Educational Technology Guidelines

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Designing and Maintaining
Instructional Technology Systems

VIRGINIA DEPARTMENT OF EDUCATION
DIVISION OF
TECHNOLOGY & CAREER EDUCATION
OFFICE OF EDUCATIONAL TECHNOLOGY

Virginia Department of Education

Dr. Billy K. Cannaday, Jr.
Superintendent of Public Instruction

Division of Technology & Career Education
Lan Neugent
Assistant Superintendent

Office of Educational Technology
Dr. Tammy McGraw
Director

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1. Introduction

1.1. Purpose

This document provides key information for designing and maintaining instructional systems that transition technology seamlessly into teaching, learning, and school management. Because technological considerations vary with the purpose and audience, the design and maintenance of a technology integration plan necessitate a systems approach. Stakeholders at each level are responsible for such processes as procurement, infrastructure, design, security, and technology administration. Teachers play a key role in technology integration; they provide a basic knowledge of available tools, whose interoperability facilitates appropriate classroom use and integration. As a result, this document addresses the specific concerns of instructional systems managers at different levels of technology integration and across the learning community—state, division, building, and classroom.

1.2. Background

Since 2001, when Congress passed the *No Child Left Behind Act*, which included the Enhancing Education Through Technology Program, states and public schools have a renewed motivation to use technology to improve student achievement and ensure that all students, especially those in high-need schools, have an equal opportunity to become technology literate. The Commonwealth has seen a tremendous increase in technological support for education since the launch of the *Educational Technology Plan for Virginia: 2003-09* (Virginia Department of Education, 2003). The backing of the Virginia General Assembly and a commitment of more than $350 million has produced enormous advances in infrastructure, hardware, software, teaching and learning resources, professional development, and administrative applications. The Commonwealth consistently has been viewed as a national leader in employing powerful technologies to improve teaching, learning, and school management.

Educational technology plans aim to capitalize on these gains by ensuring that all students develop the skills and knowledge needed to realize their potential as leaders in a technology-supported information economy. The Web-Based Standards of Learning (SOL) Technology Initiative began the work of providing school access to Web-based instructional, remedial, and assessment programs, which include delivering Virginia's SOL assessments online. Several other developments have boosted support for educational technology in Virginia. For example, the *SOL Technology Initiative Architectural Guidelines for High School Readiness* (2001) provided guidelines for school divisions and high schools to participate in the initiative. In 2002, using funding from the Enhancing Education Through Technology Program, the Office of Educational Technology (OET) of the Virginia Department of Education established eight regional technology consortia to implement professional development strategies for training teachers and administrators in technology-integration skills. The 2005 Virginia General Assembly amended the Standards of Quality to require school boards to employ one instructional technology resource teacher per 1,000 students to help teachers integrate technology into the classroom. In 2006, the Virginia General Assembly added a requirement that acceptable Internet use policies, developed by division superintendents, include components on Internet safety for students.

2. Statewide Instructional Systems

At this time, a major function of the statewide instructional system is to support electronic test delivery; however, Virginia also utilizes the largest WAN—the Internet—to support teaching, learning, and school management. Educators around the world already use professional development, virtual learning, online collaboration, virtual field trips, and modeling and simulation applications.

2.1. Educational Information Management System (EIMS)

The Web-based EIMS system is accessible to Virginia's divisions and schools at no charge. It contains multiple years of state assessment data that can be disaggregated by school, student group, and teacher with an easy-to-use decision support tool. Individual student longitudinal reports are also available. During testing windows, assessments scored as of Thursday are available in EIMS the following Monday. Local data managers use EIMS to manage student data and obtain state testing identifiers. For more information on EIMS, contact your division's EIMS manager at https://p1pe.doe.virginia.gov/ssws/contactlist.do.

2.2. Single Sign-On for Web Systems (SSWS)

SSWS is the access portal to the Department of Education's Web-based data collection and reporting systems. Individuals with multiple roles can access all necessary applications with only one logon and password. Each division has an SSWS account manager, who assigns staff to the proper roles and applications. For more information, contact your division's SSWS account manager at https://p1pe.doe.virginia.gov/ssws/contactlist.do.

2.3. Electronic SOL Test Delivery

The Web-based PEMSolutions System provides the functionality required by the SOL assessment program. School personnel administer the testing system via a computer with Secure Socket Layer (SSL) Internet access and an industry-standard Web browser. Administrative personnel must have a valid user ID and password to enter the system and specific assigned rights to access certain parts of the system, such as test scheduling, test administration, student demographic data, and student test results. Divisions must adhere to technical guidelines detailed in the Virginia Online Testing Technical Guidelines that are available at http://www.doe.virginia.gov/VDOE/Assessment/Online/.

