Student Home Connectivity Study

Preliminary findings and recommendations based on the study conducted by CoSN. Made possible by the Chan Zuckerberg Initiative.

CoSN

LEADING EDUCATION INNOVATION

Spring 2021

Remote learning has increased our reliance on the internet

But many school districts lack insight and guidance into how to best ensure a good student experience in online learning. The purpose of the Home Internet Connectivity Study is to provide bandwidth, device, and other guidelines for remote learning.

Chan Zuckerberg Initiative

CoSN gratefully acknowledges the support of the Chan Zuckerberg Initiative.

innive K12 360°

We also appreciate our data partner, Innive K12 360°.

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Note: This report references commonly-used terms and concepts related to student internet network connectivity. Go to **Appendix A: Glossary** to familiarize yourself with the definitions utilized in the study.

A Letter from CoSN

The Consortium for School Networking (CoSN), is proud to release this important breakthrough study on Student Home Connectivity. Few topics are more timely and critical today than addressing digital equity and closing the so-called Homework Gap.

Digital equity is not a new topic for CoSN. Since our founding, we have focused on addressing the digital divide and ensuring that fast connectivity, devices and equitable use happen in all classrooms. But since March 2020, the imperative of this outside-of-school challenge has become readily apparent to all. The Homework Gap was a chasm for millions of students and educators as the shift to remote learning occurred.

Unfortunately, educators and policymakers have mostly lacked data about the student experience of learning from home. Fortunately, with the help of the Chan Zuckerberg Initiative (CZI), we have data that informs these key findings and recommendations around student home connectivity. The thirteen school districts participating in this exciting project have actionable data for approximately 750,000 students learning from home. Because of this dataset, CoSN is able to provide evidence-based advice to all districts and inform policymakers.

CoSN is eternally grateful to the impressive team at Innive, our data analytics partner, including Gautham Sampath, John Parker, Shahyrar Khazei, Munmun Saha, and Jenny Boronyak. They have gone above and beyond what we hoped when we developed the original concept. Thanks also to our external research partners, Dr. David Drew, Ph.D., and Dr. Frances Gipson, Ph.D., Claremont Graduate University (CA). We would be remiss if we didn't also thank Dr. Tom Ryan, Ph.D., Chief Information & Strategy Officer at Santa Fe Public Schools (NM), CoSN Board Member, and Chair of the Educator Advisory Committee, as well as all the leaders from school districts who are helping us make sense of this initial data. We also thank Ookla for Good for their generosity in providing speed tests to the participating districts. Finally, this work could not be done without the support of CoSN's talented staff.

CoSN sees this study as a key foundational step toward addressing digital equity for students learning from home. There is much work remaining, but the work has begun.

Sincerely,

Keith R. Krueger

CEO, CoSN

Steve Langford

Chair, CoSN Board of Directors

CIO, Beaverton School District (OR)

Introduction

Many families with school-age children have faced significant challenges during the COVID-19 pandemic, an event which has caused an unprecedented shift to online learning. The burden is greatest for the estimated 15 to 17 million students who cannot afford or access a home internet connection. While remote learning is not new in K12 education, it has become a primary learning setting due to the pandemic because it filled a need, allowing students to continue education while school buildings are closed. Many schools are operating remotely in full or part-time mode during and subsequent to the pandemic; however, the lack of adequate internet precludes the child's ability to participate in online instruction or, in some cases, do any schoolwork at all.

Recognizing this imperative, policymakers passed the American Rescue Plan Act in February 2021, which established a new Federal Communications Commission (FCC) program (Emergency Connectivity Fund) with $7.171 billion made available to address internet connectivity needs for students learning from home. In addition, many school districts are using resources provided under the Elementary & Secondary School Emergency Relief Fund (ESSER Fund) to solve remote learning challenges around devices and connectivity.

The need for online remote access for K12 instruction and learning resources is now integral to the US education system. This is a result of several factors.

First, many school districts are offering virtual learning options within existing schools, like remote learning days, or full virtual academies. These options provide varied content and flexibility for schools, students, and teachers to avoid the loss of instructional days during inclement weather conditions and emergencies.

Second, to address the loss of instructional time and engagement caused by the pandemic, many students will need some form of intervention, acceleration, and support. This will be provided in several forms such as tutoring, an extended school year, and online learning resources, which will require student access to devices and high-speed internet.

Third, some students have thrived in the remote learning environment. Many have accelerated academically, more so than they did in the traditional classroom environment. In addition, many parents prefer the option of a more flexible school day which is offered by distance learning. These families may decide to continue their child's education using online methods.

Lastly, even with students returning to the classroom full-time, they still need reliable home internet to participate in class assignments. Ensuring adequate home internet availability provides an opportunity for an equitable education experience.

Regardless of an individual student's chosen learning path, digital tools that were necessary during the pandemic will continue to be leveraged by educators, requiring students utilize home internet access for assignment completion and class participation. School districts require a variety of technologies and strategies to facilitate and expand remote learning access for students, especially for meeting the needs of isolated rural households and other higher cost areas.

