The Impact of the Covid-19 Pandemic on Student Performance and Assessing the Impact among Different Socioeconomic Groups*

Tulin Erdem† New York University

Masakazu Ishihara‡ New York University

Zekun Liu§ New York University

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†Leonard N. Stern School Professor of Business and Professor of Marketing at Leonard N. Stern School of Business, New York University (email: te17@stern.nyu.edu)

‡Associate Professor of Marketing at Leonard N. Stern School of Business, New York University (email: mi25@stern.nyu.edu)

§PhD student of Marketing at Leonard N. Stern School of Business, New York University (email: zl3126@stern.nyu.edu)

1 Introduction

Education is often referred to as the great equalizer and the solution to poverty. It opens doors to jobs and career possibilities. With the advancement of digital technology, the emerging educational technology (edtech) products started to redefine how education is imparted. The broader edtech space reaches an increased number of students, provides high-quality resources and materials, and streamlines the technicalities to better cater to students' needs.

Meanwhile, long-lasting educational disparities exist across socioeconomic groups. They are evident early in childhood and persist through K-12 education, as reflected in various aspects: test scores assessing academic performance such as reading and mathematics, dropout and graduation rates, proportions of students involved in gifted and talented programs, etc. The mass disruption of schooling created by COVID-19 prompted the shift to distance learning and sent over 20 million K-12 students home to learn virtually. This further widened the existing educational divide across socioeconomic groups (Department of Education, 2021).

The COVID-19 pandemic has substantially increased the usage of digital resources and accelerated the shift to online learning. In this paper, we look into how COVID-19 has affected existing student achievement gaps by using various student involvement and performance measures. To shed light on the question, we partnered with ReadWorks, a nonprofit organization that partners with K-12 teachers across the country to solve America's reading comprehension crisis and student achievement gap. We leveraged its vast anonymized database to understand the differential impact of the COVID-19 on students among different socioeconomic groups.

Using ReadWorks' data, we looked at assignment open rate and student performance based on structured (e.g., multiple-choice questions) and unstructured (e.g., written reflections with no length guidelines) assignments. We find that while students from both high-poverty and low-poverty schools are negatively affected by COVID-19 in terms of assignment open rate, the negative impact is disproportionally concentrated among students from high-poverty schools. This is consistent with previous empirical evidence that COVID-19 has negatively affected students and widened the education divide (Garc´ıa and Weiss, 2020). In addition, for those students who opened the assignments before and after the pandemic, their performance improved for more structured assignments and declined for less structured assignments after

the pandemic.

2 Literature

After the outbreak of the COVID-19 pandemic, schools around the world were shut down, which forced both teachers and students to adapt to a new reality. Recent works have documented the disparate impact of the COVID-19 pandemic on student education. The U.S. Department of Education released a report on how the pandemic has impacted students and widened the education divide among certain groups (Department of Education, 2021). This report provides evidence showing that the pandemic has negatively affected the academic growth of K-12 students, widening pre-existing disparities in core subjects like math and reading. Specifically, COVID-19 appears to have deepened the impact of disparities in access and opportunity facing many students of color in public schools. Garc´ıa and Weiss (2020) provide evidence about how COVID-19 is exacerbating opportunity gaps that put high-poverty students at a disadvantage relative to their better-off peers. This exacerbation of the opportunity gap is also associated with uneven access to food and nutrition, shelter, health insurance, and financial relief measures.

In addition, there are surveys providing aggregate level statistics about how the pandemic has affected student performances based on their standardized testing scores. Kuhfeld et al. (2020) find that, in almost all grades, most students made some learning gains in both reading and math since the COVID-19 pandemic started. However, gains in math were lower on average in fall 2020 than prior years, resulting in more students falling behind relative to their prior standing. However, as the pandemic has also resulted in limited standardized testing, the understanding of how achievement may differ across student groups during the pandemic is incomplete. Leveraging the educator-student-level data from Readworks, we focus on users (including educators and students) that have been using ReadWorks before and after the pandemic. This way, we are able to identify the impact of the pandemic on both educator usage and student performance at a more granular level. In addition, we are able to identify the disparate impact of the pandemic on different socioeconomic groups as we also can observe their interaction with ReadWorks platform before the pandemic.