2.3.1. Operating Systems

For online testing purposes, a specific set of operating system versions are supported on Windows-based computers and Apple-based computers. Please refer to http://www.doe.virginia.gov/VDOE/Assessment/Online/ for the most current operating system specifications.

2.3.2. Browsers

Computers used to administer the Virginia Assessment Program within PEMSolutions must have certain browser software installed. Please refer to http://www.doe.virginia.gov/VDOE/Assessment/Online/ for the most current browser software specifications.

2.3.3. Test Delivery Module (TestNav™)

Computer workstations used by students to complete online tests must have access to a specific software application provided by Pearson, the assessment contractor. This Java application called TestNav™ must be installed on each computer workstation or on a network server and accessed via a shortcut on each computer. Please refer to http://www.doe.virginia.gov/VDOE/Assessment/Online/ for the most current TestNav™ specifications and installation directions.

2.3.4. Proctor Caching

Proctor caching is a technology solution used during online SOL testing that is based on the concept of storing Internet content files electronically in cache to reduce the bandwidth demand needed when accessing the Internet. Using proctor caching can greatly reduce the level of risk associated with relying on Internet connectivity and network performance while administering online SOL tests. School divisions are strongly encouraged to implement proctor caching or some other comparable cache solution during online SOL test administrations. Details about proctor caching are available at http://www.doe.virginia.gov/VDOE/Assessment/Online/.

2.4. Virtual Virginia

The Virginia Virtual Advanced Placement School (VVAPS) offers online AP and foreign language courses to students across the Commonwealth and nation. The courses use the Desire2Learn course-management software to maximize interactivity. Each course contains video segments, audio clips, whiteboard, online discussions, and text. E-Teachers are available for telephone conversations with students throughout the school day. VVAPS classes offer a rich, multimedia, learning environment that appeals to various learning styles. VVAPS courses can be scheduled flexibly throughout the day, as courses do not have to be taken in real time. Middle and high school students who meet the prerequisites may enroll through their schools.

Virtual learning is the new frontier in today's educational institutions. Twenty-first century technology provides a unique opportunity for educators to reach students who want the experience of advanced placement coursework. Technology-related professional development is now available through Virtual Virginia, which enables the OET to train a larger number of administrators, library media specialists, and instructional technology resource teachers while virtually eliminating travel and leave time.

Additional information on Virtual Virginia can be found at http://www.virtualvirginia.org/.

2.5. Virginia Education Network for Virtual Conferencing (VNET)

The OET has developed a new virtual meeting network that supports state-of-the-art conferencing solutions. The VNET offers the following communication and collaboration benefits for education administrators:

- Reduces costly travel and out-of-office time for division administrators attending meetings
- Increases division-level administrator participation in statewide discussions or collaborations
- Provides meeting support, professional development, and technical assistance to divisions and regional consortia

VNET supports two forms of virtual communications: two-way interactive videoconferencing and Web-based conferencing. The OET has developed a series of documents to support virtual conferencing, which can be found at http://www.doe.virginia.gov/VDOE/Technology/OET/vnet.shtml.

3. Divisionwide Instructional Technology Systems

In addition to the material on statewide instructional technology systems, division-level instructional systems require extensive technical specifications and other information regarding system design, security, and maintenance. The following specifications should provide division-level managers with general guidelines and recommendations for the design and maintenance of divisionwide instructional systems. These division-level managers are responsible for informing and supporting building-level and classroom-level managers about the information below.

3.1. Facilities

When installing a technology-wiring infrastructure, it is recommended the entire facility be wired to the same standards. The standards for new and existing facilities should also be the same. The existence of a single set of design criteria simplifies the use of a common wiring infrastructure. All cables should be tested under the same guidelines.

3.1.1. New Facilities

During the planning phase for new school facilities, architects typically address factors that affect technology infrastructure design and installation, including building layout, ceiling type, wall construction, space allocation for wiring, ventilation, electrical power supply and location, room layouts, and physical security, among others. Whenever possible, planning for technology expansion throughout a facility should consider the following:

- Classroom alteration to allow more student workstations
- Ability to increase circuit capacity of wiring closets
- Provisions for extra power circuits and accommodation to new or emerging technologies

To prevent overload, electrical equipment must be sized properly for the possibility of high neutral currents. Air conditioning is beneficial not only for comfort but also to protect technology equipment, particularly in year-round facilities. Lighting should be energy efficient, with various types of diffusers for flexible computer-compatible design. Integrated communications systems provide not only for voice, video, and data distribution but also for announcements, clocks, and alarm systems that tie in to the telephone system.

