study Island and summarizes by student and subject the number of questions attempted and correctly answered. The second file only covers students who ever earned a Blue Ribbon and summarizes by student and subject the number of Blue Ribbons awarded and time logged toward Blue Ribbons. A student can receive a Blue Ribbon upon completing a set percentage of questions correctly. The default settings give students 10 questions at a time and award a Blue Ribbon if they answer at least 7 correctly, but the teacher may adjust these parameters.

See table 1 for the measures we report. We focus on creating year-to-date measures, as daily data are only available from February 27, 2021, to April 5, 2021 (year-to-date measures cover the full year).

Online learning application data: iLit. iLit is a reading intervention PPS uses for students in grades 3–12 with lower reading scores. Because so few students use other versions of iLit, we focus exclusively on iLit20, a flexible model intended to be "used 15-20 minutes per day, two to five times per week, to supplement a core ELA curriculum."[3]

The iLit data contain cumulative, weekly measures of minutes spent using iLit, reading growth in iLit, words read in iLit, and activities completed. Because weekly usage measures are only available for Weeks 26 to 34, we focus on constructing year-to-date total measures as of the last week available (Week 34). Please see table 1 for the measures we report.

Academic calendar. We used PPS's academic calendar for 2020/21 to identify all instructional days and whether those days were full days that were synchronous, full days that were asynchronous, full days that were half synchronous and half asynchronous, or half days that were synchronous. For all products that provided daily usage measures (i.e., Clever, Schoology, and Edmentum), we merged these day type indicators into the files to summarize usage by type of day.

Table 1. Student characteristics and outcomes used in the study

Characteristic	Description
Demographic and behavior variables	
School year	Academic year (either 2019/20 or 2020/21)
Grade level (fall)	Which grade level (K–12) the student was at the time of NWEA fall MAP testing
Grade level (winter)	Which grade level (K–12) the student was at the time of NWEA winter MAP testing
Grade level (spring)	Which grade level (K–12) the student was at the time of NWEA spring MAP testing
Female	Whether a student was female
Race/ethnicity	Whether a student was • Black • White
Economically disadvantaged	Whether student directly certified for the national school lunch program
IEP (Individualized Education Program)	Whether student received special education services
Chronic absentee	Whether a student was absent for more than 10 percent of the first semester (quarter 1 and quarter 2)

[3] MySaavasTraining. (n.d.) *iLit*. https://mysavvastraining.com/products/ilit#:~:text=What%20is%20iLit%3F%20iLit%20is%20a%20comprehensive%20reading,devices%2C%20and%20it%20utilizes%20a%20proven%20instructional%20model.

Characteristic	Description
Grades	
Indicator for failing any courses/subjects	Indicator for failing any graded course/subject (received an E) in the first semester
Grade point average (GPA)	Average grade in graded courses/subjects that students took in the first semester. Courses that were pass/fail or ungraded were not included in GPA.
NWEA MAP tests	
Math scale score fall	NWEA MAP scale score for math in the fall
Math standardized (std.) scale score fall	NWEA MAP scale score for math in the fall, standardized within grade level relative to national norms
Reading scale score fall	NWEA MAP scale score for reading in the fall
Reading std. scale score fall	NWEA MAP scale score for reading in the fall, standardized within grade level relative to national norms
Math scale score winter	NWEA MAP scale score for math in the winter
Math standardized (std.) scale score winter	NWEA MAP scale score for math in the winter, standardized within grade level relative to national norms
Reading scale score winter	NWEA MAP scale score for reading in the winter
Reading std. scale score winter	NWEA MAP scale score for reading in the winter, standardized within grade level relative to national norms
Math scale score spring	NWEA MAP scale score for math in the spring
Math standardized (std.) scale score spring	NWEA MAP scale score for math in the spring, standardized within grade level relative to national norms
Reading scale score spring	NWEA MAP scale score for reading in the spring
Reading std. scale score spring	NWEA MAP scale score for reading in the spring, standardized within grade level relative to national norms
Quartile 1 of std. math scale score fall	Indicator that standardized math scale score in fall is below the 25th percentile
Quartile 2 of std. math scale score fall	Indicator that standardized math scale score in fall is in the 25th percentile and below the median
Quartile 3 of std. math scale score fall	Indicator that standardized math scale score in fall is in the 50th percentile and below the 75th percentile
Quartile 4 of std. math scale score fall	Indicator that standardized math scale score in fall is in the 75th percentile and above
Quartile 1 of std. reading scale score fall	Indicator that standardized reading scale score in fall is below the 25th percentile
Quartile 2 of std. reading scale score fall	Indicator that standardized reading scale score in fall is in the 25th percentile and below the median
Quartile 3 of std. reading scale score fall	Indicator that standardized reading scale score in fall is in the 50th percentile and below the 75th percentile
Quartile 4 of std. reading scale score fall	Indicator that standardized reading scale score in fall is in the 75th percentile and above
Quintile 1 of std. math scale score winter	Indicator that standardized math scale score in winter is below the 20th percentile
Quintile 2 of std. math scale score winter	Indicator that standardized math scale score in winter is in the 20th percentile and below the 40th percentile
Quintile 3 of std. math scale score winter	Indicator that standardized math scale score in winter is in the 40th percentile and below the 60th percentile
Quintile 4 of std. math scale score winter	Indicator that standardized math scale score in winter is in the 60th percentile and below the 80th percentile
Quintile 5 of std. math scale score winter	Indicator that standardized math scale score in winter is in the 80th percentile or above
Quintile 1 of std. reading scale score winter	Indicator that standardized reading scale score in winter is below the 20th percentile
Quintile 2 of std. reading scale score winter	Indicator that standardized reading scale score in winter is in the 20th percentile and below the 40th percentile
Quintile 3 of std. reading scale score winter	Indicator that standardized reading scale score in winter is in the 40th percentile and below the 60th percentile

