Trends and Issues of Digital Learning in the United States of America

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Abstract

The U.S. education system is overseen by a federal Department of Education, but each locality and state has a level of autonomy to determine how curricula are implemented for their specific group of learners. Digital transformation and equity in digital learning are cornerstones of United States K-12 education, and the federal Department of Education provides oversight and financial assistance to school systems to assist in providing digital learning artifacts. U.S. public school education has a strong background in ensuring students have access to technology tools to assist learning by either classroom technology use of 1:1 device programs. The U.S. public education system is in the digitalization stage for most of its levels except for early childhood which is still at the digitization stage due to recommended restrictions on early learner technology use. Personalization of learning experiences, use of gaming applications to promote engaged learning, e-texts and interactive textbooks are the primary digital tools employed for engaged learning. U.S. education also has a strong presence in data-driven decision making using digital tools to assess learner progress, individualize instruction, and provide data to the federal Department of Education for funding purposes. During the COVID-19 pandemic, U.S. education was catapulted into a major shift of online learning which brought to the forefront disparities in connectivity for rural areas of the country. The changes initiated by the global pandemic saw implementation of new digital tools to assist learners, and most are still in use today. Infrastructure, professional development, and the digital divide, including the newer terminology of digital use divide are noted as major issues in ensuring all learners receive equity in their digital learning experiences. U.S. K-12 education is focused on providing increased access and opportunity for all learners by enhancing its infrastructure and digital transformation for global learning opportunities.

Keywords: digital learning, digital divide, K-12 education, artificial intelligence, infrastructure

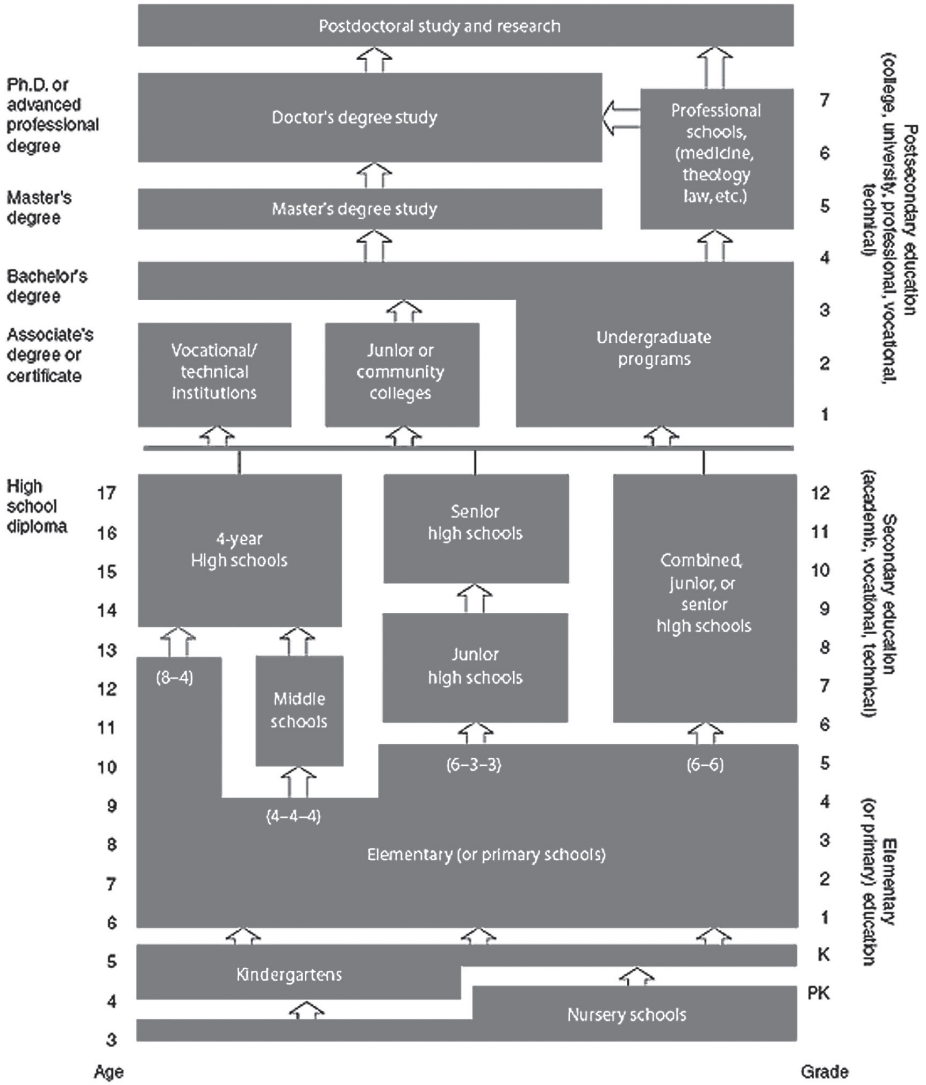
Introduction

Structure of the educational system in the United States

The United States (U.S.) utilizes a comprehensive pattern of schooling. It encompasses early childhood education (called elementary schools in the U.S.), middle school (or middle level education), secondary education (high or senior high schools) and the tertiary level of education denoted as postsecondary education. Post-secondary education can include non-degree programs leading to career studies certificates, general education certificates, or a diploma. There are also six different categorized degree levels including associate, bachelor, first professional, master, advanced intermediate, and research doctorate. The U.S. does not offer a second or higher achievement level doctorate, but does have post doctorate opportunities to continue in research programs. The U.S. system also offers numerous adult and continuing education opportunities, often denoted as workforce training or learning, as well as special education programs throughout many of the educational levels (U.S. Department of Education, 2008). Figure 1 below provides an overview of the U.S. educational system structure.

U.S. education benchmark performance to peer countries shows that U.S. scored in the top 25% of participating systems in mathematics and science at 4th- and 8th-grade levels as reported by the 2019 Trends in International Mathematics and Science Study (TIMMS) (Irwin et al., 2023). Irwin et al. reported "92% of 25-64-year-olds have completed a high school degree, the United States was among the top 6 out of 36 countries in 2021 reporting data…to the Organization of Economic Cooperation and Development" (p. 40).

Figure 1 The Structure of Education in the United States



Note. U.S. Department of Education, National Center for Education Statistics https://nces.ed.gov/programs/digest/d01/fig1.asp

The U.S. education system has a national department of education to provide oversight, yet the system does not have a centralized model of regulation, but a very decentralized one that allows for a wide variety of regulations, laws, court decisions, and local policies to define educational systems. Each locality, be it a city or a county in a state, has oversight in how, when, and why educational programs are offered. Each state department of education has oversight to ensure there is a modicum of continuity in providing federally mandated framework laws. According to the U.S. Department of Education (2021), establishment of schools, curricula, enrollment and graduation requirements are primarily a responsibility shared by each state and its localities.

The U.S. Department of Education oversight provides important policy leadership for states which in turn provide policy and leadership for localities (U.S. Department of Education, 2021). The U.S. Department of Education also provides minimal monetary support, approximately 8% of the $1.15 trillion spent nationwide on all levels of education. These funds come from the Department of Education, but also include other federal departments such as Health and Human Services, the Head Start program, and the school lunch program from the Department of Agriculture (U.S. Department of Education, 2021). In the U.S., the White House ensures the citizenry is apprised of Presidential activities and initiatives related to education in conjunction with the U.S. House of Representatives Committee on Education and Labor, which provides information on legislative bills, hearings, testimonies or other actions pertaining to education. The U.S. Department of Education states its goal has remained the same over the years since its inception in 1867 which is "to promote student achievement and preparation for global competitiveness [emphasis added] by fostering educational excellence and ensuring equal access [emphasis added]" (para. 10).

