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The Evolution of the Chief Technology Officer and the Modernization of Technology in Education

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**THE EVOLUTION OF THE CHIEF TECHNOLOGY OFFICER AND
THE MODERNIZATION OF TECHNOLOGY IN EDUCATION**

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Abstract

The role of technology in education has changed dramatically over the past 20 years. From the advent of individual workstations to networked labs to one-to-one technologies, computers have transformed how teachers and students consume information. School districts today support hundreds if not thousands of devices and end users. Technology supports mission critical systems like financial, human resources, library, and student information systems and ensures they are integrating rostering information to numerous third-party programs like Clever, Classlink or textbook specific websites. They also support the district operations as well by assisting in or managing building automation controls which can include lighting, heating and cooling along with physical security which includes security cameras and access control systems.

With this rapid change of technology's usage, the rise in the individuals who support these systems and maintaining them have rapidly grown as well. Gone is the position that began as a part-time teacher who knew a little bit about computers. Now this person is a visionary leader for the school district. A pillar to any administrative team today is the Chief Technology Officer (CTO) who is tasked with being a leader, a bridge between technology, operations and instruction, is collaborative and has a wide, diverse skill set.

Today's CTO is paving the way forward integrating new technologies in the classroom, onsite and virtually, while ensuring that it is done in the safest and most secure ways. CTOs are looked upon as experts in their field who constantly research new opportunities, stay on top of trends and whose department has a hand in working with every employee in a school district.

With the rapid rise of cloud computing and more student data residing in the cloud, CTOs have been susceptible to third-party vendors data breaches or malware attacks. This is in addition to similar attacks that can happen internally with DDoS, ransomware or malware attacks on a school's internal systems. CTOs must have a balance on understanding the needs of the present, looking at new future trends, and improving from the past.

Introduction

The role of technology in education has dramatically transformed the landscape of how K-12 teachers are instructing their students, how current teachers prepare lessons and how students consume information. This research paper will seek to show how the advancement and changes in technology has affected the education institution over the past 20-30 years.

Almost 20-30 years ago, the CTO title did not exist, they were considered technology managers or coordinators; very few held the title of director. Their purpose was to begin building out connecting computers and departments with on-premise file servers using either Microsoft Active Directory or Novell's NetWare. They were the ones having conversations with the leadership about the need to spend large amounts of money on designing an infrastructure within schools, providing employees with computers and printers. The cost of these items were not cheap so a school district's investment were easily hundreds of thousands of dollars. Originally, educational grants funded this initial infuse of technology in schools. This was just the cost of hardware, now add on the cost of software like client access licenses or licensing for Microsoft Office. However, very few developed lifecycle replacement plans for any of this equipment and three-to-five years later school district had to begin budgeting replacing expenses.

While these employees were trusted with building out these new technologies and managing hundreds of thousands of dollars, many were never given a seat at the leadership table. Early on, what was occurring were others making decisions that those in technology departments had no say or opportunity to guide in those discussions.

Over the years, the path of the CTO has evolved from two unique paths – nuts and bolts (networking) people and teachers. In its infancy, there were also instructional leaders who would help integrating the technology into the curriculum. Regardless of the path, to be the best, those in the technology roles needed to begin to learn about both sides and become the bridge.

The Emergence of Technology in Schools

Decades before we ever knew what a keyboard or mouse were, there was technology advancement in our classrooms. The creation of the overhead projector, radio, films, typewriters, cameras, television, photocopiers, calculators and Scantrons were significant inventions because these brought a new style of learning into education. Then, the first computer labs appeared in the 1980s where Apple Macintosh computers were the cornerstone device. However, it was the creation of the World Wide Web (WWW) or the Internet that really ignited this revolution.

In the early 1990's, information was passed around on floppy disks, albeit in a limited amount of data at 1.44MB but with the growth of the CD-ROM manufacturers could share upwards of 700MB of data. With CD-ROMs gaining popularity, we saw our first digital encyclopedia called Encarta which was developed by Microsoft.

When the World Wide Web (WWW) was made public in 1993, the only available means of getting there was through dial-up modems that used existing telephone lines and connected at speeds of 14.4kbps, 28.8kbps and eventually 56kbps. With the World Wide Web and its information in existence, were now able to use search engines like AOL, Webcrawler, Lycos, Excite, Ask Jeeves, and Yahoo to help us find websites that contain what we were searching for. These search engine sites all existed before Google launched in 1998.

Also, launching in 1998 was the redesigned Apple iMac G3, an all-in-one computer that became an instant success in the educational sector. This was a computer that made it easy for all teachers, staff and students to use and these would become staples in teacher's classrooms and in student computer labs.

At this time, school districts began investing in developing a network infrastructure that would be rooted in the ethernet 802.3 protocol. Up to this point, networks were connected through protocols like AppleTalk (phone cable) and 10BASE2 (coax cable) and were limited in the amount of data that could be shared between devices. Internet connectivity was created through bonded dial-up or ISDN modems which were faster than traditional modems but more expensive.

Instructionally, the mass addition of computers into schools was exciting. Schools dedicated rooms to these new computer labs, signed out times and brought classes of students down to work on computers. Was it unique, yes; but nothing instructionally significant. It was an advancement from the previous typewriter labs.

A 14th century illustration by Laurentius de Voltolina shows a university lecture in medival Italy which parallels many of today's classrooms. Teachers lecture from a podium in the front of the room while students sit in rows and listen. Some students have books open in front of them, some look bored, and some are talking to their neighbors. (Purdue Online)

Figure 1: de Voltolina depiction of lecture in medieval Italy

Modernize the classroom spaces by trading out books for laptops and one can say today's classrooms look no different than these same spaces centuries ago. The addition of technology access of information in education has drastically changed. Initially, books were rare and only the elite few had access to them. Now, because of technology and the Internet massive amount of information (books, audio, images, and videos) are available at one's

fingertips because of the Internet. The access to learning opportunities today is unpresented in thanks to technology. (Purdue Online).

