Educational Technology Infrastructure

By Dan Grigoletti and Derek George
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Abstract

Educational institutions today are faced with many challenges in establishing, developing and maintaining technology infrastructure within their organizations in support of student learning. As educational organizations have great responsibility in educating all levels of student for future occupations and academic careers, foundational technologies need to be examined and researched to find ways to improve upon them and to find solutions to issues such as data privacy and security, bring your own device (BYOD), educational technology policy, and many other areas. Fundamental to public, private, K-12 higher education, and corporate training and development is producing effective and sustainable educational technology infrastructures. There is a need for a thorough understanding of the major issues, factors, and variables that influence educational stakeholders to use and/or implement technology for maintaining and sustaining services to educators and learners. The U.S. Department of Education (USDOE), and their technology arm (USDOE EdTech) has published a multi-faceted, practical framework for examining tools, technologies, policies, resources and solutions to challenges facing educational organizations. This paper seeks to identify and expose the issues and propose solutions available for building and maintaining effective educational technology infrastructures. The elements involved in an educational technology infrastructure system are complex, interrelated and interdependent. By starting with the established framework from the USDOE, a roadmap can be drafted and followed to address each of the areas. It is imperative that the stakeholders in educational technology be provided with thorough information in order to design new systems and find solutions and applications of technology to serve as the modern digital infrastructure for educational systems. By doing so, our educators will have a sound, reliable and sustainable foundation to build new pedagogical, teaching and learning processes. In addition, by addressing the leadership challenges and finding better ways for educational leadership to make decisions about EdTech infrastructure, the programs and processes can be made more effective in terms of the ROI to educators, students and the public.

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Overview

We will discuss applications of infrastructure technology which can be applied to either primary, secondary and/or tertiary educational institutions. Some of the key infrastructure topics which will be discussed include:

- Data Privacy & Security
- High-Quality/Low-Cost Devices
- Maintaining the quality of digital content.
- High-Speed Connectivity (including Internet, Mobile and WiFi)
- Digital Citizenship & Responsible Use

We will discuss these in the context of what's best for teaching and learning, emerging research, and current literature related to infrastructure designs, development and implementations, as well as assessment of effectiveness of this educational technology.

In addition, we will explain and examine the components, usage, current issues and future considerations of infrastructure for educational technology, focusing on the framework which the U.S. Department of Education provides, outlining the tools and technology available for building effective educational technology infrastructures systems. Topics within the subject of infrastructure will apply to primary, secondary and tertiary educational institutions, and include high-speed connectivity (including Internet, mobile and WiFi), data privacy & security, high-quality/low-cost devices, digital citizenship & responsible use, and maintaining the quality of digital content. We will present this in the context of what's best for teaching and learning, including current literature related to infrastructure designs, development and implementations, as well as assessment of effectiveness of this educational technology.

We examined the resources that a university or K-12 school district provides on sight, but also identified issues of offsite resources, which may or may not be considered part of the core infrastructure within an educational environment. One of the areas that we find infrastructure components like network access (Internet), hardware and software is especially acute, is when we examined the digital divide. Many students face challenges utilizing technology at home because of their socioeconomic standing. The lack of Internet access or equipment at home to adequately provide the tools needed to complete homework assignments, affects many student's successes in the classroom. This could happen in K-12 environments, but also may be involved with college students who commute to universities or community colleges and may not have adequate resources to compete with students that have equipment at home. For example, if a student doesn't have Internet access, they may be challenged at completing computer-based homework, unable to be responsive to discussion threads, and at a disadvantage when working on group collaborative assignments through email and other asynchronous communication methods. Or, they simply may have to use the campus computers to complete work, taking them away from home responsibilities (The Homework Gap, 2017).

We have discovered that there is a trend toward cloud based infrastructure. In examining the various technologies, we find that cloud computing is really the virtualization of infrastructure, essentially data centers connected via the Internet. This new model enables educational institutions and educators to access Internet-based computer and data resources which are available on demand. This shift benefits schools because they save on infrastructure costs of servers, enabling the school to focus even more on educating students instead of being bogged down with infrastructure concerns. The schools can also take advantage of the scalability of resources per their needs (Infrastructure, 2017).

There are many issues that arise with regard to data privacy and computer security in educational environments. For example, there may be gaps in security training of teachers and staff between the optimal understanding of security threats and the appropriate skills needed to establish and enforce good security policy. The issue of preventing identity theft and abuse must be addressed to ensure identity protection of students when using internal or external computer resources. Mobile computing using various devices on premise or off can also provide a security risk if the devices are used on open networks, or if the devices is lost or stolen while containing personal and confidential information. Since students are extremely involved in social networks, the risk of personal and private information being recorded, stolen or abused is high. Students may not use appropriate security mechanisms when using informal and casual social media sites. There are also concerns that when using computing devices over networks that are not locked down to prevent inadvertent download of malware, especially when devices are removed from the premises and operate on open networks. There are many vulnerabilities that hackers can take advantage of either on wired or wireless networks. In addition, opportunistic individuals can take advantage of younger and less experienced students through deception in the form of social engineering. And, of course, as with users in any environment, there may not be enforcement in educational environments of the use of adequately strong passwords. One possible solution is to use Chromebooks, which are highly secure, reducing computer security expenditures on such things as virus protection. They enables higher compliance on privacy and offering IT departments in schools many advantages.

High Speed Connectivity

Central to educational technology infrastructure's effectiveness is high speed Internet connectivity. Primary and secondary schools, in order to leverage the power of the Internet for extending content and facilitating learning, need access to high-speed Internet. The manifestation of high-speed Internet comes in the form of broadband technologies (as opposed to baseband) which include internal networks running Ethernet technologies, and other wireless technologies such as cable modems, DSL and mobile/cell networks. Broadband is a crucial component necessary in educational environments. Data service in the form of broadband technology is essentially a new utility, joining water, HVAC, power, and gas infrastructures (all having a "network" of pipes, wires, etc. for delivery) as the new networked resource needed not only in business but in public and private sector organizations, including schools. The same tools and resources that have transformed our personal, civic and professional lives must be part of learning experiences within educational settings, intended to prepare today's students for college and careers (The Broadband Imperative, 2017).

