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# K-12 Digital Infrastructure Brief: Adequate and Future Proof

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# Acknowledgments

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# Introduction & Overview

This is the first in a series of five briefs[1] published by the U.S. Department of Education Office of Educational Technology on the key considerations facing educational leaders as they work to build and sustain core digital infrastructure for learning. These briefs offer recommendations to complement the fundamental infrastructure considerations outlined in the 2017 update to *Building Technology Infrastructure for Learning*. They are meant to provoke conversations, challenge conventions, and deepen understanding. These briefs have been purposefully designed to be easily consumed and shared.

The needs, capabilities, and expectations of technology infrastructure vary significantly by context. A rural outdoor learning school in the mountainous American Southwest will face challenges and have needs much different than a district within an urban center along the East Coast with an all-digital curriculum. The recommendations within these briefs are meant to help build, augment, and sustain digital infrastructure supportive of learning no matter the location.

America has made incredible progress in closing the digital access divide,[2] providing an ever-greater proportion of students with access to broadband connectivity, devices, and digital resources. At the same time, we must acknowledge the last frontiers of connectivity can also present the most wicked problems[3] of closing that divide. To help readers build solutions for their own contexts, these briefs offer examples from the field of those who faced pernicious challenges to connectivity, accessibility, cybersecurity, data privacy, and other infrastructure issues and designed solutions for their challenges. More examples can also be found at tech.ed.gov/stories.

## Education Infrastructure is Critical Infrastructure

Education's digital infrastructure is officially considered critical infrastructure,[4] and just as we work to provide physical infrastructure that is safe, healthy, and supportive for all students, we need to align resources to create digital infrastructure that is safe, accessible, resilient, sustainable, and future-proof. Digital infrastructure includes "the resources that make digital

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[1] The inclusion of non-Federal resources in this document is not intended to reflect its importance, nor is it intended to endorse any views expressed, initiatives, or products or services offered. Any opinions expressed in these materials do not necessarily reflect the positions or policies of the U.S. Department of Education or the Federal government. The U.S. Department of Education does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

[2] https://www.gao.gov/blog/closing-digital-divide-millions-americans-without-broadband

[3] https://www.stonybrook.edu/commcms/wicked-problem/about/What-is-a-wicked-problem

[4] The Education Facilities Subsector (EFS) within Government Facilities Sector was established with ED identified as the corresponding Sector Specific Agency (SSA) in the 2006 National Infrastructure Protection Plan (NIPP). The designation of EFS as "critical infrastructure" and ED's role as the agency responsible for the EFS has been reaffirmed in the 2009 NIPP, 2013 NIPP, Presidential Policy Directive 21, and, most recently, in Section 9002 of the Fiscal Year 2021 National Defense Authorization Act (NDAA). The 2021 NDAA renamed SSAs as Sector Risk Management Agencies (SRMAs) and articulated specific SRMA responsibilities. https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/national-infrastructure-protection-plan-and-resources

systems possible and how individuals and organizations access and use these resources."[5] This considers the complex interplay of people, processes, and tools, including elements such as connectivity, security, interoperability, accessibility, affordability, and digital literacy as well as "behavioral, social, and physical barriers and opportunities for equitable adoption—who uses and does not use digital technologies and why."[6]

## What Are We Working Toward?

To understand this imperative, consider the following hypothetical scenario, outlining one of many possibilities when digital infrastructure is operating optimally.

### A Guiding Scenario[7]

*A middle school principal opens a pre-meeting of school personnel who are part of the multidisciplinary team for an upcoming Individualized Education Program (IEP) meeting to discuss any anticipated revisions and opportunities for additional services. The case manager starts by pulling up a school-wide dashboard showing trends in the school's academic, attendance, and wellness data and showing how the student's data aligns with schoolwide data.*

*As the team navigates the student profile—a dashboard with the student's picture, grades, attendance, interests, and IEP goals—a special educator points out that the student has made progress on math goals but has continued to struggle with reading comprehension.*

*The Speech Language Pathologist (SLP) proposes that the student be considered for assistive technology (AT) services, which would include an evaluation of the student to determine whether and what AT could aid in addressing current learning needs. The proposal would include the ability for staff to safely collect the data they need to monitor the intervention's effectiveness and securely share the data with other systems like the student profile the team is currently reviewing. The Assistant Principal (AP) notes that in order to ensure that the AT evaluation also addresses the district's cybersecurity and data privacy requirements, the process would need to include input from the district's IT personnel. The AP asks the SLP to proceed with exploring this option, coordinate with IT staff, and copy the AP on emails to ensure that the various departments-special education, procurement, and IT continue to coordinate.*

*One of the student's general education teachers at the meeting notes the student's family is part of the district's affordable connectivity partnership with local internet providers and volunteers to include as part of the AT service proposal, a series of virtual meetings with the student and their family to demonstrate how to use the technology at home. The teacher, seeing a note on the dashboard that one of the student's parents is*

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[5] Borrowing from the United States Agency for International Development's definition in their August 2022 Digital Ecosystem Framework: https://www.usaid.gov/sites/default/files/2022-05/Digital_Strategy_Digital_Ecosystem_Final.pdf

[6] https://www.usaid.gov/sites/default/files/2022-05/Digital_Strategy_Digital_Ecosystem_Final.pdf

[7] It is important to note that personally identifiable data, information, and the education records of a student with a disability must be protected consistent with the Family Educational Rights and Privacy Act (FERPA) and the confidentiality protections of the Individuals with Disabilities Education Act (IDEA).