Global competitiveness and equal access are critical components of digital learning. The U.S. education system experienced an unforeseen awakening when the pandemic, COVID-19, hit all schools, businesses, and communi-

ties, forcing complete shutdowns of most businesses, and requiring the use of virtual learning for all levels of education. The pandemic brought to the forefront the fragmented relationship between U.S. education systems and our current infrastructure. The Center for Digital Government survey (2022) highlighted that states agree that among other top priorities such as cybersecurity and modernization of legacy technologies, an important priority is increasing "broadband/connectivity/addressing the digital divide" (Government Technology, para. 4). The digital divide issue is widespread throughout the U.S. and a cause for concern related to digital transformation (Dx) in this country.

Digital transformation (DX) in U.S. K-12 schools

Digital Learning (DL) revolves around the ability to exercise a level of control of learning time and place by using blended or virtual modalities through various mobile technologies and systems. DL is also a key construct of successful digital transformation. The U.S. has made progress in expanding access to technologies through federally supported initiatives and projects. Statistically, 90% of all U.S. schools report at minimum one computer for every five students, and 98% of classrooms have internet access (Baruffati, 2023). Yet, there is still a digital divide across the country with many areas, especially rural, remote areas, having very limited access to broadband internet, along with the financial divide of those who cannot afford the technologies to undertake digital learning. The following paragraphs provide an overview of the digital transformation in the United States.

ISCED level 0--early childhood: Birth to age 2

The U.S. education system does not have a formal educational setting for early learners aged from birth to age 2. It does, however, address this stage of learning and digital usage considerations in its policy brief (Office of Educational Technology, 2016). Digital transformation at this educational level is limited due to age restrictions supported by the American Academy of Pedi-

atrics (AAP) 2016 Media and Young Minds Brief recommending appropriate technology usage, of one hour daily inclusive of home, early learning settings, and across multiple devices (Office of Educational Technology, 2016). Due to limited technology use in educational settings but more widespread use in educational recordkeeping, this level of the U.S. educational system is at stage one, or digitization.

ISCED level 1--lower primary

This level in the U.S. education systems encompasses two distinct groups – lower primary (elementary) education and upper primary (elementary), broken into segments of Prekindergarten through grade 2 and grades 3 through 5 (although some systems include grade 6 in upper primary). The U.S. system of education places a strong focus on early childhood education as supported by many federal programs encouraging children to begin school as early as age 3 or younger if the learner has special educational requirements. Learners have opportunities to use technology in simpler forms, but this usage is guided and overseen by the educators. AAP again recommends one hour of technology use as appropriate for this age grouping. In addition to limiting technology time, it is important to ensure the quality of content, and how technology is used in the educational setting. Both the teachers and the family ideally monitor these constraints to ensure these early learners still have opportunities for free, creative play.

The administrative side of this level of learning does employ numerous technology database tools for reporting and recordkeeping purposes. Data collection of students enrolled, their time spent in formal classrooms, along with educational resources provided to these learners, assists the U.S. in serving these early learners and providing needed resources based on socioeconomic, racial/ethnic, and linguistic data. As stated previously, the U.S. does not have a national education system, but each individual educational system reports data to their state departments and are awarded funding based on these metrics.

For the lower level of primary education, the U.S. system is in the digitization stage.

ISCED level 1--upper primary

For the upper level of primary education in the U.S., ages 6 through 8, grades 3 through 5, this level has a more intentional integration of technology into the learning program, but is used in conjunction with academic materials such as art, writing, play, books, and "should give learners an opportunity for self-expression" (Office of Educational Technology, 2016, p. 8). The National Association for the Education of Young Children (NAEYC) and the Fred Rogers Center (2012) state, "technology and interactive media should be used in ways that support existing classroom developmental and educational goals rather than in ways that distort or replace them" (p. 8). This position paper further supports that technology usage should not "replace paints, markers, crayons, and other graphic art materials but should provide additional options for self-expression" (p. 8). For these grade levels of primary education, the U.S. is straddling the stages between digitization and digitalization as more investment is made in provisioning of technology equipment, professional development and training of educators, and technical support.

ISCED level 2--lower secondary education

In the U.S., the level considered lower secondary education is typically grade levels 6 through 8, characteristically ages 9-13. Learners in this level are subject to more locality and state mandated testing due in part to national educational standards such as the Common Core (CC) and state mandated standards such as end-of-course (EOC) or standards of learning (SOL). Common Core standards were enacted in 2010 to provide continuity for students, grades K-12, in their educational achievements if they moved from one school district to another, or to another state. Initially embraced by all but four states in the U.S., recently these standards have been repealed by more than 20

states due to testing controversies (Goldstein, 2021). The testing occurs online, and therefore there is a more intentional use of technology through the online learning process via gaming, scenarios, and guided practice, along with local benchmark or point in time testing prior to the mandated testing. Lower secondary education is at the digitalization stage as the school systems invest more in training for educators and make use of more digital processes to enhance the learning opportunities for the learners.

ISCED level 3--upper secondary education

Upper secondary education is considered to be grades 9 through 12, traditionally called high schools, with learners aged 14 to the upper limit age of 20 or 21 (after 21 students are referred to adult education centers). Learners in this level are again assessed in multiple courses with some assessments presenting barriers to graduation if passing scores are not earned. Students typically take eight core subjects of English, mathematics, social studies, and science, along with elective coursework during their four years of high school education. Students are offered a variety of electives such as visual arts, career and technical education (CTE), or honors classes for academically gifted students. Students must earn a total of 30 credits to graduate from their core and elective coursework. Students in upper secondary have multiple opportunities to utilize technology in their course work via simulations for business or CTE courses such as computer applications, Computer Aided Design, and in their core academic classes using technology-enhanced lessons in sciences, mathematics, and English. The upper secondary level of education in the U.S. is still at the digitalization stage.

The Status of Digital Learning

Digital learning has been gradually increasing in the U.S., but experienced huge growth during the COVID-19 pandemic years of 2020-2022. Digital learning began in the early 1990s and was generally referred to as "K-12 online and blended instruction" (Black et al., 2020, p. 119). According to the National Center for Education Statistics (2019), in 2017-18, 27% of all public schools offered courses online. Yet digital learning is more than online coursework as it encompasses access to technology, robust internet connectivity, and digital curricula. The U.S. government enacted Title IV Part A authorized under the Elementary and Secondary Act (ESEA 1965) as amended by the Every Student Succeeds Act (2015) to promote overall academic achievement for all students. This act provided more power to U.S. states, local education agencies (LEAs), and schools to "(1) provide all students with access to a well-rounded education, (2) improve school conditions for student learning, and (3) improve the use of technology to improve the academic achievement and digital literacy of all students" (T4PA Center, n.d., para. 1). Part A of the act provided monetary support, $400 million to $1.17 billion (2017-2019) (para. 4), to achieve these goals. Specifically, goal three mandates activities to support the effective use of technology focused on increased professional development for school personnel, specifically educators, building infrastructure and technological capacity, effective or innovative strategies for academic content delivery using technology, and providing enhanced access to educational opportunities for those in rural, remote, and underserved area (T4PA, n.d.; National Association of Secondary School Principals, n.d.). Local school districts and LEAs receive money with restrictions that no more than 15% of their allocation may be spent on purchasing technology infrastructure including devices, software, and peripheral equipment (National Association of Secondary School Principals, n.d.).