We are in the midst of the information and telecommunications revolution (c. 1985-present), joining the revolutions the world has undergone historically such as from 1600–1740 (agricultural revolution), 1780–1840 (the industrial revolution), 1870–1920 (the 2nd industrial revolution, or technical revolution), 1940–1970 (the scientific-technical revolution) (Technological Revolution, 2017). Therefore, by definition, fundamental changes in the organizational structures (data communications) is taking place in a relatively short period of time, and is affecting all aspects of modern society.

The table below identifies the State Educational Technology Directors Association's (SETDA) recommendation for Internet connection speeds between the ISP (Internet Service Provider), educators and students within school districts and among schools within a particular district. (Fox, 2012). Internet connectivity supporting communications in educational institutions has been one of the missions of the SETDA organization.

Broadband Access for Teaching, Learning and School Operations	2014-15 School Year Target	2017-18 School Year Target
An external Internet connection to the Internet Service Provider (ISP)	At least 100 Mbps per 1,000 students/staff	At least 1 Gbps per 1,000 students/staff
Internal wide area network (WAN) connections from the district to each school and among schools within the district	At least 1 Gbps per 1,000 students/staff	At least 10 Gbps per 1,000 students/staff

There are many resources and organizations that attempt to establish standards and policies for educational technology, including SETDA. Another objective of SETDA is to help train and develop individuals for leadership roles in order to design, develop and implement better educational technology in our schools.

As a not-for-profit membership association, SETDA has established a number of priorities for 2017-2020. The key priorities of SETDA are 1) Advocacy for educational technology policies and practices; 2) Assisting states to take action on improving overall educational technology; 3) Forming strategic partnerships with various organizations in order to improve educational technology; 4) Providing EdTech PD opportunities for the membership; 5) Maintaining open communications among the stakeholders in educational technology; and 6) Serving as a resource for planning and making policy on operational issues in educational technology. Their focus is to improve educational technology for teaching, learning, and school operations.

SETDA members seek to build and increase the capacity of state and national leaders to improve education through technology policy and practice. In carrying out this mission, SETDA is committed to serving the states and territories within the US. They have set out to maintain a future-focused, holistic view on how to leverage technology for education, and foster collaborative, strategic partnerships with education leaders and policymakers throughout the country. As a 3rd party organization, SETDA members are making efforts to address and solve complex issues facing public educational systems in the US (SETDA, 2017).

The eRate program (also called the universal service Schools and Libraries Program) from the USDOE is a leading resource to bring Internet-based educational technology infrastructure into US schools. The USDOE's Office of Nonpublic Education offers assistance in the form of funding to school systems and provides significant discounts to assist eligible schools and libraries in the US to obtain affordable telecommunications technology. They also partner with leading telecommunication firms such as AT&T to help school districts develop and their educational technology infrastructures.

The table below outlines some of the data provided in the FCC 470: 2017 database for eRate engagement of school districts, by state.

STATE	**NUMBER OF SCHOOL DISTRICTS ENROLLED**
FL	288
AK	40
NY	526
TX	945
MI	372

Additional categories of education technology infrastructure support are logged in the FCC 470 database as follows:

1. Basic Maintenance of Internal Connections
2. Internal Connections
3. Internet Access and/or telecommunications
4. Managed Internal Broadband Services

Another USDOE partner, which is assisting with addressing deficits in the US school systems regarding educational technology, is the Universal Service Administrative Company. (USAC), a non-profit corporation which the FCC has designated to administer the $10 billion Universal Service Fund, collecting and delivering funding to schools for broadband and connectivity needs.

Data Privacy & Security

The proliferation of educational multimedia content, especially video, in education, has amplified the need for high capacity storage systems. It is becoming increasingly critical for educational institutions to focus on improving security and privacy. These are prime concerns because the amount of data being generated opens up more points of vulnerability to hacking and discovery by users with malicious intent. Security in educational environments is especially sensitive because of the nature of the data which may refer to minors in K-12, for example, and the regulations on educational data usage and dissemination such as outlined in FERPA. Hardware and software have been the traditional costs for computing resources, but now we find data being a most valuable component of systems in education. Data, if exposed, could be gerous in the wrong hands, from student grade records, scholarship records, employee payroll records and benefits data, educational curriculum and assessment data, to records of graduations, degrees and enrollments.

If sensitive data were compromised or lost in educational environments, for example, the data provided as responses to surveys, forms that are filled out when registering for free software or services, information gleaned from social networks, bots, search terms, usage data, location data, and many others can form a profile of a student, which can then be used in malicious ways to target them. This could be simply nuisance type of invasiveness (as with spam), or truly harmful as with a stalking situation or targeting gullible students with phishing scams. Private data in many forms (student records and financial information such as credit card numbers) needs to be stored and secured in closed (proprietary) systems behind network firewalls to protect it. In addition, much of the subject matter and content, in the form of lectures and lessons (such as the LMS contents) may be stored in the cloud as proprietary data, and if hacked, the results could be catastrophic. However, if a school pays for an LMS service like Blackboard, the security and protection onus is on the corporation. Furthermore, since university and community college systems and K-12 school districts have large centralized data storage, they may become targets for hackers. The theft of data itself may be more lucrative to hackers than the computer systems and networks at brick-and-mortar, on-ground educational institutions. (NCES 98-297, 2017).

Data security involves the technical and physical requirements that protect against unauthorized entry into a data system and helps maintain the integrity of data. Data privacy is about data confidentiality and the rights of the individual whom the data involve, how the data are used and with whom data can legally be shared (SREB, 2017).