About the Home Internet Connectivity Study

With funds provided by the Chan Zuckerberg Initiative (CZI), CoSN has undertaken this study to address home bandwidth, device, and related guidelines for students learning in a remote or hybrid environment. The study was supported and informed by an advisory group of school district technology leaders.

This first-of-its-kind study employed recent de-identified student data to capture the experience of students using computing devices and accessing the internet at home. Each participating school district provided data such as student characteristics, network logs, Quality of Service (QoS) data for meeting software, Internet Service Provider (ISP) data, and geolocation data. Thirteen urban, suburban, and rural school districts representing approximately 750,000 students from across the United States participated in the study over the course of six weeks. The preliminary findings and recommendations in this report have already informed policymakers at the FCC around expanding use of E-Rate funds to address the Homework Gap. This report is also the beginning to ensuring educational technology leaders have data-informed recommendations around student home connectivity.

Note: This study focused on the experiences of students at home and did not include data regarding school or teacher connectivity. Further analysis is required regarding teacher connectivity at school and home. Anecdotal evidence suggests poor connectivity for the teacher can have a significant negative impact on the experience for all students in the class.

Participating School Districts

1. Aldine ISD, TX
2. Beaverton School District, OR
3. Boston Public Schools, MA
4. Ector County ISD, TX
5. Dallas Independent School District, TX
6. Fauquier County Public Schools, VA
7. Forest Ridge School District 142, IL
8. Hillsborough County Public Schools, FL
9. MSD of Wayne Township, IN
10. Santa Fe Public Schools, NM
11. St. Charles CUSD 303, IL
12. Rock Hill Schools York 3, SC
13. Wake County Public School System, NC

Findings Summary

The findings and recommendations in this report are divided into four distinct topics. The recommendations in this report should be considered a guide for school leaders to support local decisions. There is no one-size-fits-all approach to implementing supports for student home internet connectivity. In fact, it is evident that no one solution will meet the needs of all students. Therefore, school districts must use a variety of strategies and interventions to ensure digital equity. The findings in this report are organized into four topics:

1. Learning with Video is Essential for Education
2. Students are Mobile and Rely on WiFi
3. Certain Communities, Especially Remote and Rural Areas, Require More Support and Resources
4. The Remote Learning Experience is Significantly Impacted by Device Quality

1. Learning with Video is Essential for Education

a. Over 85% of network traffic in remote learning is used for video (both synchronous and asynchronous).

b. A sufficient upload speed is critical for uninterrupted participation in synchronous video.

c. A sufficient download speed is critical for uninterrupted viewing of synchronous or asynchronous video.

d. Video-intensive content and applications are increasing in use and this trend is expected to continue for the foreseeable future.

2. Students are Mobile and Rely on WiFi

a. Many students participate in online learning activities outside of the student's home, including joining from peers' homes, and even attending classes from other cities, states, and countries.

b. 92% of students use WiFi instead of a wired connection, which makes it critical to address home WiFi issues.

c. Alongside district-provided devices, students often concurrently use mobile devices, such as their personal phone or tablet, which contributes to increased home bandwidth needs.

3. Certain Communities, Especially in Remote and Rural Areas, Require More Support and Resources

a. Students in more remote or rural areas most often have limited internet access.

b. Students working in areas with a large concentration of students may experience poor connectivity.

c. Even students from higher socioeconomic families have frequent problems in remote learning/online meeting experiences.

4. The Remote Learning Experience is Significantly Impacted by Device Quality

a. Quality of student experience can be impacted by age, type, and quality of device, as well as device configuration (i.e., user authentication and network filtering tools).

b. Student experience can be improved by routinely collecting datasets that provide insight into the student use of district-provided devices.

In addition to the findings and recommendations in this report, the study helped to determine recommendations for student home internet bandwidth requirements.

Student Home Bandwidth Recommendations

Students need fast internet connections to participate in remote learning. The current FCC household minimum bandwidth guideline of 25 Mbps download speed and 3 Mbps upload speed is inadequate to support even a single student in a household, let alone multiple students. Based on the findings in the study, CoSN recommends a per-student minimum bandwidth standard of a download speed of 25 Mbps and upload speed of 12 Mbps to support concurrent activity and usage.

To determine this recommendation, actual network traffic was reviewed to identify applications used, how much traffic is going to each application, and how much of the traffic is video. Analysts in the study identified the activities where bandwidth is needed based on actual network traffic patterns. Then, they researched the recommended bandwidth from application vendors to determine the estimated bandwidth for the activity. Network traffic was also used to analyze activity concurrency; that is, students regularly perform more than one activity at a time. For example, one student may be actively participating in an online meeting while simultaneously performing an internet search via web browser while, in the background, email is automatically refreshing. This scenario, and others like it, are extremely common in remote learning. For this reason, it is important that a minimum is set at 25 Mbps download and 12 Mbps upload speed.