Contexts of digital learning (DL)

Digital learning covers many aspects of the educational environment from individualized instruction to classroom collaborations. Gillpatrick emphasizes that "the pace of change brought about by digitization is fundamental and transformational for education" (2020, p. 195). The U.S. Department of Education is promoting the need for these changes to ensure equity in education and accessibility for learners (Office of Educational Technology, 2017). In the United States, digital learning is a main priority and is offered in many modalities dependent upon the location, funding, and accessibility to broadband services for K-12 schools nationwide. The Office of Educational Technology (2017) provides "a national vision and plan for learning enabled by technology" (p. 3) for all educational stakeholders, including but not limited to researchers, school district leaders, entrepreneurs, and nonprofit organizations. This plan is not mandated as each state and locality have certain levels of autonomy, but compliance is recommended to ensure all learners are afforded the best educational opportunities possible. Nationally, K-12 schools are tasked with developing a vision and a workable plan to ensure all learners achieve their educational goals through the intentional use of digital learning technologies. The plan, the National Educational Technology Plan (NETP), challenges educational systems to ensure a robust infrastructure which must include digital learning content, assessments, as well as professional development for educators and education leaders. In the U.S. Department of Education's *Fast Response Survey: Use of Educational Technology for Instruction*, schools nationally reported that digital learning helped students be more independent and self-directed (33%), while 41% reported that it promoted engagement in more active learning, and it also allowed students to learn at their own pace, reported at 35% (Gray & Lewis, 2021).

Digital learning policies, projects/programs, strategies, and research and development

As outlined in the status of digital learning, Title IV, Part A of the Every Student Succeeds Act (ESSA) of 2015 was developed to improve overall student academic achievement. The U.S. government provided funding for this program in three major areas: (a) well-rounded educational opportunities with a minimum of 20% of school allocation expended, (b) safe and healthy students with a minimum of 20% of allocation expended, and (c) technology and digital literacy with no more than 15% of allocation used for technology infrastructure (National Center for Safe Supportive Learning Environments, n.d.). This government act specifically defines "blended learning as a formal education program that leverages both technology-based and face-to-face instructional approaches" (National Center for Safe Supportive Learning Environment, n.d., Section 4102 [20 U.S.C. 7112]) and digital learning as:

> any instructional practice that effectively uses technology to strengthen a student's learning experiences and encompasses a wide spectrum of tools, practices, including –
> (A) interactive learning resources, digital learning content (which may include openly licensed content), software, or simulations, which engage students in academic content;
> (B) access to online databases and other primary source documents;
> (C) the use of data and information to personalize learning and provide targeted supplementary instruction;
> (D) online and computer-based assessments;
> (E) learning environments that allow for rich collaboration and communication, which may include student collaboration with content experts and peers;
> (F) hybrid or blended learning, which occurs under direct instructor supervision at a school or other location away from home and, at least

in part, through online delivery of instruction with some element of student control over time, place, path, or pace; and

(G) access to online course opportunities for students in rural or remote areas (National Center for Safe Supportive Learning Environment, n.d., Section 4102 [20 U.S.C. 7112]).

This specificity is key to ensuring that government funding is allocated to school systems and LEAs for digital learning. This act also encourages the concept that this funding is to supplement, not supplant, non-Federal funds that are allocated for digital learning initiatives (National Center for Safe Supportive Learning Environment, n.d.).

The National Educational Technology Plan (NETP) is considered the flagship educational technology policy for the U.S., and works in tandem with the federal policy of ESSA, Title IV, Part A. The overarching communication of the policy is to ensure equity for all stakeholders, active use by educational entities, and collaborative leadership. The plan promotes the need for all "in American education to ensure equity of access to transformational learning experiences enabled by technology" (Office of Educational Technology, n.d., para. 2). According to the National Education Technology Plan (2017), the precepts and principles detailed in its NETP align to federal legislation in Title IV A, which is a part of the Elementary and Secondary Education Act of 1965 (ESEA), which was amended by the Every Student Succeeds Act (ESSA) in 2015. The U.S. Department of Education, Office of Educational Research and Improvement, in conjunction with the National Center for Education Statistics, published recommendations and guidelines for technology in schools in 2002. The intent of this document is to assist school districts, which operate independently yet receive federal funding for initiatives, in understanding all the nuances needed for transformational educational learning. The National Center for Education Statistics (NCES) (n.d.) provides a *Forum Unified Educational Technology Suite* assimilating various educational reports from the U.S.

Department of Education, IES, and NCES. This site and provided documents are designed to provide updated resources for individual school systems, and presents a "practical, comprehensive, and tested approach to assessing, acquiring, instituting, managing, securing, and using technology in education settings" (NCES, n.d., para. 11) to ensure understanding of all local, state, and federal requirements for digital literacy for student academic advancement.

Research and development for digital literacy in the U.S. is driven by government support and funding through various national centers. Their mission is "to contribute to the production and dissemination of rigorous evidence and products that provide practical solutions to important education problems" in the U.S. (U.S. Department of Education, National Center for Education Research, n.d., para. 1). The U.S. Department of Education supports numerous active (13) and completed (21) R&D centers including The National Center for Rural Education Research Networks (NCRERN), the National Center for Research on Gifted Education, Postsecondary Teaching with Technology Collaborative, and the National Research and Development Center on Instructional Technology: Center for Advanced Technology in Schools (completed) (U.S. Department of Education, National Center for Education Research, n.d., paras. 2 & 3). The newest R&D center is *Precision Education: The Virtual Learning Lab*, which has a focus on personalizing and improving virtual learning. It will utilize data from prior students to support learning opportunities for students in future learning environments.

DL implementation in K-12 schools

Digital learning implementation in U.S. K-12 school is an on-going process, especially during the past decade with increased government support. Nationwide there are varying levels of adoption and integration into the schools and curricula specifically due to vast discrepancies in funding from local educational systems, internet connectivity issues, and geographic divides, which make integration for larger groups of students difficult in certain midwestern

sections of the United States.

The Office of Educational Technology (OET) provides policies and vision statements regarding digital inclusion, ecosystems, and emerging trends and technologies for all school systems to guide their efforts for successful digital learning.

Early childhood education

The U.S. Department of Education, Office of Educational Technology (2016), set forth four guiding principles for early learners and technology usage.

> Guiding Principle #1: Technology - when used appropriately – can be a tool for learning.
> Guiding Principle #2: Technology should be used to increase access to learning opportunities for all children.
> Guiding Principle #3: Technology may be used to strengthen relationships among parents, families, early educators, and young children.
> Guiding Principle #4: Technology is more effective for learning when adults and peers interact or co-view with young children (p. 7)

These principles support early limited technology use for young learners and emphasize the need for "unstructured, unplugged, interactive, and creative play" (Office of Educational Technology, 2017, p. 13). The early learning school environment and its educators, therefore, do not integrate multiple technology approaches in their learning routines, but do utilize technology for the recordkeeping and business functions of the system.

Primary education – lower and upper

Lower elementary learners from ages 2 through 5 are the entrance level for lower elementary education. This group adheres to the same guiding principles as listed above for level 0. In 2020, about 55% of 3- to 5-year-olds were

enrolled in schools, with enrollment higher for 5-year-old learners than for 3- to 4-year-olds (Irvin et al., 2022).

In the upper elementary age group, 6 through 8, one must consider whether the technology extends the learning opportunities for all learners in ways that traditional educational methods cannot. Careful consideration of content, context, and individual learners should drive the use of technology at this age (Guernsey, 2012). This level of learners requires a strong focus on ensuring technology use does not distract from teacher and peer interactions, nor does it employ features that distract from learning in general. Guiding principle #2 reinforces how technology can support STEM in early learning situations utilizing social interactions and guidance from educators, along with video and games, to increase mathematical skills and computational thinking. This age of learners is ideal for learning mastery of technology artifacts and learning how to create content, that is, be producers, of technology-based information (NAEYC, n.d.).

Grades 4 and 5 in upper primary employ more learner-based technologies as some activities used to engage learners are in a digital format, yet the time spent with technology is monitored for learners in this group. The administrative side is heavily invested in digitalization as the reporting requirements for this age of learners are more structured and mandated by government testing and recording processes.