3 Background and Data

ReadWorks leverages cognitive science and reading research to create content, teacher guidance, and integrated tools to improve teacher effectiveness and student reading achievement. ReadWorks contents and tools are designed for immediate use within the practical realities of current U.S. classrooms. Currently, over 1 million teachers and 17 million students are using ReadWorks each year. Eighty-eight percent of k-8 public and charter schools across the United States had educators using ReadWorks in 2019-2020.

Educators

We focused on 20,000 educators who created their ReadWorks account between 2017-08-01 and 2021- 07-15 and have used ReadWorks digitally. Among these educators, 88% are from public schools, 6% from charter schools and 6% from private schools. In the United States, the percentage of students eligible for free or reduced-price lunch (FRPL) under the National School Lunch Program provides a proxy measure for the concentration of low-income students within a school. Public schools are divided into categories by FRPL eligibility. High-poverty schools are defined as public schools where 75.0 percent or more of the students are eligible for FRPL. Based on this definition, 30% of the teachers in our sample are from high-poverty schools.

Figure 1: Educator Accounts Created Time by Poverty Level

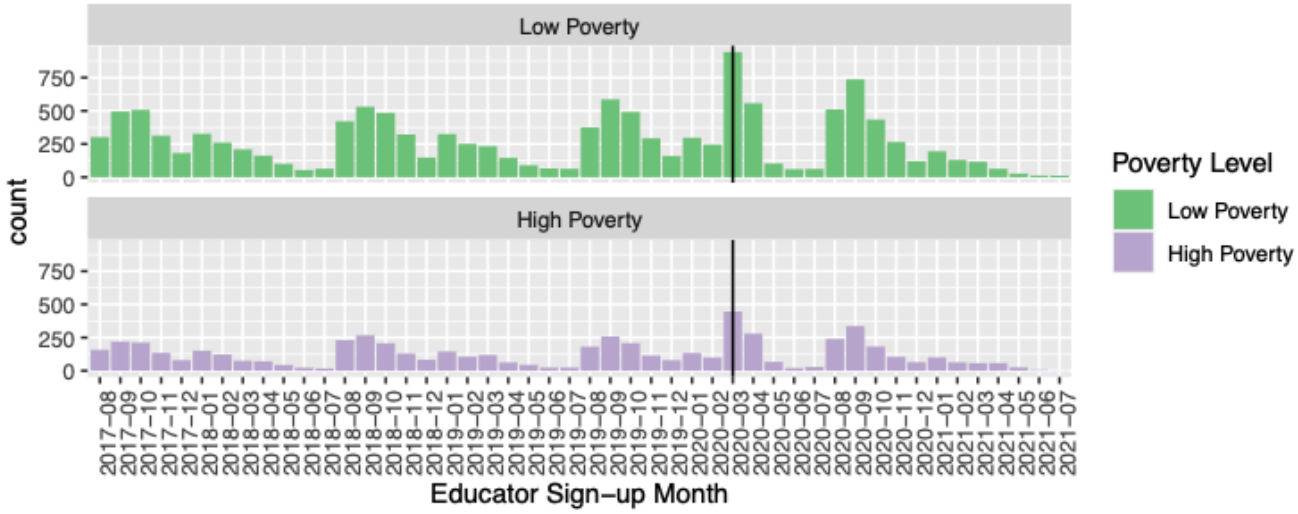
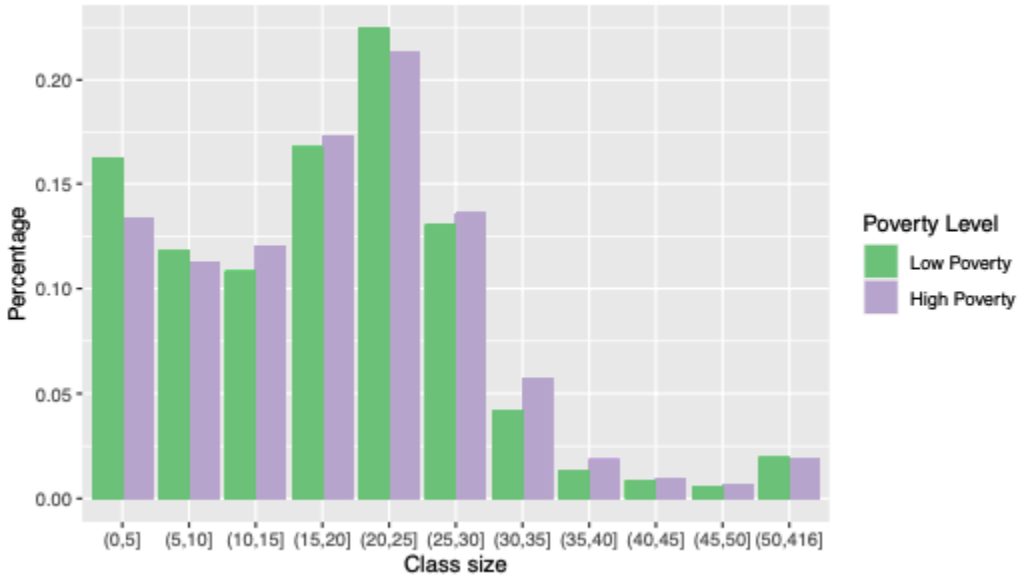