*deaf, writes a reminder to re-familiarize himself with the contracted interpreter services and closed captioning function of the district's virtual conferencing platform. By taking these steps, the team ensures that the technology that best meets the student's needs also works with existing district tools and keeps the network secure prior to inclusion within the student's IEP.*

The scenario above demonstrates the safe, effective, and helpful use of technology in support of learning and highlights the interplay of tools and processes, as well as the individual and organizational capacity that enables the use of technology to support students. Such scenarios rely on the following key tenets of digital infrastructure, which also guide the organization of this resource:

1. **Digital infrastructure should be adequate and future-proof.** Connections, speeds, and devices should be designed to meet the needs of modern education with plans for financial sustainability. This infrastructure should also be scalable to meet future needs.
2. **Digital infrastructure should be defensible and resilient.** Cybersecurity risk presents both a management and technical challenge. Ensuring the safety of people, data, and systems requires continuously building capacity to mitigate and respond to current risks like ransomware, as well as evolving cyber threats.
3. **Digital infrastructure should be privacy-enhancing, interoperable, and useful.** By prioritizing privacy and ensuring data protection measures, schools build trust with stakeholders and maintain the confidentiality and integrity of sensitive student data. Embracing interoperability standards can enable the seamless exchange of data between systems, empowering educators to make informed decisions and personalize learning experiences. Adherence to interoperability and privacy standards should be required from any third-party vendor or developer considered for inclusion within that infrastructure. Furthermore, personal data connected with users should be portable, allowing authorized users to take it with them and share it within and between educational systems.
4. **Digital infrastructure should be accessible to individuals with disabilities and multilingual learners.** Schools must provide equal access to individuals with disabilities. Planning for accessibility at all stages of the technology lifecycle—procurement, implementation, training, and support—as well as ensuring alignment to key accessibility-related frameworks and guidelines helps ensure that a school's digital infrastructure is readily accessible to individuals with disabilities. Schools must also take reasonable steps to ensure meaningful access to their programs and activities to people with limited English proficiency, which may include the use of multilingual digital content.
5. **Digital infrastructure should enhance student digital health, safety, and citizenship skills.** Digital infrastructure should be designed to protect and improve the digital health, safety, and citizenship[8] skills of the people within that system, including

[8] Digital citizenship is appropriate, responsible behavior when using technology, including social media, websites, online forums, communities, comments, and apps and other device features.

the privacy of their data. The existence and expansion of all such infrastructure should include clear plans for how to educate the end users and custodians of those systems in building and maintaining digital health, safety, and citizenship skills.

## Whose Job Is It?

Building and maintaining safe, accessible, resilient, and effective digital infrastructure is a whole-of-community challenge requiring whole-of-community solutions. While every person has a role to play, the following groups play key roles:

- **District Leaders**: As organizational leaders, superintendents and senior district leaders play an important role in prioritizing secure digital infrastructure across the district and owning cyber risk management and digital accessibility at the executive leadership level. Put differently, if someone needs to announce a closure due to a cyberattack or answer questions from the board or press, it is likely to be the superintendent. To proactively address those risks, district leaders can focus the time, attention, and resources of students, staff, and leadership on practices that support secure, privacy-enhancing, accessible, and interoperable digital infrastructure.
- **District Technology Leaders**: As the primary implementers and maintainers of a district's digital infrastructure, chief technology officers and IT directors are often responsible for carrying out key aspects of mitigating cyber risk and supporting powerful teaching and learning for all students and staff. Technology leaders can create a culture of trust and security awareness by building processes for collaboration and coordination with students, staff, leadership, and outside experts. Technology leaders can also create the conditions for accessibility for all users by working closely with vendors during the design and procurement stages, and, when feasible, including individuals with disabilities in those processes.
- **Educators**: As the group tasked with facilitating high-quality teaching and learning to all students, educators (including general educators, special educators, related service providers, paraprofessionals, and others) often see the greatest possibilities and most frustrating constraints when it comes to digital infrastructure. As those often closest to the educational and social-emotional needs of students, educators seek out the most effective tools to meet their students' needs. They can have a powerful impact by practicing essential cyber hygiene and modeling it for students and families. By collaborating with IT/technology professionals to consider cybersecurity, data privacy, and accessibility when reviewing digital tools, educators can help to ensure all students have access to safe, secure, accessible, and powerful learning experiences.
- **Students and Families**: In partnership with schools and communities, families can collaborate with teachers and support secure access to digital infrastructure at home. Feedback from students and families can be an important way for schools to understand when tools or experiences are inaccessible, when data in progress reports are confusing, or when they feel unsafe in school or online. Students and families can also advocate that districts and vendors protect the privacy of students' data. For more on student

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citizenship skills can help prevent cyberbullying and its negative effects. When children learn positive online behaviors, social media can be used in productive ways. (source: [Digital Citizenship Skills | StopBullying.gov)](#)

data privacy and federal laws see *K-12 Digital Infrastructure Brief: Privacy-enhancing, Interoperable, and Useful*.