3.1.2. Existing Facilities

The introduction of a technology wiring infrastructure into an existing facility affects several systems, such as electrical and HVAC. Space must be identified for wiring closets, distribution frames, the network room, and workstation locations.

Renovating existing facilities begins with a review of the physical layout and spatial accommodations in technology-related areas. Even in schools where space has not been a problem, the addition of classroom technology devices, such as computers and video monitors, requires a reevaluation of space availability. Existing furniture (computer tables, rolling carts, and surplus furniture) should be reused, if possible, to reduce costs. It may be possible to use, change, or reconfigure existing furniture to satisfy the needs of new technology devices.

Upgrades to the electrical services of existing facilities may be necessary even if the facility is not being enlarged. The location and power circuit rating of each electrical outlet must be identified and recorded. A professional should review computer labs to determine the safest and most cost-efficient method of meeting each technology area's electrical supply needs.

3.2. Hardware/Software

Procuring, maintaining, and supporting the hardware and software is critically important to division technology administrators. A variety of factors affect these decisions.

3.2.1. Servers

Considering the ever-changing nature of computer technology, the specifications in Table 1 are based upon information available at the time of publication. More current specifications may be available. Please check periodically with computer manufacturers and the state procurement contract documents on the Virginia Information Technologies Agencies (VITA) Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

Table 1. Recommended Computer Specifications

	SERVER	MONITOR
Good	Intel® Pentium® Processor 336 at 256K Cache (2.8GHz, 533MHz FSB) 1GB DDR2, 667MHz, 2X512MB Single-Ranked DIMM On-Board Single Gigabit Network Adapter 2 Hard Drives—RAID 1 Internal RAID adapter, PCI-Express 2 - 250GB, SATA II, 3.5-inch, 7.2K RPM Hard Drive 48X CD-ROM Drive 48XCD 1.44 Floppy Drive Removable Disk and Tape Drives: DAT72, 36/72GB, Internal Tape Backup Unit with Cable Keyboard: USB Mechanical Two-button mouse, USB Uninterruptible Power Supply (UPS): 750VA Uninterruptible Power Supply, Stand Alone	17-Inch Analog Flat-Panel LCD Monitor
Better	Dual Core Intel® Xeon® 3060, 4MB Cache (2.4GHz, 1066MHz FSB) 2GB DDR2, 667MHz, 2x1GB Dual-Ranked DIMM On-Board Single Gigabit Network Adapter 3 Hard Drives—RAID 5 Internal Raid adapter, PCI-Express 3 - 500GB, SATA, 3.5-inch, 7.2K RPM Hard Drive 48x CDRW/DVD IDE Internal 1.44MB 3.5 inch Floppy Disk Drive Removable Disk and Tape Drives: LTO-2-L, 200/400GB, Internal Drive Keyboard: USB Optical Two-Button Mouse, USB Uninterrupted Power Supply: 1500VA Uninterruptible Power Supply, Stand Alone	17-Inch Analog Flat-Panel LCD Monitor
Best	Dual 3.4GHz/800Mhz/16mb Cache, Dual-Core Intel® Xeon 7140M Processors 8GB DDR2 400MHZ (4X2GB), Dual-Ranked DIMM 8G4D4D [311-5324] 3 Dual Power Supplies 24X IDE CD-RW/DVD ROM Drive 1.44MB Floppy Drive Keyboard: USB Optical Two-Button Mouse, USB Hard Drive Configuration: 3 Hard Drives—RAID 5 Internal Raid adapter, PCI -Express 8 - 300GB 10K RPM Ultra 320 SCSI Hard Drive Tape Backup: LTO-3 Tape Backup, 400/800GB Dual Onboard Gbit. NICs Uninterrupted Power Supply: 2200VA Uninterruptible Power Supply, Stand Alone	19-Inch Analog Flat-Panel LCD Monitor

3.2.2. Clients

Table 2 includes recommended computer specifications for machines designed for the office environment (e.g., certified, consistent components for better reliability, longevity, and supportability). Due to the ever-changing nature of computer technology, these specifications are based upon information available at the time of publication. More current specifications may be available. Please check periodically with computer manufacturers and the state procurement contract documents on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

Table 2. Recommended Computer Specifications for Office Environment

	CLIENTS	MONITOR
Good	IIntel® Core™ 2 Duo Processor E6300 (1.80GHz, 2M, 1066MHz FSB) 2.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 80GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy Internal Audio Speaker 24X CDRW/DVD Combo	17-Inch Analog Flat-Panel LCD Monitor
Better	Intel® Core™ 2 Duo Processor E6600 (2.4GHz, 2M, 1066MHz FSB) 2.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 250GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy External Audio Speaker 24X CDRW/DVD Combo	19-Inch Analog Flat-Panel LCD Monitor
Best	Intel® Core™ 2 Duo Processor E6700 (2.66GHz, 2M, 1066MHz FSB) 4.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 750GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy External Audio Speaker 24X CDRW/DVD Combo	19-Inch Analog Flat-Panel LCD Monitor

3.2.3. Videoconferencing and VoIP

A videoconference system requires a video input (camera), video output (monitor or screen), audio input (microphone), audio output (speakers), and digital network (Internet). The Virginia Department of Education recommends IP-based, H.323, Polycom and Tandberg videoconferencing systems.