Figure 1 shows the number of accounts created within each month from August 2017 to July 2021 broken down by poverty level. We see that for schools of all poverty levels, there is a surge in educator account creation after the outbreak of the pandemic in March 2020. In addition, among the 60,218 classes in our sample, classes taught by teachers from high-poverty schools tend to have a bigger class size, according to Figure 2.

Figure 2: Class Size Histogram by Poverty Level



Assignments

Educators on ReadWorks mainly use two products for assignments: Article-A-Day, which includes a written reflection, and reading passages with text-dependent question sets, as strategic reading comprehension practice.

Article-A-Day (AAD) is a 10-15 minutes daily routine focused on increasing three critical aspects of reading comprehension: background knowledge, vocabulary and reading stamina. The hand-curated AAD text sets focus on a new topic each week, and the passages in the text sets are relatively brief and contain clear, direct sentences that provide content on a topic. Students choose an article to read each day, and then they write or type in their Books of Knowledge two or three things that they learned from the article and would like to remember. We refer to this type of assignment that requires written reflections without length guidelines as unstructured assignments.

The second product is ReadWorks text-dependent ques- tion sets. They provide carefully scaffolded practice in activating prior knowledge about text structure, inferring, monitoring and clarifying, and questioning. They help readers engage with texts and dig deeply into what they are reading, strengthening students' skills as strategic readers. Question sets include multiple-choice and open-ended questions with most questions being multiple choice. We refer

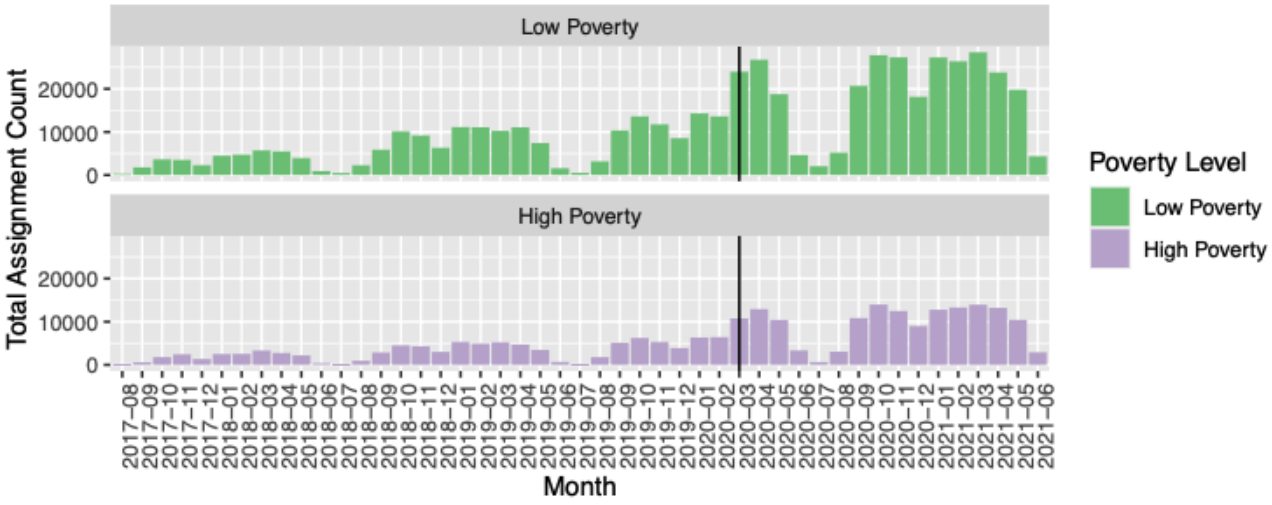
to this type of assignment that is made up of predominantly multiple-choice questions as structured assignments.