- **State Leaders**: State educational agency (SEA) leaders help support educational technology (edtech) infrastructure by modeling institutional best practices, developing thoughtful policy and guidance, and providing adequate resourcing to support policy implementation. For example, SEA staff may leverage the Office of EdTech's 2023 Dear Colleague Letter to help districts plan for and use their federal education funds to support digital equity, including hiring instructional coaches and providing professional learning for educators.
- **Vendors and Service Providers**: Vendors and service providers play an outsized role in the privacy, security, accessibility, and interoperability of K-12 digital infrastructure. The K-12 education sector's reliance on third-party providers includes costs and benefits. While each vendor and service provider adds supply chain risks that can be opaque and challenging to mitigate, these providers often provide services districts cannot support and maintain on their own, such as secure backups and cloud storage, as well as web templates, electronic portals, and applications. In addition, some vendors invest substantial resources in cybersecurity and data privacy (often more than a district could afford on its own). Finally, improvements in the security posture or digital accessibility of a vendor or service provider used widely in K-12 can benefit thousands of school districts, rather than needing to fix vulnerabilities or accessibility barriers district by district.

**And many more**: Within school districts, district and school staff interact regularly with sensitive student and staff data, while district leaders in special education, finance, human resources, operations, and curriculum play important roles in managing risk and ensuring accessibility. Educational service agencies (ESAs) often help build the capacity of thousands of school districts across the country, sometimes by managing a district's entire digital infrastructure. Federal partners like the U.S. Department of Education (ED),[9] Cybersecurity and Infrastructure Security Agency (CISA), Federal Bureau of Investigation (FBI), and others play a critical role in providing technical assistance, sharing intelligence and analysis, and investigating criminal cyber activity, while the Federal Communications Commission provides vital funding via the E-Rate program.

## Key Considerations

Key considerations within this brief include:

**Adequacy and Future-Proofing:** Digital infrastructure should be both adequate for current needs and future-proof to accommodate evolving technological advancements. Planning for modularity and replacement options is crucial to adapt to changing requirements.

**Connectivity Solutions:** School districts should explore various connectivity solutions to ensure reliable and high-speed broadband access. They should review available options,

[9] ED has limited authorities related to K-12 cybersecurity. The 2013 National Infrastructure Protection Plan (NIPP) and the FY21 National Defense Authorization Act (NDAA) designated ED as the Education Facilities Subsector (EFS) Sector Risk Management Agency (SRMA). Within current authorities, ED can provide technical assistance related to K-12 cybersecurity.

conduct landscape scans to stay updated with advancements, and learn from the experiences of other districts facing similar challenges.

**Digital Equity:** Achieving digital equity is essential for inclusive education. It involves addressing three components: availability, affordability, and adoption. Leaders should work toward making high-speed broadband service and technology tools universally available, ensuring long-term affordability, and providing support for adoption.

**Research and Education Networks (RENs):** Partnering with RENs can be a cost-effective solution for meeting broadband speed and connection needs. RENs collaborate with one another and with national networks to pool bandwidth demand and offer high-performance network services to schools and districts.

**Speed:** Planning for higher upload and download speeds is crucial to accommodate the increasing demands on educational networks. Build infrastructure that allows for expansion and capacity upgrades as technological developments allow.

**Financial Sustainability:** Long-term planning for scalability and financial sustainability is necessary for digital infrastructure. Developing a plan that considers the replacement cycle for devices and networking hardware helps future-proof the infrastructure and ensures educators and students can rely on it.

**Funding Sources:** Exploring ongoing federal funding sources, such as the E-Rate program, can help schools and libraries make telecommunications and information services more affordable. Being aware of available funding opportunities can assist in expanding broadband connectivity and implementing necessary infrastructure improvements.

# Digital Infrastructure Should Be Adequate and Future-Proof

Key digital infrastructure in education should be adequate and future-proof. Both terms represent a moving target. Many school districts would likely have described their infrastructure as adequate prior to the COVID-19 pandemic where devices and bandwidth were concerned. When schools and districts needed to transition within a matter of days to emergency remote learning, though, pain points became obvious. Before the pandemic, *adequate* may have meant providing students with devices and internet connectivity in the school building during the school day—with only some students online in some classrooms throughout the day—along with access to learning management systems (LMS) that some teachers used to facilitate information sharing. During the pandemic, *adequate* instantly meant each student needed their own device at home with connectivity and uninterrupted access to the LMS and dozens of edtech tools that made emergency remote learning possible.