Lower secondary education

Learners in this level are given more opportunities to choose some of their subject content and have opportunities to take more elective courses including arts, music, and technology-based courses. Learners in middle level education use technology in most of their courses in many different modalities including laptops, tablets, and mobile devices such as smart phones. Pew Research (2013) reported that "45% … use e-readers and 43% use tablet computers

in the classroom or to complete assignments" (Purcell et al., p. 2). As this research is 10 years old, it is believed that the number has increased significantly. It also stated that most educators use digital tools to assist students in conducting research online. Learners in both lower and upper secondary education often use a learning management system (LMS) that assists the school in delivering digital content, organizes the course materials and ancillary resources, and provides a digital means of secure communication between the students and the teachers.

Upper secondary education

Learners at the upper secondary level are afforded the most opportunities for digital learning through the variety of coursework offered. Many students have opportunities to take advanced or college-level (dual enrollment) courses that utilize multimedia content, educational applications (apps), and interactive textbooks. Data (Pinnell & Biddle, 2022) show that 1:1 device programs in the U.S. increased from 61% in 2020 to 63% in 2021, and the trend is expected to continue. This initiative provides each student with a laptop or tablet. This enhances digital learning by allowing the student to access their digital learning resources both at school and in the community.

As with the lower levels in primary education, the administration side of secondary education also utilized multiple technology tools for recordkeeping, assessment, and other data reporting needs. Data analytics for secondary education is a key focus for the school administrators. Use of digital learning platforms assists them in generating valuable data on student performance and progress. Data-driven decision making is a key factor in state and federal reporting for this level of education. The teachers also use data from the learning platforms to assist with student support, remediation, or enhancement.

The impact of COVID-19 on digital learning

The worldwide pandemic, COVID-19, abruptly changed the levels of digital learning for all U.S. K-12 schools as it did for most educational systems globally. In the spring of 2020, the U.S. Department of Education (2022) reported that 77% of public schools had moved to online distance learning. This required educational systems to revise their approaches to learning and utilize more digital learning opportunities to engage their learners. This online approach continued through Fall 2020 and by Spring 2021, reportedly 52% of public-school students were again enrolled in in-person instruction (U.S. Department of Education, 2022). Technology support in the school year 2021-22 was reported at 96% nationally for providing digital devices to students who needed access to them, and 70% of public schools provided internet access at homes, while 49% provided access at locations other than homes for students who had no other means of internet access (U.S. Department of Education, 2022).

During the emergency teaching conditions of the COVID-19 pandemic, educational systems moved to emergency remote learning in attempts to continue presenting educational services for all learners. This move was facilitated for the most part by offering digital or virtual learning opportunities via online video systems or school-provided LMS systems. Virtual schooling, defined as instruction for which students and teachers are separated by time and/or location with interactions via technology more than doubled in application from 2013-14 to 2021-22 (200, 343 to 566,188), which was a 182.66% increase because of the pandemic. This figure includes all virtual schools including regular, special education, vocational, and alternative educational settings. By educational level, prekindergarten showed no change with 0% virtual, elementary (22,864 to 65,579), a 186.82% increase, middle school (lower secondary) (1,414 to 22,993), a 1,526% increase, and secondary and high schools (31,392 to 111,703), a 244.85% increase (National Center for Education Statistics, 2022).

Several key features of the emergency switch to full-time remote digital learning included access to digital devices and broadband, learning recovery and tutoring required for students upon returning to in-person instruction (Institute of Education Sciences, 2022). In the switch to emergency remote digital learning for K-12, only 61% of public-school educators felt they had the support and resources they needed to be effective (rated as somewhat or strongly agree). Digital learning real-time interactions such as live video or audio lessons for public school educators and students was ranked at 46%. A key factor was the digital divide, where access is not consistent throughout all parts of the U.S., with public schools undertaking steps to ensure connectivity via digital devices such as hotspots or other devices at 61%. Public schools also offered spaces where students could safely use digital learning devices during the pandemic. Sen and Tucker (2022) asserted that there is a "child digital infrastructure divide" (p. 2) whereby lower income families with children have internet access but it is based on cellular access not broadband, which is incumbent with widespread data-usage and data-speed limitations, making it a poor substitute for access. Access was inequitable as city and suburban schools had higher rates of access at 52% and 49% respectively compared to town and rural areas of 42% and 36% respectively. Towns and rural areas were able to compensate by providing higher access to free public internet spaces at 46-47% higher rates than city and suburban schools (Berger et al., 2022). U.S. public school systems also reported that they provided digital literacy training for students and families during this time at 72% for students and 25% for families, with approximately consistent rates throughout the U.S. regions (Northeast 68%; Midwest 75%; South 73%; and West 72%) (Institute of Education Sciences, 2022).

Learning recovery data showed students were on average a grade level behind after the closures and emergency digital learning during the pandemic in the 2021-23 school years. Considering digital divide issues with lack of connectivity and unfamiliarity with fully digital learning, one could surmise that

digital learning was a contributor to this deficit. Engzell et al. (2021) posited that less time studying and home backgrounds were also contributing factors to learning loss.

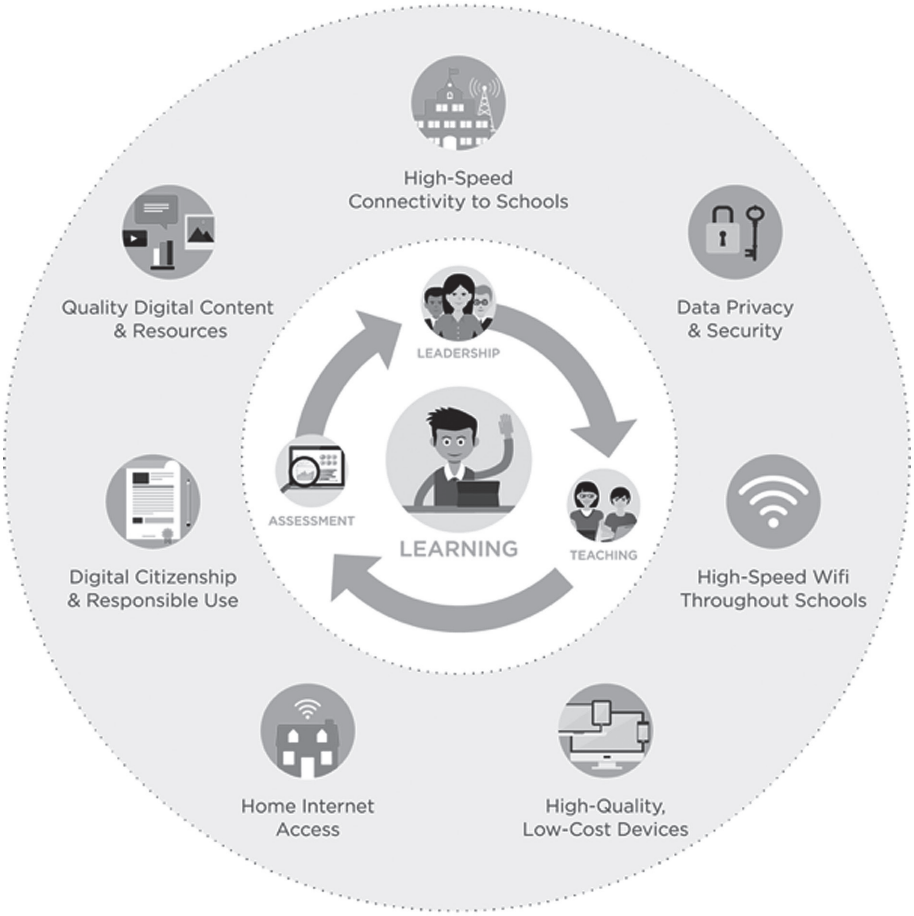
Tutoring was offered in public schools to assist with learning recovery, but again varied by locality and rigor (intensive high dosage, standard, or self-paced). Overall, 59% of public schools offered standard tutoring, 37% high dosage, and 22% self-paced. The mode of tutoring offered was predicated by funding (49%), lack of staff (40%), and time limitations (44%) (Institute of Education Sciences, 2022). Lack of materials was not a strong actor (6%), and digital learning opportunities are prime candidates to assist in tutoring, especially in self-paced or standard modalities. Digital tutoring would lessen other constraints listed previously such as funding, staff, and time.