Additionally, technology has presented new opportunities in communication. Instead of a classroom being isolated, technology has provided students in rural and urban settings the ability to collaborate with classrooms in other cities or countries and allows them to learn about a topic in a more current and modern way like through blogs, photos, websites or video conferencing. (Purdue Online) Technology has been a force to remove the classroom walls as a barrier to learning outside of school.

Furthermore, technology has provided an opportunity for teachers and learners roles to change. In the past, the teacher was the content expert or primary source of information, but now with the ease of access to information, technology has enabled students to take a greater role in their own education. Technology is a very powerful tool that is supporting and transforming education in many different ways. (Purdue Online) With most everyone having access to the Internet and a smart device, we are no longer in the early stages of "anytime anywhere education", we are fully embedded in and it needs to be embraced.

Since the start technology in education, new advances and trends have always come into play. Some of the trends have stuck while others might be considered a fad. Almost 22 years ago, Wi-Fi was introduced as an option on laptops. In 2001, research started on the importance of technology literacy, integrating technology into educational practices and the impact it will have on curriculum. In 2002, with the Open Education Resource Movement, Google had plans to create a universal library by scanning and digitizing almost every book written and making them all publicly online. Web 2.0 was a redesign on how users could consume information, this made users now the creators. Social media websites like Facebook and MySpace launched, blogging and wikis became another way for users to become the creators and video content could be uploaded to YouTube. Additionally, one of the biggest changes in education came with the launch of Google Apps for Education which consisted of Gmail, Hangouts, Calendar, Drive, Docs, Sheets, Slides, Forms and Sites.

In 2003, SMART Technologies became the leader in SMART Boards or interactive whiteboards. Teachers were able to directly connect their computers to this device and then be able to digital write on what was being presented. Initially, teachers were terrified and confused but those who used it gradually became more comfortable with it. (Yoshida, 2021) Along with

simpler lesson planning, a study in 2009 showed an increase in student engagement, suggesting that it was easier for students to participate and made class more enjoyable. (Yoshida, 2021) According to the International Institute for Science, Technology, and Education (IISTE), increased engagement stimulates thinking and leads to an increased personal understanding of concepts. Furthermore, according to the Social Science Research Network (SSRN), 65% of the population are visual learners, and SMART Boards can display high-resolution photos and graphics. (Yoshida, 2021)

Though there were drawbacks to the SMART Boards. First, they were expensive, usually over $3,000 and then add in the cost of installation. The second drawback was the board's functionality as the device aged and this technology quickly became outdated. Due to the high initial purchase price, many district could not afford to replace them with newer boards. Towards the end of board's life, teachers would just use it as a projector screen.

Figure 2: Example of a SMART Board

Today's CTO Expertise

Necessary CTO Skills

The Consortium for School Networking (CoSN) developed a Framework of Essential Skills for all K-12 Chief Technology Officers (CTO) that focused on three primary categories:

- leadership and vision
- understanding the education environment
- managing technology and support resources

Each of these categories include 10 essential skill areas focusing on responsibilities and knowledge needed to be an educational technology leader. These 10 essential skill areas are focused on:

- leadership and vision
- ethics and policies
- strategic planning
- instructional focus and professional development
- team building and staffing
- shareholder focus
- information technology management
- communication systems management
- business management
- data management

I. Leadership + Vision

Leadership + Vision | Ethics + Policies | Strategic Planning

II. Understanding the Educational Environment

Instructional Focus + Prof. Development | Team Building + Staffing | Stakeholder Focus

III. Managing Technology & Support Resources

Information Technology Management | Communication Systems Management | Business Management | Data Management

Figure 3: Framework of Essential Skills for the K-12 CTO

Today's technology leaders must be multi-dimensional. These individuals are now expected to cast visions and set goals towards technology usage. They must work with other individuals in the organization to help transform technology use not only in an instructional setting but also operationally. They must understand policies and procedures that govern their profession and school districts. Leaders must have the ability to budget, plan and provide meaningful professional learning for all staff members. They must work to create strong support teams for all staff members and students. Additionally, technology leaders must have a strong knowledge in technical system, infrastructure, device management and disaster recovery. They need to ensure technology is being effectively used to reach all stakeholders. Finally, they must ensure that privacy and security practices are in place.

Network Infrastructure / Cybersecurity

Figure 4: Infrastructure - To Support Everywhere, All the Time Learning

Reliable connectivity, like water and electricity, is foundational to creating an effective learning environment. Students and teachers cannot take advantage of the opportunities to connect and engage globally or leverage high-quality learning resources without consistent and

reliable access to the Internet. Preparing students to be successful for the future requires a robust and flexible learning infrastructure capable of supporting new types of engagement and providing ubiquitous access to the technology tools that allow students to create, design, and explore. The essential components of an infrastructure capable of supporting transformational learning experiences include the following: (Office of Educational Technology, 2017)

- **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

In 2013, President Obama's ConnectED initiative set a goal for 99 percent of students in the country to have Internet access at a minimum of 100 megabits per second per 1,000 students, with a target speed of one gigabit per second by 2018. (Office of Educational Technology, 2017) Through the help of the existing E-rate program this financially assisted school districts to begin to improve the speed of their internal networks and access to the Internet. With that said, gone are the days of 10-basedT hubs or switches and Category 5 ethernet cable. Since the COVID-19 pandemic, school districts with antiquated network infrastructure will not be able to support the volume of devices trying to connect to the network. Most schools have moved to a one-to-one model, with 90 percent of district leaders reporting a device for every middle and high school student and 84 percent reporting the same for elementary students, according to an Education Week survey. (Hargis, 2022)

Today's modern network infrastructure is rooted in multi-gigabit networking. School networks maintain enterprise-level devices like multi-gigabit firewalls, switches, fiber backbones, wireless bridges, wireless access points, data centers with numerous physical and virtual servers, redundant co-location data centers, uninterruptable power supplies (UPS), and generators.

