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How K-8 Schools Use Digital Learning Materials

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Abstract

Online learning tools have become an integral component of K-8 education in the last decade, especially after the COVID-19 pandemic, with more than 13 million users in the 2022-2023 school year on one platform alone. Their rapid emergence begs the question, “how are digital tools used?” An in-depth investigation on usage patterns is necessary for designing how digital tools can be implemented to optimize learning outcomes. We used the available data from one digital tool, i-Ready, in a five-year span (2017-2022) to measure usage trends and uncovered the following trends:

- Students in schools that administer digital tools to the entire grade use them more consistently throughout the school year, while students in schools that administer digital tools to a small subset of the grade use them sparingly in the school year.
- Some schools that administer digital tools to a small subset of the grade use them as supplemental tool for students placing below-grade in assessments.
- In schools with gradewide administration of digital tools, we observed increased usage over the years in schools with higher composition of students placing below-grade in assessments. Additionally, there is a widening gap in usage, where students placing on-grade use digital tools more than students placing below-grade.

Introduction

The COVID-19 pandemic impacted both student performance and teaching patterns in the United States. Average math and reading scores dropped since the pandemic for K-8 students, especially in math. These are the largest declines recorded by the National Assessment of Education Progress (NAEP) since they began collecting data in 1969 (1). Moreover, with the closure of school buildings across all states, schools transitioned to remote learning, which led to a higher reliance on digital tools for administering both assessments and instruction. Even though most schools have returned to in-person teaching, the use of digital tools is still rising. One such tool, i-Ready, doubled the number of K-8 users from 4.9 million in academic year 2017 to 2018 to 9.7 million students in 2021-2022. In 2023, it is close to 13 million users. In the same time span, the number of participating schools nearly doubled from approximately 14,500 to 27,500 and the number of completed lessons nearly tripled from 107 million to 288 million annually.

Despite the rapid incorporation of digital tools in K-8 education, little research has been done on the students' usage patterns with these digital tools. For instance, it is unclear whether these digital tools are being adopted broadly for all students at a school, or if usage is targeted, either to struggling students in need of additional assistance or advanced students in need of additional challenges. Analyzing usage patterns is critical for assessing how digital tools can be administered to maximize learning and student performance improvement. We use the available data from i-Ready as a proxy to gauge how students are interacting with digital learning tools and illuminate trends observed in the last five years.

Methods

We use I-Ready's diagnostic and instructional data for 4th grade students from *pre-pandemic* (2017-2018 and 2018-2019) and *post-pandemic* (2020-2021 and 2021-2022) school years. Note we excluded the 2019-2020 data due to unreliable data collection caused by the pandemic. We isolated the study to one grade level to control the variance of different usage patterns by grade. We identified the following school and student characteristics that yield interesting usage differences:

- *Gradewide-use* schools are defined as those where more than 80% of the 4th grade students who took the i-Ready diagnostic exam in the fall also used the i-Ready instruction modules during each school year. *Limited-use* are defined as those where 80% or less of 4th grade i-Ready diagnostic exam takers went on to use instruction modules.
- *On-grade* and *below-grade* students are defined by whether students place on and above their grade level on the fall diagnostic i-Ready exam *(on-grade*) or not *(below-grade).*
- Schools are categorized by the proportion of on-grade students:
    - *Higher-achieving*: 50% or more students are *on-grade*
    - *Middle-achieving*: 10-50% of students are *on-grade*

- *Lower-achieving*: 10% or less students are *on-grade*

We separated these schools separately for math and reading, so that, for example, a school can be *gradewide-use* in reading but *limited-use* in math.

To quantify i-Ready usage, we analyzed the following measurements:

- *Total instruction time* measures how many hours a student spent on lessons over the entire school year
- *Number of distinct weeks* measures how many weeks during the school year each student accessed lessons, regardless of amount of time spent within a week
- *Mean weekly instruction time* = Total instruction time / number of distinct weeks, which measures the average time a student spent on i-Ready instruction in a week among weeks when i-Ready was accessed.
- *Percent of instruction hours completed by on-grade students* for each school measures the proportion of total hours logged by on-grade students. A high percentage indicates mostly on-grade students access digital tools, while a low percentage indicates more usage by below-grade students.

