COVID-19 Döneminde Eğitim Amaçlı Kullanılan Önde Gelen Dijital Öğrenme Araçlarının İncelenmesi

Yazılım Mühendisliği Ana Bilim Dalı - Tezsiz Yüksek Lisans Uzaktan Öğretim - Dönem Projesi

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Öz

Bu araştırma projesi, 2020 yılındaki uzaktan öğrenme manzarasına, 200'den fazla okul bölgesinden ve neredeyse 400 araçtan oluşan geniş bir veri kümesi kullanılarak derinlemesine bir bakış sunmaktadır. Üç tablodan oluşan veri kümesi, neredeyse 12 milyon satır ve 17 değişken içeren ayrıntılı bir veri kümesi oluşturmak üzere filtrelenmiştir. Analiz, katılım endeksine dayalı olarak en popüler araçları belirleyerek Google Docs, Google Classroom ve YouTube'un en yaygın kullanılanlar olduğunu ortaya koymaktadır.

Çalışma daha sonra odak noktasını en üst 10 araca daraltarak, bu araçların 23 eyalet genelindeki kullanımını incelemektedir. Analiz, araç katılımındaki bölgesel desenleri ortaya çıkarmayı amaçlayarak, uzaktan öğrenmenin çeşitli dinamiklerine dair içgörüler sunmaktadır. Proje, araç popülerliğini etkileyen faktörleri anlama konusuna katkıda bulunur, böylece bölgesel farklılıklar, zamansal eğilimler ve demografik ve sosyoekonomik değişkenlerin etkisi gibi.

Esasen, bu araştırma, 2020'deki uzaktan öğrenme manzarasına kapsamlı bir genel bakış sunarak, Amerika Birleşik Devletleri'ndeki çeşitli eğitim ortamlarında araç kullanımını şekillendiren faktörleri aydınlatmaktadır.

Anahtar Kelimeler: Uzaktan öğrenme, Eğitim teknolojisi, Akademik performans, Dijital eğitim, Eğitim araçları, Uzaktan eğitim, Koronavirüs

An Examination of the Preeminent Digital Learning Tools Utilized for Educational Purposes During the COVID-19 Era

Abstract

This research project delves into the landscape of remote learning in 2020 using a vast dataset from over 200 school districts and nearly 400 tools. The dataset, comprising three tables, is filtered to create a detailed dataset of almost 12 million rows and 17 variables. The analysis begins by identifying the top tools based on the "engagement index," revealing Google Docs, Google Classroom, and YouTube as the most popular.

The study then narrows its focus to the top 10 tools, exploring their usage across 23 states. The analysis aims to uncover regional patterns in tool engagement, providing insights into the diverse dynamics of remote learning. The project contributes to understanding factors influencing tool popularity, such as regional variations, temporal trends, and the impact of demographic and socioeconomic variables.

In essence, this research provides a comprehensive overview of the remote learning landscape in 2020, shedding light on the factors shaping tool usage across diverse educational settings in the United States.

Keywords: Remote learning, Educational technology, Digital education, Educational tools, Distance education, Coronavirus

Content

List of Figures

1. Introduction and Data Preparation

In the past 1.5 years, the educational landscape has undergone a transformative evolution unparalleled in its history. The use of computers for educational purposes, once deemed unthinkable just 50 years ago, became an imperative reality in 2020, underscoring the indispensability of societal computerization. The advent of the SARS-CoV-2 virus, precipitating the COVID-19 pandemic, prompted a global imperative to restrict direct human interactions. Consequently, numerous entities, including educational institutions, transitioned to remote learning as a precautionary measure, compelling teachers to conduct lessons through online platforms. This shift affected over a billion students in 133 countries, presenting a significant challenge that was mitigated by the utilization of pre-existing educational tools. The surge in popularity of e-learning, already on an upward trajectory pre-pandemic, positioned it as the most viable educational modality during these unprecedented times.

The inherent interest in this subject arises from its novelty, effecting swift and substantial changes in the lives of millions of students and educators. Consequently, researchers globally have delved into extensive investigations concerning distance learning and its repercussions. Noteworthy among these studies is the research conducted in India, emphasizing substantial disparities in hardware and internet access for distance learning across the country. These discrepancies are particularly pronounced when comparing rural and urban areas, with up to a fivefold difference in accessibility, and inter-state variations exceeding 50 percentage points in internet access. This underscores a pervasive inequality in access to distance learning, leading to profound educational challenges (refer to the bibliography, point 2, for further details).

Additionally, research endeavors have explored optimal learning methodologies to yield effective results for students engaged in distance learning. Notably, a survey among Culinary Arts students in Indonesia revealed a preference for technology-mediated learning tools such as Google Meet, Moodle, and WhatsApp. The ease of use, daily familiarity, well-organized content, and brevity of presentations were cited as key factors contributing to their popularity, fostering flexibility and ease of assimilation. For comprehensive insights, refer to the bibliography, point 3.

This study adopts a distinctive perspective on remote learning by scrutinizing specific tools employed during the process. The analysis focuses on data pertaining to the utilization of technology during learning in the United States in 2020, examining the timing, locations, methods, and rationales behind the use of particular tools. The primary objective of this project is to delineate the multifaceted aspects of remote learning in the United States during 2020, exclusively concentrating on the ten most widely used tools. The research methodology entails exploratory data analysis, centering on a comparative examination of variable levels to discern discrepancies in the phenomenon under scrutiny. This approach involves two stages: the extraction of a data frame from tables through database merging, grouping, arithmetic operations (e.g., summation, counting), and data cleansing (including alterations of data types and addressing missing data). Subsequently, the visualization of the resultant database employs graphical representations, specifically bar and line graphs, recognized for their simplicity, comprehensibility, and efficacy in portraying data dependencies.

The ensuing exploratory analysis and model development will be executed employing the R programming language, supplemented by pertinent packages. Of paramount importance are the packages encompassed within the "tidyverse" framework, renowned for facilitating seamless data manipulation, preparation, analysis, and visualization. The utilization of these tools is imperative for the comprehensive investigation of the dataset under scrutiny.

Central to the graphical representation of findings are two distinct backgrounds: "fivethirtyeight" and a custom background tailored to accommodate specific modifications, primarily pertaining to font sizes and chart elements such as legends. This judicious combination aims to enhance the visual clarity and interpretability of the ensuing charts, ensuring that they effectively convey the nuances of the data.

The adoption of the "tidyverse" package suite signifies a commitment to a systematic and integrated approach in handling the data. Leveraging its diverse functionalities, encompassing data cleaning, manipulation, and visualization, contributes to the coherence and efficiency of the analytical process. The incorporation of custom chart backgrounds further underscores a meticulous attention to detail, allowing for a nuanced representation of the analytical outcomes.

The ensuing sections will expound upon the specific steps involved in the exploratory data analysis, data preparation, and the subsequent modeling endeavors. This comprehensive methodological framework seeks to unravel the intricate facets of remote learning in the United States during the pivotal year of 2020, with a particular focus on the ten most prevalent tools.

This research encompasses an extensive dataset gathered in the year 2020, comprising data from over 200 school districts spanning numerous states. The dataset, meticulously curated and filtered, incorporates three integral tables:

- Regional information delineating district specifics
- Comprehensive details about nearly 400 tools designed for remote work
- Granular insights into the utilization of specific tools in distinct locations, encapsulated in over 200 tables

These tables have been amalgamated into a cohesive, refined database, eliminating cases where tool matches were unavailable. The resultant database is characterized by almost 12 million rows and 17 variables, each entry signifying specific attributes related to a particular tool on a specific day within a distinct location.

While the presented table showcases a snapshot of the data—comprising the initial 10,000 rows and selected variables—this study embarks on a comprehensive analysis of this rich dataset. The ensuing exploration aims to discern patterns, trends, and factors influencing the landscape of remote learning, providing valuable insights into the intricate dynamics of educational technology utilization during the transformative year of 2020.

2. The most popular tools

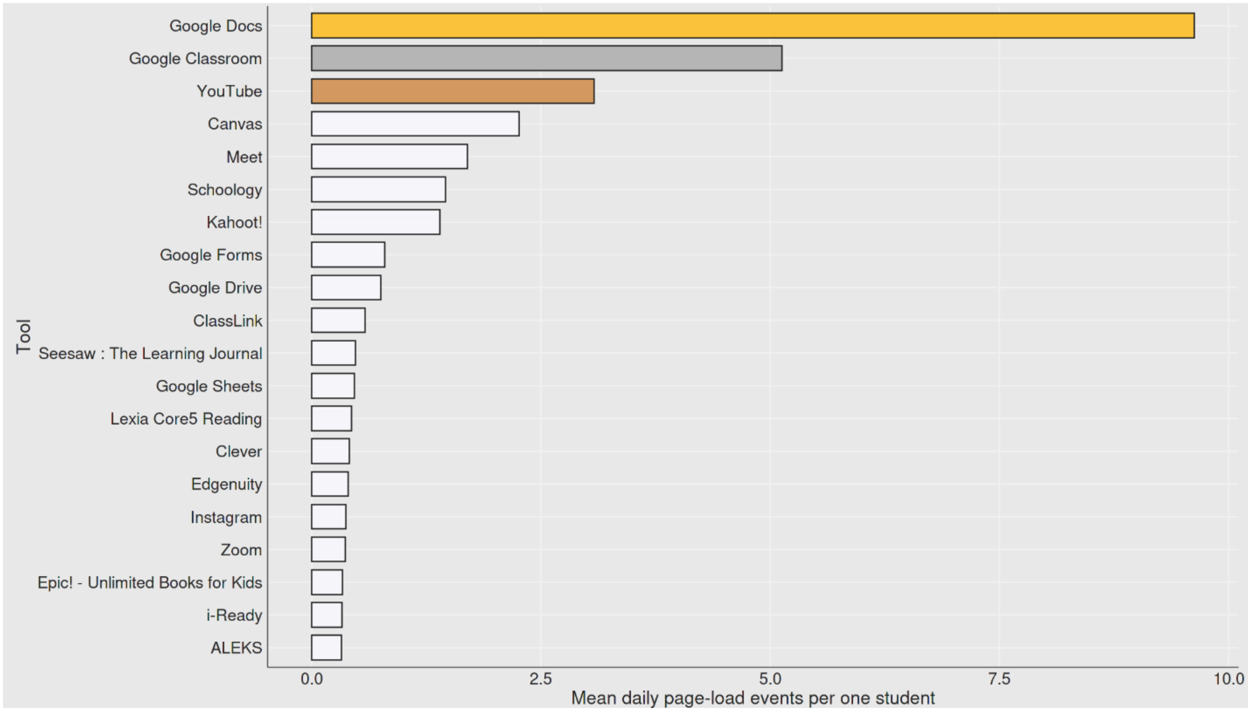

Figure 1 Mean daily page-load events in top 20 tools

The commencement of our analysis involves a meticulous examination of the most salient tools within the dataset. This judicious selection, focusing on the top 20 tools based on the calculated "engagement index" – denoting the total page-load events per student for a specific product on a given day – is instrumental in consolidating our subsequent investigations. This approach enables a nuanced exploration by prioritizing tools with notable prevalence, thereby mitigating the potential dilution of key insights.