Characteristic	Description
Quintile 4 of std. reading scale score winter	Indicator that standardized reading scale score in winter is in the 60th percentile and below the 80th percentile
Quintile 5 of std. reading scale score winter	Indicator that standardized reading scale score in winter is in the 80th percentile or above
Online learning application data: Schoology	
Logged into Schoology on a given instructional day	An indicator for whether a student logs into Schoology on a given day, for instructional days from 9/8/20 through 4/5/21
Logged into Schoology on full day with synchronous instruction	An indicator for whether a student logs into Schoology on a given day, for full days with synchronous instruction from 9/8/20 through 4/5/21
Logged into Schoology on half day with synchronous instruction	An indicator for whether a student logs into Schoology on a given day, for half days with synchronous instruction from 9/8/20 through 4/5/21
Logged into Schoology on half synchronous/half asynchronous instruction day	An indicator for whether a student logs into Schoology on a given day, for full days with half synchronous and half asynchronous instruction from 9/8/20 through 4/5/21
Logged into Schoology on full day with asynchronous instruction	An indicator for whether a student logs into Schoology on a given day, for full days with asynchronous instruction from 9/8/20 through 4/5/21
Items opened, all courses	Average count of unique course material opened weekly from 9/8/20 through 4/5/21
Items submitted, all courses	Average count of unique course material submitted weekly from 9/8/20 through 4/5/21. Students can submit assignments, discussion posts, or assessments. Assessments include two item types: assessments and test/quiz.
Items submitted, math courses	Average count of unique course material submitted weekly in math courses from 9/8/20 through 4/5/21
Items submitted, English courses	Average count of unique course material submitted weekly in English courses from 9/8/20 through 4/5/21
Items submitted, science courses	Average count of unique course material submitted weekly in science courses from 9/8/20 through 4/5/21
Items submitted, social studies courses	Average count of unique course material submitted weekly in social studies courses from 9/8/20 through 4/5/21
Items submitted, all other courses	Average count of unique course material submitted weekly in all other courses from 9/8/20 through 4/5/21
Assignments submitted	Average count of unique assignments submitted weekly from 9/8/20 through 4/5/21
Assessments submitted	Average count of unique assessments submitted weekly from 9/8/20 through 4/5/21
Discussion contributions	Average count of unique discussion contributions weekly from 9/8/20 through 4/5/21
Online learning application data: Edmentum (Study Island)	
Answered any question	Whether student answered any question in Study Island through 4/5/21
Answered any math question	Whether student answered any math question in Study Island through 4/5/21
Answered any reading question	Whether student answered any reading question in Study Island through 4/5/21
Answered any science question	Whether student answered any science question in Study Island through 4/5/21
Count of questions answered	Count of questions answered in a given week, for each week from 2/27/21 through 4/5/21, if answered any question
Count of questions answered correctly	Count of questions answered correctly in a given week, for each week from 2/27/21 through 4/5/21, if answered any question
Percent of questions answered correctly	Percent of questions answered correctly through 4/5/21, if answered any question
Average time on questions	Average minutes on questions through 4/5/21, if received a Blue Ribbon
Average Blue Ribbons received	Average number of Blue Ribbons received through 4/5/21, if received any Blue Ribbon