In addition, it's crucial to highlight the importance of a per-student standard and not a per-household standard like the current FCC recommendation. Standards should be set at the student level and account for the total number of students in the home. For example, network requirements to support a home with six children should be different from network requirements to support a home with one child.

These recommendations are based on the current environment needs. In light of constantly evolving technologies, minimum bandwidth recommendations should be revisited regularly, at least every three years. Support for higher video resolution, such as 1080p high definition (HD) and 4K, will most likely be required in the future. In addition, many new technologies, such as eSports, Augmented Reality (AR), and Virtual Reality (VR) will likely be used to deliver instruction. These kinds of advanced technologies will require at least 25 Mbps download/upload speed for standard definition (SD) and up to 500 Mbps download/upload speed for 4K video.

Student Home Bandwidth Calculator

CoSN Institutional Members will receive exclusive access to the Student Home Bandwidth Calculator, which is a tool for determining the recommended amount of available bandwidth for students based on concurrent activity and usage. The calculator provides the estimated bandwidth for each activity and automatically adds up the required bandwidth for a set of students performing selected activities.

Student Activities During Online Instruction and Estimated Bandwidth

Student Bandwidth Usage	Resolution	Download (Mbps)	Upload (Mbps)
Email -- Is used to communicate to students by teachers, administrators, and other students.	n/a	1	1
Web Browsing -- Students access the internet frequently to research topics using a web browser and search engine such as Google or to read blog articles. Ad services related to various websites also consume a significant amount of bandwidth.	n/a	1	0.5
Learning Management System -- Students use a learning management system such as Canvas, Google Classroom, Schoology, PowerSchool, or D2L to access and submit assignments and communicate with their teacher and other students.	n/a	1	1
Video Instructional Content -- Students access video instructional content from sources such as PBS Kids, Khan Academy, Newsela, McGraw Hill, Discovery, National Geographic, YouTube, etc.	SD	3	0.5
Online Assessments -- Assessments for essential skills and content knowledge are provided online and taken at home. Assessment software can be divided into two broad categories: formative and benchmark. Examples of formative assessment software include Edpuzzle and Edulastic. Examples of benchmark assessment software include iReady and Renaissance.	n/a	1.5	0.5
Cloud Storage -- Students download and upload homework assignments using cloud storage such as Google Drive or Office 365.	n/a	5	2
Online Meetings -- Students participate in daily online meetings with teachers using an online video tool such as Google Meet, Zoom, Cisco Webex, or Microsoft Teams. In addition, online meetings are used for counseling and providing services for English Learners and students with disabilities. Students frequently participate in small group instruction sessions and use video to communicate with teachers and other students.	SD	3.2	3.2
Feedback -- Asynchronous video is frequently used by teachers and students to communicate and provide feedback to each other. Teachers and students often record videos using software from companies such as Loom and Screencastify to communicate. Other feedback tools are provided by companies such Class Dojo and Edmodo.	SD	2	2
Instructional Support -- Interventions and instructional support are provided through online resources. Many companies such as Edgenuity, Renaissance and Illuminate provide solutions in this category.	n/a	3	1
Multiple Devices -- Students frequently use two or more devices to access the internet (e.g. Computer, Tablet, Smart phone, etc.)	n/a	1	1
Educational Gaming Technology -- Instruction is often provided through software such as Kahoots, BrainNook, FunSchool, Socrates, ZooWhiz that utilize gaming technologies.	HD	5	1

CoSN is vendor-neutral and does not endorse products or services. Any mention of a specific solution or company is only for contextual purposes.

Detailed Findings & Recommendations

1. Learning with Video is Essential for Education

Video (both synchronous and asynchronous) is used extensively in remote learning environments to deliver instruction and to communicate with students in online meetings. Network logs from thirteen (mostly large) districts revealed that over 85% of the network traffic to support students in a remote learning environment is used for video, both for direct instruction and instructional supports. These applications use a significant amount of data and are often run concurrently with the synchronous video classroom sessions.

Synchronous video sessions, like in online meeting tools, provide an effective method for students to feel more connected by virtually interacting with their teacher and other students. However, the extensive use of video by students requires adequate upload bandwidth. Video is a growing trend in K12 education, and it is used for much more than just providing lectures or viewing learning resources. For example, students use video to interact with each other in small group instruction; teachers often encourage or require students to leave cameras on to monitor and support student engagement and participation; and students often use video to submit homework assignments and communicate with their teachers.