As the pandemic subsided, many districts and schools found the increased demand on bandwidth and numbers of supported devices has not subsided. Even with students back in physical classrooms and interacting face-to-face with their peers and teachers, this new definition of adequate remains. Educators, students, families, and leaders have come to expect constant access, the ability to stream, and on-demand supports to meet their needs. Adequate is always changing.

As if this demand didn't present sufficient worries for those in the Chief Technology and Chief Information Officers' chairs, the future keeps coming. Bandwidth that appears more than sufficient to meet a district's daily needs for today's edtech tools, cloud storage, and communication will quickly become outdated when a district school board approves the purchase of a new suite of digital instructional resources that offers on-demand tutoring, cloud-hosted digital media creation tools, and generative artificial intelligence (AI) for lesson planning and student writing revision. What's more, once a district has solved for this new problem, the next improvement on learning supported by technology is already on the horizon. The future keeps coming.

This may present a dire and impossible outlook on the possibility of building digital infrastructure in education. The example meeting in our introduction can quickly feel like a fantasy world. Fortunately, there are some key considerations and questions about people, processes, and tools that can better prepare districts and their schools for the constantly shifting demands they face.

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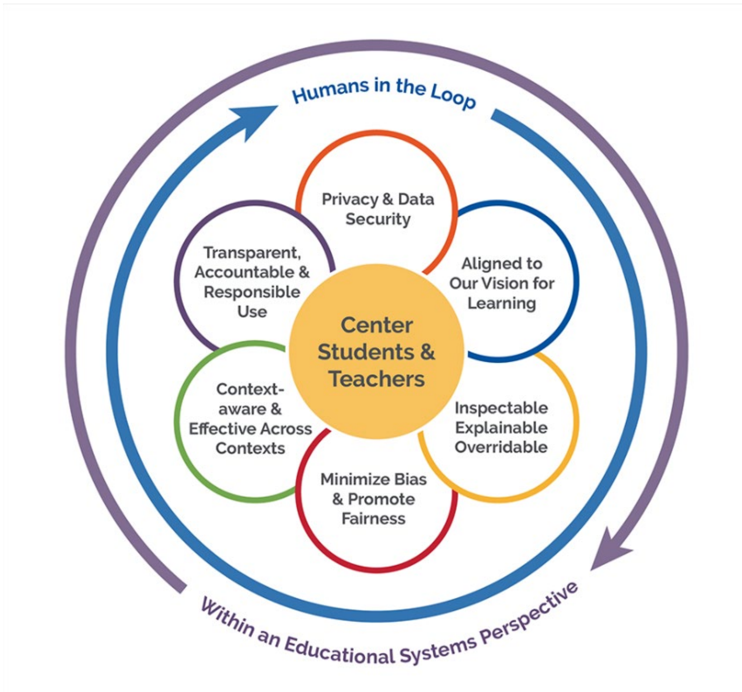
## Artificial Intelligence and the Future of Teaching and Learning

The U.S. Department of Education, Office of Educational Technology's May 2023 policy report, Artificial Intelligence and the Future of Teaching and Learning: Insights and Recommendations, addresses the clear need for sharing knowledge, engaging educators, and refining technology plans and policies for AI use in education. The report describes AI as a rapidly advancing set of technologies for recognizing patterns in data and automating actions, and guides educators in understanding what these emerging technologies can do to advance educational goals—while evaluating and limiting key risks. We envision a technology-enhanced future more like an electric bike and less like robot vacuums. On an electric bike, the human is fully aware and fully in control, but their burden is less, and their effort is multiplied by a complementary technological enhancement. For more on AI and the future of teaching and learning, visit tech.ed.gov/ai.




## Connections

As outlined in the 2017 edition of this guide, terrain, cost, usage rights, and a myriad of other obstacles have led to the need for a wide variety of connectivity solutions for districts. Even greater ingenuity has been required for those districts seeking to provide home connectivity to the communities they serve. Key guidance to those districts facing these challenges include the following:

- No matter what types of connectivity a school established, they should be sure to ask, "How can we expand upon or replace this hardware as technologies advance?" No matter what schools build, they should plan for modularity and replacement options.
- Set a plan for reviewing what is available. As speed and reliability are constantly improved, districts should set schedules for conducting landscape scans, so they do not miss these developments.
- While no one has solved a school's exact problem for their specific context, someone has come this way before. When looking for solutions to difficult connectivity issues such as providing internet access to mountain schools or across rural areas, look to those who have solved similar problems in their communities. Non-governmental organizations

like the Consortium for School Networking (CoSN), The State Education Technology Director's Association (SETDA), the Schools, Health, Libraries and Broadband Coalition (SHLB), and Education Superhighway are all examples of communities of networked professionals who have likely faced similar problems and are willing to share their learning. Similarly, the U.S. Department of Education's digital equity work highlights the trails to digital equity blazed by geographically remote communities across the country through publications like the September 2022 *Advancing Digital Equity for All* (more below), the July 2021 *Home Access Playbook*, and the June 2021 *Keeping Students Connected and Learning* wireless brief.