Schools need to follow the FERPA (Family Educational Rights and Privacy Act), which provides guidance to school systems to protect student privacy in educational environments. This includes the use of a variety of records stored electronically through software and accessible using stationary and mobile computing devices that access the Internet. Schools, in order to comply with FERPA, must have high levels of security policies and practices in place to protect students and other stakeholders (parents, teachers, administrator). The security infrastructure in which educational technology exists is evolving, utilizing IT resources to keep administrative records, and systems such as LMS with user authentication and password controls in place. There are many categories of information that require different levels of security to access and protect. High degrees of security are necessary for personal data. Usually, for best security, multiple layers of security are employed such as physical security, backups, encryption, multi-site storage, network authentication and others.

One of the primary concerns and biggest challenges for K-12 and Higher Education schools is student safety in all forms. Security and safety go hand in hand, from physical security to data security. Since technology permeates all aspects education, the ISTE has made both ensuring security and enabling productivity in educational environments a key concern.

Many institutions utilize open systems to store and share content. There is much debate whether or not open-source (Such as Linux, Google Chrome, and the is better than closed-source (such as Microsoft Windows and other Microsoft applications). For example, the open nature of the Internet, with more sharing of identities through social media sites complicates matters, where hackers may be able to learn ancillary information about students through data mining and reading feeds from social media sources.

Essentially, educators need to learn best practices for protecting their privacy and data through resources that are available from online sources. We should make it a priority to protect confidential student records. A close adherence to the regulations in FERPA, and maintaining compliance with COPPA will go a long way to ensuring a safer educational environment, which can also contribute to unimpeded learning. (Protecting Your Students' Data and Privacy, 2017).

High Speed and WiFi Throughout Schools

On its Education Technology website, the USDOE providers several case studies that exemplify how high speed internet and WiFi infrastructure have been brought to and throughout school districts. Appearing below are three (3) particularly compelling examples that show examples of successful implementations of high speed infrastructure and Wifi being being built out throughout schools. Both of the districts had predominantly low income populations in geographically disparate areas without an existing high speed Internet infrastructure.

Case #1: Starting in 2009-10 Oklahoma’s Choctaw Native American Tribe partnered with the Pine Telephone service provider applying for and winning $56 million in American Reinvestment and Recovery grants. The money (part of a public, private collaborative effort paid for the successful installation high speed internet infrastructure that connected 10 unserved Choctaw communities. This is a significant demonstration of the tremendous value of Technology infrastructure to a community that was not just underserved but not served at all. The case study reports that, "Prior to this investment, the Choctaw Nation Tribal Area lacked access to reliable broadband service. The low population density (8.3 to 19.7 people per square mile), the high poverty rate (25 percent of the population below the poverty line), and the rugged terrain made the economics of broadband infrastructure very challenging. Initial capital costs to deploy broadband meant that broadband service was limited to commercially viable areas." Inside the Choctaw nation, the Broken Bow School District has managed to bring its local internet infrastructure to the point where it can deliver a deliver robust IDT education to it students. The Broken Bow Distract, " has been able to use digital devices, online lesson plans, and supplemental online programming." Infrastructure (n.d.). Retrieved May 01, 2017, from https://tech.ed.gov/netp/infrastructure/

Case #2: Since 2013 in San Antonio, Texas "BibloTech", an all-digital public library which is accredited as a state library has been making significant inroads to provide access to educational content for underserved communities leveraging the mobility and drastically reduced physical space requirements associated with a library connected to the internet with a sufficient internet infrastructure connection. The case study does not go into any technical detail about which form of connectivity allows the "BiblioTech" to function as it does but it instead it references the fact that since, "BiblioTech branches require only 2,100 square feet of space, the library is able to co-locate within local public housing developments to put resources and connectivity within reach of patrons who might otherwise be cut off from its collections." Infrastructure (n.d.). Retrieved May 01, 2017, from https://tech.ed.gov/netp/infrastructure/

Case #3: The Coachella Valley, Unified School District, California, K-12. had a similar problem in that there was no provision for high-speed wide area

Internet access for students who were part of the 1:1 device distribution plan originated by the school district. The solution was to outfit the district's school bus fleet with wifi routers and park them in areas around the community so as to create a mobile network overnight allowing students who could not normally connect to the internet at home the opportunity to do so. This case study is significant because the unusual yet technologically sound concept of creating a model Wide Area network has resulted in the school district going on to develop, “a long-term plan for the district to become its own Internet service provider, breaking its dependence on commercial telecom companies.” This is the sort of novel thinking that both provides for the immediate provision of high-speed internet access both at school and at home and is forward thinking enough to make management of the expense associated with maintaining the infrastructure as inexpensive as possible which is essential for institutions with tight budgets such as most public schools. Infrastructure (n.d.). Retrieved May 01, 2017, from https://tech.ed.gov/netp/infrastructure/

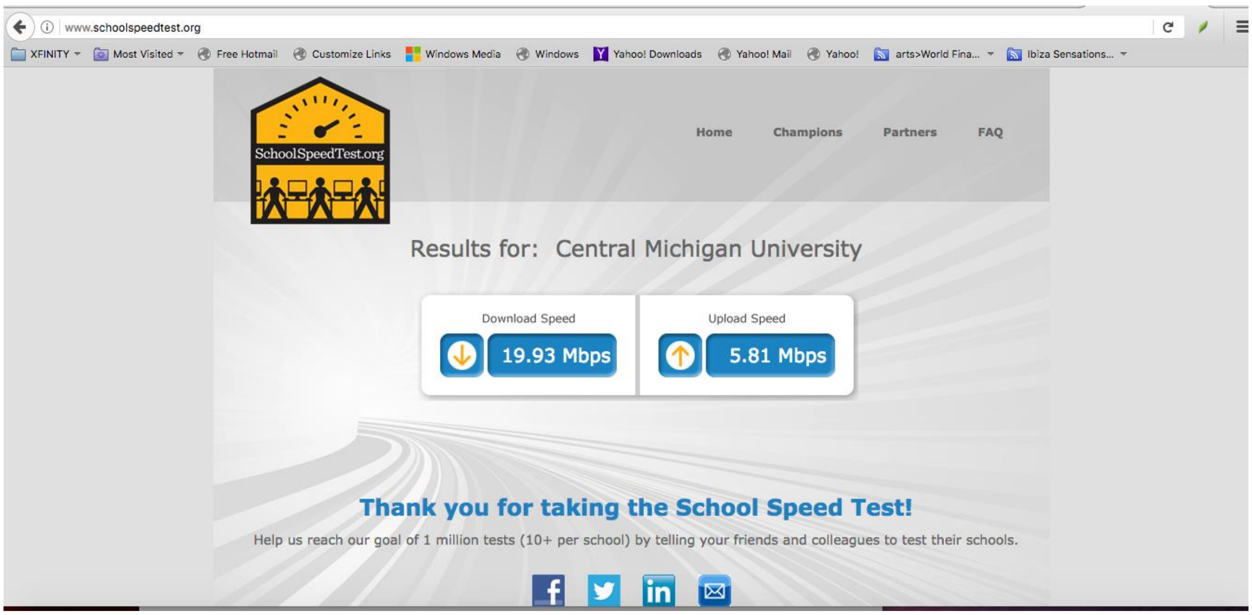
Another useful resource that can be utilized to measure educational technology in K-12 is the USDOE’s School Speed Test website. It provides an interesting tool by which reports revealing information in the effort to assess the adequacy (speed) of the Internet connection serving a given school.