Characteristic	Description
Full day, synchronous instructional days logged into Study Island	An indicator for whether a student registered any activity in Study Island on a given day, for full, synchronous instructional days from 2/27/21 through 4/5/21
Half day, synchronous instructional days logged into Study Island	An indicator for whether a student registered any activity in Study Island on a given day, for half synchronous instructional days from 2/27/21 through 4/5/21
Half synchronous/half asynchronous instructional days logged into Study Island	An indicator for whether a student registered any activity in Study Island on a given day, for half synchronous and half asynchronous instructional days from 2/27/21 through 4/5/21
Full day, asynchronous instructional days logged into Study Island	An indicator for whether a student registered activity on a given day, for full, asynchronous instructional days from 2/27/21 through 4/5/21
Online learning application data: Edmentum (Exact Path)	
Ever used Exact Path	Indicator for whether a student started any activity in Exact Path, as identified by time on task being greater than 0
Started a math activity	Indicator for starting at least one math activity from 9/8/20 through 4/5/21
Started a reading activity	Indicator for starting at least one reading activity from 9/8/20 through 4/5/21
Time practicing math	Time on task practicing any math skill, among those who start any math activity from 9/8/20 through 4/5/21
Time practicing reading	Time on task practicing any reading skill, among those who start any reading activity from 9/8/20 through 4/5/21
Number of unique activities started	Number of activities started in Exact Path through 4/19/21
Percent of reading activities completed	Percent of reading activities started that were completed, among those who started any reading activity through 4/19/21
Percent of math activities completed	Percent of math activities started that were completed, among those who started any math activity through 4/19/21
Mastered any skill in math	Indicator for whether a student mastered a math skill , among those who started any math skill from 9/8/20 through 4/5/21
Mastered any skill in reading	Indicator for whether a student mastered a reading skill, among those who started any reading skill from 9/8/20 through 4/5/21
Online learning application data: iLit	
Logged into iLit	Indicator of whether a student logged into iLit during weeks 27-34 in the 2020/21 school year
iLit total minutes	Total number of minutes student spent on iLit across weeks 27-34 in the 2020/21 school year
iLit total words	Total number of word student read on iLit across weeks 27-34 in the 2020/21 school year
iLit total assignments	Percentage of assignments completed by week 34 in the 2020/21 school year
Online learning application data: Clever	
Logged into Clever	For a given day in the 2020/21 school year through 3/26/21, indicator that a student logged into Clever
Number of resources	For a given day in the 2020/21 school year through 3/26/21, count of the number of resources that a student accessed through Clever
Logged into Edmentum (through Clever)	For a given day in the 2020/21 school year through 3/26/21, indicator that a student logged into Edmentum through Clever
Logged into Schoology (through Clever)	For a given day in the 2020/21 school year through 3/26/21, indicator that a student logged into Schoology through Clever
Logged into Teams (through Clever)	For a given day in the 2020/21 school year through 3/26/21, indicator that a student logged into Teams through Clever
Logged into supplemental math or reading (through Clever)	For a given day in the 2020/21 school year through 3/26/21, indicator that a student logged into a supplemental math or reading product through Clever

We report descriptive statistics for demographic and behavior variables, grade variables, and NWEA MAP tests in table 2. We do not include online learning application measures in table 2, as the findings in the slide deck for research question 2 provide these descriptive statistics.

Table 2. Descriptive statistics (averages by school year)

Characteristic	2019/20	2020/21
Demographic and behavior variables (grades K–12)		
Female	0.49	0.49
Black	0.52	0.52
White	0.32	0.31
Economically disadvantaged	0.70	0.70
IEP (Individualized Education Program)	0.22	0.22
Chronic absentee	0.25	0.25
Grades (grades 1–12)		
Indicator for failing any courses/subjects (first semester)	0.11	0.18
Grade point average (GPA) (first semester)	2.96	2.75
Number of courses failed (first semester)	0.29	0.57
NWEA MAP tests (grades 2–8)		
Math scale score fall	200.2	201.6
Math standardized (std.) scale score fall	-0.25	-0.19
Reading scale score fall	196.1	197.8
Reading std. scale score fall	-0.24	-0.17
Math scale score winter	204.6	203.9
Math standardized (std.) scale score winter	-0.34	-0.40
Reading scale score winter	198.3	199.0
Reading std. scale score winter	-0.42	-0.39
Math scale score spring	218.4	—
Math standardized (std.) scale score spring	-0.18	—
Reading scale score spring	208.2	—
Reading std. scale score spring	-0.31	—
Quartile 1 of std. math scale score fall	0.33	0.32
Quartile 2 of std. math scale score fall	0.26	0.26
Quartile 3 of std. math scale score fall	0.21	0.21
Quartile 4 of std. math scale score fall	0.20	0.21
Quartile 1 of std. reading scale score fall	0.32	0.33
Quartile 2 of std. reading scale score fall	0.25	0.21
Quartile 3 of std. reading scale score fall	0.22	0.21
Quartile 4 of std. reading scale score fall	0.21	0.25