The "engagement index" is derived from the arithmetic mean of page-load events per student, serving as a metric to gauge the popularity of each tool. The top 20 tools, thus identified, encompass diverse entities, with Google Docs, Google Classroom, and Youtube securing the leading positions, each boasting an average of over three page-load events per student per day. Notably, this attests to the widespread utilization of these platforms in the educational landscape.

The subsequent analysis narrows its focus to the 10 most popular tools, as an exhaustive examination of all tools, many of which likely possess negligible market share, might obscure pivotal conclusions. The ensuing investigation delves into the regional dimension, stratifying the data by state, given the impracticality of addressing over 200 distinct locations individually. A state-level perspective, with 23 states represented in the database, facilitates a more manageable and insightful exploration.

The forthcoming graphs delineate the average number of entries per student for the top 10 tools across each state. This regional stratification promises to unveil distinctive patterns and variations, shedding light on the differential adoption and usage of these tools in diverse educational landscapes. The ensuing insights aim to contribute to a nuanced understanding of the dynamics of remote learning in the United States during 2020.

3. Tools and States

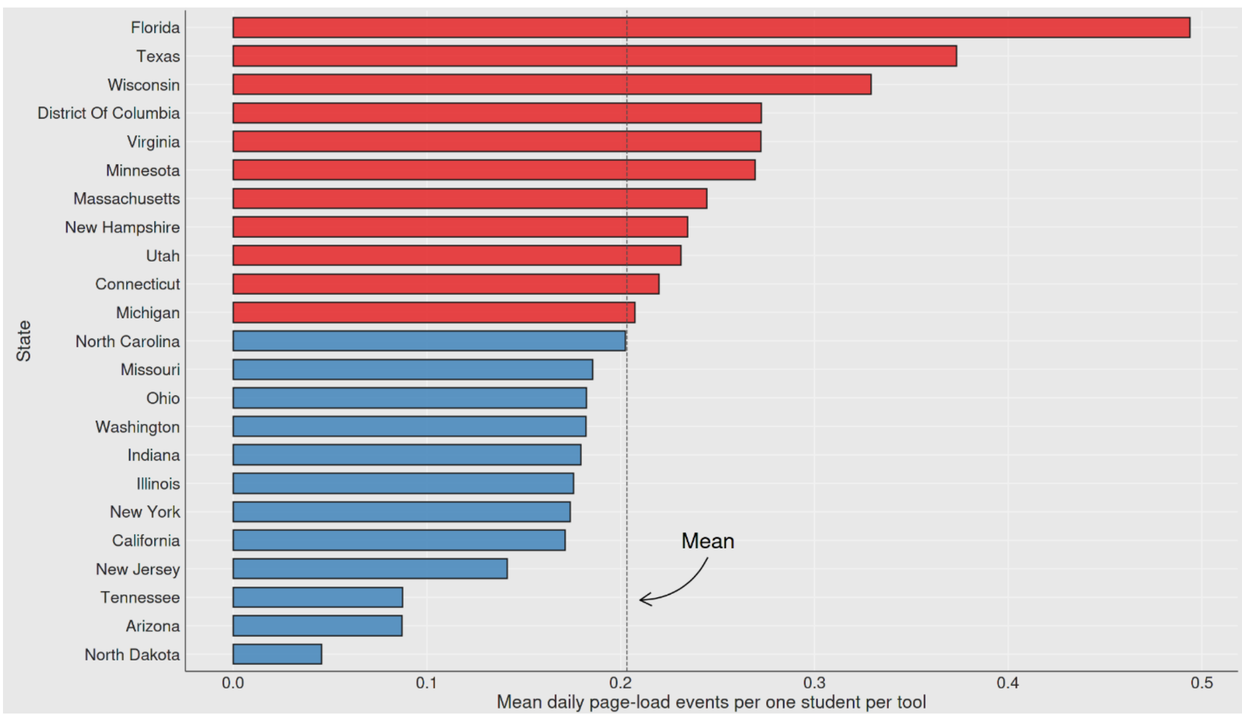

Figure 2 Mean daily page-load events in states (any tool)

Prior to delving into the detailed analysis of the top 10 tools across states, it is prudent to acknowledge the inherent regional disparities in overall activity levels. The following chart illuminates the average number of page-load events per day per person across the 23 distinguished states in the dataset.

Evidently, the state of Florida emerges as the epicenter of heightened activity, boasting an average of 0.49 page-load events per person per day. Subsequently, Texas follows closely with a mean of 0.37, signifying substantial engagement with remote learning platforms. In contrast, states such as Tennessee, Arizona, and North Dakota exhibit the lowest levels of activity within this spectrum.

This preliminary insight into the overarching activity levels across states sets the stage for a more nuanced exploration into the specific engagement patterns with the top 10 tools. The ensuing analyses aim to unravel the intricate dynamics underpinning the utilization of these tools, offering a comprehensive understanding of the multifaceted landscape of remote learning across diverse educational jurisdictions.

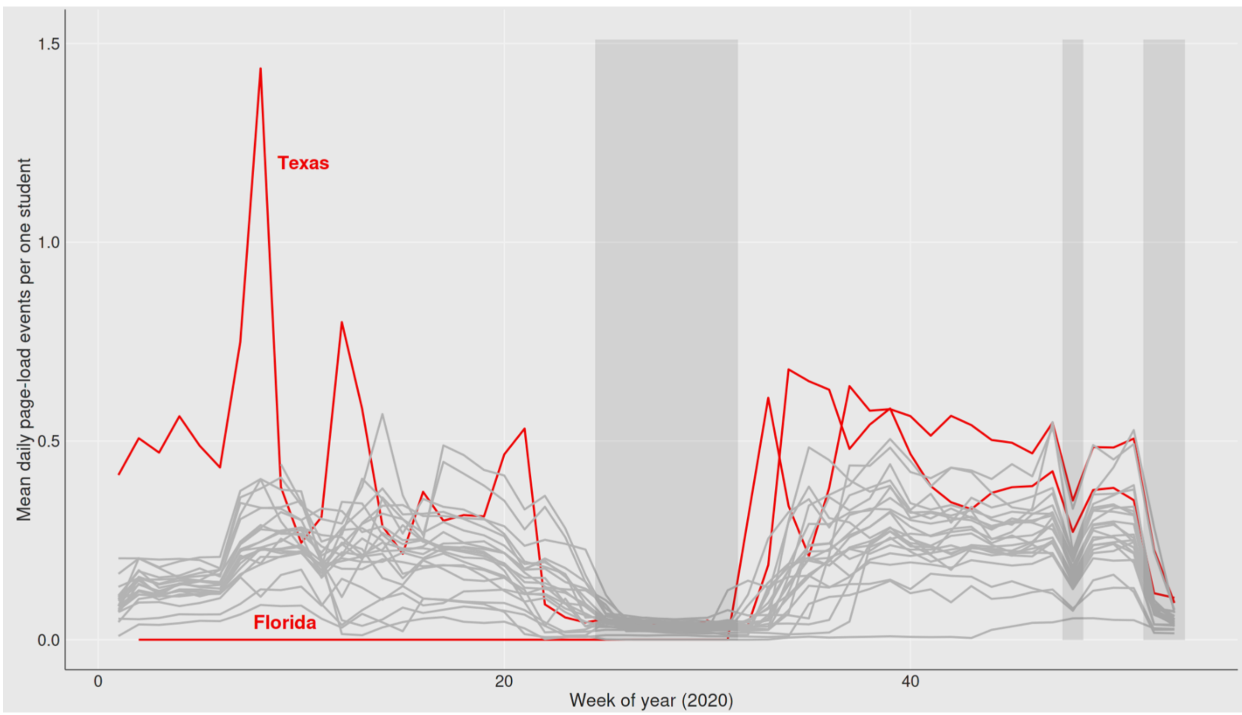

Figure 3 Mean daily page-load events in states (any tool), by state and time

Incorporating the temporal dimension into our analysis, we scrutinize the activity levels in two states demonstrating the highest engagement – Florida and Texas. The chart illustrates the average number of page-load events per day per person, encompassing the entire dataset. Shaded areas denote weeks with designated days off, including holidays.

Notably, Texas emerges as a frontrunner in e-learning tool activity, even preceding the formal introduction of distance learning at the onset of the year when the overall number of COVID-19 cases in the United States was nominal. This early leadership persists following the summer break, reaffirming Texas's consistent prominence in the utilization of e-learning tools.

Conversely, the data from Florida exhibit distortion, primarily attributed to the absence of recorded entries during the initial half of the year, resulting in an inflated average. However, in the subsequent fall period, Florida ascends to the forefront, surpassing other states with the highest daily average number of tool entries per person.

This nuanced temporal analysis, juxtaposed with regional disparities, provides a comprehensive portrayal of the intricate interplay between geographical, temporal, and activity-related dynamics in the context of remote learning. The ensuing sections will delve deeper into the specifics of the top 10 tools, elucidating their regional variations and shedding light on the factors influencing their usage patterns.

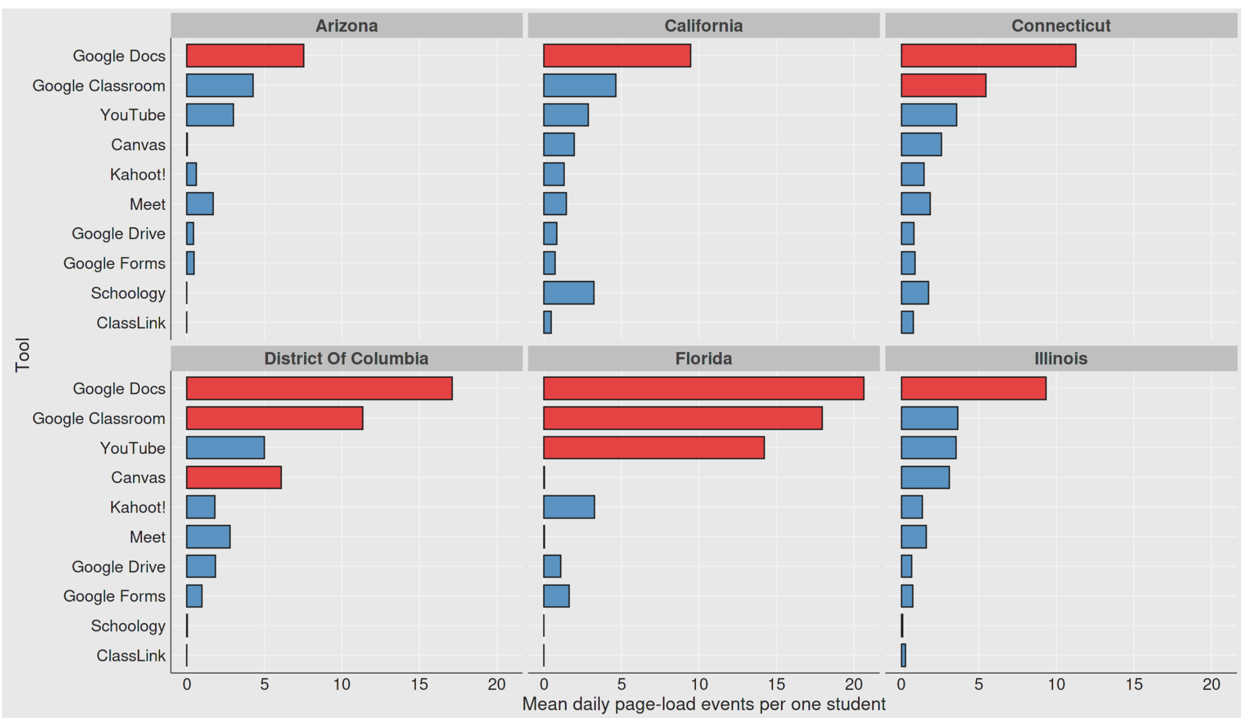

Figure 4 Mean daily page-load events in top 10 tools, by tools and states

Within the initial six states under consideration, delineated alphabetically, Google Docs emerges as the preeminent technology in terms of popularity. Remarkably, across all these states, the average number of page-load events for Google Docs surpasses 5, reaching an exceptional threshold exceeding 20 in the case of Florida. This staggering engagement underscores the pervasive utilization and reliance on Google Docs as a prominent educational tool.