Findings

Gradewide-use vs. Limited-use

Students in *gradewide-use* and *limited-use* schools spend comparable amounts of time on digital tools per week. In math, students of *gradewide-use* schools spend 57 minutes per week and students of *limited-use* schools spend 44 minutes per week. In reading, students of *gradewide-use* schools spend 60 minutes per week and students of *limited-use* schools spend 51 minutes per week. However, as shown in Figure 1, they differ in how *consistently* they use digital tools throughout the school year. Students of *gradewide-use* schools use i-Ready for 17 to 18 weeks during the school year while students of *limited-use* schools use only 5 weeks. As a result, students of *gradewide-use* schools spend 17-18 hours and students of *limited-use* schools spend only 4.5 hours.

We then analyzed each school's percentage of hours that were completed by *on-grade* students and compared it against the school's percentage of *on-grade* students, as shown in Figure 2. If a school administered digital tools equally to *on-grade* and *below-grade* students, then the two proportions should be similar and lie close to the y=x line, like the red points in the figure below. If the school administered digital tools to mainly *on-grade* students, then the percentage of *on-grade* hours would be greater than the percent of *on-grade* students. These schools then appear in the upper region of the graph like the blue dots. Conversely, if the school administered digital tools more to *below-grade* students, then these schools would appear in the bottom of the graph like the green dots.

Applying this approach to i-Ready data shows *gradewide-use* schools administer i-Ready roughly at the same rate to *below-grade* and *on-grade* students, evidenced by how the points center around the y=x line in Figure 3. This is expected as these schools administer i-Ready to over 80% of students in the grade. However, for some *limited-use* schools, only *below-grade* students are using i-Ready lessons, particularly for *higher-achieving* schools. These *limited-usage* schools form the horizontal band at the bottom of the graph, indicating 0% usage by *on-grade* students in the figure. This suggests digital tools are used as supplementary tools for *below-grade* students in some *limited-use* schools.

Pre-pandemic vs. Post-pandemic

Gradewide-use schools seem to track the y=x line closely (i.e., similar rates of usage of digital tools by both *below-grade* and *on-grade* students). In math, as shown in Figure 4a, we found *mean weekly instruction time* to be similar between *below-grade* vs *on-grade* and between *pre-pandemic* and *post-pandemic*. The only exception was in *lower-achieving* schools, where the mean time increased by 7 minutes (roughly one lesson) for both student types. Moreover, we observed decreased *total instruction time* and *number of distinct weeks* in *higher-achieving* schools *post-pandemic*. *On-grade* students spent 1.6 hour (-9.6%) and 1.7 week less, and *below-grade* students spent 2.3 hours (-13.3%) and 2.3 weeks less on average. On the other hand, there was not much change between *pre-pandemic* and *post-pandemic* in *medium-achieving* schools, but in *lower-achieving* schools, total usage increased especially for *on-grade* students. *On-grade* students in *lower-achieving* schools increased *total instruction time* by 4.9 hours (+31%) and *number of distinct weeks* by 2.9 weeks (+18.5%), while *below-grade* students in *lower-achieving* schools increased *total instruction time* by 3 hours (+21%) and *number of distinct weeks* by 1.4 weeks (+9.3%). We also observed a drop in the number of *higher-achieving* schools *post-pandemic* and drastic rise in the number of *lower-achieving* and *medium-achieving* schools *post-pandemic.* More results can be found in Table 1.

Such trends were not as strongly observed in reading, as shown in Figure 4b, as both *medium-achieving* and *higher-achieving* schools did not show significant changes *pre-* vs *post-pandemic.* However, for *lower-achieving* schools, we still observed increased usage *post-pandemic* especially for *on-grade* students.