Notes: In the first section, the sample includes all students enrolled in PPS in 2019/20 (n = 21,819) or 2020/21 (n = 20,630). In the second section, the sample includes all students enrolled in PPS in 2019/20 in grades 1-12 who have grades in the first semester (n = 19,390) or the equivalent for 2020/21 (n = 18,716). In the third section, the sample includes all students enrolled in PPS in 2019/20 in grades 2-8 who took the fall, winter, or spring tests, respectively, or the equivalent for 2020/21. Spring test scores for 2021 were not yet available when we collected data for the study

Sample

The sample sizes differed by analysis (table 3).

Table 3. Sample sizes by research question and analysis sample for the analyses presented in the slides

Research question (RQ)	Analysis sample	Sample size
RQ1a		
RQ1a. Proportion of students taking the NWEA MAP tests	Students enrolled in grade levels K–12 during the assessment window for each test administration(fall, winter, spring)	Fall 2019/20: 21,819 students Winter 2019/20: 21,394 students Spring 2019/20: 22,445 students Fall 2020/21: 20,630 students Winter 2020/21: 20,529 students
RQ1a. Changes in the composition of students taking the test (grades 2–8)	All students enrolled in grade levels 2–8 during the assessment window for each test administration (fall, winter, spring)	Fall 2019/20: 11,727 students Winter 2019/20: 11,522 students Spring 2019/20: 12,073 students Fall 2020/21: 11,229 students Winter 2020/21: 11,163 students
RQ1a. Proportion of PPS test takers in each national quartile of the fall 2019/20 reading test distribution who take the fall reading test in 2019/20 and 2020/21	All students enrolled in grade levels 2–7 who took the fall 2019/20 reading test	Took test in fall 2019/20: 8,486 students Took test also in fall 2020/21: 7,328 students
RQ1a. Proportion of students with grades	All students enrolled in grade levels K–12 during the fall assessment window for 2019/20 and 2020/21	2019/20: 21,819 students 2020/21: 20,630 students
RQ1b		
RQ1b. Change in individual student math scores (winter to winter)	Students who were enrolled in grade levels 2–7 in 2019/20 who took the winter math test in 2019/20 and 2020/21	7,547 students
RQ1b. Change in individual student math scores (winter to winter, imputed)	Students who were enrolled in grade levels 2–7 in 2019/20 who took the winter math test in 2019/20 and who had grade and absence data in 2020/21.	8,420 students
RQ1b. Change in individual student reading scores (winter to winter)	Students who were enrolled in grade levels 2–7 in 2019/20 who took the winter reading test in 2019/20 and 2020/21.	7,393 students
RQ1b. Change in individual student reading scores (winter to winter, imputed)	Students who were enrolled in grade levels 2–7 in 2019/20 who took the winter reading test in 2019/20 and who had grade and absence data in 2020/21.	8,338 students
RQ1b. Change in individual student math scores compared to NWEA study during the same period of time	Students who were enrolled in grade levels 3–7 in 2019/20 who took the winter math test in 2019/20 and fall math test in 2020/21	6,423 students
RQ1b. Change in individual student reading scores compared to NWEA study during the same period of time	Students who were enrolled in grade levels 3–7 in 2019/20 who took the winter reading test in 2019/20 and fall reading test in 2020/21	6,194 students
RQ1b. Test score density and quintile analysis (showing percentage of students in each quintile of the national distribution in math/reading in winter 2019/20 who scored in each quintile in winter 2020/21)	Students who were enrolled in grade levels 2–7 in 2019/20 who took the winter math (or reading) test in 2019/20 and in 2020/21	Math: 7,547 students Reading: 7,393 students
RQ1b. Change in grade outcomes (GPA, whether a student failed a course)	Students who were enrolled in grade levels 1–12 in 2019/20 and 2020/21 with first-semester grades	2019/20: 19,390 students 2020/21: 18,716 students