Similarly, Google Classroom attains significant traction, surpassing the threshold of 5 in three out of the six states. This observation emphasizes the widespread adoption of Google Classroom as a favored platform for remote learning. Intriguingly, Canvas gains prominence in the District of Columbia, signifying varied preferences in educational tools across distinct jurisdictions.

Moreover, YouTube emerges as a noteworthy contender, particularly captivating the attention of students and educators in Florida, where the average daily page-load events per person soar to nearly 15. This affirms the diverse spectrum of tools employed for remote learning, with YouTube evidently serving as a prominent resource in the educational landscape of Florida.

These initial insights into tool-specific regional patterns set the stage for a more comprehensive examination of the top 10 tools, unraveling the nuances of their adoption and popularity across diverse states. The subsequent sections will delve deeper into each tool's regional dynamics, providing a granular understanding of the educational technology landscape in the United States during 2020.

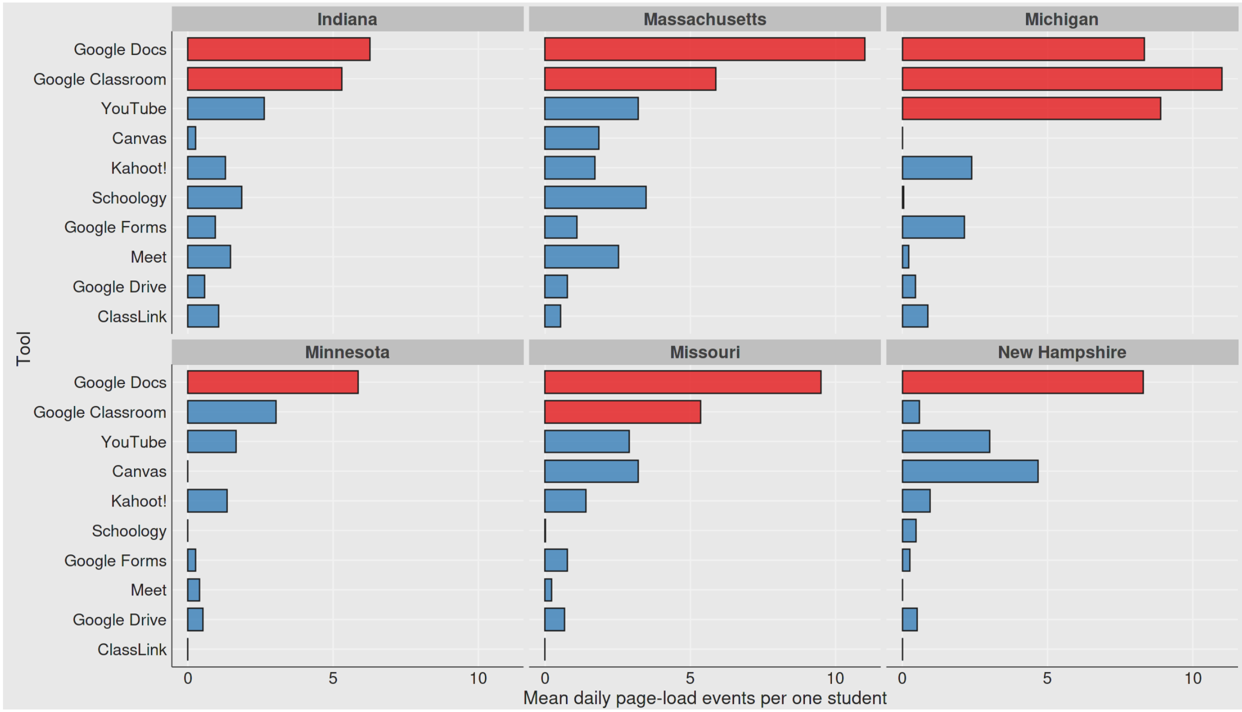

Figure 5 Mean daily page-load events in top 10 tools, by tools and states

Moving on to the subsequent set of six states, it is evident that Google Docs maintains its popularity, although noteworthy variations exist. In Michigan, Google Docs takes a notable third place, following Google Classroom and YouTube in terms of popularity. This divergence underscores the diverse preferences in educational tools even within this grouping of states.

A discernible trend emerges regarding the disproportionate use of the Canvas tool across states. In certain states, such as Missouri and New Hampshire, Canvas attains significant popularity, while in others, notably Michigan and Minnesota, its utilization is comparatively minimal. This disparity highlights the varied regional acceptance and integration of Canvas as an educational resource.

Of particular interest is the state of New Hampshire, which distinguishes itself not only due to its notable reliance on Canvas but also owing to an unusually low utilization of Google Classroom compared to the other five states in this grouping. This unique pattern underscores the idiosyncrasies in tool adoption within individual states, contributing to a nuanced understanding of the multifaceted landscape of remote learning.

These observations, when synthesized, contribute to a more comprehensive depiction of the intricate tool-specific trends across states. The subsequent sections will continue this exploration, shedding light on the regional dynamics of the remaining tools in the top 10, thereby enriching our understanding of the diverse educational technology landscape during 2020.

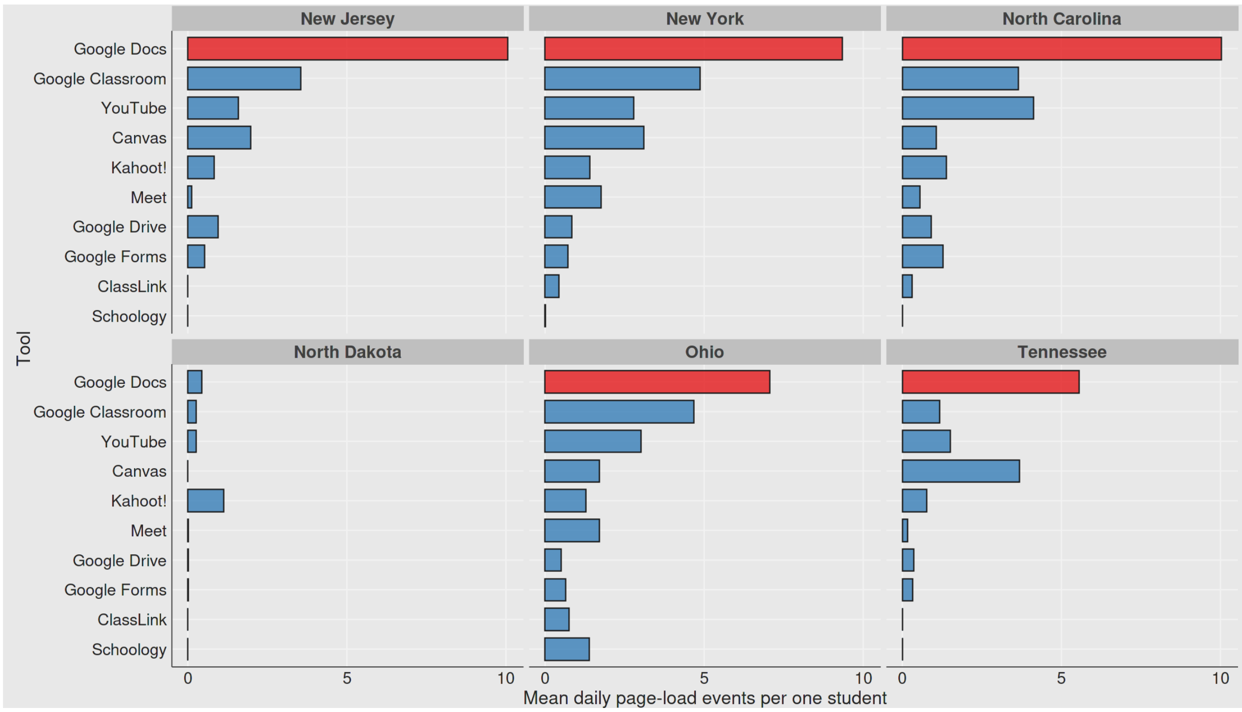

Figure 6 Mean daily page-load events in top 10 tools, by tools and states

Diverging from the observed trends in other states, North Dakota stands out conspicuously with the lowest average number of page-load events per day per person. Notably, tools developed by Google, including Docs, Classroom, and Drive, exhibit minimal popularity in this state. Instead, "Kahoot!" emerges as the unexpected leader among the top 10 most popular tools in North Dakota.

This distinctive pattern in North Dakota underscores a departure from the prevailing trend observed across the nation. In contrast, the other five states highlighted in the chart maintain a more conventional trajectory, with "Google Docs" consistently occupying a leading position. Moreover, as observed throughout the country, substantial disparities persist in the utilization of Canvas across regions, emphasizing the nuanced preferences in educational tools.

The unique scenario in North Dakota contributes to a richer understanding of the diverse educational technology landscapes within individual states. The ensuing sections will continue to scrutinize the remaining states, unraveling further idiosyncrasies and shedding light on the multifaceted dynamics of remote learning tool adoption during the pivotal year of 2020.