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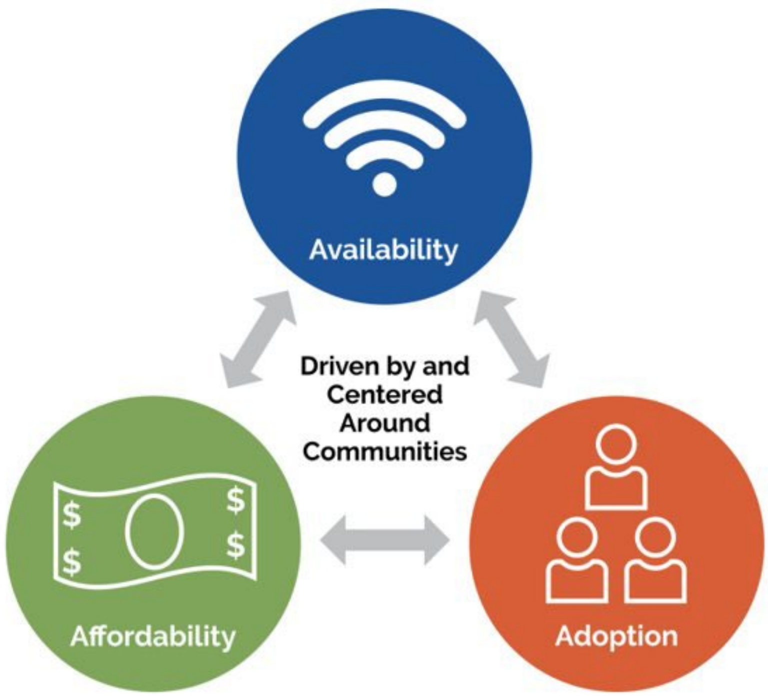
## Digital Equity and the DEER/DECAL Initiatives




**Digital equity** is the condition in which individuals and communities have the information technology capacity that is needed for full participation in the society and economy of the United States.[10] In 2022, OET committed to advancing digital equity through the Digital Equity Education Roundtables (DEER) initiative. Through DEER, OET hosted a series of national conversations with leaders from community-based organizations, as well as families/caregivers and learners furthest from digital opportunities. The *Advancing Digital Equity for All* guidance resource illuminates insights from these conversations to highlight the barriers faced by learner communities and promising solutions for increasing access to broadband and technology for learning.

[10] https://tech.ed.gov/deer/

Access to reliable, high-speed broadband and technology tools for learning is a multifaceted challenge. The broader challenge of access can be viewed through three distinct components—**availability, affordability, and adoption**. To advance digital equity, all three components must be addressed individually and in connection with one another. Learners, families/caregivers, and their communities need to have high-speed broadband service and technology tools for learning ubiquitously **available** to them, that service and those devices need to be **affordable** long-term (e.g., through the Affordable Connectivity Program), and information, technical support, and skill development opportunities must be accessible to ensure **adoption**. Building the necessary physical infrastructure, although a critical step, will not resolve the unique challenges faced by learners, families/caregivers, and communities. It is critical that leaders, in parallel, ensure access is sustainably affordable and provide adoption support.

## Research and Education Networks (RENs)

One way many districts meet their broadband speed and connection needs is by partnering with RENs. RENs are high-speed, fiber-based broadband networks borne out of the higher education sector and operated by nonprofit organizations or affiliated with state governments. Approximately 43 state- or regional-based networks interconnect with Internet2, a national REN backbone, and with one another. This interconnection creates a private broadband network for education and research purposes, which also interconnects or peers with the commercial internet. Forty-four states, through partnerships with institutions of higher education, the local REN, and other broadband partners (including state or commercial broadband providers), provide K-12 districts and schools access to the national Internet2 Research and Education Network ecosystem. Depending on the state or location of the school, RENs can provide fiber to the school district or school, work with the district to obtain fiber to the REN network, or work with other broadband providers, including commercial providers, to obtain terrestrial or wireless connectivity to their network.

RENs work with one another and with Internet2 as regional and national consortia partners to save money by pooling bandwidth demand across more users. RENs can provide a high-performance and cost-effective solution for normal usage and, in many cases, provide a flexible mechanism to manage school bandwidth, i.e., allowing schools to spike internet bandwidth for short periods, such as for assessments and software updates.

To find out if a REN is located nearby, go to https://k20.internet2.edu/get-connected. If a REN is available in a region, compare the speed and cost with those of other options.