We investigated this trend further by isolating schools that have used i-Ready since *pre-pandemic* and analyzed changes in usage year-over-year. Figures 5a and 5b show additional evidence for this finding. Between the 2017-2018 and 2021-2022 school years in *lower-achieving* schools, *on-grade* students increased *total instruction time* by 7.6 hours (+53%) while *below-grade* students increased by 4.8 hours (+36%) in math. Similarly, *number of distinct* weeks increased by 5.7 weeks for *on-grade* students (+40%) and by 3.3 weeks for *below-grade* students (23%). This widening gap in usage between *on-grade* students and *below-grade* students was not significantly observed in *middle-achieving* and *higher-achieving* schools. However, we emphasize *middle-* and *higher-achieving* schools did observe overall increased usage as the years progressed. In reading, we again observed widening gaps in *total*

instruction time between *on-grade* and *below-grade* in *lower-achieving* schools but did not see a widening gap in *number of distinct weeks*, suggesting this trend is stronger in math. More details can be found in Table 2.

Conclusion

We analyzed 4th grade students' usage of i-Ready in both the *pre-pandemic and post-pandemic* settings to understand how digital learning tools have integrated into K-8 education in the last five years. We classified students as *on-grade* and *below-grade* depending on whether they placed on or below their grade level in the fall diagnostic assessment. We divided schools into *gradewide-use,* where more than 80% of the students accessed the i-Ready instruction modules and into *limited-use,* where less than 80% accessed the instruction modules. We further categorized schools by their proportion of on-grade students. *Higher-achieving* schools contained more than 50% *on-grade* students, *medium-achieving* schools contained between 10-50%, and *lower-achieving* schools contained less than 10%. We have uncovered the following trends in digital tool usage:

1. *Gradewide-use* schools use digital tools significantly more consistently throughout the school year than *limited-use* schools, even though both school types spend similar amount of *mean weekly instruction time* on digital tools.
2. Some *limited-use* schools use digital tools as supplemental tools for *below-grade* students since limited schools do not use digital tools often enough to be a main mode of teaching. Certain *limited-use* schools had zero hours logged by *on-grade* students.
3. In *gradewide-use* schools, i.e., where most of the grade is using digital tools for much more significant amount of time than *limited-use* schools throughout the school year, we observed increased usage in the last 6 years in *lower-* and *middle*-achieving schools while no increased usage in *higher-achieving* schools. Moreover, *on-grade* students had a greater increase in usage than *below-grade* students, especially in *lower-achieving* schools.

Implications

The increased usage of digital tools that we observed in the *post-pandemic* setting indicates a shift in how K-8 learning is occurring. While this study uncovered certain patterns in digital tool usage, it is a national level study. It is imperative to confirm whether these overall trends are seen at the local level, specific to one's school district. Given the recent shift in usage, it remains to be seen how digital learning tools will shape student performance. For example, we observed certain *limited-use* schools using i-Ready only with *below-grade* students. It is unclear whether digital tools serve as a supplement to an existing lesson plan or a replacement. In the case that it is a replacement, it is imperative to know whether digital tools improve learning outcomes at least the same rate as the replaced lesson. On the other hand, if acting as a supplemental tool and it improved learning outcomes compared to students that did not use digital tools, then that is a strong indication that digital tools should continue to be used in that manner. Such analysis requires to be conducted at the school district level.

Another key observation that begs further analysis is the widened total usage gaps between *on-grade* and *below-grade* students in *lower-achieving*, *gradewide* schools. It is unclear whether *on-grade* students are completing more digital lessons outside of school hours as homework (higher level lessons tend to take more time than lower-level lessons) or *on-grade* students are completing digital lessons during school hours so that teachers have more opportunities to work with *below-grade* students. Again, such usage patterns should be investigated at the local level and will help connect the bridge between usage and performance outcomes due to these digital tools in K-8 learning.

References

1. The Center for Reinventing Public Education (2022) and Betthäuser, B.A., Bach-Mortensen, A.M., & Engzell, P. (2023) provide some of the most recent reviews of the literature.

Figure 1. Total time spent per student (in hours), average time spent per student per week (in minutes), and total weeks of usage in school year.

