Digital Application Literacy and the Modern Classroom

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Abstract
Pivoting to online learning in a pandemic posed challenges for educators, administrators, parents, and students. This exploration examined quantitative data establishing the disparities of access to computers and the internet for students, the likelihood of canceled classes, and differing experiences with virtual coursework or remote learning on paper for students based upon gender and race/ethnicity. Critical deficiencies present themselves when students lack familiarity with new learning platforms. The net result was that assessments failed to capture student learning, but instead assessed basic knowledge and facility with the application for assessment. Employing Digital Application Literacy Theory (Schmidt, 2021) indicates that learners with familiarity in the use of an application perform 10% better in the short term analysis and 25% better in the long term analysis, despite the fact that material assessed was entirely new content, not a building of incremental understanding toward a content goal. A process of Digital Application Literacy was recommended to assure that assessment results are the product of content learning and not merely savvy use of software. Schools experienced significant drawbacks when the shut-down of schools left many students without ways to participate directly in learning activities. Though many schools would pivot to online learning and Zoom classes, these suffered from a lack of preparedness among learners in the new and different styles of digital applications used in remote learning. Clear understanding and utilization of Digital Application Literacy can offer solutions to these circumstances and insight on the limited value of early assessments of learning lag.

Keywords: Digital Application Literacy, COVID, Virtual Learning, Gender, Race, Ethnicity, Learning Lag, Disparity, Pandemic, Access

Introduction

The emergency caused by the COVID-19 pandemic has officially ended in the United States, as of April 10, 2023 (Miller, 2023). The World Health Organization met on May 4 and declared the global health emergency in response to COVID-19 at an end on May 5, 2023 (Rigby & Satija, 2023). No one would deny its impact has fundamentally changed aspects of the modern classroom. The question remains whether the pendulum will swing back to the starting point, erasing gains in educational technology integration and practice or advance the resting point along the continuum.

Effectively assessing the impact of the COVID learning dynamics on the modern classroom requires analysis of the actual demographic data. With a foundational understanding of the landscape of pandemic education, it is then possible to identify meaningful impacts in classrooms which changed during the 2020-2023 school years to accommodate new realities in teaching and learning.

The Digital Application Literacy theory expressed the necessity for explicit teaching of new applications and online protocols with students before using them in assessment practices (Schmidt, 2021). When educators use unfamiliar means of assessment with students, they risk assessing facility with the application instead of the apprehension of the content knowledge in the classroom. This risk is understandably greater in an atmosphere of virtual learning when the teacher and student connect impractically through video conferencing. Teacher monitoring of student practices is impaired. Students may be less likely to ask questions about new applications because of the vigilant notice of on-screen peers. Students engaged in remote learning bear the likelihood of being less attentive to instruction details.

This mixed methods study will begin through a literature review to address the question: "What ongoing challenges did educators, administrators, and parents express publicly about using applications in the classroom?" in order to clarify the experiences of adults during this critical period before using a quantitative analysis to describe the methods for engaging in educational activities during early 2020 through 2021.

Literature Review

A clear starting point is to understand what rates of computer access in schools and in households were prior to the pandemic. According to the Institute for Education Sciences, a division of the National Center for Education Statistics, data collected in the 2019-2020 school year, prior to the outbreak of the COVID-19 pandemic, 45% of school children in America had one-to-one access to computers for educational use (Gray & Lewis, 2021, p. 3). Further, broken down by school level, for secondary students, both middle school and high school, 63% had one-to-one access to computers for learning (Gray & Lewis, 2021, Table A-1). However, only 15% of schools permitted students to take computers home, which breaks down as 10% of elementary students, 18% for middle school students, and 26% for high school students (Gray & Lewis, 2021, Table A-3).

As a result of inadequate access to computers by students who were thrust into remote, virtual, and blended learning in the spring of 2020, many districts accelerated technology acquisition plans. Superintendent of Schools in San Antonio, Texas, Pedro Martinez advanced and secured a $90 million bond to pay for new technology to meet the needs of remote learners and stated, "There's no going back now" (Herold, 2021, para. 3). However,

the possession of the devices does not ensure learning. Marlo Gaddis, the chief technology officer for Wake County, North Carolina, described the pandemic acquisitions as a "proof of concept for 1-to-1" (Bushweller, 2022, para. 3). He further admits that no school got everything right in the process of implementing new technology strategies for remote learning. District leaders surveyed indicated that 10% explored constructing an on-going model of hybrid instructional learning and 19% were seriously considering implementing remote instruction options for subsets of their students or planned to use the option in the case of a weather emergency (Herold, 2021).