There are basically three kinds of systems. A **dedicated system** contains all required components packaged into a single piece of equipment, usually a viewing console with a video camera, microphone, and speakers. A **desktop system** is a camera-and-software add-on to a normal PC that offers videoconferencing capabilities (TKO, 2003). A **portable set-top unit** has a self-contained codec, camera, and microphone attached to a standard television or monitor. All three systems can support point-to-point or multipoint (through a multipoint control unit) videoconferencing. Desktop systems and portable set-top units can support Web-based videoconferencing. In addition, these systems can facilitate virtual collaborations, which include file sharing and other applications. Although desktop systems and portable set-top units are popular options, it is worth noting that similar videoconferencing systems can be fixed permanently in a dedicated room. Dedicated virtual meeting rooms can guarantee reliability and electrical, connectivity, and ergonomic needs.

Protocols that carry voice signals over the IP network are commonly referred to as Voice over Internet Protocols (VoIP). VoIP, IP telephony, and/or Internet telephony route voice conversations over the Internet or through any other IP-based network. VoIP traffic can be deployed on any IP network, including those lacking an Internet connection, such as a local area network. Schools should consider VoIP as an alternative to traditional phone service, when appropriate, to improve their communications. VoIP simplifies the technology infrastructure by eliminating the need for separate cabling to support a telephone system. Since VoIP is managed with software, a more scalable system can be maintained at a lower cost by eliminating expenses associated with removing and replacing complete phone systems that rely mainly on hardware. VoIP can improve the overall productivity of school operations by enabling users to attach documents to voice messages or participating in video conferences.

Implementation of VoIP requires some planning. Support personnel should clearly understand their roles regarding VoIP infrastructure (e.g., switches, routers) vs. VoIP features (e.g., video conferencing, document sharing). Staff should also assess the LAN and WAN infrastructure to determine any necessary adjustments or upgrades. VoIP uses additional bandwidth; therefore, an infrastructure that can handle data may require upgrading to transmit VoIP. See section 2.5 for additional information on using IP networks with the Virginia Education Network for Virtual Conferencing.

3.2.4. Multiple Platforms

Schools contemplating a multiplatform environment—such as Windows with Linux, Mac, or UNIX—should consider several options:

- Peer-to-peer and client software file-and-printer-sharing products that do not require a server but that can be used with a server
- Windows and Mac-based server products offering server platforms that support Mac and Windows clients, including file-and-print sharing and other services
- Virtual private network (VPN) products that can put a Mac on a VPN
- Cross-platform-enabling products that offer database connectivity, group calendar and scheduling, network fax, and other functions across platforms

As an additional note, virtual machines for Mac OS X on Intel-based Macs can support almost any X86-based operating system, including Unix, Linux, and Windows. Running Linux and Unix on Mac hardware is not emulation but a real version or virtualization of Linux and Unix running natively on a Mac.

For computers used to administer online SOL tests, it is important to ensure the platform is compatible with the current version of the TestNav™ application. Please refer to http://www.doe.virginia.gov/VDOE/Assessment/Online/ for the most current TestNav™ requirements.

3.2.5. Procurement

The purchase of technological devices and services, including hardware, software, and Web-based applications, should be implemented around the division's technology plan. Choosing hardware or a software application without consideration of the division's infrastructure, support, available bandwidth, or goals for integration may lead to inoperability or cause undue strain on the instructional technology system. Procurement should be an important piece of the technology plan.

Widely available hardware solutions with powerful components will increase the useful lifetime of devices. Network hardware and workstations should be procured from major providers that use commercial-grade components with lower failure rates and that ensure compatibility with existing systems. Over time, a consistent product base can reduce administrative and support costs significantly, but do not exclude products that may provide the best computing solutions. Extended on-site warranty options (one-to-three years) should also be considered when selecting vendors.