Results can vary depending on the the time of day, the location from which the test is conducted and the other variables but interesting differences come to light after conducting tests for just a handful of for Schools. Here are some test results:

School Name	**Location**	**Type**	**Results**
Brooklyn Tech High School	Brooklyn, NY	H.S	7.24 D; 5.5 U
New York University	New York, NY	University	53.72 D; 9.19 U*
Central Michigan University	Mt. Pleasant, MI	University	19.93 D; 5.8 U
Duke University	Durham, NC	University	85.13 D; 10.04 U*
CC Spaulding Elementary	Durham, NC	K12	13.17 D; 6.94 U
M.I.T	Cambridge, MA	University	22.02 D; 4.8 U

Spelman College	Atlanta, GA	University	7.96 D; 5.07 U

The table below can be analyzed in many ways. It is presented here in an effort to illustrate the differences in download speeds that exist between public k-12 schools in Brooklyn, New York and Durham, North Carolina (Brooklyn Tech and CC Spaulding) and between CC Spaulding and Duke University (within 30 minutes of each other in Durham,North Carolina) and between MIT in Cambridge, MA and Spelman College In Atlanta, GA (A University with an international reputation as a leading engineering research facility versus a school with more modest reputation) THis tables makes clear the vast differences which exist in the type of technology infrastructure which supports schools and the communities they are situated in.



High-Quality, Low-Cost Devices

As an infrastructure technology, devices to access resources on the Internet including technical, social and educational communities can be leveraged by educational stakeholders. An example of a browser based laptop is the Chromebook, which runs Chrome OS rather than Windows or OSX, and takes advantage of the client-server model of program execution, accessing applications running on servers located on the Internet. In addition, there is a steady stream of new mobile devices entering our educational organizations. The BYOD (Bring Your Own Device) movement that has infiltrated corporate environments, is now prominent in educational institutions. We can leverage the BYOD movement with cloud applications that are browser based, therefore do not require homogenous devices to run. However, BYOD poses a management challenge in that Mobile Device Management (MDM) requires additional IT resources, hence expense.

The Google Chrome based devices (Chromebooks) can be used for student learning and teacher productivity through using Internet-based apps such as G-Suite from Google. They are cost-effective for economically challenged educational environments that need solutions to provide students to access Internet-based curriculum and online coursework. Chrome OS is free, provided by Google, so the cost factor for educational software is lowered for schools adopting this technology. Also, the hardware itself is low cost and is optimized for Internet access, efficiently taking advantage of the Cloud-based applications. Chromebooks are highly secure offering a great advantage to educational institutions, reducing computer security expenditures on such things as virus protection, enabling higher compliance on privacy and offering IT departments in many advantages: "The devices are stateless, so any updates needed come from the cloud. It takes all that stress and time away from the IT staff" (Parallels, 2017). However, one disadvantage of Chromebooks is that they rely on constant Internet connectivity, but some applications can be used offline, with the data being synchronized when the system becomes re-connected.

Chromebooks can be important as an infrastructure component for schools. The nature of a Chromebook is as a "client" as opposed to "server," which fits Chromebooks into the client-server computing model. The client model enables accessibility to the Internet by students and teachers (O'Donnell & Perry, 2013). The infrastructure of Chromebooks along with WiFi networks with Internet access in schools provides connectedness which lays the groundwork to support ISTE standard, enabling educators and students far-reaching access to applications and data for creative use. ChromeBooks, as a platform, may increase student-to-student and student-to-teacher communication and collaboration through wider access to connectivity and community building activities. Chromebooks can also enable educators another option for conducting research and information fluency through access of online libraries and databases. As a low-cost option for equipping students with computers, Chromebooks are appealing, but not the only solution. Windows computers are also available in low-cost implementations since they utilize similar hardware, and may be referred to as Netbooks.

Teachers and educational institutions can benefit greatly from Chromebooks since the costs are low and they are easy to use. Teachers and schools are adopting Chromebooks at a high rate, since they are easy to use, fast, and are less complex than Windows-based computers. (Parallels, 2017). Educators can take advantage of features of devices like Chromebooks, and that align with ISTE standards. For example, assessing data within learning environments and pertaining to student achievement may be easier when utilizing standardized devices. Also, the ease of access to numerous applications (usually termed apps) through online app stores provide opportunities for educators and students to find new software that fits with their learning objectives. Having ready to use and low-cost, mobile devices available to students both in and out of the classroom, can accelerate the movement to flipping lessons for more effective in-class learning, enabling the teacher to facilitate rather than lecture or try to broadcast content during valuable classroom time. In addition, the standardized hardware infrastructure platforms like Chromebooks direct students and teachers into a mindset of sharing and collaboration with such tools as Google Drive, the Google+ social media site, Google Classroom, Gmail, and other Google technologies. Finally, the deployment and use of Chromebooks other Internet-connected devices can be provided to every student, leaving no disparity among the socioeconomic characteristics within a classroom. They also will enable all students to participate in open educational resources beyond just eBooks, such as MOOC's like Khan Academy, tutorial sites, Wikipedia, and other Internet based repositories of content (Google in Education, 2017). The Open Distance Learning (ODL) models and solutions provide an open, secure platform for equipping K-12 and higher education students with cost-effective computers to access the Internet. They also support Self-Regulated Learning (SRL) which is a strong predictor of academic achievement (Kirmizi 2015).