The United States Census Bureau collects regular data beyond the decennial census through the American Community Survey (ACS). According to the ACS, 92.9% of households had computers and 86.4% had regular subscriptions to broadband internet in 2019 (USCB, 2019). By 2021, computer access was 95.0% and internet access was 90.1% (USCB, 2021). To clarify, the ACS surveys households with individuals of all ages, so rates of access among households with school-age children would vary.

Families

In addition to the acquisition of devices, methods for learning remotely caused new challenges for students and for the adults in the households with them. During March through June of 2020, Annette Anderson of Johns Hopkins University and deputy director of the Center for Safe & Healthy Schools, describes a "small, but significant subset of families" who became aware of discrimination and microaggressions toward their children when students were learning virtually, in the presence of alert parents (Lieberman, 2020). Still other families learned about concerning content in the curriculum choices and questioned teachers, administrators, and school boards. Anderson points out that being able to monitor the interactions between children and their teachers and peers brought a mindshift for families which they were not willing to leave behind (Lieberman, 2020). Therefore, some students and their families who experienced the online learning model elected not to return to the traditional atmosphere.

Teachers

Teachers, too, experienced changes in expectations while teaching virtually, including teaching to blank screens (students with cameras off) and an inability to manage assessment in ways analogous to the classroom. According to teachers surveyed, 41% indicated that they were not well-trained to use educational technology effectively (Bouchrika, 2022). This included frustration with hybrid learning while attempting to manage in-person students at the same time as students online in order to reduce classroom sizes in the return-to-school protocols because the needs of remote student engagement and connecting with in-person students were divergent. Teachers indicated that they were required to switch teaching methods at least once during the 2020-2021 school year, but the average teacher indicated switching twice, necessitating revision of teaching materials and a learning curve for students with each change (Zamarro et al., 2021). Another question indicated that 39% of teachers surveyed stated that their schools did not actually support the elearning tools that teachers were expected to use (Bouchrika, 2022). In a survey of 1045 teachers in various teaching conditions, 42% responded that they considered leaving the teaching profession (Zamarro et al., 2021). These frustrations would lead many educators to elect not to return to the classroom. Respondents further shared that, of those colleagues who considered leaving teaching, 40% did leave (Zamarro et al., 2021). According to the survey, in-person teachers

were less likely to resign than fully remote or hybrid counterparts (Zamarro et al., 2021). Many who returned to the classroom elected to leave later in response to other challenges.

Students

In Spring 2021, Renaissance Learning, an industry technology assessment specialist, conducted a study in its' "How Are Kids Performing" series which concentrated on the year following the outbreak of the pandemic, and saw students split between in-person classrooms and virtual learning at various levels throughout the year, depending on geographic location (Renaissance Learning, 2021). Their results indicated that students of Black, Hispanic, and American Indian/Alaska Native heritage were performing at 6 to 8 points lower in Reading and 11 to 14 points below the pre-pandemic baseline in Mathematics. Students with disabilities were six points lower in Reading and nine points lower in Mathematics. English Language Learners performed five points below baseline in Reading and ten points lower in Mathematics. Locality did not demonstrate a differentiation in Reading with both rural and urban students performing at four points below the baseline, but rural students were only one point below the baseline in Mathematics, whereas urban students were nine points below the same baseline. Students at Title I eligible schools performed five points lower in Reading and seven points lower in Math. Catholic and private schools performed at the baseline, but public schools were four points below their pre-pandemic baseline. Students who completed the assessments outside of the school environment performed seven to nine points lower than students who were tested in a classroom setting. Across all subgroups except private and Catholic schools, students performed below the baseline set in the previous year prior to the pandemic outbreak. Renaissance tests three to four times per year and was able to get more detailed information on the timing effect than other annual assessments for that reason.