School divisions can purchase technology equipment from the state procurement contracts on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

3.2.6. Software Licensing

When a school purchases software, it acquires a user license by default; however, it is important to purchase the most appropriate license. Generally speaking, there are three types of software licenses. A **single license** permits the software to be loaded on one machine only; a backup copy often can be made (in case the original software is damaged or lost). A **multiple user license** allows software to be installed on numerous machines, but only a specific number of people can use the program at any one time. A **site license** either allows unlimited use of the software throughout the school or specifies the maximum number of machines on which it can be installed. Site licenses for educational software often permit teachers to install the software on their home computers. Note that multiple user and site licenses may require subscriptions, which limit the number of concurrent users. Compare these options carefully and select the best value for your school or district.

In addition, school divisions should be aware of Section 508 requirements when purchasing software. See section 4.2.3.

3.2.7. Ongoing Maintenance and Support

3.2.7.1. Support Personnel

Educators need to have confidence that the equipment and infrastructure will respond successfully. To help achieve this goal, the 2004 Virginia General Assembly passed legislation recommended by the Board of Education to amend the Standards of Quality (SOQ). The legislation requires a ratio of one instructional technology resource

teacher (ITRT) and one technology support position for every 1,000 students in grades K-12. ITRT are essential for effective technology integration, while technology support personnel help ensure the continued operation of teaching and learning applications and administer and manage technology.

The Office of Educational Technology's *Instructional Technology Resource Teacher and Technology Support Positions: A Handbook for School Divisions* (http://www.doe.virginia.gov/VDOE/Technology/) provides a framework as division administrators fill positions and implement support services for technology integration. The handbook addresses the roles and attributes of an instructional technology resource teacher but also includes basic information, such as sample job descriptions; a list of knowledge, skills, and abilities; and responsibilities for technology support personnel.

3.2.7.2. Service-Level Agreements

Several considerations are necessary when developing and negotiating service-level agreements (SLA). Technology administrators should have a trouble-ticket or incident-tracking system that measures and assesses the past and current performances of network-related equipment. Understanding the past performances of a network and its related equipment can help determine future performance expectations. The details of SLA should be based partially upon future performance expectations. SLA should include the roles and responsibilities of the division and vendor. As the user, the division must be able to provide specific information about the system at the time of the problem. The vendor may be able to suggest alternative solutions. Divisions need to have key vendor contact representatives; generic contact telephone numbers may inhibit response times. The SLA should also specify the expected response times and the consequences of any vendor that does not meet service expectations.

3.2.7.3. Replacement Cycles

For the replacement of computers, school divisions—including administrative offices—should consider a replacement cycle of three years for both desktop and notebook computers. The cost of replacing computers should be included in a regular budget schedule. Divisions should attempt to keep computers upgraded on a regular basis until replacement is necessary. Consideration should be given to the cost of maintaining and supporting older computers for performing simpler tasks. Since divisions may not always know when funds will be available, they should purchase computers with as much processing power and memory as possible—allowing greater capability and flexibility for adding new or expanded software.

3.2.7.4. Total Cost of Ownership

Total cost of ownership (TCO) estimates the direct and indirect costs of a technology investment, including, but not limited to, computer software or hardware. A TCO analysis and assessment should consider the costs of purchases and continued maintenance, including the training of support personnel and system users, downtime due to a failure or outage (planned and unplanned), low performance occurrences (e.g., slow processing of data), security issues (legal and recovery costs), disaster preparedness and recovery, and infrastructure tests. TCO analysis originated with the Gartner Group in 1987. The Gartner Group, in partnership with the Consortium on School Networking (CoSN), developed a TCO tool (http://classroomtco.cosn.org/gartner_intro.html) that allows educational technology professionals to examine the client, network, and server cost of ownership.

3.3. Interoperability and SIF

The interoperability of software applications is essential when considering software purchases. Schools Interoperability Framework (SIF) is a data-sharing specification that enables diverse applications to interact and share data seamlessly. The main focus has been in the United States, but active work has occurred in the United Kingdom, Australia, and other places. SIF comprises two parts: an XML (extensible markup language) specification

for modeling educational data and an SOA (service oriented architecture) specification for sharing that data between institutions. SIF is maintained by the Schools Interoperability Framework Association (SIFA). Virginia has adopted the SIF Specification as a standard for statewide system interoperability.

The SIFA is a unique, nonprofit collaboration composed of more than 550 schools, districts, states, the U.S. Department of Education, international government agencies, software vendors, and consultants who collectively define the rules and regulations for educational software data interoperability. The SIF Specification enables diverse applications to interact and share data efficiently, reliably, and securely, regardless of the platform hosting those applications. Currently, more than 90 SIF-Certified software applications are available, ranging from student information systems and grade book applications to library and transportation software. For more information on SIF, visit http://www.sifinfo.org. Divisions are encouraged to consider purchasing SIF-Certified products to meet their interoperability needs.