Digital learning infrastructure

The Office of Educational Technology NETP website (n.d.a.) states essential components for successful infrastructure to support transformational learning include and address the following components:

- Ubiquitous connectivity. Persistent access to high-speed Internet in and out of school
- Powerful learning devices. Access to mobile devices that connect learners and educators to the vast resources of the Internet and facilitate communication and collaboration.
- High-quality digital learning content. Digital learning content and tools that can be used to design and deliver engaging and relevant learning experiences.
- Responsible Use Policies (RUPs). Guidelines to safeguard students and ensure that the infrastructure is used to support learning (para.1).

Figure 2 Infrastructure: To Support Everywhere, All the Time Learning



Note. Office of Educational Technology, National Educational Technology Plan, Section 5. https://tech.ed.gov/netp/infrastructure/

The Office of Educational Technology developed a vision for digital equity and transformation for all K-12 educators so they can thrive in digital learning environments, use technology for professional development, create effective digital learning coursework and experiences, and collaborate with their school

leaders with technology approaches appropriate to the vision, culture, and infrastructure of their school (Office of Educational Technology, n.d.a.)

DL infrastructure in K-12 schools

Infrastructure in U.S. public schools was promoted through various federal acts and laws as well as local initiatives, but the equity in availability of digital learning assets still varied by state and localities, urban as compared to rural specifically. ConnectED (2017) was an initiative by President Obama to increase high speed internet for 99% of the nation's students' low-income households by 2018. This initiative would see a lack of progress as the pandemic began in 2020.

Digital learning infrastructure in K-12 schools is vital for all students to have equitable access to learning opportunities and to leverage high-quality learning resources. High quality resources include technology devices provided by the school system, consistent high speed internet connectivity, technology leadership and dependable budgeting practices, access to open educational resources, and protections for student data and privacy through the intentional use of responsible use policies (Office of Educational Technology, n.d.). Flexible infrastructure is a term used by some school systems to promote agility in spending technology funding by promoting openly licensed educational resources and open sharing of these resources with other systems.

School-provided technology devices, desktop computers, tablets, Chromebooks, or laptops, are key to a school's infrastructure. Slightly less than half of U.S. public schools reported they have a computer for every student (45%) and 37% reported having a computer for every student in some grades or classrooms (Gray & Lewis, 2021). One-third (34%) of schools reported that computers were assigned to individual students for use during the school day, and 15% of schools reported students were allowed to take computers home. According to Mouhanna (2019), at the school district level, schools not having

a 1:1 program rated Bring Your Own Device programs (BYOD) at 65% for students. Internet connectivity was ranked as high for most schools (64%), yet there is still a disparity for the more remote, rural areas of the U.S. in providing connectivity (Gray & Lewis, 2021).

Digital learning leadership and technology support are key components of K-12 infrastructure. The U.S. Department of Education, Office of Educational Technology, published a nonbinding guide to digital leadership to assist in ensuring school leaders embrace digital learning and all it entails. The guide provides leaders with resources to help them "consider, plan, fund, implement, maintain, and adapt learning programs that meet the unique needs and requirements of the students and teachers that you serve" (Office of Educational Technology, n.d.b., p. 4). This guide promotes key constructs such as:

- Developing a shared vision and goals
- Prioritizing professional learning for teachers
- Assessing, building and maintaining your school's infrastructure
- Personalizing learning for students, specifically competency-based learning and real-time assessments
- Collaborating with parents and families (Office of Educational Technology, n.d.b.)

Key statistics and practical examples

The National Center for Education Statistics (NCES)(2021) Fast Response Survey collected data from approximately 1,300 public schools in the 50 states and the District of Columbia (D.C.). This survey collects findings from schools as part of the National Educational Technology Plan (NETP) developed to provide a blueprint for using technology to improve learning. This survey reports findings about their technology use for teaching and learning during the 2019-2020 school year (pre-pandemic). The report is designed to present data on technology resources and how select school systems through-

out the U.S. utilize these resources to ensure students are receiving a quality educational experience. The survey also queried teachers about challenges faced in using technology, training received for using technology, and staff support to assist in using technology. Principals and other building staff, called respondents in the survey, were also questioned on views of how student learning is affected by their use of educational technology. Computers in the resultant data tables refer only to desktop, laptop, and table computers including Chromebooks and iPads. Smartphones were not included as a computer device (Gray & Lewis, 2021). Overall, the survey found that "8 out of 10 schools rated the overall quality of computers. . .as good or very good" (p. 3). Nearly two-thirds of the schools stated their internet connections in their learning areas were reliable, although more than half reported slight issues when large numbers of students were online relative to speed and connectivity. Another notable finding was that teachers felt they did not have adequate time to become familiar with new technology and then use it to teach (43% moderate to 22% large challenge) (Gray & Lewis, 2021).

Findings at the elementary level are shown in the following tables. The numbers represent the percentages from combined responses of public elementary schools reporting throughout the U.S. in this survey.

Table 1 School Provides Computers for Students, Elementary Level, 2019-2020

Characteristic	Yes	Yes, in some levels	No
Computer for every student	33	45	22
Allowed to take computer home	~	6	93

Note. Reporting standard not met. The coefficient of variation for this estimate is 50% or greater.Information is excerpted from Table A-1 , https://nces.ed.gov/pubs2021/2021017.pdf

Table 2 Access To And Quality of Educational Technology, Elementary Level, 2019-2020

Characteristic	Poor or fair	Good	Very good
Overall quality of instructional computers	19	52	29
Overall quality of software used for instruction	17	53	30

Note. Information is excerpted from Table A-3, https://nces.ed.gov/pubs2021/2021017.pdf

Notable findings about the extent to which computers meet schools' instructional needs of elementary students were reported at 47% large extent, 40% moderate extent, and 13% not at all or small extent. Also reported was how easy it was to find enough computers to use with students, with the rankings of 49% for always easy, 42% usually easy, and 9% always or usually difficult (Gray & Lewis, 2021).

Table 3 shows the findings on the use of online tools for instruction at the elementary level.

Table 3 Online Tools for Instruction, Elementary Level, 2019-2020

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Interactive textbooks	20	35	31	14
Non-interactive ("click through") textbooks	31	39	25	5!
Supplemental Materials	5	38	41	16
Self-contained instructional materials	12	31	35	24
Interactive experiences	22	57	19	~

Table 3 (continued)

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Resources teachers locate themselves	~	17	48	34
Online materials teachers created	7	47	34	13

Note. Interpret data with caution; the coefficient of variation is at least 30% but less than 50%.
~ reporting standards not met. The coefficient of variation for this estimate is 50% or greater.
Information is excerpted from Table A-4, https://nces.ed.gov/pubs2021/2021017.pdf

Teachers at the elementary level reported use of technology for instructional activities normally done in the classroom at 4% not at all, 33% small extent, 46% moderate extent, and 17% not at all, 51% small extent, 34% moderate extent, and 7% large extent (Gray & Lewis, 2021).

Table 4 shows responses to professional development statements about educational technology for elementary teachers.