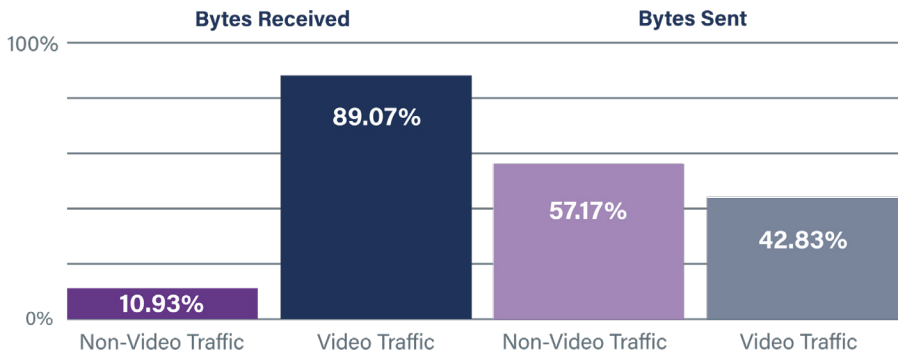
According to the study, over 70% of students live in a household with one or more other students. Concurrently supporting multiple students using video from the same internet connection is problematic when bandwidth availability is low. Home network bandwidth capacity must account for concurrent usage by multiple students, including current video use.

Over

70%

of students live in a household with one or more other students.

Most broadband connections offer different speeds for downloading versus uploading. In the past, uploading data was not as common a task as it is today; therefore, the Federal Communications Commission (FCC) established a household minimum standard of 25 Mbps for download speed and 3 Mbps for upload speed. However, 3 Mbps is not an adequate upload speed to support distance learning for an individual student, let alone multiple students in a household.



The above graph depicts video versus non-video network traffic for all participating school districts. Traffic sources that were analyzed to determine video use include web-based applications such as online meeting tools, video streaming, learning management systems, and other learning tools.

Recommendations for Learning with Video

Increase the Minimum Standard for Student Home Internet Bandwidth - School districts must assure home internet access provides sufficient enhanced upload availability. As previously mentioned, the current FCC household broadband definition of 25 Mbps download speed and 3 Mbps upload speed is inadequate and should be replaced by a per student broadband definition. A new minimum standard should be set at 25 Mbps for download speeds and 12 Mbps for upload speeds per student.

When calculating the bandwidth requirements for a household, the recommended per student bandwidth requirements should be multiplied by the number of students in the household and adjusted for other household members and factors impacting internet usage.

Remove Data Caps for Classwork and Learning Activities - Given the new requirements of video conferencing for classroom communication and student collaboration, ISPs receiving federal support should provide unlimited data for home learning connections without throttling.

2. Students are Mobile and Rely on Wi-Fi

During the study, many students participated in online school activities from locations outside of the student's home. Students accessed school learning resources from other student homes and even other cities, states, and countries. In the study, many students shared an IP address with other students that were not from the same household. Likely causes include students wanting social interaction with other kids, finding a faster internet connection at a friend's house, and parents who share childcare responsibilities.

In addition to other student homes, the study also identified a trend in students accessing the internet from more than two locations during the six-week period of the study. For example, a student living in Santa Fe, New Mexico, may also participate in learning from Albuquerque, New Mexico; Dallas, Texas; and Mexico.

Online meeting software data revealed that, regardless of the student's IP address, 92% of students in the study connected to the internet via WiFi instead of a wired connection. However, WiFi presents significant challenges. Factors such as router location, home construction, and available support for modern router standards can impact the strength of the WiFi connection.

92% **of students connect to the internet via WiFi instead of a wired connection.**

For example, mounting a router on a brick wall or placing it behind a television can impede WiFi signals. Just as important is to consider the home construction materials, such as plaster or concrete, which can also weaken a WiFi connection. When needed, families of students should receive guidance from the school district regarding appropriate WiFi router placement to mitigate obstacles in student internet access.

Many users believe they have slow internet connection, but in some cases the real problem is slow WiFi that is delivered through older routers using outdated wireless standards. A new WiFi standard (802.11ax) has just been released which should provide a much stronger WiFi connection.

Students are not just using WiFi on their district-provided devices to participate in online learning activities. According to device usage data captured in the study, many students concurrently use their personal phone or tablet in addition to their district-assigned device to participate in online meetings. Using multiple devices simultaneously will contribute to increased home bandwidth requirements.

Recommendations for Home WiFi

School districts must ensure that students not only have high-speed bandwidth to the home, but that the student receives dedicated high-speed access within the home. Student households must have a sufficient router to support the number of users and devices in the home. Here are some steps to be taken by school districts:

- Help families acquire new routers if their router has not been upgraded in a few years
- Work with ISPs to replace outdated routers
- Provide network extenders in areas with poor signals
- Educate families on router placement and maintenance

Since so many students use WiFi from various locations, school districts should enforce authentication of students in order to access district resources. This ensures only known students are connecting from outside the district, state, and country to learn. It also provides the ability to identify users, provide better support, and provide a safe and secure learning environment.

Security

It's important to be vigilant about student and district data security. Public and private institutions like school districts are common targets for hackers. Having fine-tuned filtering and authentication tools in use helps address security vulnerabilities before attacks can occur.