Digital Application Literacy theory was created in response to a one-year study of eighth grade students in a Language Arts course in which they were assessed using the NoRedInk platform at intervals throughout the school year, particularly October, December, and April (Schmidt, 2021). Between October and December, the mean score of students on grammar content material which did not reflect a progression of learning, but specific and discrete concepts, score range improved by 10% (Schmidt, 2021). Then, from December to April, scores on similarly discrete concepts improved by another 15% to reveal an overall improvement of 25% from the first assessment (Schmidt, 2021). Therefore, the improvement suggested an increased facility with the means of assessment and not with the content. The idea that facility with an application could be responsible for such a dramatic variation in assessment results calls into question the validity of online assessment unless explicit instruction and experience has been dedicated to mastering the platform before any meaningful assessment is undertaken.

Literature provided an understanding of the magnitude of the shift in education to remote, online, and blended learning to various degrees. The next step was to examine the numbers of students in these various conditions and how long the alterations continued. This yielded the following research questions: 1) What percentage of students had access to computers for learning in each period? 2) What percentage of students had access to the internet for learning in each period? and 3) How did experiences of demographic groupings based on gender and race/ethnicity vary?

Methods

This study relies on the Household Pulse Survey (USCB, 2023) which was administered to randomly-sampled American households from April 23, 2020 to the present, with the latest survey date as May 17, 2023. Participation in the survey was voluntary. The survey questions were designed for inclusion by eighteen federal agencies, including the Centers for Disease Control and Prevention, the Department of Health and Human Services, and the National Center for Education Statistics. The first weekly collection of data from April 23, 2020, to May 5, 2020, included responses from 65,371,463 households. For clarity, the United States Census Bureau states that as of 2021, there are 124,010,992 households in the United States, therefore indicating that the Household Pulse Survey was initially completed by 52.71% of the households in America.

In a report to address the methodology and nonresponse bias of the Household Pulse Report, measures detail the inclusion of housing units "where at least one email address or cell phone number was known" (2021). Further specifications included sampling across 50 states and the District of Columbia, as well as the top 15 metro areas in the United States to represent 66 reporting areas. The sample size for each of the 66 areas was equal to avoid effects based on population. A caveat was included to mention that "some small states had smaller sample sizes because the sampling frame did not contain enough addresses" (Peterson, et al., 2021, p. 2). The study recognizes limitations in that data based upon the frame condition relating to use of a cell phone and email address as a potential bias (Peterson, et al., 2021, p.10). This requirement limits survey respondents to those who were enabled to make initial contact through a connected device and would, therefore, not include those with no cell phone and no email contact, which could impact the results used pertaining to device and internet usage in the home. According to the Pew Research Center, 97% of Americans own a cell phone and 85% own smartphones (Pew, 2021). While 97% of Americans own cell phones, this does not assure that the United States Census Bureau has the contact information for all 97% of Americans or that this percentage was utilized in sampling. Ultra conservative individuals might avoid promoting government access to their devices. Elderly individuals might also be less likely to be represented in the study from a less technology-based lifestyle as a result of age and differing experiences.

In order to capture a progression of data across the developing landscape of pandemic learning, this study analyzed results for Weeks 2 (5/7/2020), 7 (6/11/2020), 12 (7/16/2020), 17 (10/14/2020), 22 (1/6/2021), and 27 (3/17/2021). Data presented focuses on the first and the last date for simplicity and contrast. For each week, Education Table 2 (COVID-19 Pandemic Impact on How Children Received Education, by Select Characteristics: United States) and Education Table 3 (Computer and Internet Availability in Households with Children in Public or Private School, by Select Characteristics: United States) were analyzed. From Table 2, data used included: Total and Impact of pandemic on children's education (five factors) across total values, sex (two factors), and Hispanic origin and Race (five factors). From Table 3, data used included: Total and Availability of computer for educational purposes (five factors) across total values, sex (two factors), Hispanic origin and Race (five factors), Computer provided by… (three factors), and Internet provided by… (three factors).

Proportions were utilized to determine the relative percentage across total households which were impacted by each condition, given that the number of students in each condition would vary.