Equipping students with a standardized, accessible, open system for utilizing the Internet also supports self-regulated learning (SRL), providing self-efficacy, and empowering students to acquire knowledge through community, then interact, organize, and reflect on their formed knowledge (Bandura 2001). Millennial students tend to be computer platform agnostic, and not partial to a particular operating system (like OSX, Windows or Linux) or computer configuration (tablet, laptop, smartphone, netbook, desktop, etc.), and simply need access to the applications and information on the Internet in an open way, preferring the things that matter most such as immediate social community engagement, interactivity, digital literacies, connectivity, experiential learning, and teamwork (Oblinger, D., & Oblinger, 2005).

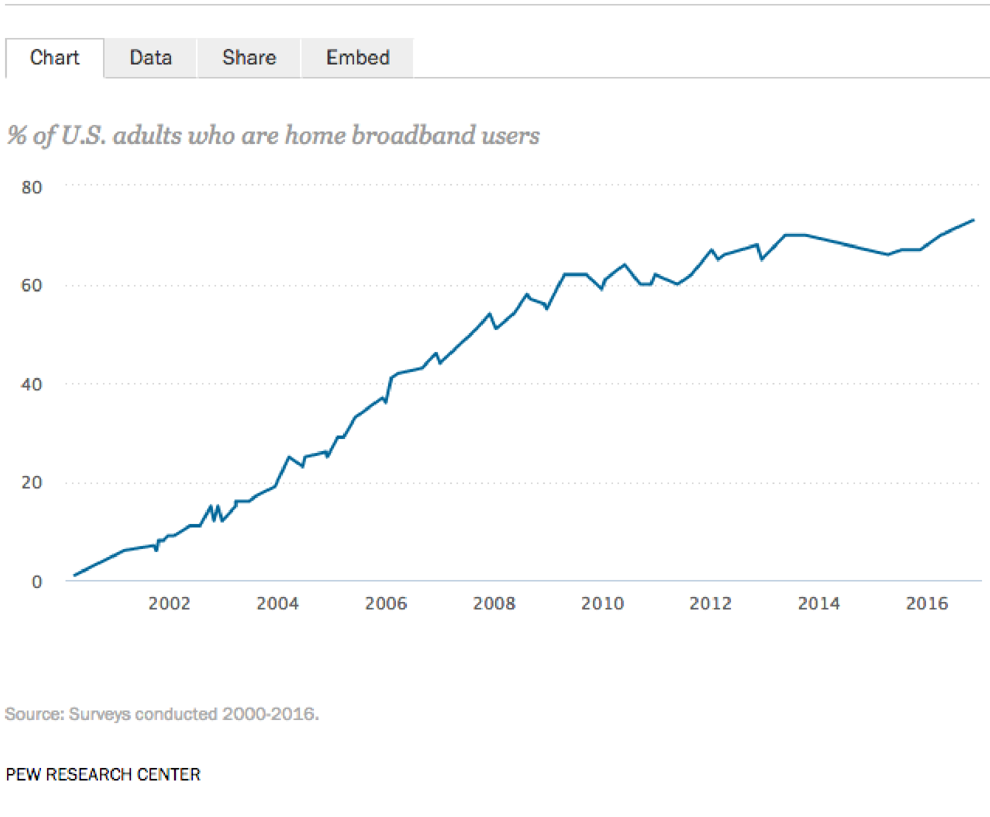
The ChromeBook technology is continually refined through advancements in hardware technology and improvements to the Chrome OS. It takes advantage of the Open Source Community bringing together software developers from around the world to contribute their skills to producing software which is the best it can be. The critical mass, collective activity and aggregate effort to keep improving upon it, makes the Chromebook a superb quality product, which enables widespread adoption by educators, hence providing another learning tool for students . (Granovetter, 1978).

Home Internet Access

The USDOE Office of Technology addresses the critical importance of home Internet access in the infrastructure section of their National Educational Technology Plan (NETP). Home Internet access appears in the NETP infrastructure section. This highlights the essential nature of Home Internet Access for students, since learning can be continued outside of the classroom, when students go home. If students do not have access to the

Internet at home, they are at a disadvantage. This "digital divide" has become an issue in K-12 education, and should be addressed when educational technology leadership designs a technology infrastructure.

According to a report from the Council of Economic Advisers, approximately 55 percent of low-income children under the age of 10 in the United States lack Internet access at home. The not-for-profit group called everyone on, reports that 1 in 4 households in the US is without internet access. Also, data from The Pew organization reports fairly consistent adoption of broadband technology generally in the US but class and income differences make a difference in Internet access in the US. The research from these organizations have assessed the level of Internet access and use by students at home highlights the concept of Disproportionate Internet Access. This phenomenon occurs largely for students in low-income and minority communities, since these students are somewhat isolated from many of the digital communities necessary to aid students in social scholarship. The awareness generated by these studies and research can go a long way to help alleviate the problem of the digital divide. If Internet access is propagated to lower income areas, students in those conditions can more freely access information and participate in e-learning opportunities (such as online coursework, MOOCs, tutorial sites, YouTube videos, social networks and many other sites and tools that can contribute to their education, which classmates already do. Ultimately home Internet access is the means by which the "digital divide" issue is most likely to be addressed.
Get Connected. (n.d.). Retrieved May 01, 2017, from http://everyoneon.org/



Digital Citizenship & Responsible Use

All of the concerns that the USDOE raise on educational technology are interrelated, so a discussion of one really needs to show the interconnectedness between all aspects of educational infrastructure. An educational technology infrastructure will be of limited value if processes and procedures that support good digital citizenship and responsible use of systems and the platform as a whole are not taught, encouraged and enforced/enforceable. In fact, it could be argued that the digital citizenship and responsible use training/education dimension of an educational technology program should precede, or at least spin up simultaneously with the educational technology infrastructure because educational technology infrastructure without an effective system for governance is road to nowhere without rules.