3.
Certain Communities, Especially Remote and Rural Areas, Require More Support and Resources

Through review of ISP data (Form 477 data obtained from the FCC) and Ookla Speed Test® data, the study identified upload and download speeds within small geographic areas in each school district. Generally, the study found that the majority of cities and suburban areas where students live have high speed internet available (Source: FCC Form 477) and deployed in the home (Source: Ookla Speed Test®). However, students in more rural areas or on the edges of suburban areas can have extremely limited internet availability and access.

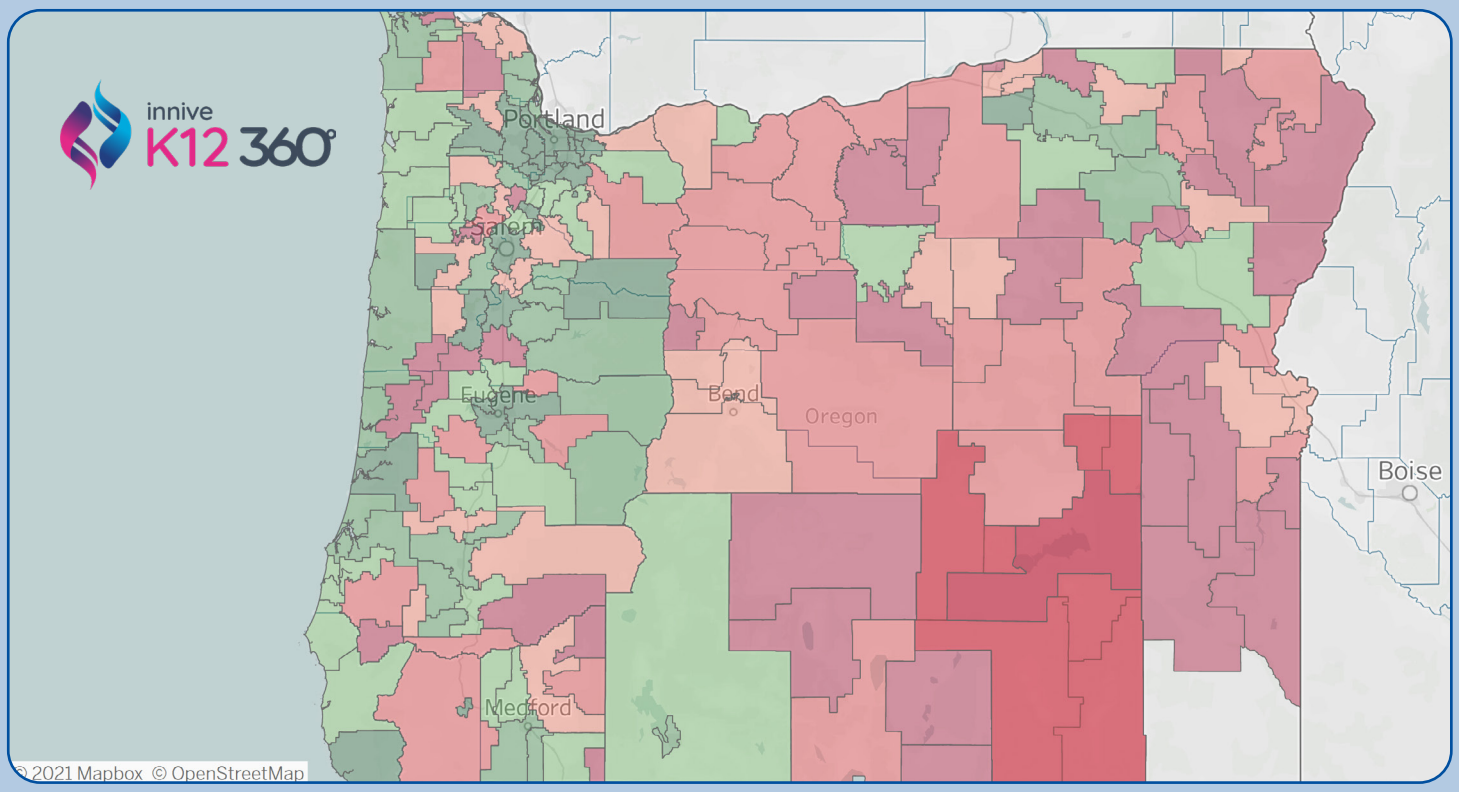
Likewise, users within high population areas of a city also experience limited internet speeds. For example, Santa Fe Public Schools found that areas with large concentrations of students, like in mobile home parks or subsidized apartment buildings, frequently have poor levels of throughput. This inequity may be attributed to capacity issues on the part of ISPs brought about by oversubscribing or related to overloaded network switching equipment.

While remote and rural areas are a primary concern, the study also found that students living in areas with above average socioeconomic status (SES) do not automatically have access to adequate home internet. The study examined network resources used for online meetings and organized them by student and IP address. Students using IP addresses in areas with higher SES and available access to excellent internet connectivity still see frequent problems with their online meeting experience in the home.

The cause for poor meeting experiences may vary from suboptimal network equipment in the home to multiple devices (e.g., smart devices, Internet of Things, etc.) accessing the network concurrently. Multiple devices and people sharing the same network resources significantly reduces resources available to students for learning. Students and families may require education and technical support around best practices to improve their online meeting experiences.