Results

In Week 2, which was collected beginning May 7, the data provided on 67,138,021 respondents indicates 72.26% of respondents used online resources, compared to 21.27% using paper materials sent home (see Table 1, Household Pulse Report Pandemic Education Reception, Week 2). Respondents reported class cancellations in 41.29% of cases, 4.21% experienced some other type of change, and 0.26% experienced no change due to closure. Separating genders, 71.61% of boys and 72.82% of girls used online resources, compared to 20.74% and 21.72% using paper materials sent home, respectively. Additionally, 42.37% of boys and 39.50% of girls experienced class cancellations, 4.15% of boys and 4.25% of girls had classes changed in another way, 0.26% of boys and 0.21% of girls experienced no change to classes due to school closure. Separating race/ethnicity, 68.53% of Hispanic/Latino students, 74.58% of White students, 66.00% of Black students, 78.54% of Asian students, and 75.07% of students of two or more races used online resources, compared to 20.55% of Hispanic or Latino students, 22.67% of White students, 21.11% of Black students, 12.51% of Asian students, and 20.44% of students of two or more races who used paper materials sent home. Additionally, 44.08% of Hispanic or Latino students, 38.22% of White students, 49.43% of Black students, 34.27% of Asian students, and 45.07% of students of two or more races experienced class cancellations, 6.59% of Hispanic or Latino students, 2.72% of White students, 6.42% of Black students, 2.09% of Asian students, and 6.52% of students of two or more races had classes changed in some other way, and 0.23% of Hispanic/Latino students, 0.19% of White students, 0.23% of Black students, 1.13% of Asian students, and 0.18% of students of two or more races experienced no changes to classes due to school closure.

Impact of pandemic on children's education

Select characteristics	Classes were moved to a distance learning format					
N=67,138,021	Using online resources	Using paper materials sent home	Where classes were cancelled	Where classes changed in another way	Where no change to classes because schools did not close	Did not report
Total	72.26%	21.27%	41.29%	4.21%	0.26%	0.97%
Male	71.61%	20.74%	43.37%	4.15%	0.21%	1.07%
Female	72.82%	21.72%	39.50%	4.25%	0.31%	0.88%
Hispanic or Latino (any race)	68.53%	20.55%	44.80%	6.59%	0.23%	1.47%
White alone, not Hispanic	74.58%	22.67%	38.22%	2.72%	0.19%	0.50%
Black alone, not Hispanic	66.00%	21.11%	49.43%	6.42%	0.23%	0.83%

Asian alone, not Hispanic	78.54%	12.51%	34.27%	2.09%	1.13%	3.87%
Two or more races, not Hispanic	75.07%	20.44%	45.07%	6.52%	0.18%	0.45%

Table 1 - Household Pulse Report Pandemic Education Reception, Week 2

In Week 27, collected beginning March 17, the data provided on 48,720,070 respondents indicates 68.65% of respondents used online resources, compared to 16.19% using paper materials sent home (see Table 2, Household Pulse Report Pandemic Education Reception, Week 27). Respondents reported that in 25.40% of cases, classes experienced cancellations, 10.73% experienced some other type of change, and 10.58% experienced no change due to closure. Separating genders, 67.29% of boys and 69.78% of girls used online resources, compared to 15.27% and 16.95% using paper materials sent home, respectively. Additionally, 27.16% of boys and 23.94% of girls experienced class cancellations, 10.10% of boys and 11.25% of girls had classes changed in another way, 11.06% of boys and 10.18% of girls experienced no change to classes due to school closure. Separating race/ethnicity, 70.55% of Hispanic/Latino students, 67.57% of White students, 67.65% of Black students, 74.77% of Asian students, and 67.61% of students of two or more races used online resources, compared to 15.83% of Hispanic or Latino students, 16.38% of White students, 14.19% of Black students, 13.82% of Asian students, and 24.40% of students of two or more races used paper materials sent home. Additionally, 32.80% of Hispanic or Latino students, 22.09% of White students, 27.01% of Black students, 19.32% of Asian students, and 36.03% of students of two or more races experienced class cancellations, 5.85% of Hispanic or Latino students, 12.84% of White students, 11.99% of Black students, 7.21% of Asian students, and 9.13% of students of two or more races had classes changed in some other way, and 7.67% of Hispanic/Latino students, 12.99% of White students, 7.60% of Black students, 5.82% of Asian students, and 7.32% of students of two or more races experienced no changes to classes due to school closure.