Research question (RQ)	Analysis sample	Sample size
RQ1b. Distribution of first-semester grades in 2019/20 vs 2020/21	All grades received in instructional courses in grade levels 6–12	High school: 2019/20: 47,741 grades 2020/21: 46,786 grades Middle school: 2019/20: 34,641 grades 2020/21: 33,622 grades
RQ1b. Change in proportion of students chronically absent	Students who were enrolled in grade levels K–12 in 2019/20 and 2020/21 with absence data	2019/20: 21,806 students 2020/21: 20,628 students
RQ1b. Average Days Absent by Number of Courses Failed	Students who were enrolled in grade levels 1–12 in 2019/20 and 2020/21 with grades and absence data	2019/20: 19,105 students 2020/21: 18, 481 students
RQ2		
RQ2. Descriptive Statistics of Online Learning Applications: Schoology	Students who were enrolled in grades K–12 in 2020/21	20,630 students
RQ2. Variance decomposition for materials opened and submitted via Schoology	All core courses (math and English) students are enrolled in first semester of 2020/21 for grades 6–12	45,552 class enrollments
RQ2. Fraction of instructional days logged into Schoology and average weekly materials opened and submitted in Schoology, by chronic absence and number of courses failed	Students who were enrolled in grades 1–12 in 2020/21	19,157 students
RQ2. First-semester course grades and materials opened and submitted in Schoology in first semester 2020/21 for core courses (grades 6–12)	All core courses (math, English, science, social studies) students are enrolled in first semester of 2020/21 for grades 6–12	45,552 class enrollments and grades
RQ2. Descriptive Statistics of Online Learning Applications: Clever	Students who were enrolled in grades K–12 in 2020/21	20,630 students
RQ2. Descriptive Statistics of Online Learning Applications: Edmentum (Exact Path)	Students who were enrolled in grades K–12 in 2020/21	20,630 students
	Students who were enrolled in grades K–12 in 2020/21 who started at least one Exact Path task	9,645 students
	Students who were enrolled in grades K–12 in 2020/21 who started at least one Exact Path math task	9,522 students
	Students who were enrolled in grades K–12 in 2020/21 who started at least one Exact Path reading task	1,914 students
RQ2. Descriptive Statistics of Online Learning Applications: Edmentum (Study Island)	Students who were enrolled in grades K–12 in 2020/21	20,630 students
	Students who were enrolled in grades K–12 in 2020/21 who started at least one Study Island task	6,419 students
	Students who were enrolled in grades K–12 in 2020/21 who received at least one Study Island blue ribbon	5,096 students

Research question (RQ)	Analysis sample	Sample size
RQ2. Descriptive Statistics of Online learning application data: iLit	Students who were enrolled in grades 3–12 in 2020/21	15,867 students
	Students who were enrolled in grades 3–12 in 2020/21 who ever use iLit	4,285 students

Source: Authors' samples based on administrative data and online learning application data provided by Pittsburgh Public Schools, 2019/20 and 2020/21.

Analysis methods

Research question 1. This research question is focused on understanding how academic achievement, as measured by test scores and semester grades, changed during the pandemic. One challenge in this analysis is that the pandemic may have disrupted the number of students tested in the 2020/21 school year or the number of grades submitted. As a result, taking the average student performance during the baseline period (before school closures in 2019/20) and comparing it to 2020/21 may be misleading.

To understand the scope of this problem, we first address research question 1a.

First, we describe changes in the proportion of students enrolled in each grade level in PPS during the the NWEA MAP assessment windows (fall, winter, and spring 2019/20 and fall and winter 2020/21) who took the reading and math tests.

Second, to understand whether the sample of students taking the tests are representative of the enrolled students, we calculated the proportion of students who have a given characteristic (e.g., who are female) in the enrolled student population and the tested student population. We then calculated the difference between these two and determined if the standardized difference exceeds 0.05 standard deviations. For this analysis, we focus on students in grade levels 2–8, as these are the tested grade levels that we use for the analysis of the change in test scores. We examined differences in the proportion of students who are female, Black, White, economically disadvantaged, or have an Individualized Education Program (IEP). (We did not include English learners as a group because they represent less than 5 percent of students in PPS in 2020/21. Similarly, we do not include other non-Black minority groups because 83 percent of students enrolled in 2020/21 are either Black or White and no other race/ethnicity groups exceed 10 percent of the enrolled population).