To quickly address internet access needs produced by the pandemic, some ISPs have begun offering free satellite internet for a limited time and government-funded discount programs like Lifeline and the new Emergency Broadband Benefit program to qualifying families and households. When funds are available, school districts may offer the option of portable hotspots to students. However, these solutions often come with data caps that limit the amount of online work a student can perform.

Illustration of Oregon Bandwidth by School District



This map, created by Innive K12 360°, shows an example of the difference in available bandwidth (according to Ookla Speed Test® data) between rural/remote school districts and urban school districts [according to their territory classification by the National Center for Education Statistics (NCES)]. In Oregon, one can clearly see that the more remote school districts in the southeast corner of the state have poorer connectivity than urban and suburban school districts along the west coast.

Recommendations for Supporting Communities in Need:

Below are specific recommendations for this area. As previously mentioned, it's important to note that there is no one-size-fits-all approach to connectivity solutions. Each solution has its strengths and weaknesses depending on the diverse challenges and needs of the students, school district, and community.

- **Flexibly provide students with hotspots for areas with limited internet access using requested E-Rate funds.** It is critical that adequate internet bandwidth is available to all students including students who do not have permanent homes; students that may frequently move; or students that rely on emergency locations for shelter and care. The National Center for Education Statistics reported that for school year 2015-16, 2.6% of public elementary and secondary students were homeless[1]. For this reason, location flexibility is important when determining strategies for providing students with hotspots or other access points.
- **Work with ISPs and community leaders to ensure that ISPs offer suitable plans for the community.** This includes adequate bandwidth availability and lower pricing for students and families.
- **Leverage new federal and state funding, such as the Emergency Connectivity Fund that the FCC is establishing, to leverage a variety of internet access pathways.** School districts should choose the solution(s) that works best for its environment:
  - **District-Provided Mobile Wi-Fi (like buses, stadiums, etc.) –** This approach uses mobile WiFi delivery points and works particularly well for providing WiFi access to high density residences such as apartment complexes and mobile home parks. Using this model, the district implements dependable, high-speed WiFi on a school bus or in a public location that can broadcast WiFi capabilities to households in surrounding areas. Optimally, connections are limited to school-owned devices to ensure bandwidth is preserved for school-related activities. Many districts have applied this approach; for example, Kanawha County School District (WV) offers WiFi-enabled school buses that can be strategically placed in certain areas to provide internet service to students who do not have the ability to connect at home. When in-person school is in session, students have the opportunity to use the WiFi available on the school bus to complete schoolwork before and after the school day.
  - **District-Provided Citizens Band Radio Service (CBRS) –** CBRS is a private, two-way communications service that traditionally provides voice services but can also transmit data packages and extend internet connectivity. School districts can use CBRS to stand up private CBRS 4G and 5G networks. Boulder Valley School District (CO), among other districts in the country, have chosen this approach.
  - **Long-Term Evolution (LTE) Broadband –** LTE Broadband is a 4G wireless connection that is similar to district-provided CBRS. It may be carrier-provided or owned and operated by the district. Carrier-provided approaches leverage a provider-owned LTE radio access network (RAN) to connect end user devices in homes via carrier-provided radio transmissions. Dallas ISD (TX) is one of many school districts using this approach.

1 National Center for Education Statistics, Digest of Education Statistics, Table 204.75a. Homeless students enrolled in public elementary and secondary schools, by grade, primary nighttime residence, and selected student characteristics: 2009-10 through 2015-16

- **Satellite –** Offering internet access via satellite connectivity is an increasingly viable option, particularly for access in rural areas where connectivity reliant on transmission via cable, fiber, or cellular service is less likely. Internet access through satellite eliminates the need to build miles of infrastructure to deploy services to remote locations. Satellite internet can also be leveraged to connect those students living in locations where other options are not available. Many districts have implemented this solution, such as Ector County ISD (TX).
- **Cellular Hotspots -** Cellular hotspots are an increasingly common strategy for addressing lack of home connectivity by school districts and libraries. Because hotspots are dependent on the cellular network, they will not work in many parts of the country, including more rural and remote communities. Cellular hotspots should be distributed/allocated per student not per household. Unless the cellular network can meet the recommended bandwidth requirement described on page 5, this should not be considered a long term solution.

To ensure the success of activities and programs, such as providing internet hotspots and other devices, school districts must provide channels for technical support. For example, school districts utilizing online learning resources should provide technical support resources for families to address suboptimal internet access. To accomplish this requires the use of funds to provide enhanced resources such as training content and, if possible, expanding help desk resources and equipping technical support staff with better tools to address home connectivity issues. Here are some areas where additional district-provided technical support is needed:

- Help families identify and troubleshoot slow internet problems in the home
- Educate families on router maintenance and placement
- Provide tools to assess weak WiFi signals
- Work with application service providers to improve application performance

4. The Remote Learning Experience is Significantly Impacted by Device Quality

Computing devices that are designed for work in classroom environments (e.g., strong WiFi signal and no demand for synchronous video), may not be sufficient for remote learning and home environments. High quality devices are important to instruction for many reasons, especially in lower grade levels that are more dependent on synchronous video and secondary grade levels which offer programs like career technical education which may require devices that depend on higher-processor applications.