There are nine elements of digital citizenship and responsible use. 1) Digital Access (school/home); 2) Digital Rights and Responsibilities; 3) Digital Communication; 4) Digital Literacy; 5) Digital Etiquette; 6) Digital Security

(Self-Protection); 7) Digital Health and Wellness; 8) Digital Law; and 9) Digital Commerce.

The USDOE refers to Responsible Use Policies (RUP's), which is a document outlining how computing resources should be used responsibly, and expresses what the consequences should be for misuse. The document is composed by stakeholders such as parents, students and educators. They can be used as best practices for school districts that are attempting to adopt, build and/or maintain a best-in-class educational technology infrastructure system. When schools follow a well-written and effective RUP, they are taking steps to form an environment of success and responsibility for students. They also reinforce the best practices that students and educators should follow to be good digital citizen in today's increasingly technological society.

There is a need in the US to reach underserved students with connectivity resources and Internet access. The USDOE recommends that Responsible Use Policies should be implemented. When writing these "RUP's" the USDOE recommends a readable, accessible document that stakeholders such as parents, students and educators can use. Some important resources that the USDOE recommends to answer questions for administrators responsible for the development of a RUP include 1) Policies for Users of Student Data Checklist 2) The Consortium for School Networking (CoSN); and 3) Rethinking Acceptable Use Policies to Enable Learning: A Guide for School Districts.

The stakeholders need to take ownership of their children's education and how technology affects it. Therefore, the recommendations frequently include family involvement as well as the educators. They are also sensitive to the diversity of many school districts and recommend translating the policies to other languages. The policies especially emphasize how schools need to protect students from harmful content on the Internet by good policies and procedures such as monitoring compliance, providing guidance on such things as proper Internet etiquette and behavior so that personally identifiable information (PII) is not at risk. Other recommendations are that schools should provide students with good access to digital media to support engaged learning.

Another resource is the USDOE Privacy Technical Assistance Center (PTAC) . This is where data security policy and the actual technology meet. PTAC is a valuable source of information on confidentiality, data privacy and security. They provide educational materials for families and PD videos for educators on phishing scams, transparency, data breach responses, and best practices in security for K-12 education. Here is a sample video from their website called Student Privacy 101 which discusses FERPA.

Finally, regarding Digital Citizenship, there are many ways we can measure and improve participation. First, we must find good technology leadership, then develop training programs to educate teachers on being good digital citizens, so they can model this for their students. It's part of the culture of an organization to show the stakeholders the level of commitment to digital citizenship. So, the behaviors that the adults exhibit form the normal culture that students will adopt and inherit. Features of good digital citizenship include good security and safety of the people and systems so that there are not threats to the well-being of the stakeholders. Also, establishing responsible use and ownership of the trappings of technology that are used in educational environments should be encouraged. When students take responsibility for the implements in their educational experience (laptops, printers, network access, software, etc.), they put a higher value on the technology, become more engaged and communicative and can form better community among their classmates, teachers and the outside world (Ribble, 2004).

Quality Digital Content & Resources

Public, private organizations and foundations provide repositories called LOR’s (Learning Object Repositories) of open educational resources. The purpose of these organizations are to maintain quality and consistency, to facilitate the proliferation of reusable digital assets or DLO’s (Digital Learning Objects) which they have accumulated for educational purposes, and to provide robust infrastructures to capture, store, edit, maintain and deliver DLO’s. DLO’s are comprised of any element that can be reused and is usually packaged to include a lesson, an activity, and an assessment (Oviatt, 2017). Creating and using DLO’s can provide a persistent and accessible set of assets for educators to use to help motivate and engage students as they develop their content. DLO's should have a stated and specific educational purpose, are reusable and encapsulated or grouped into units, modules, courses, and educational programs (McGreal, 2004).

Today, we see a proliferation of these LOR's. For example, Blackboard Open Content provides access to a huge storehouse of digital content to use within the LMS. This provides customized learning designs, enabling collaboration. Collectively, we call this OER, or Open Educational Resources (OER). Here are some examples of OER's include OER Commons, UNESCO Open Course Library, and Washington State Open Course Library. Some examples of digital learning objects (DLO's) include animations and simulations, digitized course content and assessments, as well as video lectures and lessons followed by discussion opportunities and assessments. DLO's are useful since once they are created, they can be reused. They can be made searchable through defining and embedding metadata (data about data) within each one so that they can be identified by search engines, and content management systems. Typical types of metadata which DLO's may include are (1) the educational objective which the DLO is instructing; (2) a list of prerequisite skills/objectives required by students before consuming the DLO; (3) The topic area which the DLO is instructing; (4) the type of interactivity, if any, of the DLO; and (5) which technology is required use or view the DLO (Learning Object, 2017).

Leadership in EdTech Infrastructure

The US Department of Education has determined that there is an acute need for leadership in the implementation of educational technology at the K-12 school level.   A key factor in developing and implementing new educational technology infrastructure is collaborative leadership, involving all stakeholders in the educational process. Even though good technology infrastructure is essential to facilitate today's EdTech, having talented leadership is very important for effective utilization of technology. Leaders possessing certain leadership attributes and knowledge will affect the successful implementation of EdTech, and in turn contribute to success in teaching and learning outcomes (Anderson, 2005).