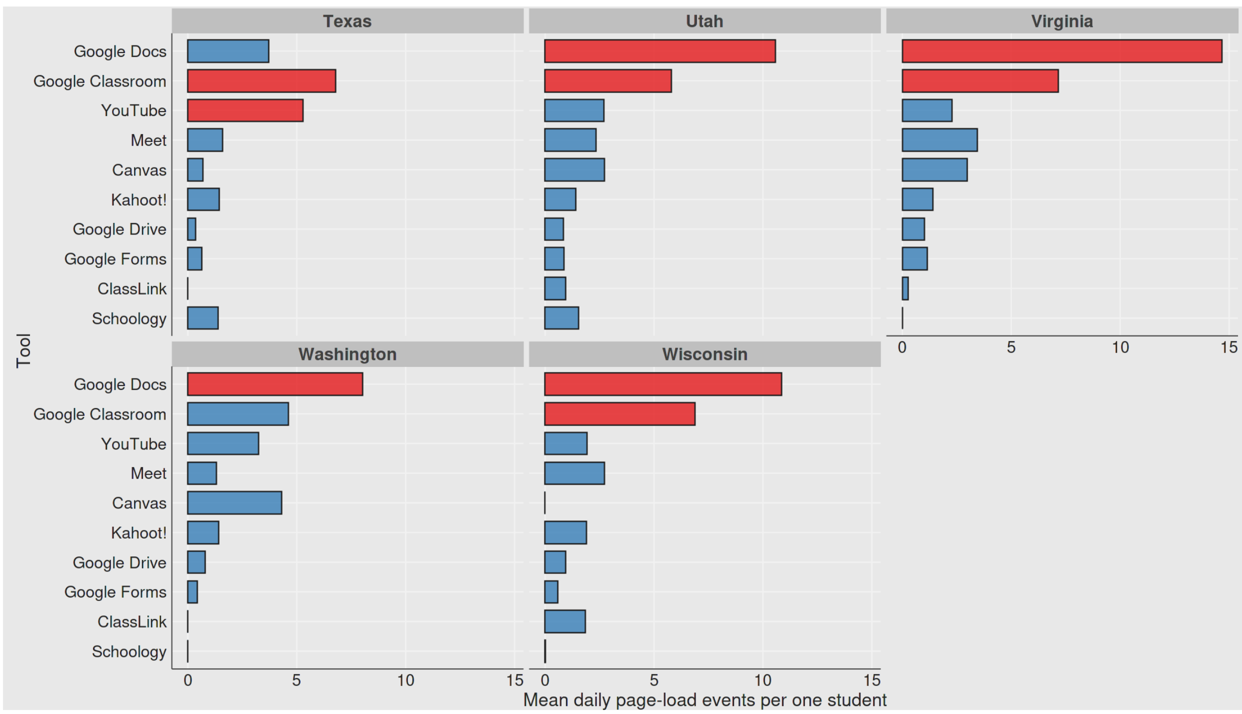

Figure 7 Mean daily page-load events in top 10 tools, by tools and states

An intriguing departure from the prevailing trends is observed in Texas, standing out among the final five states included in the analysis. Despite ranking as the second state with the highest average of the analyzed coefficient, Google Docs does not secure a daily page-load events average exceeding 5 per student, nor does it claim the top spot. Notably, in Texas, Google Classroom takes precedence, leading the pack ahead of Youtube. This distinctive preference sets Texas apart from the remaining four states, where Google Docs and Google Classroom consistently emerge as the top two tools in distance learning.

This atypical pattern in Texas contributes to a nuanced understanding of the regional dynamics in educational tool adoption. The varying popularity and utilization of specific tools underscore the intricate interplay of factors influencing the preferences of students and educators in different states.

As we conclude this analysis of regional trends in remote learning tools across the United States in 2020, the diverse patterns unearthed in each state collectively contribute to a comprehensive understanding of the multifaceted educational technology landscape during this pivotal period.

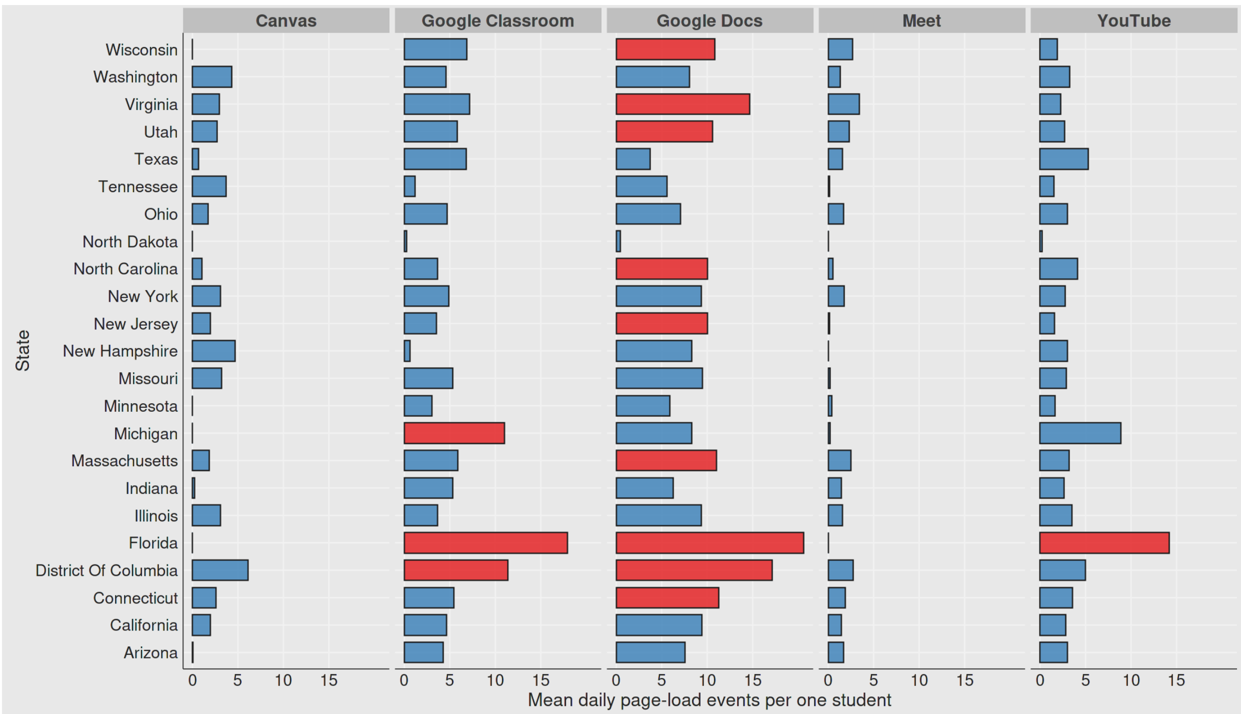

Figure 8 Mean daily page-load events in top 5 tools, by state and tools

Turning our attention to the popularity of specific tools across states, an analysis of alphabetical order reveals distinctive trends in the adoption of various tools within different jurisdictions. Noteworthy observations include:

Canvas:

Experiences significant variability in popularity across states, ranging from being virtually unknown in some regions to emerging as the foremost tool in others.

Attains peak popularity in the District of Columbia and New Hampshire, where it garners an average of 5 visits per person per day.

Google Classroom:

Surpasses the value of 10 in three states, with Florida registering the highest value.

Demonstrates notable popularity across states, cementing its status as a widely embraced tool in various educational landscapes.

Google Docs:

Emerges as the most popular tool overall, registering consistently high or very high values in every state, except North Dakota where tool engagement averages extremely low for all tools.

Meet:

Remains largely unused in numerous states, but gains traction in specific regions, notably the District of Columbia and Virginia.

YouTube:

Secures a distinctive regional dominance, particularly in Florida, where it emerges as the most popular tool overall.

Demonstrates varying popularity across states, positioning itself as a prominent resource for remote learning in several jurisdictions.

These tool-specific observations contribute to a nuanced understanding of the diverse preferences and adoption patterns prevalent across states. The intricate dynamics of tool popularity shed light on the nuanced educational technology landscape during the transformative period of 2020.

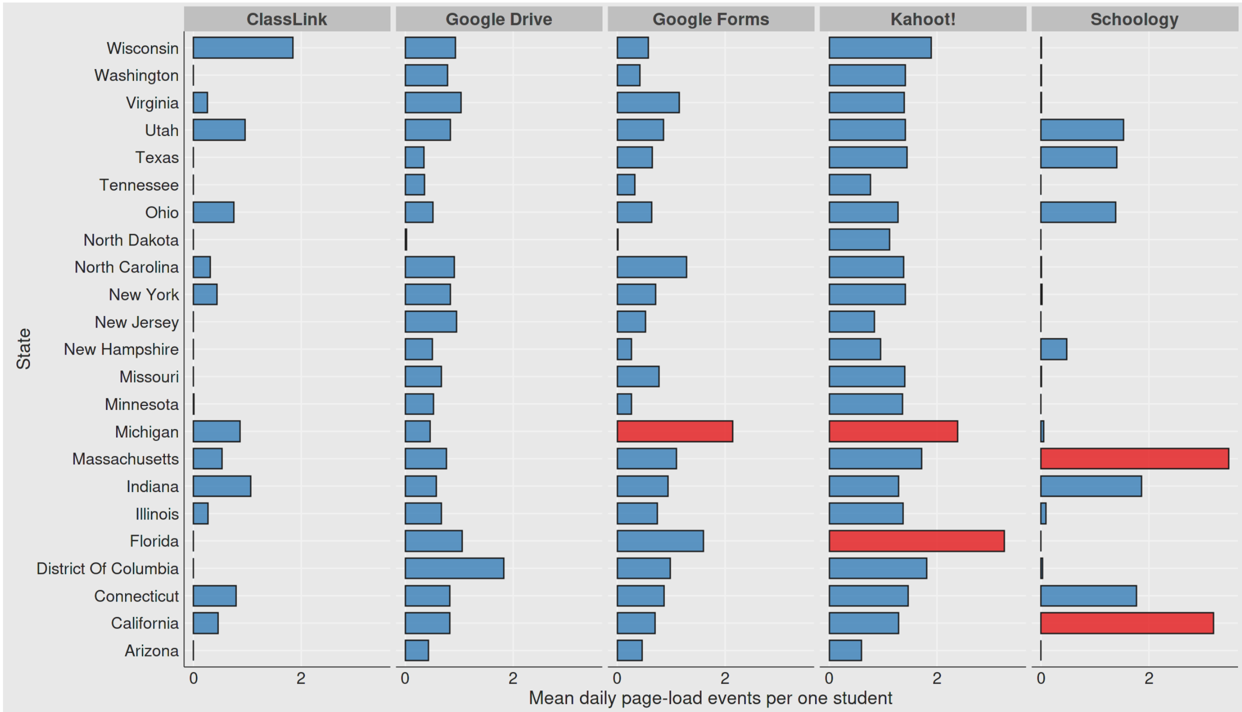

Figure 9 Mean daily page-load events in top 6th-10th place tools, by state and time

Examining tools ranked 6 to 10 in the dataset reveals substantial disparities in popularity across states, underscoring the diverse preferences and adoption patterns. Key observations include:

ClassLink:

Notably gains prominence in Wisconsin, where the average number of page-load events per student reaches almost 2 per day.

Demonstrates significant variability in popularity, emphasizing the nuanced regional dynamics in tool adoption.

Google Drive:

Lacks similar popularity as other products from the same company, such as Drive or Classroom, across all states.

Google Forms:

Emerges as particularly popular in Michigan, where the average exceeds 2 page-load events per student per day.

Highlights the varied regional acceptance of specific tools, even within the Google suite.

Kahoot!:

Present in nearly every state, but attains noteworthy popularity, breaking an average of 2 views per person per day specifically in Michigan and the District of Columbia.

Showcases varied adoption patterns and utilization levels across states.

Schoology:

Exhibits substantial inter-state variability, with notable recognition among students in Massachusetts and California, registering an average of around 3 visits per day per person.