According to data regarding the types and performance of district-provided devices, upload and download speeds during online classes/meetings can vary significantly by the age, type, and quality of device used. Students that were provided with older and less powerful equipment had an inferior experience than students with newer devices. Students that received newer devices with limited specifications (e.g., memory and processor) also had more challenges than students that were provided with devices with better specifications. To determine this, the study included examining students who were using the same ISPs and their device information to show that some students experienced a significant reduction in throughput depending on the device used. There are several factors that can contribute:

- Type and speed of processor
- Amount of memory
- Central Processing Unit (CPU) utilization
- Number of applications running at one time
- Quality of WiFi antenna and signal strength received
- WiFi standard used and access frequency

In addition to characteristics such as device age, type, and quality, *device configuration* can have an impact on student experience. For example, requiring user authentication for online classroom or meeting participation can provide significant insight into meeting sessions. On the other hand, network filtering products can provide usage data but they can also slow down an internet experience, especially when used on websites for online meeting tools and virtual classrooms. These online applications should be whitelisted in the network filter to improve student experience. Impact on device network throughput should be included as criteria for the evaluation and selection of network filtering products and services.

In working with thirteen districts, the study discovered that most school districts do not routinely collect quality, curated data to assess device and home connectivity issues. To determine its findings and recommendations, this study depended on large volumes of data and APIs which most districts do not have the resources to collect or implement. Data was harvested from network logs and quality of service (QoS) data from online meeting software. The study also involved the extraction and analysis of hundreds of millions of records. This included using APIs to determine access locations and ISPs for each online meeting conducted. Advanced geospatial capabilities were used to determine geographic areas needing attention because of suboptimal internet connections.

School districts need sophisticated information and data systems to adequately manage home connectivity and ensure students are provided ample resources to learn. With access to this type of adequate data analytics, the participating school districts have been able to work with ISPs, application service providers, families, and community resources to address identified obstacles to adequate home internet access. Without actionable data, school districts may make ill-informed judgements, exhausting limited financial resources. In addition, many school districts continue to use basic methods of data collection and analysis, like spreadsheets. Districts that have advanced data and analytics available are better able to make quick, well-informed strategic decisions.

Recommendations for District-Provided Devices:

Students need a high-quality device(s) to participate in online remote learning. Device capabilities must sufficiently support the needs of the student, whether the device is required for basic classroom use like online classwork and non-synchronous video or advanced use like coding and content creation. The following factors, provided by participating districts, should be considered when purchasing learning devices for the home or student use:

- CPU type, speed, and number of cores
- Amount of memory
- WiFi connection
- Integrated webcam
- Integrated microphone
- Headphone port

Device requirements vary by how the student uses the device. Go to the URLs below to view device requirements for applications and devices commonly used in K12 education.

Google Meet
http://bit.ly/GoogleMeetReq

chromebook
http://bit.ly/GoogleDeviceReq

zoom
http://bit.ly/ZoomDeviceReq

Cisco webex
http://bit.ly/WebExDeviceReq

Microsoft Teams
http://bit.ly/TeamsDeviceReq

Note: CoSN is vendor-neutral and does not endorse products or services.

Using funding to improve data capture and analysis will help districts make more informed decisions around student devices and home internet supports. Here are some areas where improved data and analytics capabilities can benefit school districts:

- School districts need the ability to capture internet speed and quality data and integrate it with other datasets. For example, Ector County ISD is incorporating the ability to capture data such as the location, download speed, upload speed, latency and jitter (i.e., time delay in data delivery) every time a student signs into the student learning management system.
- School districts need to work with online video conferencing software to provide aggregated Quality of Service (QoS) data at the student level to assist in identifying students that are experiencing issues during online instruction.
- Internet speed data should be integrated with other student data such as assignments and assessments to determine the impact on student participation. This requires extending the industry-recognized Ed-Fi Data Standard and providing a standard API, which could be used for a variety of purposes. For example, before assigning an intervention to students, the school district should have data available to determine if the student has appropriate internet access to participate in the intervention.