	Impact of pandemic on children's education					
Select characteristics	**Classes were moved to a distance learning format**					
N=48,720,070	**Using online resources**	**Using paper materials sent home**	**Where classes were cancelled**	**Where classes changed in another way**	**Where no change to classes because schools did not close**	**Did not report**
Total	68.65%	16.19%	25.40%	10.73%	10.58%	2.54%
Male	67.29%	15.27%	27.16%	10.10%	11.06%	2.67%
Female	69.78%	16.95%	23.94%	11.25%	10.18%	2.43%
Hispanic or Latino (any race)	70.55%	15.83%	32.80%	5.85%	7.67%	4.21%

White alone, not Hispanic	67.57%	16.38%	22.09%	12.84%	12.99%	1.87%
Black alone, not Hispanic	67.65%	14.19%	27.01%	11.99%	7.60%	2.36%
Asian alone, not Hispanic	74.77%	13.82%	19.32%	7.21%	5.82%	3.60%
Two or more races, not Hispanic	67.61%	24.40%	36.03%	9.13%	7.32%	1.79%

Table 2 - Household Pulse Report Pandemic Education Reception, Week 27

In Week 2, the collected data from 61,361,903 In total, 58.44% of respondents reported that a device was “always” available for educational purposes, 21.72% “usually,” 11.37% “sometimes,” 4.21% “rarely,” and 2.29% “never” available. Separating genders, 62.08% of boys reported that a device was always available (see Table 3, Household Pulse Report Computer and Internet Availability, Week 2)., 21.22% “usually,” 10.29% “sometimes,” 2.84% “rarely,” and 1.51% “never” available; contrasted with girls, where 55.49% reported that a device was “always” available, 22.13% “usually,” 12.25% “sometimes,” 5.32% “rarely,” and 2.93% “never” available. Separating race/ethnicity, Hispanic/Latino students reported that 50.58% had a device “always” available, 20.96% “usually,” 15.67% “sometimes,” 5.18% “rarely,” and 3.91% “never” available. White students reported that 63.95% had a device “always” available, 20.82% “usually,” 9.72% “sometimes,” 2.76% “rarely,” and 1.55% “never” available. Black students reported that 50.05% had a device “always” available, 23.58% “usually,” 12.02% “sometimes,” 8.55% “rarely,” and 3.36% “never” available. Asian students reported that 64.70% had a device “always” available, 25.50% “usually” available, 6.42% “sometimes,” 1.84% “rarely,” and 0.32% “never” available. Students of two or more races reported that 49.31% had a device “always” available, 26.64% “usually,” 13.49% “sometimes,” 6.40% “rarely,” and 2.19% “never” available. Separating computer sources, computers provided by the school or district were always available in 61.80% of responses, 22.08% “usually,” 11.58% “sometimes,” and 4.53% “rarely” available. Computers provided by the household were “always” available in 63.19% of responses, 23.85% “usually,” 10.34% “sometimes,” and 2.62% “rarely” available. Computers provided by the other sources were “always” available in 32.34% of responses, 13.40% “usually,” 27.25% “sometimes,” and 27.00% “rarely” available. Separating internet sources, internet provided by the school was “always” available in 53.67% of responses, 19.38% “usually,” 22.09% “sometimes,” 4.38% “rarely,” and 0.39% “never” available. Internet provided by the household was “always” available in 61.20% of responses, 22.56% “usually,” 11.06% “sometimes,” 3.74% “rarely,” and 1.16% “never” available. Internet provided by other sources was “always” available in 29.91% of responses, 13.88% “usually,” 30.22% “sometimes,” 20.90% “rarely,” and 4.72% “never” available.

Select characteristics N=61,361,903	Availability of computer for educational purposes Device always available for educational purposes	Device usually available for educational purposes	Device sometimes available for educational purposes	Device rarely available for educational purposes	Device never available for educational purposes	Did not report
Total	58.44%	21.72%	11.37%	4.21%	2.29%	1.97%
Male	62.08%	21.22%	10.29%	2.84%	1.51%	2.06%
Female	55.49%	22.13%	12.25%	5.32%	2.93%	1.89%
Hispanic or Latino (any race)	50.58%	20.96%	15.67%	5.18%	3.91%	3.71%
White alone, not Hispanic	63.95%	20.82%	9.72%	2.76%	1.55%	1.19%
Black alone, not Hispanic	50.05%	23.58%	12.02%	8.55%	3.36%	2.44%
Asian alone, not Hispanic	64.70%	25.50%	6.42%	1.84%	0.32%	1.22%
Two or more races, not Hispanic	49.31%	26.64%	13.49%	6.40%	2.19%	1.96%
Computer provided by school/district	61.80%	22.08%	11.58%	4.53%	N/A	N/A
Computer provided by household	63.19%	23.85%	10.34%	2.62%	N/A	N/A
Computer provided by other source	32.34%	13.40%	27.25%	27.00%	N/A	N/A
Internet provided by school/district	53.67%	19.38%	22.09%	4.38%	0.39%	0.10%
Internet provided by household	61.20%	22.56%	11.06%	3.74%	1.16%	0.28%
Internet provided by other source	29.91%	13.88%	30.22%	20.90%	4.72%	0.38%