Student and staff devices are not the only ed tech gear clamoring for bandwidth. Security cameras, VoIP phones and Internet of Things technologies, from cloud-based digital signage to smart door locks for access control, also connect to the school's network. School networks contain multiple virtual networks (VLANs) which divide a single existing physical network into multiple logical networks. Communication between two different VLANs is only possible through a router that has been connected to both VLANs. With the increased amounts of devices that now exist on networks like access points, security cameras, access control devices, VoIP

phones and guest devices, VLANs are extremely important to have configured to help reduce network traffic, improve network performance, and increases the network's security.

CTOs must ensure that their network infrastructure is secured. School networks need enterprise-class security measures to help protect their students, staff, and data from cyberattacks. The educational sector saw an incredible rise in cyberattacks during the COVID-19 pandemic as more and more people started using connected devices for school. Cybersecurity threats have been around before targeting educational institutions, they were primarily in the banking and financial sectors. Cyberattacks not only compromise the safety and security of teachers and school administrations, but also the privacy of students particularly minors in K-12 institutions. (Intel, 2021)
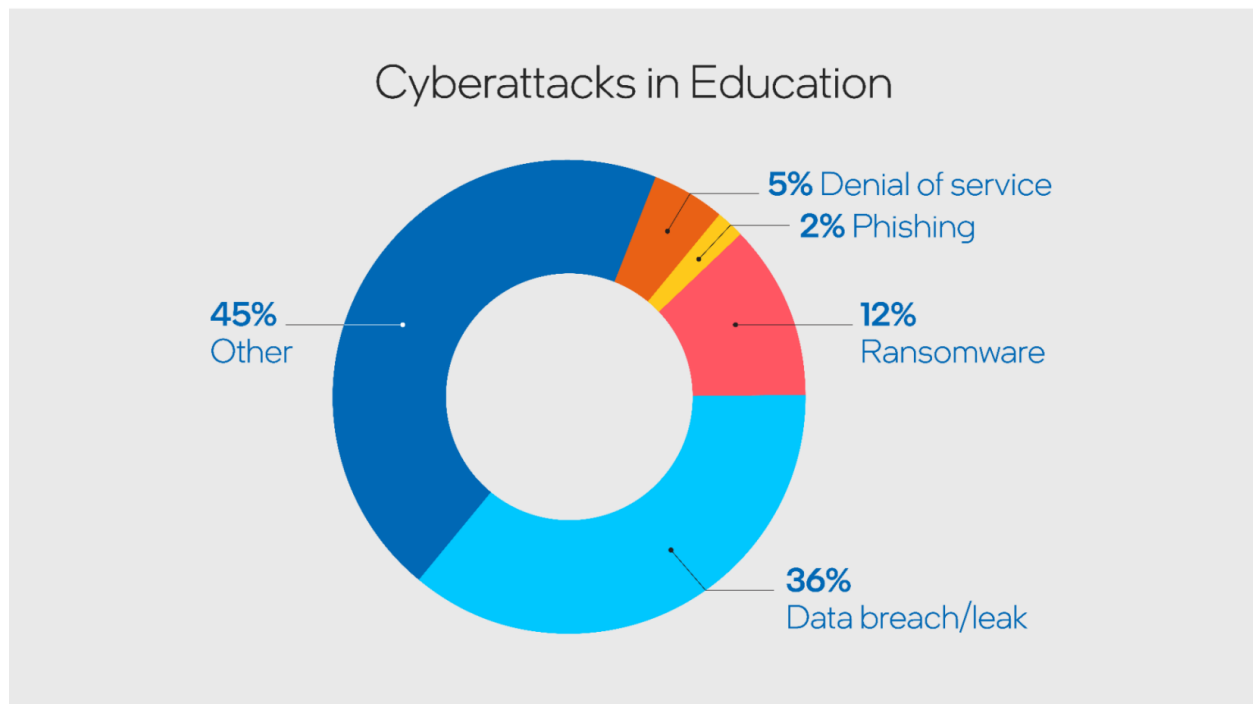
Figure 5: Cyberattacks in Education

- 44% of technology leaders in the education sector experienced a ransomware attack. This is the highest level of attack compared to a variety of other industries such as healthcare, IT, and local government.
- 87% of K-12 school districts have experienced at least one attack.
- Among all industries, the education sector is one of the least secure, and schools are the second most lucrative target for ransomware.
  (Intel, 2021)