Third, we examined changes in the demographics of students who took the NWEA MAP tests in 2020/21 compared to 2019/20 to understand if students who took the test in both periods had higher or lower test scores in 2019/20. To do so, we used a sample of students in grade levels 2–7 who took the test in fall 2019/20 and assigned them to quartiles based on national norms. We then report the proportion of students who took the test for each quartile in fall 2019/20 and those who also took the test in fall 2020/21.

Next, we address research question 1b. From research question 1a, even for grade levels 2–8 which have the highest rates of participation in the NWEA MAP tests, we still observe a small decline in the proportion of students taking the test and some shifts in the characteristics of students taking the test, although these changes did not exceed 0.05 standard deviations. To address these challenges, we conducted a longitudinal analysis comparing individual students' performance to their own performance in a prior period. For example, we compared a student's score in winter 2020/21 to a period in 2019/20, specifically fall 2020/21 or winter 2020/21. (We focused on winter 2019/20 to winter 2020/21, except for an analysis comparing the changes in PPS against another study [Kuhfeld & Tarasawa, 2020] which reported differences from winter 2019/20 to fall 2020/21.) This has the benefit of holding constant the sample with test scores in 2019/20 and 2020/21. However, one drawback of this approach is that we cannot examine the changes in test scores for students who do not take the test in 2020/21.

To address this drawback, we also conducted a sensitivity check in which we imputed scores for those with scores winter 2019/20 who do not have them in winter 2020/21. To do so, for students within grade levels 2–7 in

2019/20, we regressed the winter 2020/21 score for a given subject on the winter 2019/20 score for that subject, first-semester 2020/21 GPA, the number of course failures in the first semester of 2020/21, and the number of absences in the first semester 2020/21. We also included indicator variables for the following demographic characteristics: gender, race/ethnicity, economically disadvantaged, IEP status, and English learner status. To improve model fit, we included second- and third-order polynomials for the winter 2019/20 score, GPA, number of courses failed, and absences. We ran regressions separately for students in each grade level. We then imputed the predicted winter 2020/21 score for those who are missing winter 2020/21 scores. In total, 90.5 percent of students with winter 2019/20 reading scores and 90.4 percent of students with winter 2019/20 math scores were enrolled in winter 2020/21. Among these students, 12 percent (915 students in math, 985 in reading) who took the winter 2019/20 math test did not take the winter 2020/21 test. We imputed scores for all but 14 of these students who were missing course grades. We did not attempt to impute scores for students no longer enrolled in PPS. In total, we have real or imputed scores for 90.4 percent of those with winter math scores in 2019/20 and 90.4 percent of those with winter reading scores in 2019/20. (Students with actual scores in winter 2020/21 constitute 80.1 percent of those with scores in the preceding winter, and 89.2 percent of those who had scores in the preceding winter and were enrolled in PPS in winter 2020/21.)

Imputing scores allows us to include almost all students (99.8 percent) who took the test in winter 2019/20 and were still enrolled in the district during the winter 2020/21 assessment window. Additionally, one advantage of using variables based on grades and absences in 2020/21 for the imputation, as opposed to only prior test score, is that we are able to use information about students from the 2020/21 school year to inform the imputation. However, all imputation has error and may over- or underestimate the test scores for those who did not take the test. In this case, imputed scores may overestimate true scores, given that many students who were failing courses in the first semester of 2020/21 did not take the MAP test in 2020/21 (table 4).

Table 4. Proportion of students in grade levels 2–7 in 2019/20 who have a winter 2020 math score, by the number of courses failed during the first semester of 2020/21

Number of courses failed in first semester of fall 2020	Proportion with a winter 2020 math score	Frequency
0	0.89	7,802
1	0.72	522
2	0.64	213
3	0.49	155
4	0.39	110
5	0.30	63
6	0.38	39
7	0.40	5
8 or more	0.29	9
Total		8,918

Source: Sample includes all students in grade levels 2–7 in 2019/20. Authors' samples based on administrative data provided by Pittsburgh Public Schools, 2020/21.

To interpret test score findings, we used a threshold of 0.1 standard deviations to identify meaningful changes in standardized test scores. For scale score changes, we used a threshold in scale score points that is equivalent to 0.1 standard deviations in the pre-pandemic national distribution. (For example, for grade 2 in math, this would be 1.3 scale score points.) We used these thresholds when discussing how individual students' scores changed from 2019/20 to 2020/21 and when discussing average differences in the changes students experienced in different groups (e.g., male versus female students). Because the analyses are not intended to generalize to a larger population, we did not conduct tests of the statistical significance of differences.