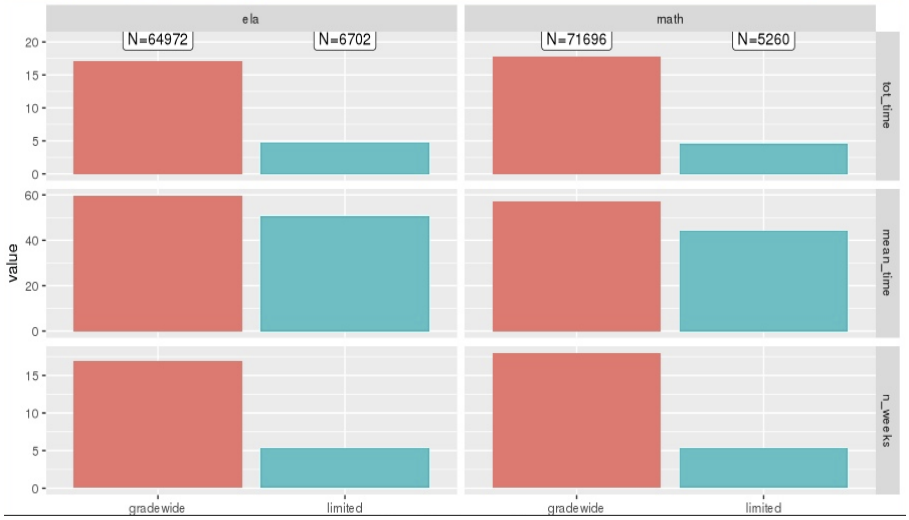

Figure 2. School percentage of hours that were completed by on-grade students vs. the school percentage of on-grade students.

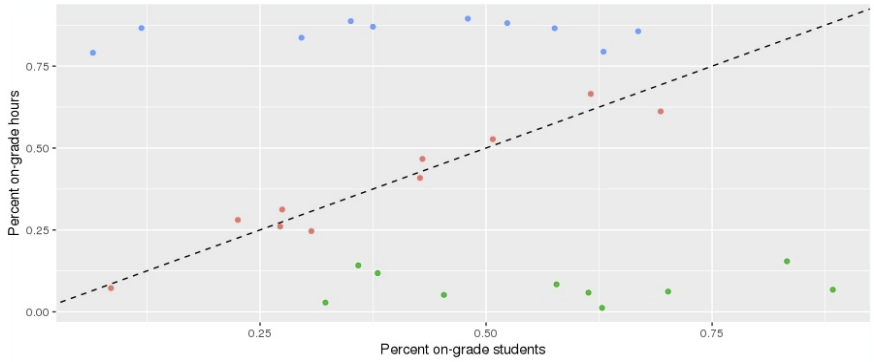

Figure 3. School percentage of hours that were completed by on-grade students vs. the school percentage of on-grade students, in gradewide and limited (targeted) use contexts.

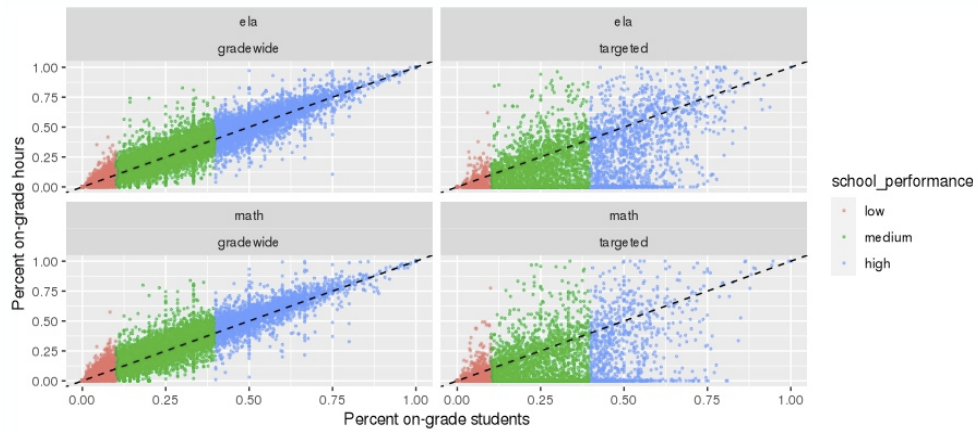

Figure 4a. Math. Total time spent per student (in hours), average time spent per student per week (in minutes), and total weeks of usage in school year, before and after the pandemic and by grade-level status.