3.4. Networks (WAN/LAN)

In designing a network, it is vital to understand how switches and routers handle traffic. The financial cost of network installation is not the primary consideration when deciding which kind of network to install. Purpose, clients, and administration should have a bearing on the kind of network that should be implemented. Normally, the greater the number of network users, the greater the need for security. Additionally, more users typically require more time for network administration due to the larger number of devices, users, and related issues.

A wide area network (WAN) is a combination of local area networks (LAN) joined together. The Internet is an example of a global WAN. Divisions can combine their school building networks together into a WAN. The development of wireless networking solutions represents a significant evolutionary step in this arena. Devices can be networked fully even though they are not connected physically to a computer network via cable.

The term *wireless network* usually refers to a wireless LAN, known as a WLAN. A WLAN can be installed as the only network in a school or building; however, it also can extend an existing wired network to areas where wiring is too difficult or expensive to implement or to areas located away from the main network or main building. Wireless networks can be configured to provide the same network functionality as wired networks, ranging from simple peer-to-peer configurations to large-scale networks accommodating hundreds of users. See Appendix B for information on wireless protocols.

With the installation of an access point, the network's range increases to approximately 380 yards outdoors or 165 yards indoors (optimum performance within 32 yards). An access point can support up to 50 clients; however, several access points may be needed to support numerous clients. Access points are connected via a wired LAN. The access point can also act as a bridge, allowing the wireless network to connect to a wired network. When users need to be mobile and still retain their network connections, the coverage provided by the access points should overlap. As the user moves from one area of coverage to another, the network connection is transferred from one access point to the next, without the user noticing.

Additional equipment may be required to support a wireless LAN:

- Extension points extend a wireless LAN by relaying signals to an access point.
- Directional antennae can share a single network between two buildings.
- Network interface cards for wireless networks are more expensive than their wired counterparts. The cost of the access points also must be considered.

- Wireless networks work at 54 Mbps, whereas wired networks normally work at 100 Mbps (Fast Ethernet) or 1000 Mbps (Gigabit Ethernet). A new standard for wireless, 802.11n, is awaiting final certification from IEEE. This new standard operates at speeds up to 540 Mbps and at longer distances. This data transmission rate is dependent on the number of users, distance from the access point, and fabric of the building (metal structures in walls may have an impact). A wireless network will be noticeably slower when a group of users are transferring files 500 MB or larger in size. This should be considered if multimedia applications are to be delivered over the network to a significant number of users.

- Since the network range may extend beyond the walls of the building, it can be accessed from outside. Consider the equipment's security features to ensure that only valid users have access to the network and that data is protected. Various security options include the following: configuring access restrictions in the access points by encryption or checks on MAC addresses, forwarding all Web traffic to a captive portal that provides for authorization, or requiring users to connect to a privileged network using a Virtual Private Network.

Wireless networking has been implemented successfully for administering online SOL tests and is increasingly more common for this purpose. The added flexibility of how computer workstations may be arranged in a classroom or lab is highly desirable when attempting to maximize a secure testing environment. Specific details regarding the use of wireless networking for administering online SOL tests are available in the Virginia Online Testing Technical Guidelines at http://www.doe.virginia.gov/VDOE/Assessment/Online/.

For more information, review the state procurement contracts for wireless LAN infrastructure on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

3.4.1. Facility

Establishing and maintaining a network infrastructure is a significant monetary investment. Guidelines for housing and caring for servers and networking components (e.g., switches, routers) include the following:

- The network components should be housed in secure climate-controlled areas; racks or cabinets can alleviate space constraints.

- Keep the room climate consistent. The temperature generally should not go below 55°F or above 82°F; ideally, the temperature should be close to 68-71°F (Laverty, 2003).

- Remember that wiring closets should not be used to store janitorial supplies; corrosive chemicals, equipment, and humidity can cause significant damage. Consider purchasing servers that contain internal sensors that monitor temperature, air flow, and humidity. These servers send e-mail or paging alarms along with audio alarms when conditions warrant.

- Provide adequate space for a technician to gain easy access to the front and rear of network equipment and servers.

3.4.2. Infrastructure

All infrastructure projects must comply with appropriate building codes. Wiring/cabling for a building's computer network services and telephone system infrastructure include the following:

- Dedicated electrical power

- Wiring with equipment racks

- Cabling with wireless devices
- Connectivity (e.g., routers, switches, patch panels)
- Telephone patch panel
- Networked multimedia computers (servers) with 200-volt UPS, surge suppression, and printer
- Surge protector for computers or built-in surge protection for circuits at the demarcation *demark* point inside the building
- HVAC systems that adequately control temperature and humidity
- Uninterruptible power supply

An uninterruptible power supply (UPS) is an important part of a comprehensive power delivery system (Technical Services Group, 2006). It consists of continuously recharging batteries; when a power supply interruption occurs, the UPS ensures the system continues to operate for several minutes. This allows time for the operating system to shut down and prevent data loss. All network equipment should be plugged into a UPS.