According to a Gartner article, K-12 institutes will continue to be a prime target for ransomware attacks through 2028. Numerous law enforcement agencies like the Federal Bureau of Investigation (FBI), the Cybersecurity and Infrastructure Security Agency (CISA) and the Multi-State Information Sharing and Analysis Center (MS-ISAC) anticipate an increase in attacks over the next few years as criminals view potential opportunities for successful attacks.
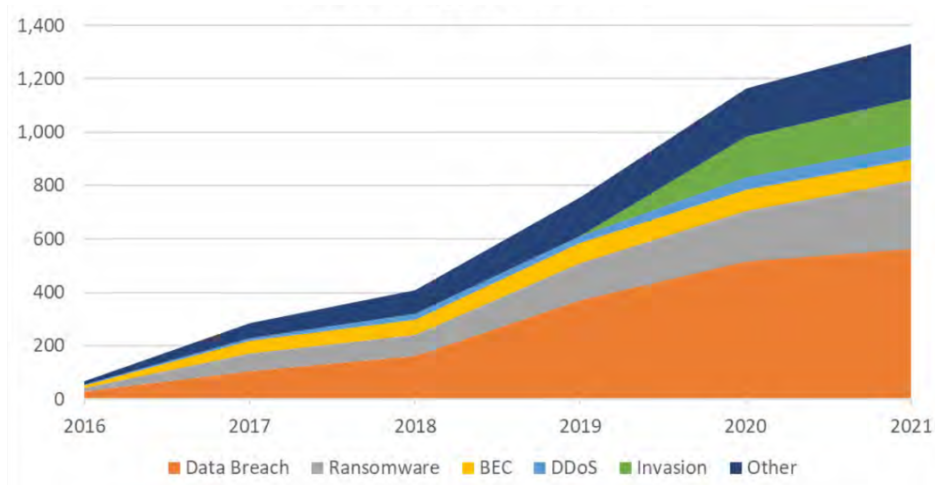
Figure 6: Number of Publicly-Disclosed K-12 Cyber Incidents by Incident Type (2016-2021)

Most insurance companies now require K-12 school districts to hold cybersecurity insurance. Over the past five years, premiums have gone up exponentially in addition to deductible amounts. Some insurance companies have gone as far as asking their members to go through a cybersecurity audit. Starting on July 1, 2021, Illinois public schools must "implement and maintain reasonable security procedures and practices that otherwise meet or exceed industry standards designed to protect covered information from unauthorized access, destruction, use, modification, or disclosure" (105 ILCS 85/15) (Learning Technology Center, 2021)

With the assistance of the Illinois Learning Technology Center, they selected 43 security best practices that all districts should implement to comply with the state legislation. Topics include: (Learning Technology Center, 2021)

- Hardware and software assets
- Vulnerability management
- Admin privileges and secure configurations
- Maintenance, monitoring and auditing logs

- Malware, email and browsers
- Network ports, protocols and services
- Data recovery and protection
- Wireless access control

Cybersecurity varies slightly between K-12 and higher education but is equally important. Keeping student information secure is especially vital for those under the age of 18 in K-12 institutions. While the Family Educational Rights and Privacy Act (FERPA) of 1974 protects student records, it does not require K-12 schools to adopt specific security protocols. Some states have individual laws that protect students online, like the Student Online Personal Information Protection Act (SOPIPA) in the United States [In Illinois, it is called the Student Online Personal Protection Act (SOPPA)], but these laws are not enforced at a federal level, often leaving an individual school district's CTOs to protect student and teacher data and privacy. (Intel, 2021)

Moreover, CTOs are also protecting against the human factors of cybersecurity. Human error is the leading cause of cybersecurity breaches like opening spam messages, malicious URLs and malware. Furthermore, CTOs work to protect against Distributed Denial-of-Service (DDoS) attacks. This cybercrime is where the attackers flood a school district's Internet connection with internet traffic to prevent users from accessing connected online services and sites.

Ransomware attacks are a global issue. In a recent survey, 320 K-12 institutions in 31 countries, 56% stated that they have been hit by ransomware. (Calhoun Williams, 2023). In 2021, there were 62 instances of ransomware attacks on K-12 institutions in over 24 states. Those who attack school districts are fully aware of the direct impact their attacks have on K-12 environments. School districts manage a significant amount of sensitive information but lack the significant resources compared to other industries to adequately protect this information.

Ransomware attacks have caused the following types of disruptions:

- Cancellation of in-class learning between one to three days
- Recovery of services prior to the attack levels might take weeks or months
- Data breaches have resulted in personal data of student, faculty and staff being exposed

For example, in a recent data breach in the file sharing application called MOVEit, up to 45,000 NYC students and staff sensitive data was exposed. Almost 19,000 documents were accessed in this breach which included student evaluations, Medicaid reports and other internal records. While the software was patched within hours of the breach, the damage was already done. (Shen-Berro, 2023)

Over 90% of cyberattacks start with a phishing attack. (CoSN) Phishing emails are becoming more complex and harder to detect. These emails are deceptive and fraudulent where they try to mimic the Superintendent to elicit proprietary information.

Digital Equity and Bandwidth

In the 2022 paper *Driving K-12 Innovation: Hurdles and Accelerators* by CoSN, since the pandemic 20-40% of U.S. students now have access to high-speed internet and a device. The pandemic highlighted challenges that are faced by students in higher poverty areas. "Schools have to remain agile and plan for any circumstance. There also needs to be renewed commitment to ensuring access to education and digital learning for the less resourced parts of the U.S. and the world in general." (Lucy Gray, Lucy Gray Consulting, Illinois)

Since the pandemic school districts have worked quickly to create equitable access for all students. Technology leaders must work to provide students the resources to experience anywhere, anytime learning. To achieve this school districts, need to provide equitable access to devices and access to high-speed Internet. This could require leaders to devise out of the box ideas and solutions ensuring students come first. In Illinois, with the creation of Public Act 101-0012 which went into effect on July 1, 2019, this enabled all K-12 school districts to take advantage of e-Learning days which could be used in place of traditional snow days.