Underscores the diverse regional landscapes in tool adoption and popularity.

These nuanced insights into the popularity of tools 6 to 10 contribute to a comprehensive understanding of the intricate dynamics shaping the educational technology landscape across states during the transformative period of 2020.

4. Tools over time

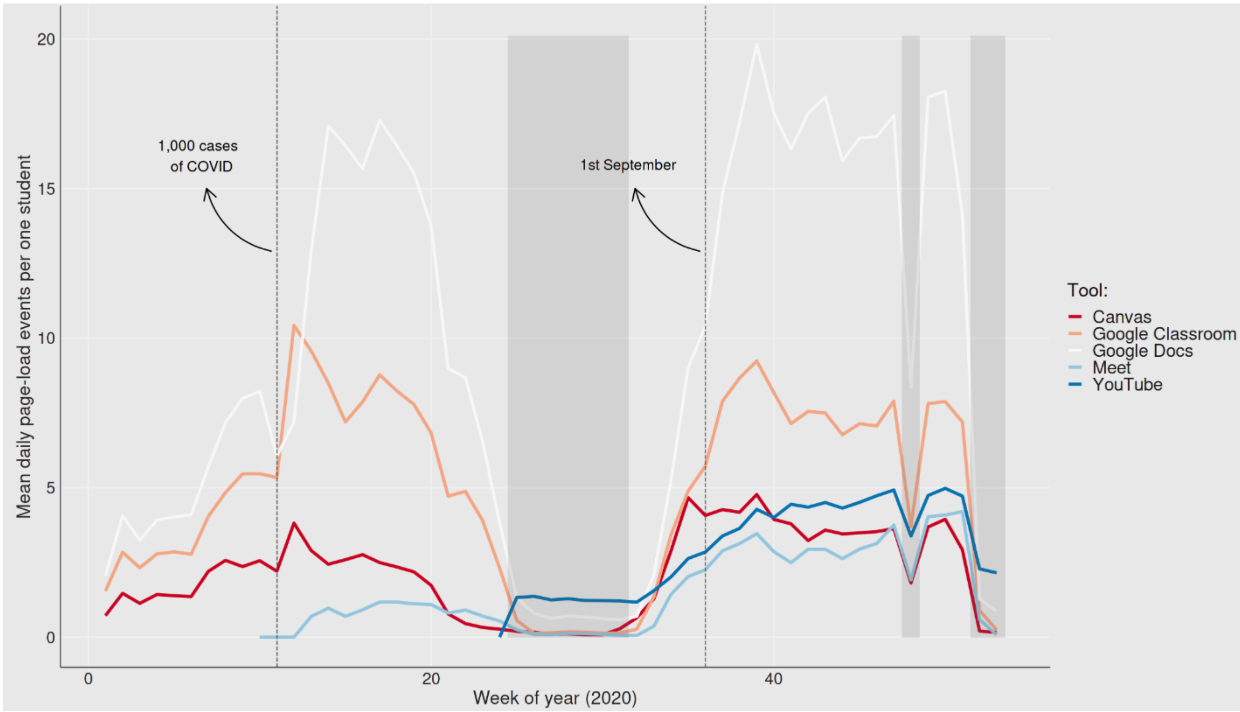

Figure 10 Mean daily page-load events in top 5 tools, by tools and time

Incorporating a temporal dimension into our analysis, we aggregate the data on a weekly basis throughout 2020, with shaded areas denoting weeks featuring designated days off. The focus is on the top 5 tools, unraveling their popularity dynamics over time. Key observations include:

Google Docs, Google Classroom, and Canvas:

Exhibit two distinct waves of popularity corresponding to the onset of remote learning for summer holidays and the resumption of classes after the Christmas break.

This dual surge suggests a consistent reliance on these tools during distinct phases of the academic calendar, emphasizing their pivotal role in facilitating remote learning.

YouTube and Meet:

Experience a different trajectory, with an increase in popularity observed from August/September onward.

This delayed surge may be attributed to a variety of factors, including potential reclassification of these tools or noise in the data during earlier periods.

These temporal dynamics underscore the evolving landscape of tool popularity throughout the year, revealing distinct phases and patterns in their adoption. The nuanced interplay between temporal factors and tool popularity contributes to a comprehensive understanding of the dynamic educational technology landscape in 2020.

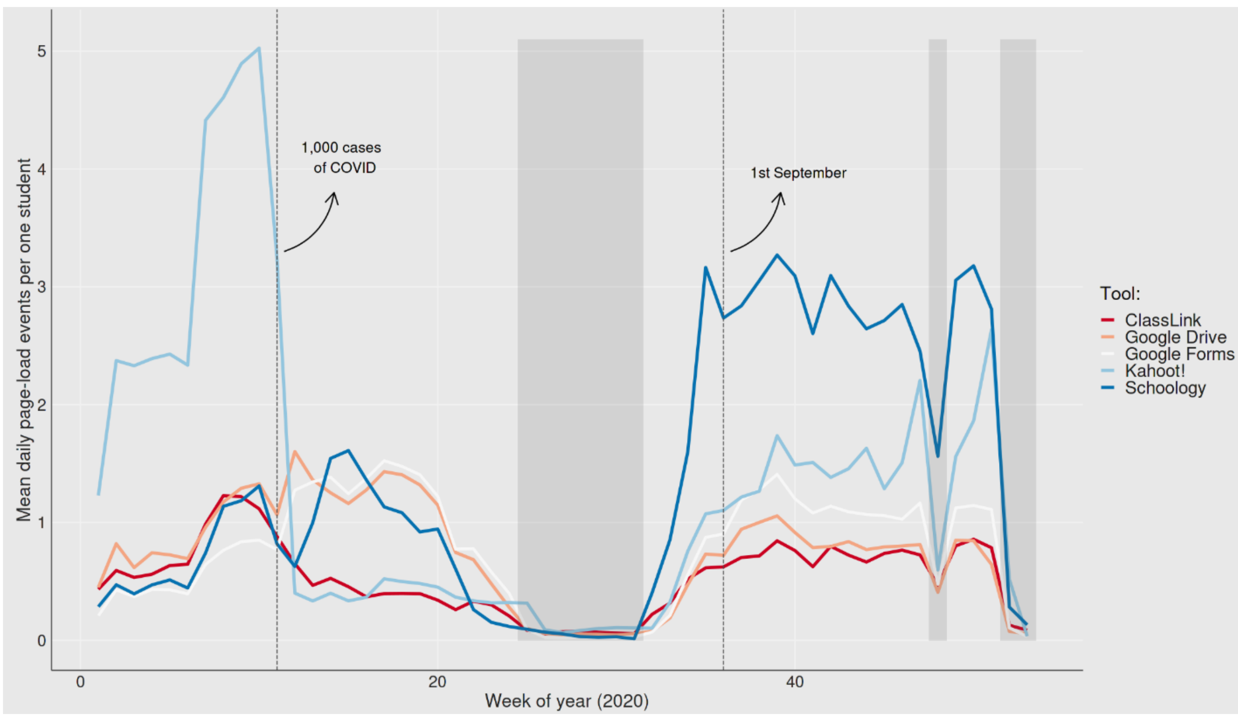

Figure 11 Mean daily page-load events in top 6th-10th place tools, by tools and time

5. Tools and Location, financial and social features

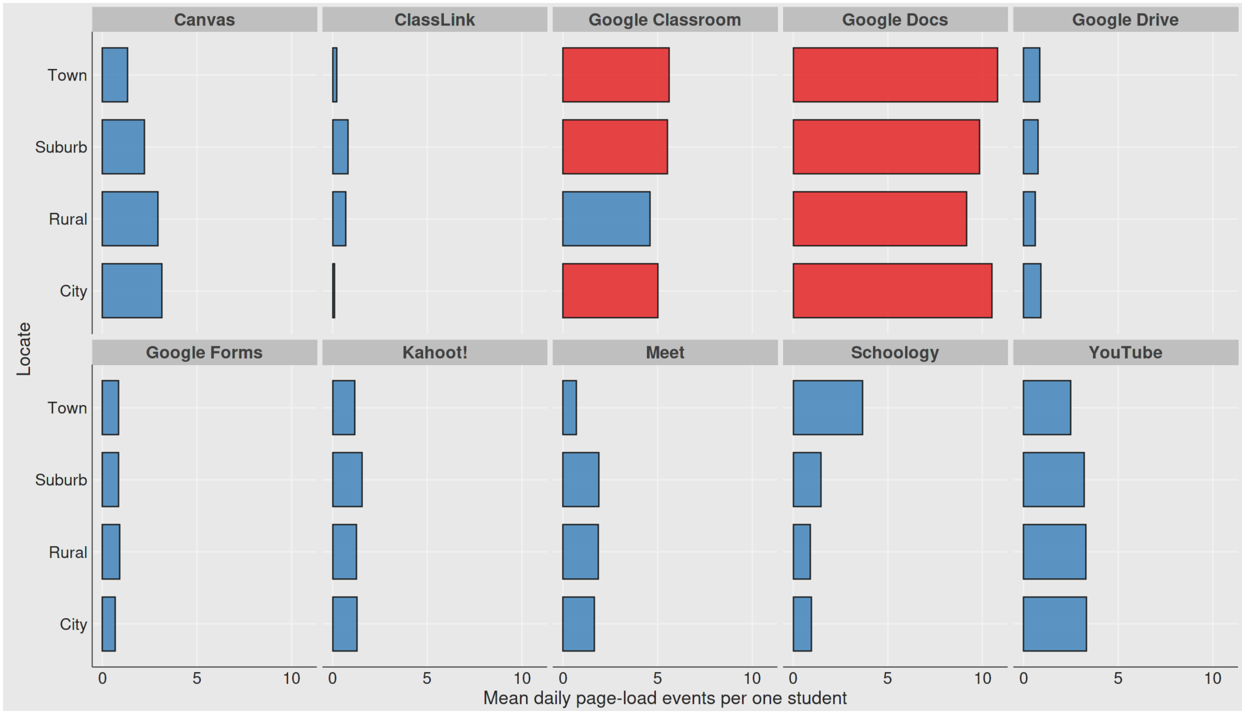

Figure 12 Mean daily page-load events in top 10 tools, by locate and tools

Analyzing the popularity of the top 10 tools based on the location of residence reveals minimal variations across different types of locations, namely town, suburb, rural, and city. Key observations include:

General Trends:

Across all 10 tools, the differences in the average daily number of visits are consistently small or very small based on location. It appears that the place of residence does not significantly impact the popularity of the top 10 tools.

Schoology:

Exhibits a slight increase in activity in towns compared to other locations, indicating a marginally higher popularity in urban settings.

Meet:

Demonstrates a notably lower level of popularity in towns, with other locations showing more comparable levels of engagement. Suggests a distinct preference or usage pattern for "Meet" in non-urban settings.

These nuanced differences underscore the generally consistent popularity of the top 10 tools across various locations. The minimal impact of location on tool preference emphasizes the universal accessibility and adoption of these tools across diverse educational settings.