- When selecting a UPS, consider the load rating. This is the maximum amount of load, expressed in amps and watts, that can be supported. In addition, 30 minutes of battery backup should be provided for file servers and systems.

3.4.2.1. Cabling and Data Transfer

Twisted pair and fiber optic are the two current cabling standards used to connect computers:

- *Twisted-pair cable* consists of strands of copper wire. This is the industry standard in new installations. There are several international standards for twisted-pair cable. Unshielded twisted-pair category 3 (UTP Cat 3) is used for phone wires, whereas Cat 5e is the most popular category for networking because it can support data transmission of up to 1000 Mbps. Cat 6 and Cat 7 are also available.
- *Fiber-optic cable,* made of high-quality glass strands, uses light pulses instead of electricity to carry data. However, it is the most expensive form of cable and typically used only for connecting larger networks.

A wireless infrastructure for networking the machines is also possible. The following is a salient issue to consider for wireless networking:

- For wireless technology, use the best available transmission standard (802.11a/b/g/i) and segment the LAN as much as possible. Wireless LAN implementations should utilize the highest number of possible and/or practical security keys, with an encryption protocol to encrypt data; security keys should be changed from their default values. Currently, there are three encryption protocols to consider: Wired Equivalent Privacy (WEP), WiFi Protected Access (WPA), and WPA2. WPA2 is the latest implementation of WPA. All three protocols provide security by encrypting data over radio waves, protecting the data as it is transmitted from one end point to another. WPA2 offers stronger data protection and network access control than the two alternate security standards. Virtual Private Network (VPN) software ensures proper authentication of wireless devices/users.

For more information, review the state procurement contracts for wireless LAN infrastructure on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

There are four network standards for connecting computers and data transfer via an Ethernet network. Table 3 describes these network standards. Ethernet provides a fast network at a reasonable cost. Most modern computers are supplied with an integrated Ethernet interface or can easily accommodate an Ethernet network interface card.

Table 3. Network Standards

	Network Standards
Ethernet (10 Mbps)	The Ethernet standard is rarely used today due to its low data capacity. Since the late 1990s, it has been replaced increasingly by 100 Mbps and Gigabit Ethernet.
Fast Ethernet (100 Mbps)	The Fast Ethernet standard supports data transfer rates of up to 100 Mbps. Fast Ethernet is the most common Ethernet standard in computer networks today. The main topology is called 100BASE-T. Although newer and faster than 10 Mbps Ethernet, it is essentially the same. The 100BASE-T topology is subdivided into the following: • 100BASE-TX: Uses twisted-pair copper cabling (Cat 5) • 100BASE-FX: 100 Mbps Ethernet over optical fiber Note: Most 100 Mbps network switches support both 10 and 100 Mbps standards to ensure backward compatibility (commonly called 10/100 Network switch).
Gigabit Ethernet (1000 Mbps)	Gigabit Ethernet is the current standard that networking equipment companies endorse for desktop computers. Its most common use is in connections between network servers and network switches. The widely used Gigabit Ethernet is subdivided into the following: • 1000BASE-T: 1 Gbps over Cat 5e or Cat 6 copper cabling • 1000BASE-SX: 1 Gbps over multimode fiber (up to 550m) • 1000BASE-LX: 1 Gbps over multimode fiber (up to 550m)—optimized for longer distances (up to 10km) over single-mode fiber • 1000BASE-LH: 1 Gbps over single-mode fiber (up to 100km)—a long-distance solution
10 Gigabit Ethernet (10,000 Mbps)	10 Gigabit Ethernet is considered the new choice for enterprise network infrastructures. The 10 Gigabit Ethernet standard uses seven different media types for LAN, WAN, and MAN (Metropolitan Area Network). It is currently specified by the supplementary standard IEEE 802.3ae and will be incorporated into a future revision of the IEEE 802.3 standard.

3.4.2.2. Routers, Switches, Access Points, and IPv6

A *router* buffers and forwards packets of data across networks toward a certain destination. A *switch* forwards data from one device on the network directly to the intended recipient without sending it to all other devices. *Access points* extend the range of wireless networks and usually connect to a wired network to relay data between wireless devices and wired devices.