In 2020, Utah's REN, known as Utah Education and Telehealth Network (UETN), used Coronavirus Aid, Relief, and Economic Security Act (CARES Act) funding to help school districts expand broadband access to students' homes via a private Long Term Evolution (LTE) network.[11] For example, Murray City School District (MCSD) extended the impact of its existing municipal fiber network by leveraging Citizen Broadband Radio Services (CBRS) technology[12] to bring a private LTE network to its students—first outside the school buildings, then to students in high-density housing, and finally to the broader student community. According to MCSD

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[11] https://www.fiercewireless.com/private-wireless/25-utah-schools-to-deploy-private-lte-using-cbrs
[12] https://uetn.org/network/cbrs/

Superintendent of Schools Jennifer Covington, "this really was our opportunity to look at how to build that [network] out so no matter where our students live, no matter what income category they fall into, or what their situation is they could open up their Chromebook and connect automatically to our district network. And so it really was about making sure all of our students had access to the tools that they needed for a high quality education no matter what their background."[13] Since all of the internet traffic comes back to the district network through a core gateway virtual machine (VM) set up by UETN, students access broadband safely and securely with the safeguards districts need to provide, such as content filtering.

## Speed

The shorthand when thinking about upload and download speeds for devices on educational networks is simple – plan for more. In the 2017 edition of this guide, we used the FCC definition of "adequate broadband speed": 25 Mbps down and 3 Mbps up. Just 4 years later in 2021, the Bipartisan Infrastructure Law set standards of 100/20,[14] and the U.S. Department of Agriculture's ReConnect Loan and Grant program sets goals of 100 Mbps symmetrical network capacity.[15] While these speeds may be currently unattainable in some of the most remote areas of the country, the rule for connection types applies to speeds as well – whatever you are able to build to move toward current adequacy, plan for the possibility of expanding capacity as technological developments allow.

Where available infrastructure limits a district's ability to sustain adequate speeds, people and processes become even more important in protecting available bandwidth on school networks. The decisions on how to regulate traffic on educational networks are context-specific and should include a wide range of representation to make certain decisions are informed, adequate, and defensible. The following questions can help to make decisions concerning how to allocate resources:

1. What are our district expectations of equity of bandwidth based on current network capacity?
2. Which sites or resources might be restricted (blocklisted) or slowed (throttled), and what are our processes and policies for making those determinations?
3. How do we communicate these decisions to our communities, and how do we create pathways for community members to communicate their needs?
4. What is our schedule for reconsidering and updating these policies?

Demands for bandwidth will only increase over time. Planning for the extensibility and moderation of district and school network resources will ensure adequacy and help make networks future-proof.

## Financially Sustainable

As with any physical components of infrastructure, planning and implementing digital infrastructure requires long-term planning for scalability and financial sustainability. Devices

[13] https://www.youtube.com/watch?v=aS9Z0TPWdJM
[14] https://www.uschamber.com/infrastructure/the-infrastructure-bill-has-65-billion-for-broadband-deployment-now-what
[15] https://www.usda.gov/reconnect

reach end-of-life; connections require hardware upgrades; and contracts for digital learning resources expire. While the refresh cycle for equipment will vary, the following timelines can be a helpful guide:

- Devices such as laptops, desktops, and tablets: 3-4-year replacement cycle
- Networking hardware such as switches and wireless access points: 5-year replacement cycle

Older devices and hardware tend to fail more frequently, add cybersecurity risk to the organization, and require more staff time to manage repairs. Having a plan for addressing current and potential future costs not only helps future-proof your infrastructure but ensures that educators and students can rely upon digital infrastructure and resources.

Actual network costs will vary widely from district to district based on local circumstances. The following technical factors will most likely have the greatest impact on the total cost of ownership:

- The number of devices and types of digital learning resources a network must support
- The capacity and age of existing physical infrastructure, including conduits, cables, and wireless access points
- The distance and geographic difficulty (terrain, weather) of connecting school buildings to the internet
- The available internet connection paths for joining a REN, leasing dark fiber, etc.
- The level and type of security measures needed

## Capital Expenditures vs. Operational Expenditures

Traditionally, infrastructure investments have been capital expenditures (CapEx)—money a school district spends buying, maintaining, or improving its fixed assets. Buying physical servers and maintaining them on premise is an example of CapEx. With the increasing adoption of cloud computing, some districts are transitioning to digital infrastructure as an operational expenditure (OpEx)—money a school district spends on an ongoing basis for a service. Contracting with a cloud service provider—such as Amazon Web Services, Google Cloud Platform, or Microsoft Azure—for computing or storage infrastructure as a service is an example of OpEx. For district leaders interested in learning about the pros and cons of purchasing digital infrastructure through CapEx and OpEx, CoSN's "Technology Budgets: Moving from Capital Expense (CapEx) to Operational Expense (OpEx)" can be a helpful resource.

Many schools underestimate human capital and ongoing network monitoring and maintenance as cost drivers. Human capital costs include the time, personnel, sustained professional development, and expertise to manage the network and provide technical support for teachers, staff, and students. Staff can also include consultants or third-party vendors that assist with technology planning, configuration, testing, and maintenance. When calculating a network's total cost of ownership, schools and districts should be sure they are comparing like services.