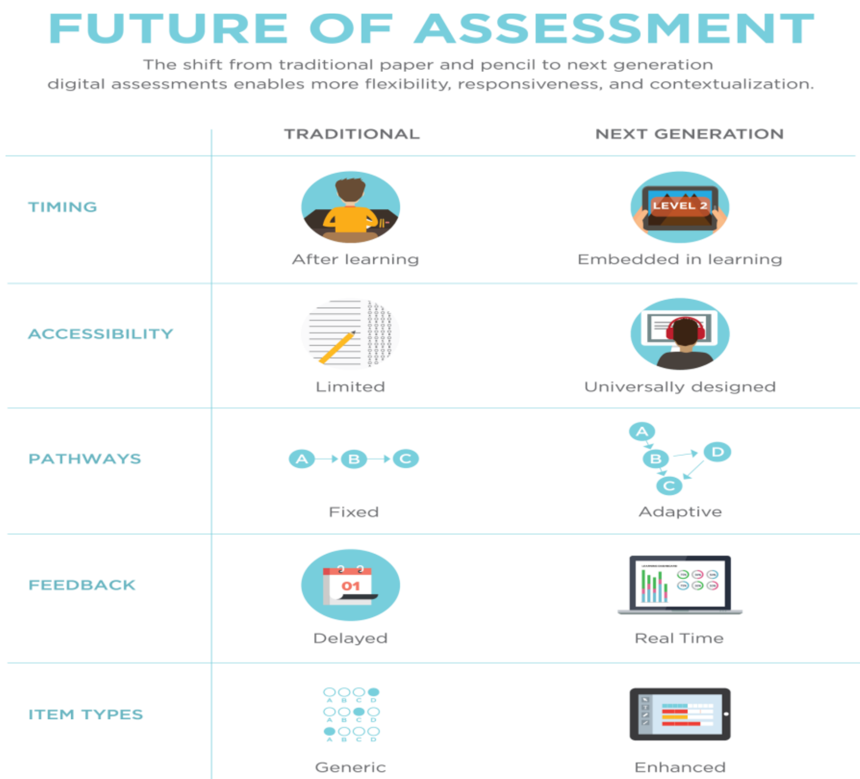
The goal of developing technologies that facilitate personalized student and professional learning, will require visionary educational leadership to determine the best way technology can be developed and implemented to support learning. The new leaders should model tolerance for risk and experimentation and create a culture of trust and innovation, excellent communication, and thoughtful strategic plans which affect student learning with educational technology. This will require professional development activities, and, of course, expenditures to support new educational technology initiatives (Leadership, 2017).

Teaching with Technology Infrastructure

To facilitate the integration of technology into the classroom, educators and institutions need to be equipped with the essential technological infrastructure to serve educator and learner needs. In addition, schools need institutional resources which serve the needs of all stakeholders in the educational organization. Some common technology infrastructure elements which need to be installed in brick-and-mortar schools, accessible to the onsite classrooms include the network gear (cables, servers, switches, hubs, routers, wireless access points, etc.), general purpose labs (computers could be Linux, Windows and/or Mac), departmental specialized labs, diskless workstations (also called thin clients), file and other types of servers (application, email, web, database, etc.), mobile devices (i.e. Android or other smartphones), projectors, robotic equipment, smart whiteboards, software licenses (for such things as Microsoft applications, and Adobe Suite), subject-related software (i.e. for math, writing, scientific), virtualized environment (such as VMWare Citrix servers), and high-end workstations for specialized applications like CAD (Computer Aided Design) or Game Development. The main considerations/challenges that are encountered when integrating technology into the classroom involve dealing with 1) Fear of change; 2) Improved training of teachers in basic computer technology; 3) Increased levels of personal (outside of work) usage to become more familiar with student contexts; 4) Which pedagogical models and techniques are utilized; 5) Implementing more learning-based pedagogies; 6) The educational climate; 7) Effective teacher motivation to incorporate new technologies in the classroom , and 8) Providing better support for integrating technology in the classroom (Bitner, 2002).

When designing which components to include in educational infrastructure, there are many important characteristics and attributes which the technology should include. First, the technology for instruction should be in digestible pieces, so keeping the implements accessible and brief in terms of student access is important. Also, utilizing technologies that translate to visual aspects of learning can have a high "bang for the buck." Also, facilitating learning through technology infrastructure should include varied and diverse access to resources on the Internet, including video, hypertext, wikis, blogs and LMSs. In addition, educational technology infrastructure components that increase the ability for educators to communicate, connect, and collaborate with students, such as accessible email systems, discussion threads within the LMS, video conferencing systems, and others (which require stable and high bandwidth capabilities) should be present. Lastly, peer-to-peer tools and technologies that enable engagement among students should be included in the design of the technology educational infrastructure. These design elements overlap, and form scaffolds to learning for K-12, higher education and even corporate learners, but especially for adult learners. Without high quality and thoughtful design of the layers of technology infrastructure for education, implementing half-measures will probably not lead to improved educational outcomes or better student learning

Assessment of EdTech Infrastructure



Gauging the value of investments made in, and improvements upon educational technology infrastructure most naturally comes through assessments of the students who rely upon and utilize such software as the LMS (Learning Management Systems) and other software tools which are scaffold upon the educational technology infrastructure.

The US DOE's Office of Educational Technology National Educational Technology core plan speaks to how the utilization of educational technology improves and accelerates the rate at which valuable information can be ported out of the Educational Technology Infrastructure and utilized by all stakeholders in the system (Students, Teachers, Administrators, Funders and Developers). Referencing the infographic above, the most consistent enhancement, above and beyond the analog system of assessing learning and changes therein, is flexibility and dynamism. These contrast the original system markedly which relied upon a linear, relatively rigid system that applied the same metrics to all students. The infographics above demonstrates the recommendations of the DOE (Assessment, 2017).