Appendix A: Glossary

Term	Description
Asynchronous Video	The viewing of the video takes place after the video has been created. An adequate download speed is required for viewing videos in different scenarios, such as viewing video in online video platforms, LMS discussions and assignments, and recorded lectures. See synchronous video.
Authentication	For the purpose of this report, computer applications and tools that are used to authenticate, or verify, the identity of an individual who is attempting to log into a district device or online application.
Bandwidth	The maximum amount of data that can travel through an internet network. See throughput.
Cloud Storage	A repository used for storing files in a location that can be accessed using a web browser. Cloud storage makes it easier for people like students, teachers, and parents to share and concurrently access documents and files. Popular cloud storage applications include Microsoft OneDrive, Google Drive, and Dropbox.
Data Cap	A limit on the amount of data an individual can use on a given device. Data caps are usually agreed-to on a per-month basis. After the limit is reached, the individual usually receives extra charges and/or experiences throttling.
Data Packet	A unit of data that travels along an internet network. See jitter.
Device	For the purposes of this report, any type of internet-enabled computer technology used to access digital files, including but not limited to laptops, personal computers (PCs), tablets, and smartphones.
Download Speed	The speed at which an internet network retrieves information.
Filter	For the purposes of this report, an application applied to a district-provided device that enables schools to ensure students do not use the district-provided device to access inappropriate or non-school-related websites and applications.
Hacker	An individual who use computers to gain unauthorized access to information.
Home Setting	Students may participate in remote learning activities outside their official home address, including the homes of friends, relatives, or other family members. For the purpose of this report, "home" can refer to any residence in which the student logs into at least one remote learning activity, unless otherwise specified.
Jitter	A measurement in milliseconds of the variation in latency. High jitter has a negative impact on activities like participating in online meetings and streaming live videos. See Data Packet, Latency.
Latency	A measurement in milliseconds of the time it takes for a data packet to travel from a source to the destination and back. See Data Packet, Jitter.
Meeting (Online Meeting)	For the purposes of this study, an instance in which two or more users connect with one another in real-time synchronous audio and/or video via a web browser. Commonly used online meeting applications include Microsoft Teams, Google Meet, and Zoom.
Mbps	Acronym for "megabits per second" used in reference to download and upload speeds.

Term	Description
Modem	An object that connects a home network to the broader internet. The modem performs different functions than the router but may be provided to ISP customers in one box.
Pod	A group of students (typically 3-7) learning online together in a shared space. Pods are often supervised by adults such as parents/guardians or privately-hired tutors.
Processor (CPU)	A physical hardware component within a computing device that enables the device to interact with installed applications. Most computers consist of multiple processors in addition to the CPU. A higher-capacity processor is necessary for advanced student activities like computer-aided design (CAD) or video editing.
Quality of Service (QoS) Data	For the purposes of this study, QoS data refers to data specifically pulled from online meeting tools like Zoom, Google Meet, or Microsoft Teams that includes information about meeting session performance organized by participant (e.g., missing/dropped participants, jitter, latency, etc.).
Remote Learning	A learning setting in which student completion of learning activities (such as lectures, assignments, assessments, extracurricular activities, and more) takes place outside of the traditional in-person school environment.
Router	An object that allows all connected wired and wireless internet-enabled devices to access the internet by routing information to/from devices. The router performs different functions than the modem.
Synchronous Video	Online meeting platforms like Zoom, Google Meet, and Microsoft Teams that allow students and teachers to converse and collaborate in real time through audio, video, and screen sharing. See asynchronous video.
Throttling	The intentional slowing or limiting of an internet service by an ISP to reactively regulate bandwidth traffic, reduce congestion, and/or avoid overloading device processing capacity.
Throughput	Whereas bandwidth is the amount of data that can possibly travel through an internet network, throughput is how much data actually does travel through a network successfully. This can be limited by a ton of different things including latency, and what protocol you are using.
Upload Speed	The speed at which an internet network sends information.
Web Browser	A computer application used to access web-based applications and webpages. Commonly used browsers include Google Chrome, Mozilla Firefox,and Microsoft Edge. An internet connection is required for use.
WiFi	A technology used for access to the internet that does not require a physical wired connection to the device. Instead, the device receives radio waves carrying data packets.
Whitelist	The ability to provide permissions to an application for automatic access on a network filtering tool or other security application. The process of "whitelisting" allows an application to bypass filters or authentication tools to improve network performance.

Appendix B: Advisory Committee Members

Name	Title	Organization
Andrew Moore, MBA	Chief Information Officer	Boulder Valley School District (CO)
Christine Fox	Senior Director of External Relations	CoSN
Eileen Belastock, CETL	Director of Technology and Information	Nauset Public Schools (MA)
Jeremy Bunkley	Chief Technology Officer	Hillsborough County Public Schools (FL)
Julia Legg	State E-Rate Coordinator	West Virginia Department of Education (WV)
Keith Krueger	Chief Executive Officer	CoSN
Kellie Wilks, Ed.D.	Chief Technology Officer	Ector County ISD (TX)
Louis McDonald	Director, Technology Services	Fauquier County Public Schools (VA)
Mark Finstrom, CETL	Chief Technology Officer	Highline Public Schools (WA)
Mark Racine	Chief Information Officer	Boston Public Schools (MA)
Steve Buettner	Director of Media and Technology	Edina Public Schools (MN)
Tom Ryan, Ph.D.; Advisory Chair	Chief Information and Strategy Officer	Santa Fe Public Schools (NM)

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