Artificial Intelligence

In CoSN's paper *Driving K-12 Innovation 2023 Tech Enablers*, mentions Artificial Intelligence (AI) as one of its top three tech enablers with 52% of responses. AI has potential for helping teacher craft better lesson plans by pulling content online (text, images and video) and these lessons can then be personalized to individual students or learning needs. School districts need to ensure that if using AI that the idea of equity is at the forefront so it helps all students in

positive and constructive ways. Technology leaders will need to be the ones guiding our school leadership, state and federal legislatures on appropriate laws and policies.

School districts must communicate and educate their staffs about the potential benefits of AI because it already exists in schools and our society, even if it is not always recognized. Look at cars that use sensors to make "intelligent" decisions about traction control, changing lanes or parallel parking! (Holland, 2023). Look at the widespread use of Fitbits and Apple Watch, it helps us avoid traffic, send text message by voice and even remembers our to-do lists!

Meta Platforms and Netflix utilize AI to recommend what movies to recommend to us in their dashboards. Facebook uses AI to screen images so nude images are not shown. (Bowman, 2023). Products like Duolingo have already incorporated some AI into its product to assist users with language translation. AI products like ChatGPT are finding usefulness in assisting students with writing or improving their writing skills. An example is Grammarly which boasts about 30 million users.

Artificial Intelligence has the potential to be influential in almost all aspects of education and in our lives. So technically, AI are sets of algorithms, rules and data sets that operate within a specific domain; however, in education, most of AI is really machine learning. (Holland, 2023) Machine Learning is the process of training AI by developing algorithm responses based on sets of programmed rules within a defined context of a data set. (Holland, 2023) Furthermore, within Machine Learning is Deep Learning, a technology that uses inter-connected sets of algorithms similar to neural networks to look for and recognize complex patterns. (Holland, 2023) As a result of this, AI can be used for facial recognition, recognizing speech patterns or translations services. AI can provide usefulness in early childhood education like helping track children's behaviors and helping to develop language skills. Another area it can serve useful is in tutoring students. AI can provide students a detailed and personalized study plan in any subject. Classes topics that best suit AI are geography, languages, physics, math, computer programming and chemistry. (Bowman, 2023)

EXAMPLES OF AI IN EDUCATION

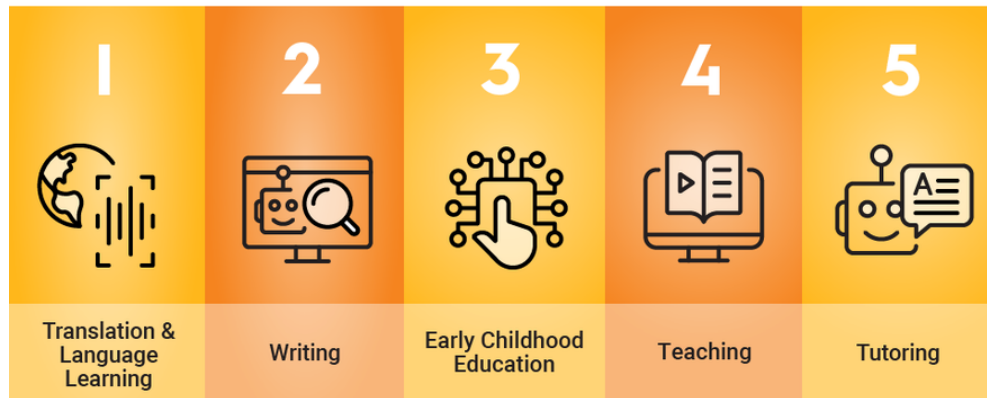| 1	2	3	4	5
Translation & Language Learning	Writing	Early Childhood Education	Teaching	Tutoring

Figure 7: Effects of AI in Education

The potential in education lies in how teachers use AI to augment what they already are doing in the classroom which could allow them to become more adaptive to the needs of their students and less worried about routine, repetitive tasks. (Holland, 2023) AI could allow teachers and administrators the ability to track indicators of a student's progress on traditional tests or classroom outcomes and instead support a collaborative learning approach. Artificial Intelligence will not completely disrupt the school system ecosystem but it will likely supplement the existing infrastructure. Most of all, in the end AI will likely improve learning outcomes and free up teachers to focus on areas where they can add more value. (Bowman, 2023).

Additionally, AI has been used to enhance campus security by implementing fingerprint readers, drivers' license scanners like Raptor Technologies, and security cameras. Using Maching Learning AI can analyze the signatures of know malware and use this information to detect similar malware. It can be used to scan and analyze log files, unauthorized access attempts and other suspicious activities quicker than any human can.

AI is developing faster than policies or oversight committees can discuss and so a potential downfall is the concerns about student privacy, potential discrimination, and truthfully the long-term effect of student learning in a constant state of surveillance. (Holland, 2023).

Devices and Software

Technology leaders 20-30 years ago worried about maintaining a couple computer labs in their schools and those in different departments for staff members. The labs were likely updated with an imaging software like Symantec's Ghost where a "golden master" was created which had
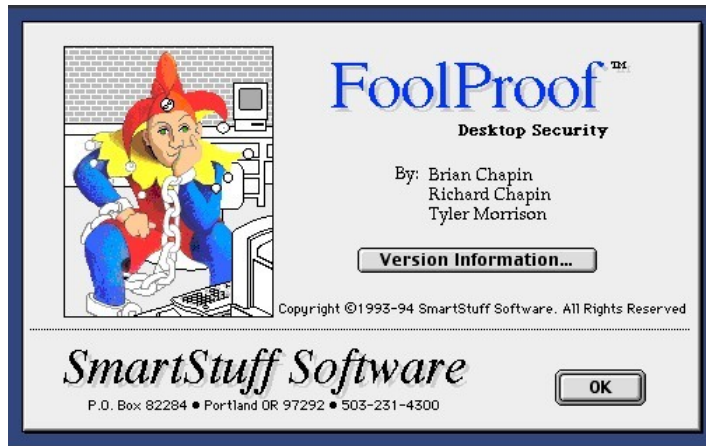
all the latest Windows Updates, drivers and necessary software that needed to be installed on the client computers. Then this image was deployed through a centralized server to the client computers. In some lab environments there was additional software used called Deep Freeze or Fool Proof Security for Macintosh environments. The purpose of this software was to restrict access to specific operating system features, such as saving to the root of the hard drive or in temp folders, or running applications from a floppy disk or USB drive.