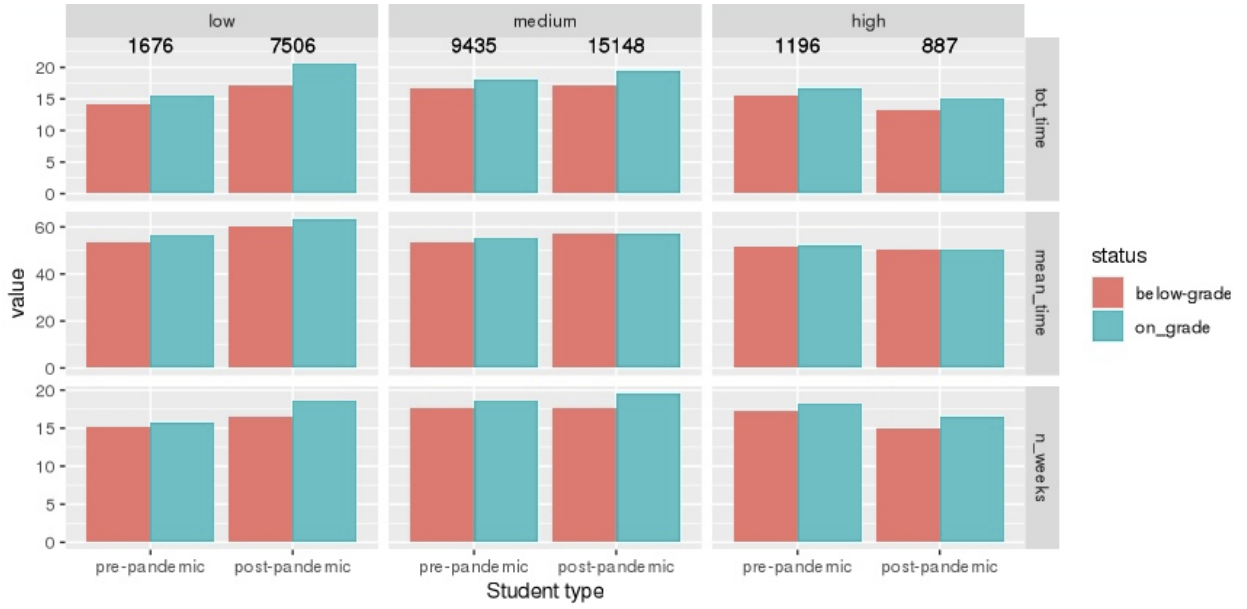

Figure 4b. Reading. Total time spent per student (in hours), average time spent per student per week (in minutes), and total weeks of usage in school year, before and after the pandemic and by grade-level status.