Table 4 Elementary Teacher Use of Educational Technology, School Year 2019-20

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Are provided with professional development on mechanics of how to use a computer or software	8	49	34	11
Are provided with professional development on how to use technology for instructing specific curriculum areas	6	42	42	10

Note. Information is excerpted from Table A-5, https://nces.ed.gov/pubs2021/2021017.pdf

Of note, elementary teachers' response data showed 59% somewhat agreed

(20% somewhat disagree) that they were sufficiently trained in the mechanics of technology, 47% somewhat agree (29% somewhat disagree) that they were sufficiently trained to integrate technology, yet 51% strongly agree that they were interested in integrating technology into their instruction. Teachers also ranked challenges – small to moderate - in staying up to date with technology (75% combined), identifying high quality technology resources (78% combined), and helping students learn basic computer skills (79% combined) (Gray & Lewis, 2021).

From an administrative viewpoint, school respondents stated challenges with staying up to date with computers and software for the school were overall not a challenge (28% no challenge, small challenge 37%), not a challenge for adequate numbers of computers nor a challenge with insufficient or inadequate software (38% no challenge, 36% small challenge) and internet speeds were not a challenge (51%) (Gray & Lewis, 2021).

Lower secondary education data are shared below. Lower secondary had more opportunities to engage with digital learning as previously mentioned due to increased standardized testing and accountability on the part of the learners and educators.

Table 5 School Provides Computers for Students, Lower Secondary Level, 2019-2020

Characteristic	Yes	Yes, in some levels	No
Computer for every student	63	20	16
Allowed to take computer home	31	67	61

Note. Information is excerpted from Table A-1 , https://nces.ed.gov/pubs2021/2021017.pdf

Table 6 Access to and Quality of Educational Technology, Lower Secondary Level, 2019-2020

Characteristic	Poor or fair	Good	Very good
Overall quality of instructional computers	14	53	33
Overall quality of software used for instruction	10	56	34

Note. Information is excerpted from Table A-3 , https://nces.ed.gov/pubs2021/2021017.pdf

Notable findings about the extent computers meet schools' instructional needs of lower secondary students were reported at 62% large extent, 33% moderate extent, and 4% not at all or small extent. Also, reported was how easy it was to find enough computers to use with students, with the rankings of 55% for always easy, 38% usually easy, and 7% always or usually difficult (Gray & Lewis, 2021).

Table 7 Online Tools for Instruction, Lower Secondary Level, 2019-2020

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Interactive textbooks	7	29	42	22
Non-interactive ("click through") textbooks	18	45	30	7
Supplemental Materials	~	21	51	26
Self-contained instructional materials	11	29	40	20
Interactive experiences	16	60	21	4!
Resources teachers locate themselves	~	10	45	45

Table 7 (continued)

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Online materials teachers created	3	39	44	14

Note. Rreporting standards not met. The coefficient of variation for this estimate is 50% or greater. Information is excerpted from Table A-4 , https://nces.ed.gov/pubs2021/2021017.pdf

Teachers at the lower secondary level reported use of technology for instructional activities normally done in classroom at ~ for not at all [~ reporting standards not met], 14% small extent, 49% moderate extent, and 26% large extent. They also ranked activities possible only through use of technologies at 3%! not at all, 39% small extent, 44% moderate extent, and 14% large extent (Gray & Lewis, 2021). Table 8 shows responses to professional development statements about educational technology for lower secondary teachers.

Table 8 Lower Secondary Teacher Use of Educational Technology, School Year 2019-20

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Are provided with professional development on mechanics of how to use a computer or software	4	42	37	16
Are provided with professional development on how to use technology for instructing specific curriculum areas	2	39	42	17

Note. Interpret data with caution; the coefficient of variation is at least 30% but less than 50%. Information is excerpted from Table A-5, https://nces.ed.gov/pubs2021/2021017.pdf

Of note, lower secondary teachers' response data showed 57% somewhat agree (21% strongly agree) that they are sufficiently trained in the mechanics

of technology, 57% somewhat agree (21% somewhat disagree as well as 21% strongly agree) that they are sufficiently trained to integrate technology, yet 49% strongly agree they are interested in integrating technology into their instruction. Teachers also ranked challenges – small to moderate - in staying up to date with technology (78% combined), identifying high quality technology resources (82% combined), and helping students learn basic computer skills (72% combined) (Gray & Lewis, 2021).

From an administrative viewpoint, school respondents stated challenges with staying up to date with computers and software for the school were overall not a challenge (32% no challenge, small challenge 37%), not a challenge for adequate numbers of computers nor a challenge with insufficient or inadequate software (55% no challenge, 19% small challenge) and internet speeds were not a challenge (47%) (Gray & Lewis, 2021).

Upper secondary education presented the highest level of public K-12 integration as the learners have more opportunities to explore elective coursework such as technology-based learning, and have more rigorous standards for mandatory coursework attainment for matriculation requirements. This level also provides opportunities for students to explore college-level coursework that is accompanied by enhanced use of digital learning opportunities.

Table 9 School Provides Computers for Students, Upper Secondary Level, 2019-2020

Characteristic	Yes	Yes, in some levels	No
Computer for every student	63	27	10
Allowed to take computer home	39	12	49

Note. Information is excerpted from Table A-1 , https://nces.ed.gov/pubs2021/2021017.pdf

Table 10 Access to and Quality Of Educational Technology, Upper Secondary Level, 2019-2020

Characteristic	Poor or fair	Good	Very good
Overall quality of instructional computers	19	51	30
Overall quality of software used for instruction	19	49	32

Note. Information is excerpted from Table A-3, https://nces.ed.gov/pubs2021/2021017.pdf

Notable findings about the extent to which computers meet schools' instructional needs of upper secondary students were reported at 57% large extent, 36% moderate extent, and 48 not at all or small extent. Also reported was how easy it was to find enough computers to use with students, with the rankings of 55% for always easy, 39% usually easy, and 7% always or usually difficult (Gray & Lewis, 2021).

Table 11 Online Tools for Instruction, Upper Secondary Level, 2019-2020

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Interactive textbooks	9	37	43	12
Non-interactive ("click through") textbooks	14	50	30	6
Supplemental Materials	#	20	56	24
Self-contained instructional materials	12	40	33	14
Interactive experiences	21	57	18	5!
Resources teachers locate themselves	~	8	44	47
Online materials teachers created	~	27	43	29

Note. ounds to zero. Iinterpret data with caution; the coefficient of variation is at least 30% but less than 50%. ~ reporting standards not met. The coefficient of variation for this estimate is 50% or greater. Information is excerpted from Table A-4 https://nces.ed.gov/pubs2021/2021017.pdf

Teachers at the upper secondary level reported use of technology for instructional activities normally done in the classroom at 0% (rounds to zero) not at all, 17% small extent, 49% moderate extent, and 34% large extent. They also ranked activities possible only through use of technologies at 3% not at all, 44% small extent, 40% moderate extent, and 14% large extent (Gray & Lewis, 2021).

Table 12 Upper Secondary Teacher Use of Educational Technology, School Year 2019-20

Characteristic	Not at all	Small extent	Moderate extent	Large extent
Are provided with professional development on mechanics of how to use a computer or software	4!	42	37	16
Are provided with professional development on how to use technology for instructing specific curriculum areas	2!	39	42	17

Note. Interpret data with caution; the coefficient of variation is at least 30% but less than 50%. Information is excerpted from Table A-5, https://nces.ed.gov/pubs2021/2021017.pdf

Of note, upper secondary teachers' response data showed 58% somewhat agree (21% strongly agree) that they are sufficiently trained in the mechanics of technology, 53% somewhat agree (20% somewhat disagree) they are sufficiently trained to integrate technology, yet 46% strongly agree they are interested in integrating technology into their instruction. Teachers also ranked challenges – small to moderate - in staying up to date with technology (72% combined), identifying high quality technology resources (78% combined),

and helping students learn basic computer skills (76% combined) (Gray & Lewis, 2021).