This type of software and the concept of the "golden master" has now evolved into Mobile Device Management (MDM) software which after enrolling the computer begins to download the necessary software and policies to the client computers. MDM software has the ability to work with all operating systems - Windows, MacOS, iOS and ChromeOS. This has allowed technology departments to have one centralized software that can manage all the district's devices.

Technology leaders have the important task of ensuring that they are providing staff and students with equitable and appropriate devices. Today, they are presented multiple options for devices whether is it brand, screen size, touch screen, processor, memory, and hard drive size. These device purchases cost districts hundreds of thousands of dollars each fiscal year so it is important to have a technology lifecycle schedule and plan in place for budgeting.

The National Association for the Education of Young Children (NAEYC) has a position statement on the use of technology and interactive media in early education. NAEYC's position, based on a large body of research, is that technology and media can support learning and relationships, when used intentionally. Technology can be collaborative, and shared experiences optimize the potential for children's learning and development with both peers and adults. (Wilmoth, 2023) Technology in all classrooms should be age-appropriate and tailored to the developmental needs of the children in that grade level. Technology leaders need to focus on the safety and well-being of every student. Any technology adoption must meet that expectation.

The technology must be free of harmful content, have robust privacy controls, and have appropriate filtering to block inappropriate sites or images.

NAEYC puts it this way - technology, and the content consumed on it, should never be emotionally damaging, physically harmful, disrespectful, degrading, dangerous, exploitative, or intimidating to young children. (Wilmoth, 2023) CTOs have many different concerns to focus on and consider when viewing the whole picture for providing devices to our students.

Additionally, savings can be found if technology leaders look for software they may not be using. It is not shocking to learn that school districts today could have hundreds of educational apps in their arsenals that might not being used to its fullest. It is imperative that they utilize usage reports or third-party software like LearnPlatform to help ensure that the right edtech pieces are in place and being fully utilized.

Instructional Technology and Curriculum

In 2015, school districts provided students minimally one computer for every five students and spend about $3 billion per year on digital content (Herold, 2016). At this time, school districts were being pushed into purchasing more devices because around 2016 more states were administrating their standardized testing via technology than paper and pencil.

Research has revealed that teachers collectively have been slow to transform their ways of teaching, despite the increasing amounts of new technology available. Even in 2023, teachers continue to fear and be apprehensive about trying new technologies. There is the believe that it will not work or be effective or both. Teacher low self-efficacy is also a key to resistance as well as a desire to not have to change their instructional practices. However, counterpoints to trying new technologies reside at the district level with poor implementation, poor professional development, lack of support, resources, time, or equipment, or simply institutional barriers.

The term "personalized learning" has been talked about for probably 15 years but there has yet to be a school district that has demonstrated that it can be done and effectively. I believe it is a concept that CAN become reality with all students having access to a device, with software and learning platforms becoming cheaper, more sophisticated and tailoring learning to an individual student's needs. This is where Artificial Intelligence I believe can take personalized learning to the next level and make it a reality.

School districts and teachers alike have to increase the opportunities for students to utilize the district-owned devices at home when they are not at school. Another term that has been passed around education is "24-7" learning but we never give the students the ability to do this. The implementation is the biggest challenge, changing the mindset, habits, and routines of teachers and balancing flexibility.

The hurdle school districts need overcome is that when going or planning to go to a 1:1 device model, they must have an educational vision. This is something that is severely lacking especially with the pandemic as we saw school districts purchasing devices in response to the potential of remote learning but never with any further vision than to have a device for each student. Without school districts having a clear picture of how teaching and learning could change in a 1:1 model, this often amounts to a "spray and pray" approach of distributing devices to students and simply hoping for the best (Herold, 2016).

There will be even more necessity for students to have devices because states are moving school districts to online standards testing because it can provide real-time results that can be then used to diagnose a student's abilities. In the *2017 National Education Technology Plan*, it challenges states and school districts to "design, develop, and implement learning dashboards, response systems, and communication pathways that give students, educators, families, and other stakeholders timely and actionable feedback about student learning to improve achievement and instructional practices." (Herold, 2016)

The *2022 State EdTech Trends Report* highlighted four key findings in ways that the states could better assist school districts. Prior to the pandemic fewer than half the schools had 1:1 programs for students and some barely maintained adequate levels of broadband connectivity. (Cohen, 2022) Forward months later and now almost every student had a device and schools worked to increase broadband connectivity for students so that instruction could continue no matter where they were located. (Cohen, 2022)

However, with the introduction of so much technology at a rapid pace, it expedited numerous challenges like student data privacy, cybersecurity, and home access. In addition, school districts were trying to rapidly train educators, students and families on how to use the edtech tools effectively. (Cohen, 2022) Technology has become a required asset, a utility in some sorts. Schools priorities have been broadband equity, using technology for instruction and cybersecurity.