Here is a brief summary of statistics of the two types of assignments in our sample.

- Unstructured Assignments:
  - 147,505 AAD assignments from 8,567 educators
  - One assignment includes 5-13 articles: 57.2%, 13.1%, 12.0%, and 10.5% of the assignments include 6, 10, 7, and 8 articles, respectively
- Structured Assignments:
  - 463,615 assignments with question sets from 16,844 educators
  - 87% of the assignments have only one article, and 90% of the assignments include only one question set.
  - Median numbers of multiple-choice questions and open-ended questions are 7 and 3, respectively

Further, figure 3 plots the total assignment count over time across the high- and low-poverty groups. We see a surge of assignment count after the outbreak of the pandemic for both groups.

Figure 3: Total Assignment Count Over Time



Student Involvement and Performance Measures

We focus on different student performance measures for the two different types of assignments. For each unstructured assignment, we observe if a student has ever opened the assignment. Therefore, we can use the assignment open rate to measure student involvement. Furthermore, we observe the number of written text entries submitted and the word count of each submitted text entry. Therefore, for each unstructured assignment, we can evaluate a student's involvement and performance using the following four measures: 1) assignment open rate, 2) submission rate of written text entries given the student has opened the assignment at least once, and 3) total word count of a written submission for an assignment.[1]

Similarly, for each structured assignment, we use the assignment open rate to measure student involvement. Furthermore, we observe the number of multiple-choice questions and that of open-ended questions a student has answered. In addition, as the multiple-choice questions are auto-graded, we also observe the number of multiple-choice questions a student got correct. Therefore, for each structured assignment, we can evaluate a student's involvement and performance using the following four measures: 1) assignment open rate, 2) multiple-choice questions response rate, 3) open-ended questions response rate, and 4) multiple-choice questions correct rate.

Except for the assignment open rate, which is at the assignment level, all other measures can be created for each student submission (student-assignment level). Tables 1 and 2 show the average student performance measures across different poverty groups before and after the outbreak of the COVID-19 pandemic. We find that the average performance for high-poverty groups is lower than that of students from low-poverty groups. Also, assignment open rates for both types of assignments decrease for both high- and low-poverty groups after the outbreak. We see after the outbreak increases in performance measures related to multiple-choice questions in structured assignments for both groups of students and decreases in performance related to unstructured assignments. Moreover, COVID-19 seems to affect the two groups of students unevenly, e.g., students from the high-poverty group suffered a greater drop in assignment open rates.

Table 1: Student Unstructured Assignment Performance Based on Article-A-Day assignments with Book of Knowledge

	Low Poverty		High Poverty	
	pre-COVID	post-COVID	pre-COVID	post-COVID
Assignment Open Rate	0.773	0.705	0.734	0.591
BOK Submission Rate	0.444	0.411	0.424	0.362
Total Word Count per assignment	101.941	87.270	101.317	79.669

[1]Note that having longer summary doesn't necessarily translate to better performance. However, the word count is informative as it may serve as a proxy for involvement.

Table 2: Student Structured Assignment Performance Based on Assignments with Question Sets

	Low Poverty		High Poverty	
	pre-COVID	post-COVID	pre-COVID	post-COVID
Assignment Open Rate	0.784	0.761	0.740	0.664
MC Response Rate	0.852	0.865	0.813	0.829
SA Response Rate	0.744	0.709	0.664	0.643
MC Correct Rate	0.624	0.644	0.546	0.574

4 The impact of COVID-19 pandemic on student performance

We investigate how COVID-19 affects student performance by performing the following regression:

$$y_{sjt} = \mu_k 1\{month_t = k\} + \theta_g 1\{grade_s = g\} + \gamma_i 1\{educator_s = i\} + \lambda_s + \beta_1 after\ covid_t + \beta_2 after\ covid_t \times high\ poverty_s + \beta_3 assignment\ difficulty + \varepsilon_{it},$$

where y_{sjt} represents student s's performance on assignment j at time t, μ_k is the month fixed effects, θ_g is the grade level fixed effect of the student s's class, γ_i is the educator fixed effect, λ_s is the student fixed effect, β_1 captures the effect of the COVID-19 on the performance of students from the low-poverty group, β_2 represents the difference between the COVID-19's effects on low-poverty and high-poverty groups, β_3 captures the impact of assignment difficulty level using the

assignment grade information, and $_{sjt}$ is the error term.