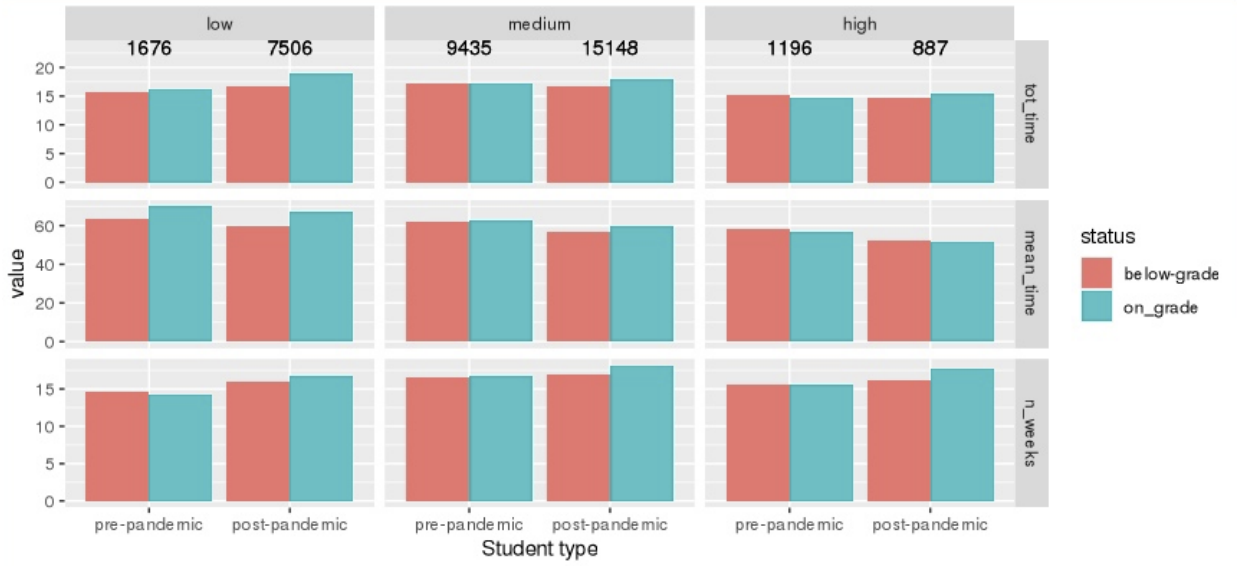

Figure 5a. Changes over time by grade-level status in Math.

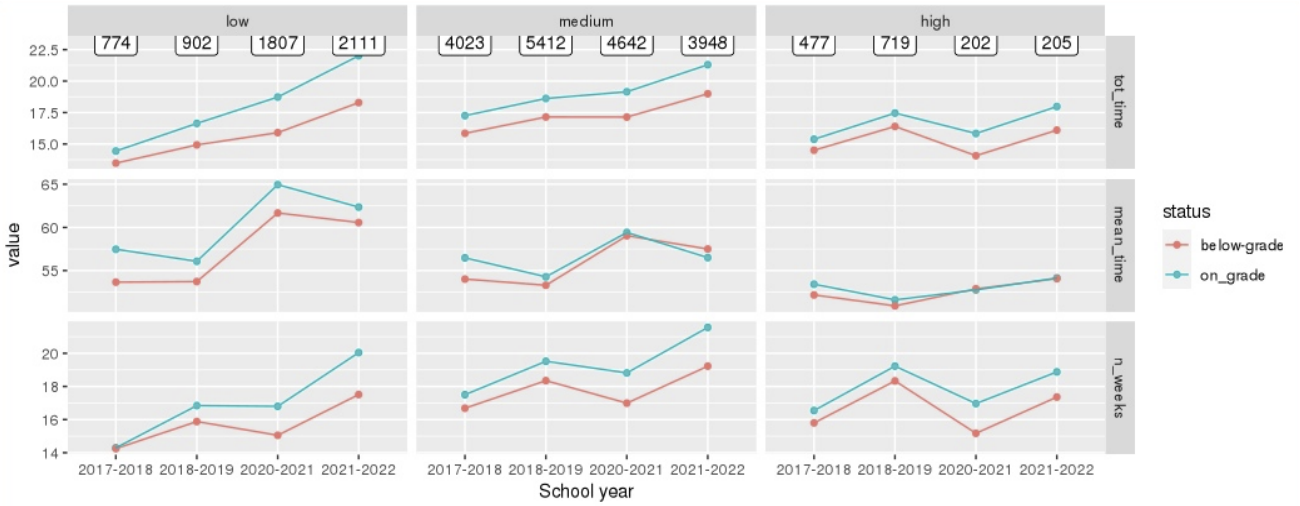

Figure 5b. Changes over time by grade-level status in Reading.