As a supplemental analysis for the test score analysis, we also examined how the distribution of test scores changed in PPS for students in grades 2–7 in 2019/20 who took the math or reading test in both winter 2019/20

and winter 2020/21. We first plotted the winter test score distributions from the current year and prior year overlaid in the same figure for both math and reading (for all students and separately by grade) to understand how the structure of the test score distribution has shifted. Second, we grouped into one of five quintiles based on their winter 2019/20 score using the national distribution as the reference point. For students in each quintile of the 2019/20 test, we reported the share that ended up in each quintile of the 2020/21 distribution. The goal of this analysis is to explore which quintiles of the test distribution experienced declines and which (if any) did not. We performed these analyses separately for math and reading.

In contrast to test scores, the proportion of students with outcomes based on grades (specifically, whether they fail a course and GPA) is high in all grades but kindergarten and does not change from 2019/20 to 2020/21 (see slide 13 in the attached deck). We therefore conducted a cross-sectional analysis for grade-based outcomes because we are not concerned about the composition of the sample changing in ways that might bias the results from 2019/20 to 2020/21. Specifically, we compared successive cohorts in the same grade levels or subgroups, calculating the difference in outcomes based on first-semester grades from 2019/20 and 2020/21. The cross-sectional analysis is preferable to a longitudinal analysis because there are increases or declines in course failures that typically occur at some grade level transitions (e.g., students moving from grade 8 to grade 9 often experience an increase in course failures). A longitudinal analysis would conflate the effects of the pandemic with these natural changes that occur across some grade-level transitions, while the cross-sectional analysis avoids this problem by holding grade level constant.

To interpret findings when discussing changes in the proportion of students failing at least one course, we used a threshold of 5 percentage points to identify meaningful changes. When interpreting changes in GPAs, we used a threshold of 0.1 GPA points.

Research question 2. For this research question, we describe how each education technology product is used, focusing on understanding which students ever use the product and, among those who use the product, intensity of use and progress. We focus first on Schoology, the learning management system which PPS expects all students in the district to use to read and submit course materials. Then, we examine online supplemental math and reading resources. These products are intended to supplement traditional class instruction.

Schoology. For Schoology, we first describe the percentage of students ever logging into Schoology. Because this percentage is quite high (98 percent), we then examined the percentage of students logging into Schoology on instructional days throughout the year, breaking this out by the type of school day. We also describe the variation across subgroups in the average percentage of students logging into Schoology on instructional days. The subgroups include gender, race, free and reduced-price lunch status, special education (IEP) status, whether a student was chronically absent for the first semester of 2019/20, and the student's quartile of the national math test distribution for their fall 2019 NWEA MAP test. (We focus on math quartiles because patterns of use were either similar for reading or were more slightly pronounced for math.)

Next, we describe how many course materials students opened and submitted on average per week during the school year, examining how this varies over the year and by student subgroup. We also examined how the average number of course materials students submitted varies by grade level and subject and how the type of course materials students submit varies by grade.

Third, we use Schoology usage from math and English courses from the first semester of 2020/21 and decomposed the variance of the average number of weekly materials submitted to understand how much this varies across schools, across teachers within the same school, or across students with the same teacher in a school. We did the decomposition four different times, restricting the sample to: 1) ELA courses for grades 6-8; 2) ELA courses for grades 9-12; 3) math courses for grades 6-8; 4) math courses for grades 9-12. The goal of this analysis is to understand whether most of the variation in these measures is at the school or teacher level, as opposed to among students with the same teacher. Understanding this could help point to what might be causing the observed

differences. For example, if most of the variation is within students with the same teacher, it suggests that teachers' decisions about how to use Schoology in their classroom are not the main factor driving these gaps. For this analysis, we focus on students in grades 6–12 because 97 percent of math and English courses students are enrolled in in these grades have associated Schoology usage.

Last, we explore the relationship between Schoology-based usage measures and first-semester grades and absences. The goal of this analysis is to understand whether Schoology measures of usage track with other measures of attendance (absences) and learning (grades). For this analysis, we report cross-tabulations in bar charts that summarize Schoology-derived usage measures (specifically, the average fraction of instructional days logged in during remote instruction and average number of materials opened and submitted each week) by the number of absences (grouped by category) and number of course failures.