β_1 and $\beta_1 + \beta_2$ capture the COVID-19's impact on the performance of students from low-poverty and high-poverty groups, respectively. Tables 3 and 4 report the estimates of COVID-19's impact on various performance measures using structured assignments and unstructured assignments, respectively. According to Tables 3 and 4, the COVID-19 pandemic has negatively affected the assignment open rate, and the magnitude of the negative impact is larger on students from high-poverty schools. Specifically, column (1) in Table 3 implies that while a student from a low-poverty school is 4.2% less likely to open a structured assignment, a student from a high-poverty school is 7.2% less likely to open the assignment.

In addition, we check the average student performance trend for both high-poverty and low-poverty schools to explore the differential impact of the pandemic on various student performance measures. Figures 4 and 5 show the average assignment open rate over time for both low- and high-poverty groups using assignment open rate as the performance measure and display the differential impact of the COVID-19 pandemic on assignment open rate across different poverty groups: both groups are negatively affected, but the impact is larger in magnitude for the high-poverty group.

Table 3: The impact of COVID-19 on student performance measures using structured assignments

	Dependent variable:			
	assignment open rate	mc response rate	mc correct rate	sa response rate
	(1)	(2)	(3)	(4)
after covid (β_1)		0.042^{***} 0.036^{***} (0.001) (0.001)	0.012^{***} (0.001)	0.013^{***} (0.001)
after covid high poverty (β_2)	0.030^{***} (0.002)	0.003^{*} (0.002)	0.007^{***} (0.002)	0.010^{***} (0.002)
assignment difficulty	0.002^{***} (0.0003)	0.013^{***} (0.0001)	0.029^{***} (0.0001)	0.020^{***} (0.0002)
Class Grade FE	Yes	Yes	Yes	Yes
Educator FE	Yes	Yes	Yes	Yes
Student FE	No	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Observations	463,615	4,700,503	4,700,503	4,434,888
R^2	0.477	0.399	0.449	0.502
Adjusted R^2	0.458	0.304	0.362	0.419
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4: The impact of COVID-19 on student performance measures using unstructured assignments

	Dependent variable:		
	assignment open rate	BOK submission rate	logged sum words written for all articles
	(1)	(2)	(3)
after covid (β_1)	0.057***	0.041***	0.075***
	(0.003)	(0.002)	(0.011)
after covid high poverty (β_2)	0.043***	0.013***	0.039**
	(0.005)	(0.003)	(0.019)
assignment difficulty	0.0004	0.011***	0.030***
	(0.0005)	(0.0002)	(0.001)
logged num articles			0.147***
			(0.008)
Class Grade FE	Yes	Yes	Yes
Educator FE	Yes	Yes	Yes
Student FE	No	Yes	Yes
Month FE	Yes	Yes	Yes
Observations	147,505	1,580,887	1,580,887
R^2	0.566	0.292	0.255
Adjusted R^2	0.540	0.288	0.250
Note:			*p<0.1; **p<0.05; ***p<0.01