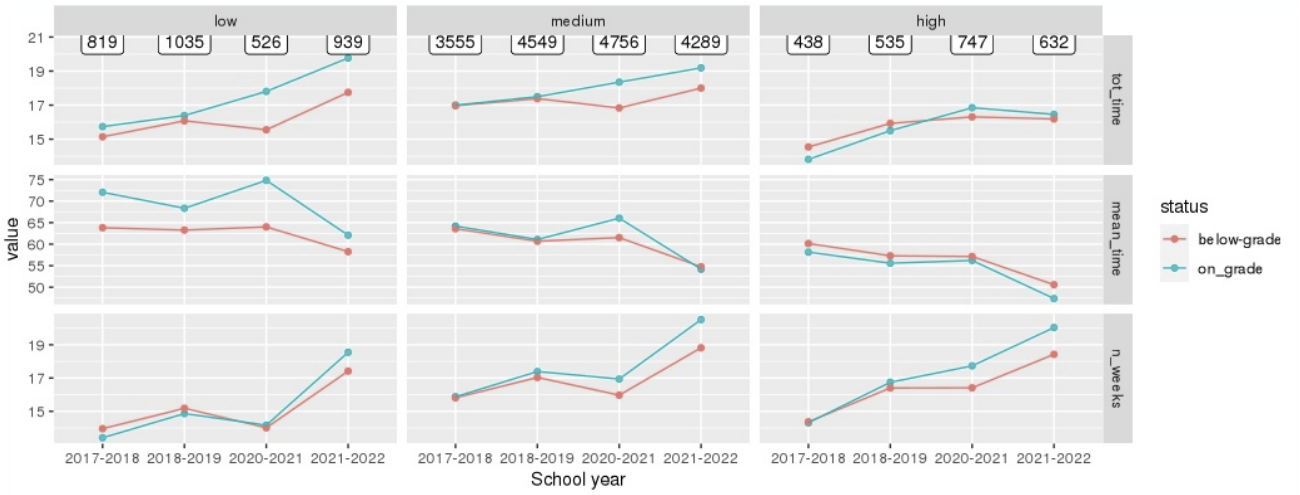

Table 1. Numbers from Figure 4.

Subject	School Performance	Variable	Status	Mean pre-pandemic	Mean post-pandemic	Std dev pre-pandemic	Std dev post-pandemic	Mean delta	Mean % change
ela	low	mean_time	below_grade	63.5	59.8	12.9	17.1	-3.7	-5.8
ela	low	mean_time	on_grade	70	66.9	22.4	28.2	-3.1	-4.4
ela	low	tot_time	below_grade	15.7	16.7	8.9	9.6	1	6.4
ela	low	tot_time	on_grade	16.1	18.9	10.5	13.5	2.8	17.4
ela	low	n_weeks	below_grade	14.6	16	6.5	6.3	1.4	9.6
ela	low	n_weeks	on_grade	14.2	16.7	7.8	8.1	2.5	17.6
ela	medium	mean_time	below_grade	62	57	13.2	16.1	-5	-8.1
ela	medium	mean_time	on_grade	62.4	59.7	15.2	20.1	-2.7	-4.3
ela	medium	tot_time	below_grade	17.2	16.6	9.5	9.3	-0.6	-3.5
ela	medium	tot_time	on_grade	17.3	18.1	10.1	10.4	0.8	4.6
ela	medium	n_weeks	below_grade	16.5	16.9	6.9	6.7	0.4	2.4
ela	medium	n_weeks	on_grade	16.7	18.1	7.6	7.4	1.4	8.4
ela	high	mean_time	below_grade	58.6	52.3	13.2	17	-6.3	-10.8
ela	high	mean_time	on_grade	56.7	51.5	19	16.8	-5.2	-9.2
ela	high	tot_time	below_grade	15.3	14.8	9.2	9.9	-0.5	-3.3
ela	high	tot_time	on_grade	14.7	15.5	9	9.4	0.8	5.4
ela	high	n_weeks	below_grade	15.5	16.2	7.3	7.4	0.7	4.5
ela	high	n_weeks	on_grade	15.7	17.7	7.8	7.7	2	12.7
math	low	mean_time	below_grade	53.7	60.4	12.7	17.4	6.7	12.5
math	low	mean_time	on_grade	56.7	63.3	17.5	25.4	6.6	11.6
math	low	tot_time	below_grade	14.3	17.3	8.1	9.7	3	21
math	low	tot_time	on_grade	15.6	20.5	10.6	14	4.9	31.4
math	low	n_weeks	below_grade	15.1	16.5	6.4	6.3	1.4	9.3
math	low	n_weeks	on_grade	15.7	18.6	8	8.2	2.9	18.5
math	medium	mean_time	below_grade	53.6	56.9	12.7	16.2	3.3	6.2
math	medium	mean_time	on_grade	55.2	57.3	14	18.7	2.1	3.8

math	medium	tot_time	below_grade	16.6	17.2	8.9	9.3	0.6	3.6
math	medium	tot_time	on_grade	18	19.5	10.1	11.2	1.5	8.3
math	medium	n_weeks	below_grade	17.6	17.6	6.8	6.6	0	0
math	medium	n_weeks	on_grade	18.7	19.6	7.6	7.4	0.9	4.8
math	high	mean_time	below_grade	51.4	50.3	13.7	16.2	-1.1	-2.1
math	high	mean_time	on_grade	52.3	50.5	13.8	17.1	-1.8	-3.4
math	high	tot_time	below_grade	15.6	13.3	9.1	9.2	-2.3	-14.7
math	high	tot_time	on_grade	16.6	15	9.7	10.9	-1.6	-9.6
math	high	n_weeks	below_grade	17.3	15	7.3	7.3	-2.3	-13.3
math	high	n_weeks	on_grade	18.2	16.5	8	7.8	-1.7	-9.3

Table 2. Numbers from Figure 5.