Ongoing network monitoring and maintenance costs can include:

- Network management and monitoring
- User help desk/technical support

- Device and equipment maintenance and upgrades
- Device insurance and service contracts
- Internet bandwidth
- Administrative software and digital learning resources
- Content filtering
- Network security
- Network redundancy

The demand for network speed and capacity will continue to increase over time. Scalability is critical. Build a network that can be improved rather than one that will require replacement as demands change. When entering a long-term contract, consider the network's maximum speed, the maximum number of devices that can be accommodated, and future internet bandwidth needs.

## Ongoing Federal Funding Sources: E-Rate Funding for Internet Connectivity

The E-Rate program makes telecommunications and information services more affordable for schools and libraries. Mandated by Congress in 1996 and implemented by the FCC in 1997, the E-Rate program provides eligible schools and libraries with discounted telecommunications, telecommunications services, internet access, and internal connections. The Universal Services Administrative Company (USAC) manages the program.

In 2014, the FCC modernized the E-Rate program, transitioning support away from legacy telecommunications technologies to advanced broadband connectivity and increasing the annual funding cap from $2.4 billion to $3.9 billion. Public, charter, and private schools are eligible to apply for E-Rate funds if they do not operate as a for-profit business or have endowments exceeding $50 million. E-Rate is one of the largest sustainable funding resources available for schools expanding upon broadband and high-speed wireless connectivity in classrooms.

The FCC adopted the following goals as part of its modernization efforts:

- Ensuring affordable access to high-speed broadband sufficient to support digital learning in schools and robust connectivity for all libraries.
- Maximizing the cost-effectiveness of spending for E-Rate supported purchases.
- Making the E-Rate application process and other E-Rate processes fast, simple, and efficient.[16]

To learn more about the E-Rate program, visit the USAC website at https://www.usac.org/sl/. School and district leaders should stay abreast of potential future changes to the E-Rate program to determine how they may impact technology initiatives.

## One-time Federal Funding Sources: ESSER and GEER

ED's Office of Elementary and Secondary Education (OESE) has clarified allowable uses of Elementary and Secondary School Emergency Relief (ESSER) and Governor's Emergency

[16] "Summary of the E-Rate Modernization Order." Federal Communications Commission, 08 Oct. 2015. Web. https://www.fcc.gov/general/summary-e-rate-modernization-order.

Education Relief (GEER) funds in the ESSER and GEER FAQs (first posted in May 2021, and then updated in December 2022). Allowable uses related to digital infrastructure include:

- Improving technology infrastructure and operations: "An LEA [local educational agency] may use ESSER and GEER funds for activities that support distance education and promote long-term improvements in technology infrastructure and operations and their effective use. These activities might include providing online learning to all students, including students with disabilities, English learners, students experiencing homelessness, and students in foster care; and training educators in the effective implementation of online learning."[17]
- Improving cybersecurity: "If a school, LEA, or State is improving cybersecurity to better meet educational and other needs of students related to preventing, preparing for, or responding to COVID-19, it may use ESSER or GEER funds. For example, if an LEA needs to increase its use of technology, such as for potential temporary shifts to hybrid learning if COVID-19 cases arise, expanded cybersecurity needs to facilitate that activity may also be addressed using ESSER or GEER funds."[18]

At the time of publication, districts and states still have time to "obligate" ESSER II, ESSER III (or American Rescue Plan ESSER), and GEER II funds. The deadline to obligate the second round of funds, ESSER II and GEER II, is September 2023, and the deadline to obligate the third round of funds, ESSER III, is September 2024.[19] For more information on deadlines, announcements, promising practices, and award resources related to ESSER and GEER, visit OESE's State and Grantee Relations website.

## Special Considerations for Rural Areas

Rural areas often have unique challenges to getting high-speed internet to their schools. Geographic barriers such as mountainous terrain, dense forests, or swampland can make it difficult to bring wired connectivity to rural communities. Remote locations with low population densities may have difficulty attracting internet providers, and cellular 4g connections are often spotty or non-existent. These challenges can lead to schools in rural areas paying significantly higher prices per megabyte than suburban and urban schools.[20] Despite these difficulties, rural districts are succeeding in developing innovative approaches to providing teachers and students with the connectivity they need within and beyond schools.