Table 3 - Household Pulse Report Computer and Internet Availability, Week 2

In Week 27, 48,720,070 respondents indicated that 78.54% of households reported that a device was "always" available, 12.96% "usually," 4.52% "sometimes," 0.89% "rarely," and 0.82% "never" available (see Table 4, Household Pulse Report Computer and Internet Availability, Week 27). Separating genders, 78.54% of boys reported that a device was "always" available, 13.64% "usually," 3.90% "sometimes," 0.68% "rarely," and 0.85% "never" available; contrasted with girls, for whom 78.54% reported that a device was "always," 12.39% "usually," 5.04% "sometimes," 1.06% "rarely," and 0.79% "never" available. Separating race/ethnicity, Hispanic/Latino students reported that 69.23% "always" available, 19.52% "usually," 5.33% "sometimes," 0.63% "rarely," and 0.71% "never" available. White students reported that 82.09% had a device "always" available, 10.66% "usually," available, 3.85% "sometimes," 1.08% "rarely," and 0.88% "never" available. Black students reported that 78.76% had a device "always" available, 12.06% "usually," 5.48% "sometimes," 1.00% "rarely," and 0.53% "never" available. Asian students reported that 80.90% had a device "always" available, 12.66% "usually," 3.32% "sometimes," 0.01% "rarely," and 0.61% "never" available. Students of two or more races reported that 75.14% had a device "always" available, 12.32% "usually," 8.69% "sometimes," 0.54% "rarely," and 1.62% "never" available. Separating computer sources, computers provided by the school/district were "always" available in 82.41% of responses, 13.18% "usually," 3.85% "sometimes," and 0.56% "rarely" available. Computers provided by the student household were "always" available in 83.19% of responses, 12.37% "usually," 3.77% "sometimes," and 0.68% "rarely" available. Computers provided by the other sources were "always" available in 49.56% of responses, 10.22% "usually," 28.23% "sometimes," and 12.00% "rarely" available. Separating internet sources, internet provided by the school or district was "always" available in 70.04% of responses, 14.41% "usually," 11.76% "sometimes," and 3.27% "rarely" available. Internet provided by the student household was "always" available in 81.33% of responses, 13.26% "usually," 4.01% "sometimes," 0.71% "rarely," and 0.34% "never" available. Internet provided by other sources was "always" available in 41.93% of responses, 15.41% "usually," 25.68% "sometimes," 9.52% "rarely," and 3.07% "never" available.

	Availability of computer for educational purposes					
Select characteristics N=48,720,070	**Device always available for educational purposes**	**Device usually available for educational purposes**	**Device sometimes available for educational purposes**	**Device rarely available for educational purposes**	**Device never available for educational purposes**	**Did not report**
Total	78.54%	12.96%	4.52%	0.89%	0.82%	2.28%
Male	78.54%	13.64%	3.90%	0.68%	0.85%	2.39%
Female	78.54%	12.39%	5.04%	1.06%	0.79%	2.18%
Hispanic or Latino (any race)	69.23%	19.52%	5.33%	0.63%	0.71%	4.57%
White alone, not Hispanic	82.09%	10.66%	3.85%	1.08%	0.88%	1.43%

Black alone, not Hispanic	78.76%	12.06%	5.48%	1.00%	0.53%	2.17%
Asian alone, not Hispanic	80.90%	12.66%	3.32%	0.01%	0.61%	2.50%
Two or more races, not Hispanic	75.14%	12.32%	8.69%	0.54%	1.62%	1.67%
Computer provided by school/district	82.41%	13.18%	3.85%	0.56%	N/A	N/A
Computer provided by household	83.19%	12.37%	3.77%	0.68%	N/A	N/A
Computer provided by other source	49.56%	10.22%	28.23%	12.00%	N/A	N/A
Internet provided by school/district	70.04%	14.41%	11.76%	3.27%	N/A	0.51%
Internet provided by household	81.33%	13.26%	4.01%	0.71%	0.34%	0.34%
Internet provided by other source	41.93%	15.41%	25.68%	9.52%	3.07%	4.39%