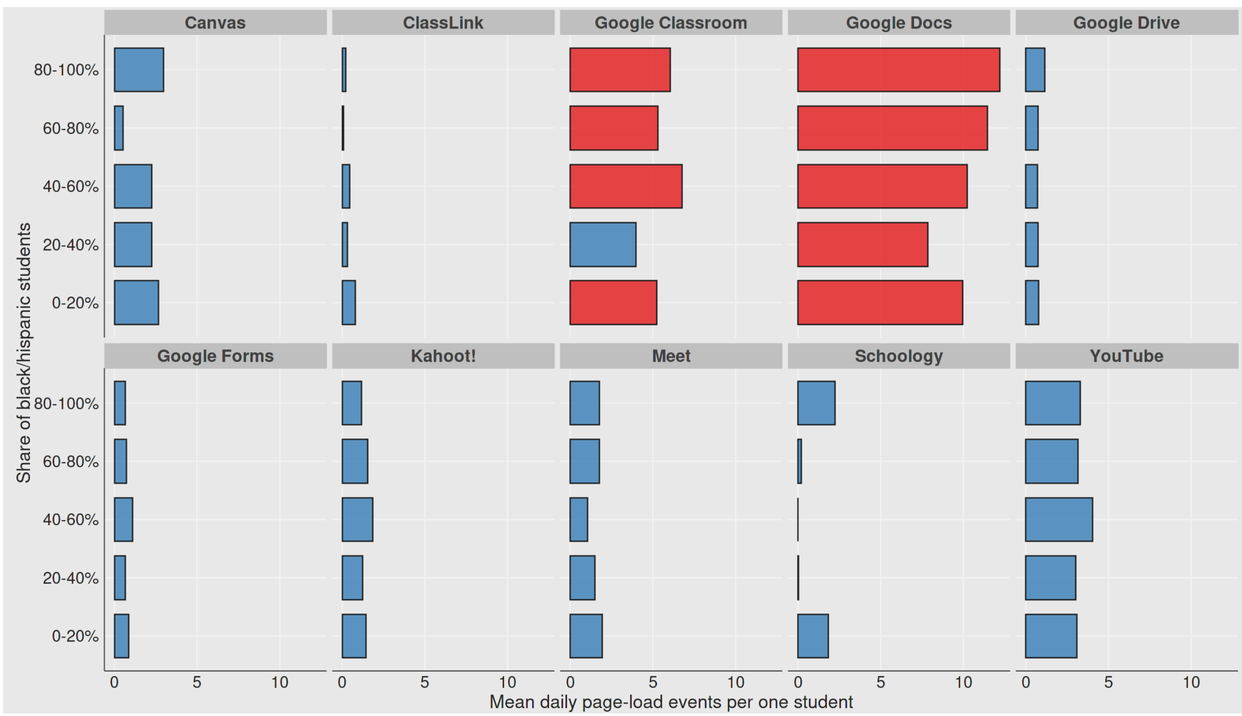

Figure 13 Mean daily page-load events in top 10 tools, by share of black/Hispanic students and tools

Examining the impact of student demographics on the popularity of the top 10 tools reveals minimal variations based on the percentage of students who are Black or Hispanic. Key observations include:

General Trends:

Across all 10 tools, the differences in average popularity based on the percentage of Black or Hispanic students are consistently small.

Overall, the share of students of Black or Hispanic origin does not significantly affect the popularity of the top 10 tools.

Google Docs:

Shows a minor trend where it becomes slightly more popular as the percentage of Black or Hispanic students increases, particularly in schools where the participation of such students exceeds 20%.

This suggests a nuanced relationship between the demographic composition of students and the popularity of Google Docs.

These findings emphasize the overall universal accessibility and adoption of the top 10 tools across diverse student demographics. While there may be minor dependencies for specific tools, the general trend indicates a relatively consistent popularity irrespective of the percentage of Black or Hispanic students in the educational institutions.

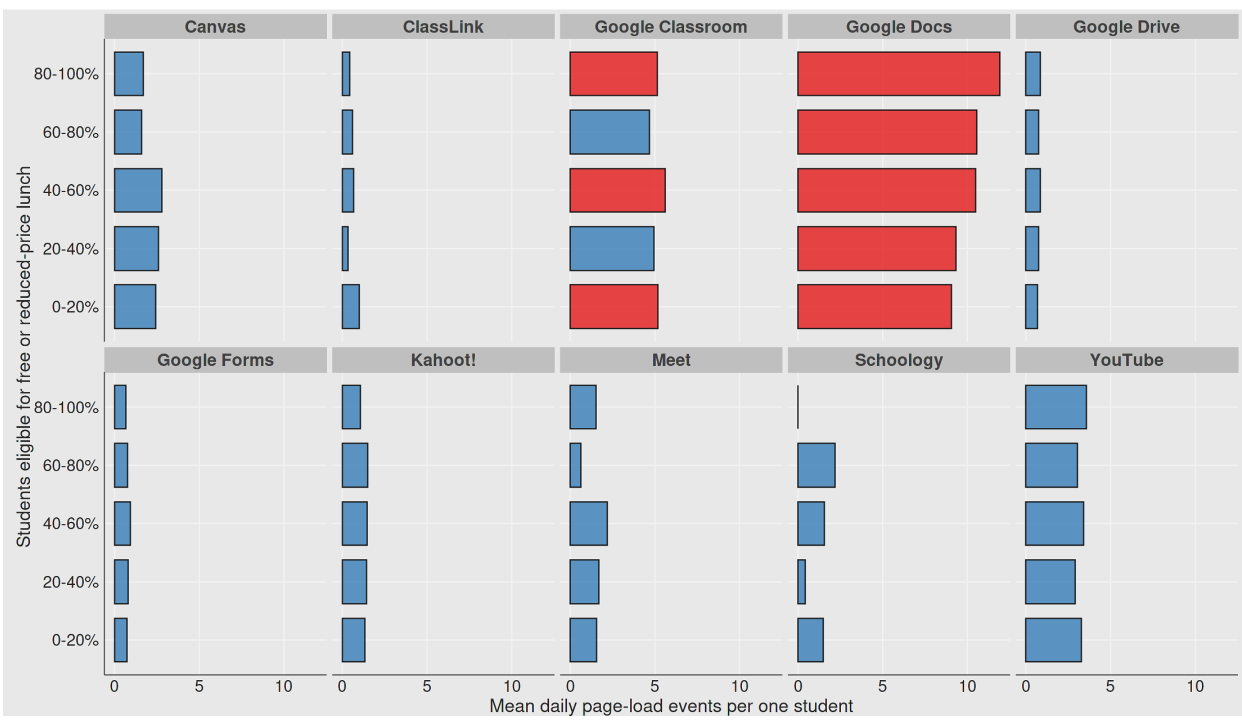

Figure 14 Mean daily page-load events in top 10 tools, by share of students eligible for free or reduced-price lunch and tools

Exploring the impact of student meal assistance, specifically the share of students eligible for cheaper or free meals, on the popularity of the top 10 tools reveals limited variations. Key observations include:

General Trends:

Across all 10 tools, the differences in average popularity based on the percentage of students eligible for cheaper or free meals are consistently small.

The availability of meal assistance does not significantly affect the overall popularity of the top 10 tools.

Google Docs:

Displays a minor trend where it becomes slightly more popular as the percentage of students eligible for cheaper or free meals increases.

This trend, however, is not consistently observed across other tools, suggesting a unique relationship for Google Docs in this context.

These findings underscore the resilience of the popularity of the top 10 tools across different levels of student meal assistance. While a minor trend is noted for Google Docs, the overall conclusion suggests that financial considerations related to meal assistance do not exert a significant influence on the adoption of these educational tools.

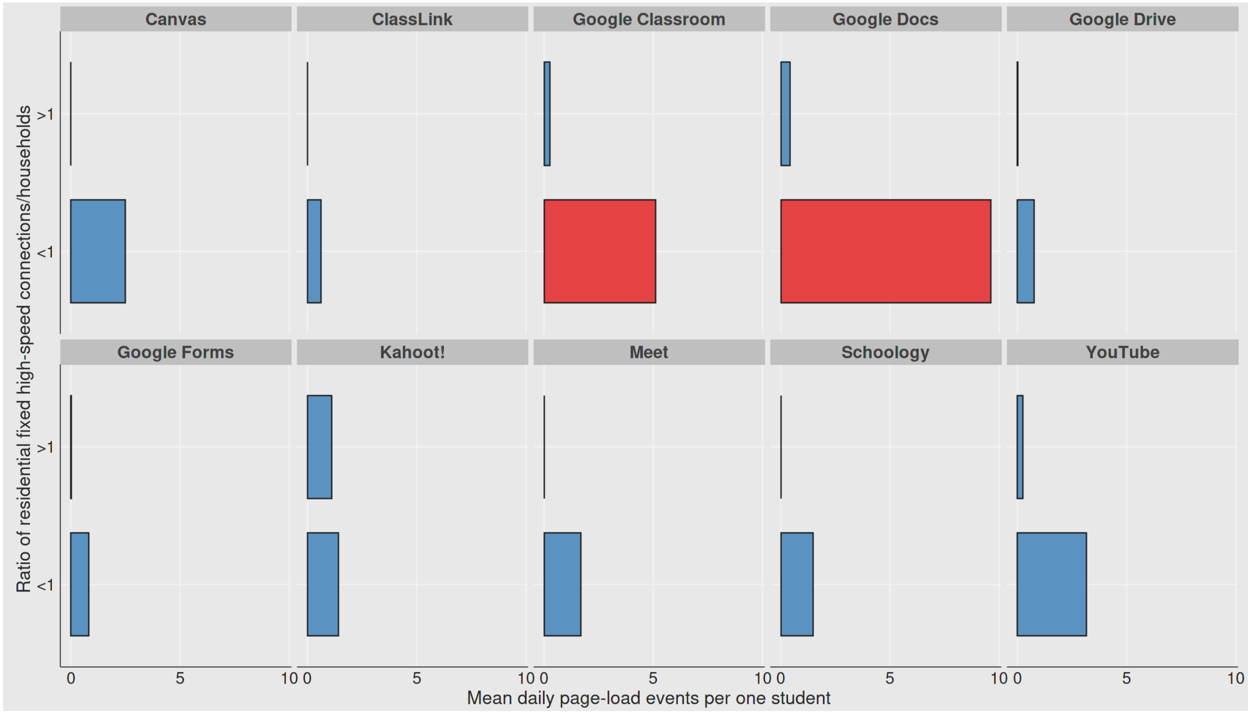

Figure 15 Mean daily page-load events in top 10 tools, by ratio of residential fixed high-speed connections/households and tools

Examining the influence of internet access, specifically the "county connections ratio," on the popularity of the top 10 tools reveals a pronounced dependency. Key observations include:

General Trends:

Across all 10 tools, there is a clear trend where the majority of page-load events occur in educational institutions located in regions with limited internet access (0.18-1 county connections ratio). The frequency of tool usage is notably higher in schools where internet access is more restricted.

Kahoot!:

Demonstrates a relatively smaller difference in popularity based on internet access compared to other tools. Despite this, the overall trend still indicates a higher usage in regions with more limited internet access.