How do school districts ensure edtech and product effectiveness? According to the SETDA survey conducted, no one thinks there is too much technology in education but only 8% believe there should be more. A common belief, over 57% of survey respondents, is that there are a lot of edtech programs and products, many times they are not used effectively. (Cohen, 2022) The state of Mississippi purchased 390,000 devices in 2020 and wanted to make sure they were able to break through the barrier from "a device shows up in a box" to "a device is in a kids' hands." The state proactively worked with academic and technology experts to help educators and district leaders statewide on implementing digital learning. (Cohen, 2022)

According to a 2020 report from PricewaterhouseCoopers only 10% of U.S. teachers feel they are prepared to teach lessons addressing higher-level technology skills. 79% of these teachers desire more professional learning for any technology-related subjects.

Children today are digital natives, meaning technology has been and always will be in their hands. They, or the Gen Zers, will begin to have higher expectations on how their learning looks and will have less tolerance for the "sit and get" style of instruction. In fact, in 2020, 74% of American college students took at least one online college course and another 15% of students attended primarily online colleges, according to the National Center for Education Statistics. (ASU Online)

These statistics have led technology department personnel to revisit their qualifications and begin to reinvest in their own professional learning. However, it is not just the educational realm that is needing to embrace these technology advancements. For decades, corporations largely relied on traditional training methods with "sit and get" models along with internal and external subject matter experts. (ASU Online) Now more than one-third of workers want self-paced training opportunities, per a LinkedIn Learning report from 2019. (ASU Online).
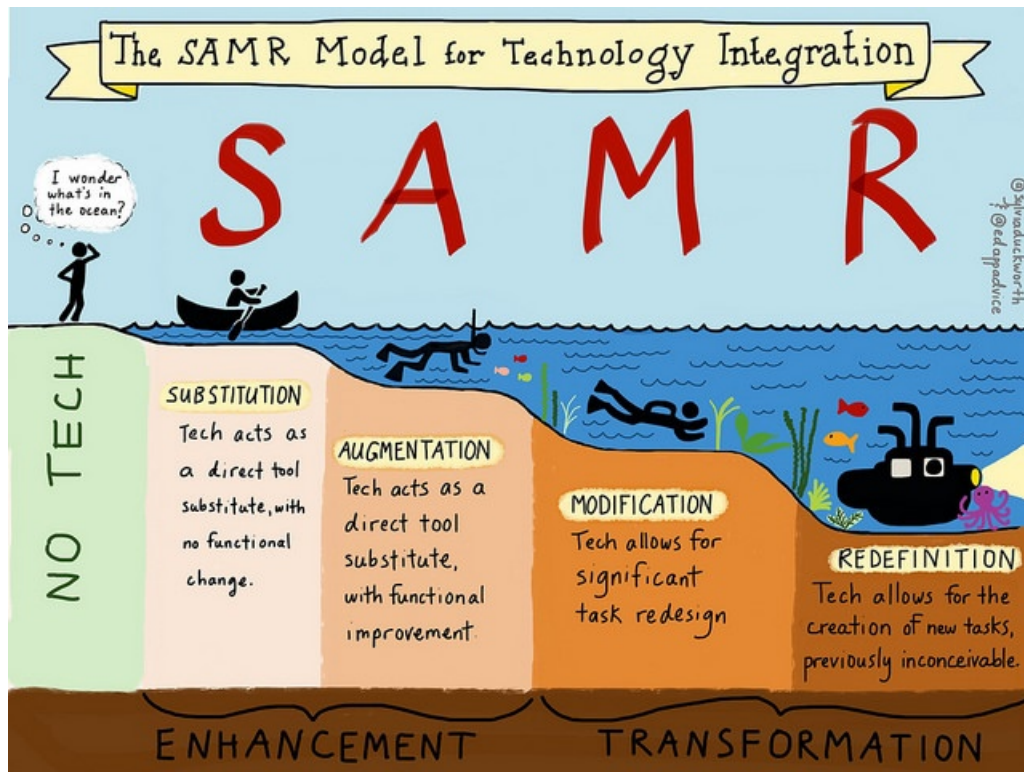
SAMR Model

Dr. Reuben Puentedura in 2009 developed the SAMR model. The model's design is a tool through which teachers can monitor the use of technology within their classroom (Hamilton et al., 2016). (Gillespie, 2022). The letters in SAMR stand for:

- Substitution – video lecture pre-recorded to be shown in class

- Augmentation – content delivery via a slide deck with embedded questions

- Modification – student-paced learning with interactive elements

- Redefinition – virtual field trip

According to Peggy Ertmer (1999), there are barriers to technology integration that educators face, external and internal. External barriers include: acquiring the necessary technical skills to use computers and other devices to teach; limited access to devices, software, apps, and Internet instability; lack of time to plan instruction; and insufficient technical and administrative support. Internal barriers have to do with: beliefs about teaching and knowledge of the pedagogical models of technology; an understanding of technological devices; beliefs about classroom practice; and resistance to change. (Gillespie, 2022)

Technology leaders must collaborate with curriculum leaders to make decisions on what devices and software provide the students the best opportunity for optimal learning.

Operations

Schools are a very complex business operations with annual budgets from $10 million to almost $700 million. Technology in schools is shifting from using tools like displaying slides on a projector in a classroom, to finding solutions that work to integrate with other software. Typically, schools have poor internal processes that are driven by paper like timesheets, requests for overtime, tuition reimbursements or stipend duty pay. By advancing this process with technology, this new digital process could provide an approval audit trail but allows these requests to be processed quicker. It eliminates the time necessary for searching through boxes and files and instead allows these documents to be easily searchable online.

Additionally, schools are required to keep employee, financial and student records for multiple decades before they can be destroyed. This requires schools to have large, secured records rooms that are temperature controlled. This is where technology can be the leader is helping to modernize internal processes.