Figure 4: AAD Assignment with BOK assigned: Open rate

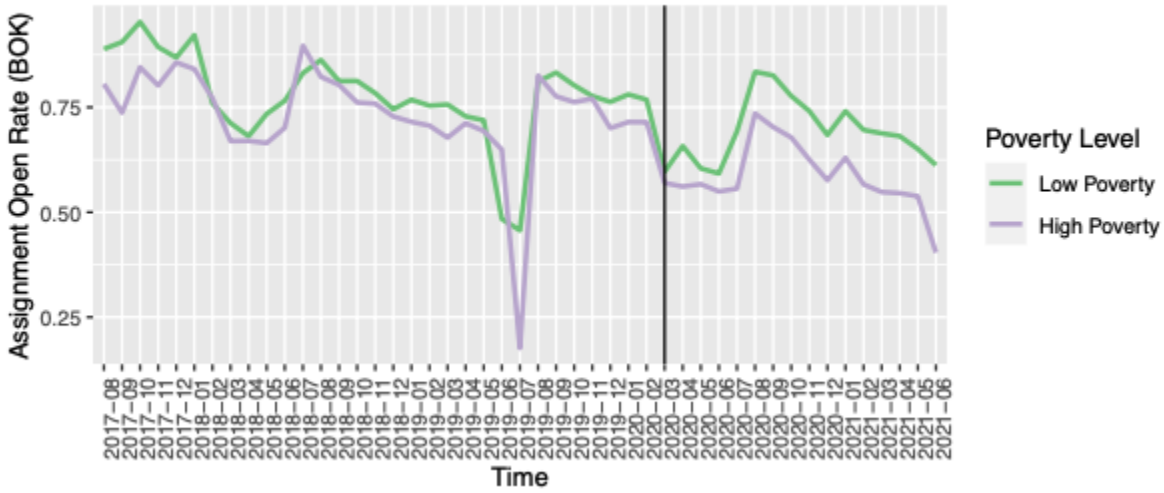
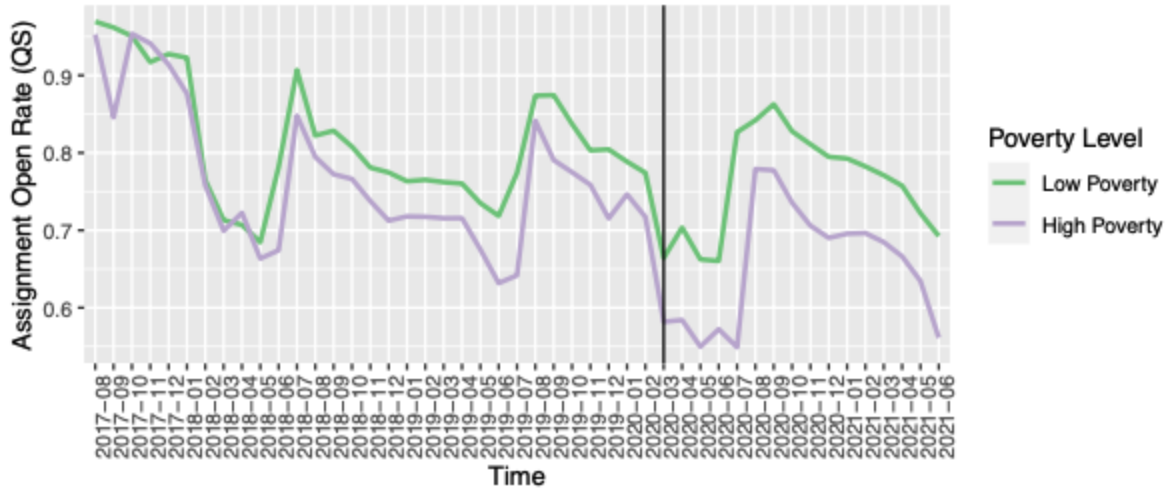


Figure 5: Assignment with Question sets: Open Rate



We further investigate the impact of COVID-19 pandemic on other performance measures given that students do open assignments both before and after the pandemic. Overall, we find that there is an increase in performance for more structured assignments and a decrease in performance for unstructured assignments. In particular, columns (2), (3), and (4) in Table 3 imply that for students who open structured assignments both before and after the pandemic, the response rate to both multiple-choice questions and open-ended questions and the correct rate of multiple-choice questions increase. While this holds for students from both poverty groups, the magnitude of the increase for students from the low-poverty group is slightly smaller. Columns (2) and (3) in Table 4 imply that, even for students that open their unstructured assignments both before and after the pandemic, their written entries submission rate and the total word count for their submitted entries decrease after the pandemic for both poverty groups. However, the magnitude of the decrease for the high-poverty group is slightly smaller.

5 Conclusion

In this paper, we study how the COVID-19 pandemic has affected the existing performance gap between high-poverty and low-poverty groups. We caution that all the analyses are correlations

as regression cannot prove causation. However, it can still provide useful insights, as specific quantitative predictions help explain relations between variables. COVID-19 has negatively affected both high-poverty and low-poverty groups in terms of assignment open rate, but the magnitude of the negative impact is larger for the high-poverty group. However, for those students who open assignments both before and after the COVID-19 pandemic, their performances for structured assignments increase while their performances for unstructured assignments decrease.

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