From an administrative viewpoint, school respondents stated that challenges with staying up to date with computers and software for the school were overall not a challenge (34% no challenge, small challenge 35%), not a challenge for adequate numbers of computers nor a challenge with insufficient or inadequate software (56% no challenge, 22% small challenge) and internet speeds were not a challenge (49%) (Gray & Lewis, 2021).

Features of digital learning

Features of digital learning nationally include blended or *tradigital* learning, learner centered education with emphasis on communication, collaboration, creativity and critical thinking and personalized learning (Seymour, 2019). These learner and educator centered types of learning are fundamental to effective digital learning with technology devices.

Feature 1: Blended or tradigital learning

Prior to the global pandemic, blended learning was becoming a strong presence in U.S. educational settings. Research showed that student engagement, achievement and overall perceptions of blended learning increased. Students developed skills outside the curricular ones such as self-pacing and self-directing for learning (Hesse, 2017). Blended learning in the U.S. combines the traditional face to face experience with an online component. In the U.S., blended learning is termed as hybrid, hyflex, targeted, multimodal, or flipped learning. Seymour (2017) utilized the phrase "tradigital learning" to emphasize a blending of best teaching practices from the traditional classroom combined with those of a digital learning environment. The Pickering Local School District in Ohio was an early adopter of tradigital blended learning for all students, with a hybrid model promoted by Seymour. Clarke County

School District, Georgia, has a student population with 34 native languages spoken and 12,000 students with the third highest poverty rate for a county of its size (Office of Educational Technology, n.d.f.). They focus on aggressive multimodal learning through innovative learning environments with digital platforms aligned to make all content accessible to all schools.

Feature 2: Digital curriculum and resources

Teachers use digital textbooks, e-books, interactive whiteboards, and educational apps to enhance the digital learning experience. The value of digital resources lies in the ability to customize the learning environment to meet the needs of the learner as well as to meet the needs of the educational system.

Bouchrika (2023) reported that gamification of content is most used to enhance overall interest in the lesson content. He further stated, "Online educational videos (67%) are the most used learning materials in K-12 classrooms, followed by educational software or apps (6%). Only 17% of K-12 classes used e-books" (para. 12). Baltimore County Public School District system developed a multi-year comprehensive plan to integrate curriculum, instruction, and assessment along with infrastructure, policy, budget, and communication to ensure an equitable, effective digital learning environment is available for all students (Office of Educational Technology, n.d.c.).

Feature 3: Learning analytics

U.S. public schools have embraced the need for data mining and analytics to understand how students learn, and how to adapt their curricula to personalize the instruction and learning environment. Use of data to make informed decisions in school systems is not a new concept, but with the increased use of learning management systems and other applications to analyze online student behavior, U.S. schools are better poised to customize their educational experiences to maximize the learning opportunities for all students through model-

ing, profiling, and trend analysis (Office of Educational Technology, 2012). Sitka School District, Alaska, needed to transform to digital learning, and to do this they focused on developing a Professional Learning Community (PLC) and curriculum integration specific to the needs of the Indigenous population for Arts, culture, and technology. They developed standards based on learner needs that ensured a respect for the place in which they lived and valued as a community (Office of Educational Technology, n.d.e.).

Feature 4: 1:1 device initiatives

Many U.S. public schools have implemented 1:1 device programs whereby each student is provided with a laptop, tablet, or other digital device. The students can access their digital learning materials, collaborate with other students online, chat or email with their teachers, and complete their assignments digitally. McAllen Independent School District in Texas is a large system with 33 campuses and approximately 30,000 students. The system supports 60,000 access points for 100,000 devices for students. Its goal was to provide each student and staff member with a tablet or mini tablet and digital folders for progress monitoring (Office of Educational Technology, n.d.).

Feature 5: Digital privacy

The U.S. Department of Education, Office of Educational Technology, provides many policies and guidelines for all school systems to use to ensure student and educator privacy while using online resources. Consistent with educational privacy acts such as Family Educational Rights and Privacy Act (FERPA), Children's Online Privacy Protection Acts (COPPA), children's Internet Protection Act (CIPA), and Protection of Pupil Rights Amendment (PPRA), the office provides a Privacy Technical Assistance Center to provide a framework for service agreements, questions related to privacy, confidentiality, and security practices for school systems. Compliance with the previously mentioned acts is mandatory to receive federal funding at a competitive rate

for broadband and computer budgeting. U.S. school systems understand the need to protect students under the age of 13 while using the internet or digital learning tools along with ensuring their school systems and libraries monitor concerns regarding students' access to obscene or harmful content over the internet (Office of Educational Technology, n.d.). Three large U.S. universities have developed programs for use in public k-12 schools to instruct students about online privacy, its danger, benefits, and appropriate use (Srivastava, 2020).

Trends and Issues of Digital Learning

U.S. educators acknowledge that digital learning is fast growing and increasingly being adopted by school systems despite some challenges associated with this growth. The sections below detail trends and issues faced by school systems.

Trends in digital learning

Trend 1: Online learning

Digital learning in the guise of online learning is here to stay, but has undergone dramatic changes in delivery, focus, and instruction since the remote emergency learning necessitated by the pandemic. School systems are now offering permanent virtual learning options and blended or flipped classrooms for students. The increased acceptance and use of online learning has also promoted an increase in the ease of digital tools and platforms to facilitate online learning, along with increases in internet connectivity access. Mobile learning is a sidebar trend to online learning as the increased demand for learning platforms has brought into focus the need for learning anytime, anywhere so the platforms are programmed to be easily accessible on mobile devices.

Trend 2: Personalized learning

Personalized learning is at the forefront of digital learning trends as educators can customize instruction and administer adaptive assessments customized to each learner's specific needs, focusing on their strengths and weaknesses in the content area. Bloom (1984) reported that students who received personalized learning outperformed others by 98%. In the U.S., the key components that are required to achieve personalized learning are flexible content and tools to meet the needs of the learner, targeted instruction, data-driven instruction (discussed below), and most importantly, student reflection and ownership of the learning. Personalized learning is touted as a new standard for students to achieve digital learning, especially those who are considered digital natives with innate desires to use technology in their learning. Personalized learning does require intense preparation, scalability, consistent instruction, and the ability to mediate between grade level standards and competency-based learning (Frackiewicz, 2023).

Trend 3: Coding and computer science

Many school systems are offering secondary school students coding and computer science courses. Schools are integrating the coding and computer science curricula into other core subjects to help learners understand the vital connections of these digital skills and literacy to mainstream academic learning.

Trend 4: Gamification and game based learning

Gamification and Game-Based Learning are trending nationally in the U.S. with 66% of K-2 teachers using games weekly or more often, 79% of grade 3-5 teachers, 47% of grade 6-8 teachers, and 40% of grade 9-12 teachers, according to a survey hosted by University of Michigan School of Information (2013a, para. 10). This survey reported that teachers used games or gamifica-

tion for formative assessments specifically of facts and knowledge (68%), concepts and big ideas (64%), and mastery of specific skills (59%) (2013b, para.5). Gamification integrates game elements, such as badges, points, and leaderboards, into the learning process to enhance student engagement and motivation. Game-based learning uses educational games as a central component of instruction to teach specific skills and concepts in an interactive and enjoyable manner. Research showed that well-designed games will help students engage in those topics they may struggle with or not have much interest in such as mathematics (Novotney, 2015).

Trend 5: Augmented reality, virtual reality, and artificial intelligence

Augmented Reality (AR), Virtual Reality (VR) and Artificial Intelligence (AI) are often seen as the same digital tools, but they do have distinct differences, yet all are used in today's digital learning environments in the U.S. AR and VR experiences allow users to immersively interact with objects and the environment. AR "combines…virtual and real object in a real environment through mobile devices" (Al-Azawi et al., 2019, p. 37). This real-world experience by using computer-generated information as an overlay and virtual reality provides experiences that mimic real or very believable experiences in a virtual way of concept immersion (i.e., virtual field trips used in schools). AR and VR technologies are being increasingly integrated into the classroom experience to provide a more equitable learning experience for all school systems.