Security and Access Control

School security is an over $3 billion annual industry. A 2020 study conducted by Omdia on behalf of the Security Industry Association showed the market for physical security equipment in K-12 and higher education was $716 million. The K-12 sector accounted for about 56% of that amount. (Belastock, 2022) School districts have been rapidly adding security cameras to their schools - inside and outside to help create a safe environment for all staff and students. Decades ago, these closed-circuit system and security cameras systems were initially maintained by the maintenance departments. They were connected to a VHS recorder and later digital video recorder (DVR), the cameras were connected by coax cables which had a limited amount of bandwidth it could support.

As camera hardware increased with the digital era, cameras now could provide higher quality with larger megapixels and resolution. With this digital migration, cameras were now IP (Internet Protocol) based and now running wired or wireless over the infrastructure network. You could install security cameras easier because they would receive power now from the network

switches through the 802.3af PoE (power-over-ethernet) standard. Security cameras are now high-definition or 4k quality, multi-lens, wireless and weatherproof. One of the biggest improvements in security cameras has been video analytics. School administrators can use video analytics to find missing students based on the clothing that they are wearing and track a person's location as that pass through different security cameras. They are a part of systems that integrate access control, communications, mass notifications, and door locks. (Belastock, 2022) With the increased bandwidth that new cameras produce on the network, technology departments will need to be proactive ensuring that school networks are up-to-date and can handle the bandwidth needs of the cameras.

Door access control systems are also another complex system that technology departments have become the owners and managers of. These systems run on the infrastructure network using the 802.3af PoE (power-over-ethernet) standard to a door controller which then powers the card reader and door strike. Having a centralized database allows for very layered approach to security per user.

Technology leaders need to be aware of future trends that will begin to use Bluetooth technology allowing users to use their smartphone to grant access to locked doors.

Phone Systems

In the late 1990's, phone systems were simple analog systems that were running over CAT3 cable. They were using POTS (plain old telephone service) or Centrex lines. This was a system that again was usually maintained by the maintenance department. But as technology evolved into the early 2000's, phone systems slowly transitioned to a digital phone system which provided a clearer sound. As dial-up was phased out and Internet connectivity became stronger so did VoIP (Voice over Internet Protocols) and its prevalence amongst the home, business, and office. (Ellis, 2019)

VoIP revolutionized the way we are able to make audio calls but now we can also make video calls. VoIP is inexpensive and provides good quality voice communication through a stable Internet connection. (Ellis, 2019) During the pandemic, VoIP systems allowed workers to be able to communicate from their homes remotely without needing any additional equipment. Phone systems have quickly evolved from needing to have equipment on-site to having everything located in the cloud.

Technology leaders need continue to be aware of future trends that will allow our end users to easily communicate regardless of their location.

Building Automation Systems

Today, most modern buildings have automated the management and operation of various systems like fire alarm, HVAC, security and access control systems. The Internet of Things (IoT) has streamlined management of systems, with sensors, devices, and equipment sending data back for collection. In the mid 1990's, an open protocol was developed called BACnet which has been used by many building automation software vendors. A competing standard called LonWorks was released a few years later but is a closed protocol and has not gained popularity. Building automation systems launched in 1999 allowing multiple protocols to be integrated and managed through a single webpage. As the automation systems matured, they have moved past being initially being developed with Java or proprietary plugins and now are developed with HTML5 which allows any device and browser to view the webpage without any plugins. These systems can integrate HVAC systems, lighting, energy and occupancy.

Technology leaders need to work with building and grounds leaders to be attentive to changes in building automation and controls that can assist in maintaining the most efficient building operations. Some examples would include optimal startup and shutdown of air handlers or chillers and optimal lighting scheduling.

Conclusion

Over the past 20 years, the Chief Technology Officer (CTO) role has emerged as one of the most important positions on a school district's leadership team. Never before has a position been so important especially when the COVID-19 pandemic occurred. This position centers on aligning technology strategies to the school district's goals or strategic plan, but the position takes on different challenges and importance when it comes to connecting technology strategies to student performance.

Beyond having a passion for technology, CTOs should also have a passion for wanting to make a difference in the lives of children, teachers, and the entire education system. It is important that CTOs have an innate curiosity to help school districts appropriately use technology to solve school and district-wide challenges. They need to have a desire to drive positive change and provide answers to questions surrounding the future role of technology in K-12 education. (PowerSchool Staff, 2018) They are the ones that can lead the charge in helping K-12 schools from manual, legacy processes to new, more efficient digital tools than can benefit all stakeholders.

Technology is best when it brings people together." – Julia Fallon

Throughout the past two decades, the CTO has been involved and seen positive outcomes of using technology in education. They have been involved in choosing the right tools and methods. Students now have information at their fingertips with eBooks, audiobooks, and online content; they have helped stakeholders learn of the increased accessibility features and assistive technologies that have come with new devices.

Today's CTO is a very unique position. They must portray numerous skills starting with technical expertise to leadership, management and communication skills to being budget mindful and being able to work with all stakeholders. CTOs are the bridge that connects numerous departments together and provide the interoperability within a school district.

As technologies evolve so must the modern-day CTO. Their mindsets must be engrained in forward thinking by continuously discovering the best software, applications, devices for staff and students while working with cross sections of various departments to ensure a successful implementation. In addition, they must continue to be proactive in protecting their school district's assets, data and resources from external threats and harm. The future of the CTO is in

marrying the power of people with the power of technology. The K-12 CTO has become an integral part of modern education and how school district's function. What a far cry from decades ago when it was seen as a part-time position.

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