Table 4 - Household Pulse Report Computer and Internet Availability, Week 27

Discussion

In data collected less than two months after the national outbreak, children in 41% of households had classes canceled, providing no educational services (USCB Week 2, Table 2, 2020). Of other students, 93% were learning remotely and 4% had other learning opportunities (USCB Week 2, Table 2, 2020). Of students learning remotely, 72% engaged through online resources and 21% used paper materials from home without virtual contact (USCB Week 2, Table 2, 2020). White and Asian students and students of two or more races (not Hispanic) were more likely to be using virtual resources than Hispanic/Latino or Black students, by 6-13% (USCB Week 2, Table 2, 2020). Among students with computers for educational purposes, only 58% always had access to the device (USCB Week 2, Table 3, 2020). Among boys, 62% had access to the device all the time, whereas only 55% of girls could say the same (USCB Week 2, Table 3, 2020). Among Hispanic/Latino students, 51% had devices available all of the time, similar to Black students at 50% and students of two or more races at 49%, whereas White (64%) and Asian (65%) student enjoyed significantly more access (USCB Week 2, Table 3, 2020).

Just under one year later, statistics among 48.7 million households were quite different and some disparities were less pronounced. While 25% of households reported school closures during the year, 11% of households indicated that schools were not closed (USCB Week 27, Table 2, 2020). Of those in districts conducting school remotely, 69% were using online resources, 16% used paper materials at home, 11% indicated other variations, and 3% did not report on that item (USCB Week 27, Table 2, 2020). Hispanic/Latino students were 11% more likely than White students, 6% more likely than Black students, 14% more likely than Asian students, and 3% less likely than students of two or more races to be in districts which canceled classes (USCB Week 27, Table 2, 2020). Boys and girls were equally likely to have access to a device "always" (79%) and "rarely" (1%) or "never" (1%) (USCB Week 27, Table 3, 2020). However, White students were 13% more likely than Hispanic/Latino students to "always" have a device available for educational purposes, 3% more likely than Black students, 1% more likely than Asian students, and 7% more likely than students of two or more races (USCB Week 27, Table 3, 2020).

Regarding Research Question 1 (What percentage of students had access to computers for learning in each period?), 80.16% of households reported computer access for educational purposes at "always" or "usually" in Week 2, whereas 91.62% had access in Week 27, which effected an 11.46% increased access in less than one year.

Regarding Research Question 2 (What percentage of students had access to internet for learning in each period?), 2.21% of households enjoyed district-provided internet which was always or usually available in Week 2 compared to 4.20% in Week 27, which increased the coverage 90.04% in less than one year. Most households (90.88%) provided their own internet in Week 2 and continued to do so with a slight increase (91.58%) of less than 1%.

Research Question 3 (How did experiences of demographic groupings based on gender and race/ethnicity vary?) demonstrated disparities in experience between boys and girls, which equalized within one year. Further, White and Asian students were more likely to engage classes virtually and were less likely to have classes canceled than Hispanic/Latino, Black, or mixed-race students in Week 2, but Hispanic/Latino and Asian students were more likely to be learning online than White, Black, and mixed-race students in Week 27. Hispanic/Latino (48.48%) and mixed-race students (63%) were more likely to experience canceled classes in Week 27 than White counterparts. Black students were 18.77% more likely to have returned to classrooms than Hispanic/Latino learners and 32.95% more likely than mixed-race children. Therefore, gender effects disappeared over time, but conditions for student groups based on race/ethnicity became more pronounced with time for Hispanic/Latino students and less true of Black students.

Conclusion

Pandemic learning in the United States was an extreme experience without planning or precedence. School closures rolled through the country in a matter of a few weeks and persisted in many cases for more than a year. Parents gained a front row seat for curriculum delivery and began to question decisions (Lieberman, 2020). Administrators were pressed to leverage district resources and even debt to acquire computers and related hardware to enable virtual and remote learning for a duration which had no end in sight (Herold, 2021). Teachers were frustrated by minimal training in new technology resources, lack of support for online applications, and the challenges of meeting the needs of virtual and in-person students with differing needs (Bouchrika, 2022). Further, 42% of teachers indicated consideration of

leaving the profession because of situations surrounding COVID-19 (Zamarro, et al., 2021). Virtual teachers in particular were most likely to consider abandoning teaching because of necessary changes in teaching modes which increased workload, although in-person teachers were more likely to leave for other reasons, like a lack of substitute teacher coverage, daily stress, and additional tasks without adequate compensation (Zamarro, et al., 2021). Across all stakeholders, adult participants in education during the pandemic encountered significant challenges which threatened their opportunity for success. Like a pendulum, they were pushed to the extreme during 2020 and 2021. However, it is the statistics of impacts on students which tell a more important story.