Chen et al. (2020) defined AI as not only a field of study but also as a study area. Chen further asserts that in educational settings, AI supports "intelligent education, innovative virtual learning, and data analysis and prediction" (p. 75267). Intelligent education assists in personalized learning, another digital trend, and data feedback is a trend described in the following paragraph. Chassignol et al. (2018) posited that "AI applications are in wide use by educators and learners today, with some variations between K-12 and university settings" (p. 17).

Trend 6: Data driven decision making

Another major trend is the use of data driven decision making and instruction. Schools are heavily into developing analytics gleaned from their learning management systems or other analytical tools to assess areas of improvement, track student progress, and make decisions. These analytics are data-informed results about digital learning or other instructional tools to enhance instruction and learning. As stated previously, AI plays a part in this data-driven analysis, specifically in data mining, prediction systems, evaluation and grading of papers and exams, and online learning scenarios (Chen et al, 2020).

Issues in digital learning

Issue 1: The digital divide

U.S. school systems face one of the largest issues due to a phenomenon defined as the "digital use divide" (Office of Educational Technology, 2017, p. 7). A traditional definition of this term, digital divide, denoted students with access to internet and devices at school and home versus those who did not. The emergency remote learning promulgated by the pandemic caused a marked increase in the connectivity offered throughout the U.S., with nearly half of public schools stating that they provided internet connectivity for those students who did not have home access or school systems, while more than 56% reported providing access at other locations such as libraries or parking lots (Institute of Education Sciences, 2022). Having access does not always include a high-speed connection (broadband) and the need to share one device in a home with slow, dial up connections still existed in some geographical regions of the country. Despite these emergency efforts during the global pandemic, nearly 12 million school age learners remained disconnected from digital learning due to connectivity issues, infrastructure, and lackluster adoption of digital learning programs (Reardon, 2021).

A student's socio-economic status impacts how likely they are to have access to technology required for digital learning. In the U.S., 35% of households with school-age students with an annual income of less than $30,000 do not have access to or easy availability of high-speed connectivity. Compared with households with incomes $75,000 and above, only 6% do not have high speed connectivity (Anderson & Perrin, 2018).

Issue 2: Digital "use" divide (expanded from digital divide)

With the insertion of the word use in the term, it now denotes learners who use technology in "active, creative ways to support their learning" from "those who predominately use technology for passive content consumption" (Office of Educational Technology, p. 7). Considerations of this definition are *active* and *creative* ways rather than *passive* consumption. Olszewski and Crompton (2020) asserted that the effect of digital learning is not necessarily guided by quantity and quality of educational artifacts, but "what students and teachers do with the technology available" (p. 7). This issue of lack of connectivity or lack of engaged creative digital learning affects all the trends listed above as each is integrally dependent on connectivity.

Issue 3: Equity and inclusion concerns

Although digital learning provides flexibility and personalized learning for students, it can also intensify existing inequities due to disabilities, special needs, or language barriers. Learners with exceptionalities (disabilities or language barriers) and English language learners struggle with accessing digital artifacts and other online resources. Students with special learning needs require technologies to support their learning needs, which often has an extreme impact on the school's already limited technology budget.

Issue 4: Professional development

Lack of professional training along with resistance to change and budget limi-

tations are other typical issues educators and school systems report as barriers to higher levels of digital learning and engagement. Due to rapid changes in technology and accompanying artifacts, many teachers had to adapt quickly without access to sufficient professional development. Many teachers also lack current technology skills which impedes their learning process to navigate the digital learning platforms. A lack of timely training for teachers has led to varying levels of digital learning proficiencies throughout the nation. Many school systems utilized in-house trainers for their professional development, and often these trainers were newer to or were not trained in utilizing digital learning platforms. Time for dedicated professional development is also a factor in providing quality, timely learning opportunities as teachers are paid for teaching hours with limited time built in for professional development opportunities.

Issue 5: School infrastructure

School infrastructure is a concern as funding is provided by local and state systems, along with varying levels of funding from the federal government, and infrastructure changes and upgrades are expensive. School buildings themselves are often outdated with no budgeting to upgrade the physical facility, much less to increase technology infrastructure needs. Most U.S. school systems do have adequate IT support to keep the technology they have on site working, which is a stress reliever to the educators using the devices. Again, funding for school facility infrastructure including building maintenance and for technology can vary from system to system, and most rely on local support to provide as much digital learning as feasible within their allotted budget.

Conclusion

Digital learning and transformation are foundations in the advancement of United States public K-12 educational systems, and have experienced tremendous growth since the global pandemic (COVID-19) in 2020, like other countries. This unprecedented growth has shown that digital learning is vital to student engagement, persistence in learning, and equity in educational access.

Most U.S. public schools operate at minimum at the digitalization level, apart from early childhood education which restricts access to technology based on input from the American Academy of Pediatrics and operates at the digitization level (Stage I). Higher levels of transformation occur in lower and upper secondary education through higher education and skilled training facilities as the learners are exposed to more opportunities for collaborative, student-based learning (digital transformation).

Digital learning in the U.S. is firmly situated in most classrooms, with schools offering access to technology to all students, either in individual classrooms or via a 1:1 program. U.S. schools are adopting more digital curricula items such as e-textbooks, interactive textbooks, multimedia content, and educational apps (applications). Using digital learning, the school systems can collect and analyze student data, thereby providing valuable insights for educators to track progress, identify areas of improvement, and personalize instruction. This data-driven decision digital instruction informs teaching strategies, student interventions, and required curriculum modifications to meet individual learner needs effectively.

As stated, COVID-19 brought about drastic, immediate changes in the modalities used to present education in the U.S. as well as globally. School systems adapted to offering learning via online methods instituted the use of Learning Management Systems in many systems, and reviewed how education was of-

fered to those who were unable to be present in the classroom. This change in instruction instituted many new digital tools to assist learners, and many of those tools are still in use for learners as systems decided to continue offering internet access and online learning for learners. Schools are also utilizing the LMSs instituted during the pandemic as improved methods of connecting content with the learners.

Infrastructure in U.S. public schools varies by localities, urban or rural for example, but for the most part, school systems feel they have adequate facilities. However, more is needed to push their digital learning into the transformative stage for learner centric design thinking. A major factor in infrastructure is the digital divide, also called the digital use divide. This divide is based on the geographic constraints of many systems to access high speed connectivity for their learners. Another key component is increase in professional development for all involved in U.S. K-12 education. These professional development learning opportunities enhance digital literacy, instructional technology skills, and pedagogical approaches for incorporating digital learning effectively for all learners.

Like other highly digital competitive countries, the U.S. school system is exploring how to integrate Artificial Intelligence (AI). Considering the upsurge in the prevalence of AI, President Biden and the White House formally asked IT companies to commit to voluntary standards to manage the risks posed by AI for all citizens. This is very impactful for K-12 education as cybersecurity and public trust including harmful bias, discrimination, and privacy are all key components of public-school infrastructure (The White House, 2023). K-12 education is endorsing digital literacy as a keystone for future economic and workplace success. Personalized learning is a trend that many systems utilized with the advent of the LMS tools, videos, and other applications to promote remote learning. Issues are the concerns about AI mentioned as well as the digital divide that is still prevalent in the country. Professional development

is a concern as it is difficult to maintain currency in training with the rapid changes in technology applications.

Overall, the United States K-12 educational system is positioned to advance its digital learning tools and achieve a stronger foothold in digital transformation for all learners throughout the country. The government has proactively addressed issues and provided funding to assist school systems in overcoming challenges so that all U.S. K-12 students have an equitable opportunity to experience a high-quality digital learning experience.

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