When assessing educational processes and systems, we examine activities conducted and performed by the primary agents of educational technology, teachers, and measure their effect on student success. However, in addition, multi-dimensional, multi-faceted assessment activities must be performed in order to bring real insight, measuring rigor and usefulness of the integration of technology in educational settings. For example, besides seeking the outcomes measured in formative and summative assessment activities are met, we could assess the effectiveness of educational technology professional development and training of teachers, for example. Also, and just as importantly, we could assess how well technology when integrated into the educational environment, can lead to better student learning outcomes. We can collect assessment information for traditional measurements such as feedback, surveys, questionnaires, grade data, etc., and a variety of other well-practiced ways and with methodologies that have been tested. However, for assessing educational technologies, we have to find other ways to measure their effectiveness on student learning. To assure the effectiveness of evaluation of today's educational technology, we should design new assessment tools that can be applied to educational technology, just as we have different types of assessment approaches to other elements that affect student learning in educational environments. Having good leadership, systematic planning, rigorous evaluation procedures, and using a project management approach can be strategies to help assess educational infrastructure (Pierson, 2010).

Conclusions

Educational Technology Infrastructure requires many components, as were discussed in this paper. These include the hardware and software systems, including high-speed connectivity in the form of wireless or wired technologies. The study of EdTech Infrastructure also requires examining the technological needs and emerging technologies that can meet these needs in educational environments. It is not just the hardware and software, but the people, processes and policies that contribute to a sound educational infrastructure. Groups and entities such as SETDA and USDOE have published valuable guides and best-practice recommendations for educational stakeholders in the evaluation, selection and implementation of hardware, software, policies and procedure that constitute current best practices.

The critical issues of data privacy & security can be addressed in many ways such as using secure systems, high quality control and assurance, good technology project management, establishing and enforcing policies which aid in ensuring quality, security and privacy in educational environments. Some of the challenges to data privacy and security may be addressed through legal memorandum, AUPs, as well as revising and updating policies and procedures as conditions change and new technologies emerge. Some of the other considerations include but are not limited to: 1) Reviewing and updating FERPA regulatory mandates; 2) Paying attention to the level of and adoption of stakeholders in digital citizenship; 3) Seeking out, securing and developing safeguards and privacy of existing hardware system, software and people; and 4) Implementing updated security measures, whether physical or logical, networked or local, data or software related (as in open source vs proprietary software adoption).

As with any hardware implementation within an organization, the scope (i.e. whether it is single room, floor, building, campus or metro) and capacity (how many users currently, and how many expected at peak times) should be considered when implementing systems (software or hardware) for educational environments. For example, the network components should be examined and analyzed so that the correct designs are in place in terms of scope and capacity in such sub components as high-speed WiFi and wired networks, their bandwidths, coverage and costs. These challenges occur throughout any educational environment, including K-12, higher education, or corporate training and development (T&D). We need to consider not just the universities, schools, districts, but also the level of technology availability in the homes of the students. In particular, the digital divide, which we can observe is still an issue despite costs of hardware and software being more accessible to families of lower income students. Solutions have been developed and deployed to address this challenge so that students are all on a level playing field with regard to home computing resources For example, private industry can be tapped to help bridge the gap by providing computing devices that are both high-quality and simultaneously low-cost. Also, the use of open hardware solutions such as Chromebooks and mobile devices can help to bridge the divide, providing a combination of resources provided internally by schools and externally by corporate or charitable donors or community based organizations.

When designing which components to include in educational infrastructure, there are many important characteristics and attributes which the technology should include. First, the technology for instruction should be in digestible pieces, so keeping the implements accessible and brief in terms of student access is important. Also, utilizing technologies that translate to visual aspects of learning can have a high "bang for the buck." Also, facilitating learning through technology infrastructure should include varied and diverse access to resources on the Internet, including video, hypertext, wikis, blogs and LMSs. In addition, educational technology infrastructure components that increase the ability for educators to communicate, connect, and collaborate with students, such as accessible email systems, discussion threads within the LMS, video conferencing systems, and others (which require stable and high bandwidth capabilities) should be present. Lastly, peer-to-peer tools and technologies that enable engagement among students should be included in the design of the technology educational infrastructure. These design elements overlap, and form scaffolds to learning for K-12, higher education and even corporate learners, but especially for adult learners. Without high quality and thoughtful design of the layers of technology infrastructure for education, implementing half-measures will probably not lead to improved educational outcomes or better student learning (Digital Promise, 2016).

Infrastructure development for educational environments requires assessment, since it is an essential part of the programs and processes that education students. Assessment improves learning because it requires a close examination of what is working and what is not. We have a lot of literature available for doing formative and summative assessment on educational units, programs, processes, etc. However, gauging the effectiveness of EdTech infrastructure can be challenging since it is more of a collective tool for meeting larger educational goals at the institutional level. One way of utilizing traditional assessments like surveys and tests, is to ask about how effective a particular technology was in the learning experience. We need to select assessment techniques appropriate to the scope of what’s being assessed. We can ask students to reflect on or demonstrate how well a particular technology. We can observe how implementing a new technology like Chromebooks, higher speed Wi-Fi, online augmentations to learning such as utilizing open courseware or MOOCs, and measuring how the level of digital citizenship has contributed to the student's ability to construct new knowledge (Assessment, 2017).

Through developing effective leadership with thoughtful planning of educational technology infrastructure, the assessment process can become more streamlined and adaptable to the infrastructures that are selected, improved upon, or implemented. The students and teachers become the beneficiaries of a sound, rigorous, secure and capable infrastructure. Through meaningful management and thoughtful decisions on making improvements, leaders can ensure that future investment in educational infrastructure are effective in terms of cost/benefit and outcomes. Assessing the ancillary technology tools in addition to the core classroom activities and methodologies will make for a comprehensive and holistic examination of the educational environment being examined. So, by including the measurement of not just how teaching affects learning, but also how the increasingly automated and integrated technologies (often times transparent to classroom stakeholders) will enable us to improve overall outcomes.

Ultimately, the examination of educational technology infrastructure ties all the systems, issues, and considerations together including hardware/software, legal/regulatory, cost/disparity, security/privacy, LOR, OER, leadership, and teaching. All of these areas can be improved iteratively as new technologies emerge and old ones are augmented or replaced. While much of the technology emerging in corporate and consumer settings may seem revolutionary, the adoption of new technology in educational institutions will likely be at a slower, evolutionary pace.

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