Students

While the survey comments and interview quotes share the perspective of adults, the Household Pulse Report provides quantitative details about student experiences. Initially, reports of canceled classes demonstrated a dramatic disparity across conditions of race/ethnicity with Asian students least likely to have classes canceled (34%) and Black students most likely to be in that condition (49%). White students were most likely to be using paper materials from home (23%) with Asian students to be least likely to experience the same condition (13%). Girls were 7% less likely to have a device always available for educational purposes than boys. Asian (65%) and White (64%) students were more likely to have a device always available to them than Hispanic/Latino (51%), Black (50%), or mixed race (49%) students.

Less than one year later, class cancellations were reported in 19% of Asian students (lowest) and 36% of students of two or more races (highest). Students using online resources ranged from 75% (Asian) to 68% (White, Black, and mixed race). Black and Asian students had the lowest rate of using paper materials (14%) with Hispanic/Latino and White students slightly higher at 16% and mixed race students significantly higher at 24%. By Week 27, rates of girls and boys with device availability at “always” were the same at 79%. Hispanic/Latino students, however, were more than 12% less likely than to identify device availability as “always” than White or Asian students.

Based on the Household Pulse Report, class cancellations were reduced by half and, at first, disenfranchising Black students the most, but mixed race students by the end of the 2020-2021 school year. At the same time, mixed race students were twice as likely to experience remote (not virtual) learning than other students. While girls were at a disadvantage about computer availability initially, that statistic equalized by the end of the school year. Hispanic/Latino students encountered limited device availability along with Black and mixed-race students early, but did not rise at the same rate as other groups, lagging 13% one year later. These results indicate an initial gender bias in device availability, which was mediated. Also, Black, Hispanic/Latino, and mixed-race students were disadvantaged at the beginning of the pandemic, but the matter was partially resolved over time, except for Hispanic/Latino students. Fortunately, the availability of devices provided by the district increased from 62% to 82% throughout the year, though the availability of school-provided Internet only increased from 54% to 70%.

In total, by the end of the 2020-2021 school year, 92% of students were reported as having a device “always” or “usually”available to them for educational purposes, up from 80% at the beginning of the pandemic. At the same time, 69% of households (over 33 million) engaged in virtual learning. Among the untold stories of the crisis is the level of unpreparedness to

move to the virtual learning platforms. While the vast majority of students engaged in online learning, many were widely reported as failing to engage in school work or connecting with the teacher regularly or at all. One culprit in the matter is the inability of teachers to fully prepare students to use the digital applications that would be necessary for effective online engagement. Among these applications were online versions of assessments, including standardized state tests and the College Board Advanced Placement exams. Without proper preparedness, Digital Application Literacy theory would indicate that students are not actually being assessed on their knowledge of the content, but their facility with the application for the assessment (Schmidt, 2021). These alternate versions of classroom assessments were used to widely report the inadequacies of pandemic learning and the learning lag recorded by them. While other assessments like the STAR by Renaissance learning also reported learning lags, such assessments had previously been given in the same digital format (Renaissance, 2021). Even this report indicated a variation between students testing at home and those testing at school (Renaissance, 2021).

In the wake of the most recent shockwave in education – ChatGPT – access to online resources has become even more limited on student devices for fear of breaches of digital citizenship and use of the artificial intelligence tools to assist with or to complete classroom prompts. The same connectivity which permitted a successful pivot to remote learning for tens of millions of students is under scrutiny and is quickly being curtailed. As Digital Application Literacy theory would indicate, the steps of preparing students to properly utilize such online resources are essential for success in this arena. When unprepared and under-equipped, students are far more likely to make mistakes in the ethics and appropriate usage of applications like ChatGPT. Without effective protocols like the Digital Application Literacy model, classroom experiences can devolve like a pendulum swinging from one extreme to the opposite. The only hope is that it will eventually return. However, physics would indicate that the next swing will never be quite as expansive as the prior one without additional energy being expended. Is there enough motivation left to push the boundaries of online educational opportunities?

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