Many communities have succeeded in creating low-cost fiber systems that benefit schools, local government, businesses, and residents. These involve partnering with municipal governments to engage in community-wide rollout of increased broadband access in schools, libraries, government buildings, and other public places. While these efforts can require years of coordination and planning, the costs are often offset for school districts and other stakeholders by lower bandwidth costs when the networks go online. Collaborating with municipal governments can reduce the cost of establishing and maintaining broadband connections to

[17] https://oese.ed.gov/files/2022/12/ESSER-and-GEER-Use-of-Funds-FAQs-December-7-2022-Update-1.pdf
[18] https://oese.ed.gov/files/2022/12/ESSER-and-GEER-Use-of-Funds-FAQs-December-7-2022-Update-1.pdf
[19] https://oese.ed.gov/files/2022/12/ESSER-and-GEER-Use-of-Funds-FAQs-December-7-2022-Update-1.pdf
[20] Consortium for School Networking (CoSN). 2016 Annual Infrastructure Survey. 2016. Web. http://cosn.org/sites/default/files/CoSN_4th_Annual_Survey_Oct16_PROOF5.pdf

schools and districts by sharing the cost over a wider number of users and expanding the potential federal, state, and local funding streams.

## Municipal Broadband Networks: Broadband for Block Island

In April 2023, BroadbandBI on Block Island became the first municipal broadband network in Rhode Island.[21] While it may be a small island with a very small school district, Block Island had some innovative approaches that other districts might find instructive. Building on the fiber included in the Block Island wind turbine project and a 2019 project to connect the island's Community Anchor Institutions such as the school, medical center, and library, the town is pulling fiber to every home on the island. The internet service is provided by OSHEAN, Rhode Island's REN, including a backup wireless point-to-point connection to the mainland. Since the utility poles are co-owned by the incumbent phone provider (Verizon) and the Block Island Utility District, the direct involvement of the Utility District facilitated a much faster (and likely less costly) make-ready process. To fund the project, the town is borrowing $8 million, which it plans to recover through a tax on all properties and monthly fees paid by broadband subscribers.[22]

Several governmental and nonprofit organizations have developed resources to assist rural communities with broadband development. The National Telecommunications and Information Administration (NTIA), part of the U.S. Department of Commerce, developed the BroadbandUSA website to provide resources to communities that want to expand broadband capacity and promote broadband adoption. This includes an annually updated federal funding guide, which outlines the range of programs available across the federal government that can support planning, broadband infrastructure deployment, and digital inclusion efforts. The Appalachian Regional Commission created a Broadband Planning Primer and Toolkit that describes how other rural communities have tackled their high-speed broadband challenges and outlines a Broadband Planning Roadmap. Next Century Cities and the SHLB have also developed toolkits and whitepapers to assist communities with broadband deployment and adoption.

California provides some inspiring examples of leveraging federal, state, local, and tribal resources to build ecosystems that support tribal sovereignty through digital equity. For example, the Lone Pine Paiute-Shoshone Reservation (LPPSR) is using a $1.86 million grant from NTIA to expand broadband access to the entire reservation through a combination of "fiber and fixed wireless networks to connect unserved Tribal households, Tribal businesses, and Tribal anchor institutions."[23] In partnership with Native-run industry and non-profits including MuralNet and NumuNetworks, as well as allied organizations like Geeks without Frontiers, LPPSR will design, build, and implement a sustainable tribal broadband network. In an example of state, regional, and tribal collaboration, the California Department of Technology, California's REN (CENIC), ESAs, and tribes are braiding funding from the Bipartisan Infrastructure Law (BIL) and a 2021 state broadband law to provide Indian Country, rural populations, and underserved urban communities with public middle-mile infrastructure via the

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[21] https://www.blockislandtimes.com/news/broadband-ready-to-go-in-first-service-area/article_40e18706-dafe-11ed-9406-33880d185c1a.html

[22] https://ilsr.org/block-island-to-build-rhode-islands-first-city-owned-citywide-fiber-network/

[23] https://www.easternsierranow.com/73-million-awarded-to-tribes-for-high-speed-internet-access-lone-pine-paiute-shoshone-granted-1-86-million/

California Middle Mile Broadband Initiative.[24] Since 2021, CENIC has administered a Broadband Infrastructure Grant for K-12 that has helped to bring fiber-based solutions to 51 sites across 13 counties that had previously lacked access to broadband.

## A Note on the Future

The COVID-19 pandemic was, in many ways, the ultimate stress test of education's digital infrastructure. With no lead time, districts and schools across the nation and the world were asked to extend access to connectivity, devices, and digital learning resources more broadly and more quickly than many systems had ever planned. Even for those systems with robust infrastructure, getting access to all educators and students as well as all the support they needed was beyond what many had imagined possible.

With the pandemic's subsidence, these districts and schools are thinking through the many lessons learned. Chief among them is that the future – immediate or distant – will require digital infrastructure to be extensible. Whether your district is solving the problem of connectivity in some of the nation's most remote rural schools or getting home access to students living in high-rise apartments with antiquated wiring, solving those most pressing problems will not mean the work of providing adequate digital infrastructure is complete. The future will keep coming, and with it will be greater demands for bandwidth, devices, and digital learning resources.

We can meet these demands. Any decisions about digital educational infrastructure must include the question, "And how might we extend this as demand increases?" Districts and schools that are planning for the extensibility of their digital infrastructure are doing the work of making that infrastructure not just adequate, but future-proof as well.

[24] https://cenic.org/initiatives/broadband-for-california-tribes