Supplemental math and reading products. For supplemental math and reading products (Edmentum Exact Path, Edmentum Study Island, and iLit), we first describe which students are using the products by grade and subgroup. Next, we focus on students using the product and describe the intensity of their use and their progress through the product. The measures available to summarize intensity of use and progress vary by online learning application:

- For Exact Path, we calculated the the median number of minutes students use the product for math activities, among those who ever use the product for math. We did the same for reading. We calculated the median rather than the mean because of some extreme values (some students have unusually high usage times). We also calculated the average number of unique activities started for those who use the product at all (for either math or reading). Last, we describe the average share of students who start any math activity who master at least one math skill and the same for reading. We show this by grade and student subgroup.
- For Study Island, wecalculate the median and average number of questions students answer as of April 2021. We show the average number of questions answered by users in each grade and the percentage of questions answered correctly by grade and student subgroup. For those who earn a Blue Ribbon during a session (typically an indicator for answering 70 percent of questions in a set of 10 correctly, though teachers can alter the threshold), we also describe the average amount of time spent using the product during sessions. (These time data are only available for sessions in which a student earns a Blue Ribbon.)
- For iLit, we describe the average amount of time spent in iLit, the number of words read, and the percentage of assignments completed in iLit through April 2021 for those who ever use the product.

Last, we use Clever, a single sign-on product that students are encouraged to use to access online resources, to identify whether students are using supplemental math or reading products other than Edmentum. Although students can access supplemental math and reading resources without using Clever, Clever provides a lower bound on the number of students using the product. We describe the share of students accessing any Edmentum product via Clever and other supplemental math and reading products via Clever. Because Clever provides daily usage data, we also describe the percentage of students logging into Edmentum and other supplemental products on instructional days throughout the year, breaking this out by the type of school day.

To interpret differences in the share of students using a product, the fraction of days a student uses a product, or the percentage of activities completed, we used a threshold of 5 percentage points. To interpret differences in the average course materials opened or submitted each week, we used a threshold of three materials per week. To interpret differences in the number of activities ever started in Edmentum, we used a threshold of five activities. Again, because these descriptive analyses are not intended to generalize to larger populations, we did not conduct tests of statistical significance.

Limitations

In research question 1, the test score analysis has a few limitations. First, the analysis sample was limited to students in grade levels 2–7 in 2019/20 who took the test in both 2019/20 and 2020/21. Students who took the test in 2019/20 but not in 2020/21 would not be included in the main analysis. It is possible students who did not take the test in 2020/21 would have different learning gains than those who did take the test. Also, the analysis sample was restricted to grade levels 2–7 because a lower proportion of students took the NWEA MAP tests in earlier grade levels (kindergarten and grade 1) or later grade levels (grades 8–12) in both 2019/20 and 2020/21. It is possible the findings could differ in these grades. Second, the tests were administered remotely in the 2020/21 school year for both fall and winter. NWEA found test scores in remote environments are reliable in grade levels 3–8 but should be used with caution in earlier grades (Kuhfeld et al., 2020). Third, MAP tests were first offered in 2019/20 in Pittsburgh. As a result, part of the change in scores from 2019/20 to 2020/21 may be due to students and teachers becoming more familiar with the test. This may have helped mitigate some of the declines relative to pre-pandemic national norms that PPS students experienced. Fourth, for the sensitivity check that uses imputation, imputation is not perfect and may under- or overestimate the scores for students who had scores in 2019/20 but did not take the test in 2020/21. In particular, it is possible imputed scores were overly optimistic given that many students who were failing courses in the first semester of 2020/21 did not take the MAP test in 2020/21.

The analysis of grades in research question 1 also faces a limitation. Criteria for failing a course may have shifted during the pandemic. To the extent that teachers lowered grading standards, the change in course failure rates we calculated would understate what the change would have been had the failure criteria stayed constant.

For research question 2, there are three important limitations to keep in mind. First, some groups of students may use online learning applications less because of differences in how their teachers or schools are choosing to use the products or differences in the supports available to them (e.g., parental support, Internet connection). Second, the study team did not examine changes in trends, such as the share logging into Schoology, in a normal school year. It is possible that some of the observed shifts, such as the decrease in course materials submitted over the course of the year, may happen in regular years, too. Third, the study team found that Schoology usage measures are associated with grades and absences, but unmeasured factors might contribute to this relationship. The findings do not provide sufficient evidence that Schoology logins and engagement with course materials cause student grades to be higher and absences to be lower, or vice versa.

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