These findings underscore the significant impact of internet access on the popularity of remote learning tools. The inverse relationship, where tools are more heavily utilized in areas with constrained internet access, highlights the potential challenges faced by schools in such regions. The implications of these findings can inform strategies for improving digital education accessibility in areas with limited connectivity.

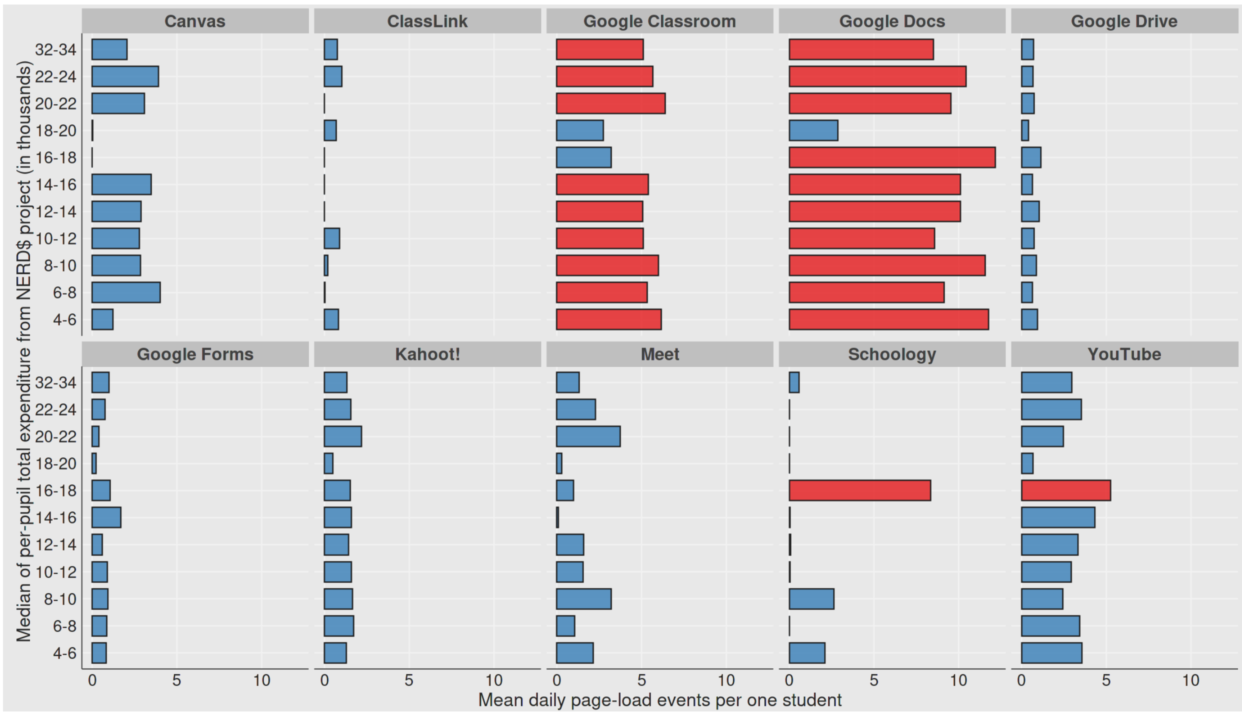

Figure 16 Mean daily page-load events in top 10 tools, by median of per-pupil total expenditure from NERD$ project and tools

Examining the relationship between the financial resources allocated through the 'NERD$' program per student and the popularity of the top 10 tools reveals no significant impact. Key observations include:

General Trends:

Across all 10 tools, there is no discernible pattern indicating a notable influence of financial resources from the 'NERD$' program on tool popularity. The variation in average page-load events does not exhibit a consistent correlation with the median resources provided through the program.

These findings underscore that financial resources allocated through the 'NERD$' program, at least within the specified ranges, do not play a significant role in determining the popularity of remote learning tools. The lack of a discernible relationship with financial factors further emphasizes the accessibility and adoption of these tools across diverse educational settings, irrespective of financial considerations.

6. Conclusions and Summary

The comprehensive analysis of the 10 most popular tools in distance learning for the entire U.S. student population in 2020 reveals several key insights:

Tool Popularity:

Google Docs and Google Classroom emerge as the clear leaders, with significantly higher average daily student entries compared to other tools.

Regional Variations:

Substantial variation in average student activity is observed between states, with the highest in Florida and the lowest in South Dakota.

Temporal Patterns:

Student activity is logically lower during holiday breaks and vacations, consistent across all states and tools.

Technology Access:

Google Docs remains popular across all states, while variations exist in the popularity of Canvas and Schoology.

Temporal Trends:

A consistent temporal pattern is observed, characterized by a bimodal distribution and increased tool popularity during the onset of the pandemic and post-summer break.

Location Influence:

Location, divided into urban, suburban, rural, and city categories, does not significantly affect the popularity of specific technologies.

Demographic Factors:

The share of Black and Hispanic students, as well as the percentage eligible for free or cheaper meals, does not determine the popularity of tools.

Internet Access:

Tools exhibit higher popularity in regions with weaker access to high-speed internet, emphasizing potential challenges in areas with limited connectivity.

Financial Factors:

The financial factor, represented by the share of students eligible for free or cheaper meals and the resources allocated through the 'NERD$' program, does not influence tool popularity.

This extensive analysis underscores the resilience and universality of the top 10 tools in remote learning, highlighting their accessibility and adoption across diverse educational settings. While regional and temporal variations exist, socio-economic and financial factors do not emerge as significant determinants of tool popularity. The findings contribute to a nuanced understanding of the complex dynamics shaping remote learning in the United States during the transformative year of 2020.

Sources

Edunomics Lab. (n.d.). National Education Research Data Service (NERDS). Retrieved from https://edunomicslab.org/nerds/

European Data Portal. (n.d.). Education during COVID-19: Moving Towards E-learning. Retrieved from https://data.europa.eu/en/impact-studies/covid-19/education-during-covid-19-moving-towards-e-learning

Geverdt, D. E. (2016). Education Demographic and Geographic Estimates Program (EDGE): Locale Boundaries User's Manual (NCES 2016-012).

LearnPlatform. (n.d.). LearnPlatform COVID-19 Impact on Digital Learning. Kaggle. Retrieved from https://www.kaggle.com/c/learnplatform-covid19-impact-on-digital-learning

Mulyatiningsih, E., Palupi, S., Ekawatiningsih, P., & Firdausa, A. R. (Year). The Characteristics of Enjoyable Online Learning for Culinary Arts Students.

Reddy, B., Jose, S., & R, V. (Year). Of Access and Inclusivity: Digital Divide in Online Education.

RStudio. (n.d.). DT: An R Interface to the DataTables Library. Retrieved from https://rstudio.github.io/DT/

The Washington Post. (2020, March 11). Coronavirus live updates. Retrieved from https://www.washingtonpost.com/world/2020/03/11/coronavirus-live-updates/

Federal Communications Commission. (n.d.). Form 477 County Data - Internet Access Services. Retrieved from https://www.fcc.gov/form-477-county-data-internet-access-services

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Tidyverse. Retrieved from https://ggplot2.tidyverse.org/

Wikipedia. (n.d.). COVID-19 pandemic in the United States. Retrieved from https://en.wikipedia.org/wiki/COVID-19_pandemic_in_the_United_States#December_2019_to_April_2020