Subject	School Performance	Variable	Status	2017-2018	2018-2019	2020-2021	2021-2022	Mean delta	Mean % change
ela	low	tot_time	below-grade	15.1	16.1	15.6	17.7	2.6	17.2
ela	low	tot_time	on_grade	15.7	16.4	17.8	19.8	4.1	26.1
ela	low	mean_time	below-grade	63.8	63.3	64	58.3	-5.5	-8.6
ela	low	mean_time	on_grade	72	68.3	74.8	62.1	-9.9	-13.7
ela	low	n_weeks	below-grade	14	15.2	14	17.4	3.4	24.3
ela	low	n_weeks	on_grade	13.4	14.9	14.2	18.5	5.1	38.1
ela	medium	tot_time	below-grade	17	17.4	16.8	18	1	5.9
ela	medium	tot_time	on_grade	17	17.5	18.4	19.2	2.2	12.9
ela	medium	mean_time	below-grade	63.6	60.7	61.5	54.7	-8.9	-14
ela	medium	mean_time	on_grade	64.2	61.1	66	54.2	-10	-15.6
ela	medium	n_weeks	below-grade	15.8	17	16	18.8	3	19
ela	medium	n_weeks	on_grade	15.9	17.4	16.9	20.5	4.6	28.9
ela	high	tot_time	below-grade	14.5	15.9	16.3	16.2	1.7	11.7
ela	high	tot_time	on_grade	13.8	15.5	16.8	16.5	2.7	19.6
ela	high	mean_time	below-grade	60.1	57.3	57.1	50.6	-9.5	-15.8
ela	high	mean_time	on_grade	58.1	55.6	56.2	47.4	-10.7	-18.4

ela	high	n_weeks	below-grade	14.4	16.4	16.4	18.4	4	27.8
ela	high	n_weeks	on_grade	14.3	16.7	17.7	20	5.7	39.9
math	low	tot_time	below-grade	13.5	14.9	15.9	18.3	4.8	35.6
math	low	tot_time	on_grade	14.4	16.6	18.7	22	7.6	52.8
math	low	mean_time	below-grade	53.7	53.7	61.7	60.6	6.9	12.8
math	low	mean_time	on_grade	57.5	56.1	65	62.4	4.9	8.5
math	low	n_weeks	below-grade	14.2	15.9	15.1	17.5	3.3	23.2
math	low	n_weeks	on_grade	14.3	16.8	16.8	20	5.7	39.9
math	medium	tot_time	below-grade	15.8	17.1	17.1	19	3.2	20.3
math	medium	tot_time	on_grade	17.3	18.6	19.2	21.3	4	23.1
math	medium	mean_time	below-grade	54	53.3	59	57.5	3.5	6.5
math	medium	mean_time	on_grade	56.5	54.3	59.4	56.5	0	0
math	medium	n_weeks	below-grade	16.7	18.4	17	19.2	2.5	15
math	medium	n_weeks	on_grade	17.5	19.5	18.8	21.6	4.1	23.4
math	high	tot_time	below-grade	14.5	16.4	14.1	16.1	1.6	11
math	high	tot_time	on_grade	15.4	17.5	15.8	18	2.6	16.9
math	high	mean_time	below-grade	52.2	50.9	52.9	54.1	1.9	3.6
math	high	mean_time	on_grade	53.4	51.6	52.8	54.1	0.7	1.3
math	high	n_weeks	below-grade	15.8	18.3	15.2	17.4	1.6	10.1
math	high	n_weeks	on_grade	16.5	19.2	17	18.9	2.4	14.5