Appendix

```
options(warn = -1)
options(scipen = 10000)
options(repr.plot.width = 18.5, repr.plot.height = 12)

library(tidyverse)
library(scales)
library(RColorBrewer)
library(ggthemes)
library(devtools)
library(factoextra)
library(viridis)
library(ggrepel)
library(lubridate)
library(DT)

annotate <- ggplot2::annotate
'%!in%' <- function(x,y)!('%in%'(x,y))

theme_michau <- theme(legend.position = "bottom", legend.direction =
"horiz plot.caption = element_text(color = "gray70", size = 12.5),
legend.text = e axis.title = element_text(size = 19, colour =
"gray15"), legend.title = ele axis.line = element_line(size = 0.4,
colour = "gray25"), panel.background = plot.background =
element_rect(fill = "gray91"), legend.background = elemen legend.key =
element_rect(fill = "gray91"), plot.title = element_text(size
plot.subtitle = element_text(size = 18.7, colour = "gray42"),
strip.backgro strip.text = element_text(size = 18, colour = "gray25",
face = "bold"), pan

products <- read.csv("../input/learnplatform-covid19-impact-on-digital-
lear names(products)[1] <- "lp_id"

districts <- read.csv("../input/learnplatform-covid19-impact-on-
digital-lea files <- list.files("../input/learnplatform-covid19-impact-
on-digital-learn

files2 <- paste0("../input/learnplatform-covid19-impact-on-digital-
learning engage <- lapply(files2, read_csv) %>%

bind_rows(.id = "source")

disctrict_joiner <- data.frame(district_id = districts$district_id,
source

engage <- engage %>% left_join(disctrict_joiner, by = "source")

engage <- engage %>%
left_join(districts, by = "district_id")

engage <- engage %>% left_join(products, by = "lp_id")
```

```
engage <- engage[complete.cases(engage$Product.Name),]
colnames(engage)[which(names(engage) == "Product.Name")] <-
"product_name" engage$engagement_index[is.na(engage$engagement_index)]
<- 0

engage <- engage %>%
mutate(pct_black.hispanic = case_when(pct_black.hispanic == "[0, 0.2["
~ pct_black.hispanic == "[0.2, 0.4[" ~ "20-40%",
pct_black.hispanic == "[0.4, 0.6[" ~ "40-60%",
pct_black.hispanic == "[0.6, 0.8[" ~ "60-80%",
pct_black.hispanic == "[0.8, 1[" ~ "80-100%"))

engage <- engage %>%
mutate(pct_free.reduced = case_when(pct_free.reduced == "[0, 0.2[" ~
"0-2 pct_free.reduced == "[0.2, 0.4[" ~ "20-40%",
pct_free.reduced == "[0.4, 0.6[" ~ "40-60%",
pct_free.reduced == "[0.6, 0.8[" ~ "60-80%",
pct_free.reduced == "[0.8, 1[" ~ "80-100%"))

engage <- engage %>%
mutate(county_connections_ratio = case_when(county_connections_ratio ==
" county_connections_ratio == "[1, 2[" ~ ">1"))

engage <- engage %>%
mutate(pp_total_raw = case_when(pp_total_raw == "[10000, 12000[" ~ "10-
12 pp_total_raw == "[12000, 14000[" ~ "12-14",
pp_total_raw == "[14000, 16000[" ~ "14-16",
pp_total_raw == "[16000, 18000[" ~ "16-18",
pp_total_raw == "[18000, 20000[" ~ "18-20",
pp_total_raw == "[20000, 22000[" ~ "20-22",
pp_total_raw == "[22000, 24000[" ~ "22-24",
pp_total_raw == "[32000, 34000[" ~ "32-34",
pp_total_raw == "[4000, 6000[" ~ "4-6",
pp_total_raw == "[6000, 8000[" ~ "6-8",
pp_total_raw == "[8000, 10000[" ~ "8-10"))

engage %>%
head(10000) %>%
select(time, engagement_index, state, locale, pct_black.hispanic,
pct_fre datatable(options = list(pageLength = 10, lengthMenu = c(10,
25, 100), in

"function(settings, json) {", "$('body').css({'font-family': 'Arial', '
caption = 'First 10,000 rows from entire databas

formatStyle('engagement_index', target = 'row',
backgroundColor = styleEqual(levels = c(0, 1), values = c('gr

engage %>%
group_by(product_name) %>%
summarise(mean = mean(engagement_index)/1000) %>% arrange(desc(mean))
%>%
slice(1:20) %>%
mutate(fill = case_when(product_name == "Google Docs" ~ "1",
```

```
product_name == "Google Classroom" ~ "2", product_name == "YouTube" ~
"3",
product_name %!in% c("Google Docs", "Google Class

ggplot(., aes(reorder(product_name, +mean), mean, fill = fill))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
scale_fill_manual(values = c("darkgoldenrod1", "darkgray", "tan3",
"ghost coord_flip()+
labs(title = "Mean daily page-load events in top 20 tools", subtitle =
"p

x = "Tool", caption = "Data: LearnPlatform COVID-19 Impact on Digita
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state != "NaN") %>%
group_by(state) %>%
summarise(mean = mean(engagement_index)/1000) %>% arrange(desc(mean))
%>%
mutate(color = ifelse(mean > 0.2032957,"0", "1")) %>%

ggplot(., aes(reorder(state, +mean), mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.7, alpha = 0.8)+
geom_hline(yintercept = mean(engage$engagement_index)/1000, linetype =
"l scale_fill_brewer(palette = "Set1")+

annotate("text", x = 5, y = 0.245, label = "Mean", size = 8)+
annotate(geom = "curve", x = 4.4, y = 0.245, xend = 2.9, yend = 0.21,
cur coord_flip()+
labs(title = "Mean daily page-load events in states (any tool)",
subtitle

x = "State", caption = "Data: LearnPlatform COVID-19 Impact on Digit
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

state_a <- engage %>%
filter(state %in% c("Texas", "Florida")) %>%
group_by(state, time = week(as.Date(time))) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop")

state_b <- engage %>%
filter(!state %in% c("Texas", "Florida")) %>%
group_by(state, time = week(as.Date(time))) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(desc(mean))

ggplot()+
geom_line(data = state_a, aes(time, mean, group = state), size = 0.8,
col geom_line(data = state_b, aes(time, mean, group = state), size =
0.8, col annotate("text", x = 10.1, y = 1.2, label = "bold(Texas)",
```

```
size = 6.9, co annotate("text", x = 9.2, y = 0.045, label =
"bold(Florida)", size = 6.98 annotate("rect", xmin = 51.5, xmax = 53.5,
ymin = 0, ymax = 1.51, alpha = annotate("rect", xmin = 24.5, xmax =
31.5, ymin = 0, ymax = 1.51, alpha = annotate("rect", xmin = 47.5, xmax
= 48.5, ymin = 0, ymax = 1.51, alpha = labs(title = "Mean daily page-
load events in states (any tool)", subtitle

x = "Week of year (2020)", caption = "Data: LearnPlatform COVID-19 I
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state %in% c("Arizona", "California", "Connecticut", "District
Of filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube",

"Kahoot!", "Google Forms", "Google Drive", "ClassLink")) %>%
group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(desc(mean)) %>%

mutate(color = ifelse(mean > 5, "0", "1")) %>%
ggplot(., aes(reorder(product_name, +mean), mean, fill = color))+

geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~state)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15, 20))+

coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Tool", caption = "Data: LearnPlatform COVID-19 Impact on Digita
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state %in% c("Indiana", "Massachusetts", "Michigan",
"Minnesota", filter(product_name %in% c("Google Docs", "Google
Classroom", "YouTube",

"Kahoot!", "Google Forms", "Google Drive", "ClassLink")) %>%
group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(desc(mean)) %>%

mutate(color = ifelse(mean > 5, "0", "1")) %>%

ggplot(., aes(reorder(product_name, +mean), mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
```

```
facet_wrap(.~state)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Tool", caption = "Data: LearnPlatform COVID-19 Impact on Digita
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state %in% c("New Jersey", "New York", "North Carolina", "North
Da filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube",

"Kahoot!", "Google Forms", "Google Drive", "ClassLink")) %>%
group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(desc(mean))%>%

mutate(color = ifelse(mean > 5, "0", "1")) %>%
ggplot(., aes(reorder(product_name, +mean), mean, fill = color))+

geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~state)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+

coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Tool", caption = "Data: LearnPlatform COVID-19 Impact on Digita
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state %in% c("Texas", "Utah", "Virginia", "Washington",
"Wisconsin filter(product_name %in% c("Google Docs", "Google
Classroom", "YouTube",

"Kahoot!", "Google Forms", "Google Drive", "ClassLink")) %>%
group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(desc(mean)) %>%

mutate(color = ifelse(mean > 5, "0", "1")) %>%
ggplot(., aes(reorder(product_name, +mean), mean, fill = color))+
```

```
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~state)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+

coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Tool", caption = "Data: LearnPlatform COVID-19 Impact on Digita
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state != "NaN") %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
mutate(color = ifelse(mean > 10, "0", "1")) %>%
arrange(state) %>%

ggplot(., aes(state, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_grid(.~product_name)+
scale_fill_brewer(palette = "Set1")+

scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 5 tools", subtitle =
"by

x = "State", caption = "Data: LearnPlatform COVID-19 Impact on Digit
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(state != "NaN") %>%
filter(product_name %in% c("Schoology", "Kahoot!", "Google Forms",
"Googl group_by(product_name, state) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
arrange(state) %>%
mutate(color = ifelse(mean > 2, "0", "1")) %>%

ggplot(., aes(state, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_grid(.~product_name)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 2, 4, 6))+
coord_flip()+
labs(title = "Mean daily page-load events in top 6th-10th place tools",
s
```

```
x = "State", caption = "Data: LearnPlatform COVID-19 Impact on Digit
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, time = week(as.Date(time))) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%

ggplot(., aes(time, mean, colour = product_name))+
geom_line(size = 1.2, alpha = 1)+
scale_colour_brewer(palette = "RdBu")+
geom_vline(xintercept = 11, linetype = "longdash", size = 0.35, col =
"gr geom_vline(xintercept = 36, linetype = "longdash", size = 0.35, col
= "gr annotate("text", x = 6.5, y = 16.1, label = "1,000 cases \n of
COVID", si annotate("text", x = 31.5, y = 15.8, label = "1st
September", size = 5.4) annotate(geom = "curve", x = 10.7, y = 12.9,
xend = 6.9, yend = 15, curva annotate(geom = "curve", x = 35.7, y =
12.9, xend = 31.9, yend = 15, curv annotate("rect", xmin = 47.5, xmax =
48.5, ymin = 0, ymax = 20.1, alpha = annotate("rect", xmin = 51.5, xmax
= 53.5, ymin = 0, ymax = 20.1, alpha = annotate("rect", xmin = 24.5,
xmax = 31.5, ymin = 0, ymax = 20.1, alpha = labs(title = "Mean daily
page-load events in top 5 tools", subtitle = "by

x = "Week of year (2020)", caption = "Data: LearnPlatform COVID-19 I
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "right", legend.direction = "vertical")

engage %>%
filter(product_name %in% c("Schoology", "Kahoot!", "Google Forms",
"Googl group_by(product_name, time = week(as.Date(time))) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%

ggplot(., aes(time, mean, colour = product_name))+
geom_line(size = 1.2, alpha = 1)+
scale_colour_brewer(palette = "RdBu")+
geom_vline(xintercept = 11, linetype = "longdash", size = 0.35, col =
"gr geom_vline(xintercept = 36, linetype = "longdash", size = 0.35, col
= "gr annotate("text", x = 14.7, y = 4.1, label = "1,000 cases \n of
COVID", si annotate("text", x = 40.2, y = 3.97, label = "1st
September", size = 5.4) annotate(geom = "curve", x = 11.4, y = 3.3,
xend = 14.2, yend = 3.8, curv annotate(geom = "curve", x = 36.4, y =
3.3, xend = 39.2, yend = 3.8, curv annotate("rect", xmin = 47.5, xmax =
48.5, ymin = 0, ymax = 5.1, alpha =

annotate("rect", xmin = 51.5, xmax = 53.5, ymin = 0, ymax = 5.1, alpha
= annotate("rect", xmin = 24.5, xmax = 31.5, ymin = 0, ymax = 5.1,
alpha = labs(title = "Mean daily page-load events in top 6th-10th place
tools", s

x = "Week of year (2020)", caption = "Data: LearnPlatform COVID-19 I
theme_fivethirtyeight()+
```

```
theme_michau+
theme(legend.position = "right", legend.direction = "vertical")

engage %>%
filter(pct_black.hispanic != "NA") %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, pct_black.hispanic) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
mutate(color = ifelse(mean > 5, "0", "1")) %>%
arrange(pct_black.hispanic) %>%

ggplot(., aes(pct_black.hispanic, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~product_name, nrow = 2)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Share of black/hispanic students", caption = "Data: LearnPlatfo
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")

engage %>%
filter(pct_free.reduced != "NA") %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, pct_free.reduced) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
mutate(color = ifelse(mean > 5, "0", "1")) %>%
arrange(pct_free.reduced) %>%

ggplot(., aes(pct_free.reduced, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~product_name, nrow = 2)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Students eligible for free or reduced-price lunch", caption = "
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")
```

In [ ]:

```
engage %>%
filter(county_connections_ratio != "NA") %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, county_connections_ratio) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
```

```
mutate(color = ifelse(mean > 5, "0", "1")) %>%
arrange(county_connections_ratio) %>%

ggplot(., aes(county_connections_ratio, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~product_name, nrow = 2)+
scale_fill_brewer(palette = "Set1")+
scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Ratio of residential fixed high-speed connections/households",
theme_fivethirtyeight()+

engage %>%
filter(pp_total_raw != "NA") %>%
filter(product_name %in% c("Google Docs", "Google Classroom",
"YouTube", group_by(product_name, pp_total_raw) %>%
summarise(mean = mean(engagement_index)/1000, .groups = "drop") %>%
mutate(color = ifelse(mean > 5, "0", "1")) %>%
arrange(pp_total_raw) %>%

ggplot(., aes(pp_total_raw, mean, fill = color))+
geom_bar(col = "gray10", stat = "identity", width = 0.75, alpha = 0.8)+
facet_wrap(.~product_name, nrow = 2)+
scale_fill_brewer(palette = "Set1")+
scale_x_discrete(labels = rev(c("32-34","22-24", "20-22", "18-20", "16-
18 scale_y_continuous(breaks = c(0, 5, 10, 15))+
coord_flip()+
labs(title = "Mean daily page-load events in top 10 tools", subtitle =
"b

x = "Median of per-pupil total expenditure from NERD$ project (in th
theme_fivethirtyeight()+
theme_michau+
theme(legend.position = "none")
```