In 2008, federal agencies will adopt a new Internet protocol architecture called Internet Protocol version 6 (IPv6). This network layer Internet protocol (IP) standard enables electronic devices to exchange data across a packet-switched Internetwork. It follows IPv4 as the second version of the IP to be adopted formally for general use. The

main feature of IPv6 is the larger address space: 128 bits. IPv6 will provide additional addresses to networked devices, including cell phones and PDAs. There are advantages and, currently, some disadvantages or challenges to this new architecture. The increased number of addresses available for networked devices and the encryption of data by the application running on the device allows for peer-to-peer data sharing. The challenge with data sharing at this level is the inability of proprietary data to be checked for authorized release. As the time draws closer for the adoption of IPv6, governments and educational institutions with networks will need to address security and other related issues. At a minimum, school networks should have a firewall that performs some level of local blocking and that can support IPv6.

3.4.3. Network Administration

The SOL technology initiative requires each school to have a high-speed network connection to the Internet, whether it is provided via the division or obtained directly from an Internet service provider (ISP).

One of the factors controlling application performance on a network is the amount of available bandwidth. As more applications and services are activated on the network, they contend for available bandwidth. Modeling and simulation applications, video streaming, and some graphics applications demand significantly more bandwidth than a spreadsheet file transfer. Schools using VoIP should consider the bandwidth requirements (a minimum of 512 Kbps) for this service while using the same network for SOL testing (Unuth, 2007). An *application impact analysis* can help determine what impact an application will have on the network prior to deployment.

Estimating bandwidth needs for administering online SOL tests is a necessary part of preparing for online SOL testing and for achieving School Readiness Certification as part of the Web-based SOL Technology Initiative. Details regarding bandwidth requirements for administering online SOL tests are outlined in the Virginia Online Testing Technical Guidelines available at http://www.doe.virginia.gov/VDOE/Assessment/Online/.

Unneeded protocols and services should be removed from workstations and servers. For example, if a server is not being used for e-mail, the e-mail services and the SMTP and POP3 protocols should be removed. Unnecessary protocols can slow down network communications and pose security threats.

Network servers and other software applications should not route traffic; instead, use routers, switches, or enhanced firewalls. To alleviate bandwidth constraints, consider installing Web-caching devices. This can significantly improve other Web-based activities where students access static content or standard HTML pages. It should be noted, however, that this will not help testing requirements because test content cannot be cached.

Transmission Control Protocol/Internet Protocol (TCP/IP) should be the network protocol. Names for each device on the network should follow geographical boundaries or functions. Define a schema for naming and assigning addresses to each device on the network. Use private IP addresses, i.e., do not assign them to others on the Internet. The Network Information Centre has reserved certain addresses that will never be registered publicly. Private IP addresses are found in the following ranges:

- 10.0.0.0 to 10.255.255.255
- 172.16.0.0 to 172.31.255.255
- 192.168.0.0 to 192.168.255.255

Other recommendations include the following:

- Use local DNS (domain name service) at the school and district level to improve name resolution and manageability

- Use DHCP (dynamically assigned IP addresses)

Implement a mechanism for managing the network and capturing performance statistics. A diagram of the network infrastructure should be developed using a copy of the building blueprints and kept up-to-date. A sample diagram is included in Appendix C.

3.4.3.1. Logical Security/Physical Security

It is essential for school divisions to secure all facilities that maintain critical assets. Technology equipment requires two types of security: physical and logical. Physical security prevents and provides access to actual equipment. Logical access prevents and provides access to information stored on a network.

Technology-based asset management can supply the practices and procedures by which physical technology components (hardware, software, and related items) are managed and tracked. Issues such as location, ownership, usage, configuration, maintenance, and disposal may be managed electronically through appropriate software or outsourcing. One such solution is radio-frequency identification (RFID), which relies on data storage devices, called *transponders*, to transmit identifying information remotely. The device is attached to or incorporated into a product; the signal is read with radio waves.

School divisions should consider incorporating both physical and logical security into one technology-based asset management package. Both security types can be integrated through a dual-authentication system, which merges physical access technologies with identity management and user authentication technologies. This system grants users logical access to a network and applications after passing physical access. Both security types also require outlays for new access-control systems and recurring budgets for end-user training. Physical access technologies increasingly depend on TCP/IP networks, servers, and digital storage mediums—resources that previously have been the domain of information technology. These technological shifts, along with budget constraints, make convergence of these systems a consideration.

Schools should understand how their information infrastructures can be threatened. Develop a security architecture that defends against malicious attacks, is highly adaptable, and provides a protection level that matches the value of the information assets being protected. The architecture also should identify the basic services needed to address security in both current and future electronic environments and the various technologies available to implement the desired services. The following are some of the primary security categories and the supporting technologies required to protect a school's information infrastructure:

- Identification—the process of distinguishing one user from all others; technology components include user IDs and biometrics

- Authentication—the process of verifying the identity of the user; technology components include encryption, secure sockets layer (SSL), public key infrastructure (PKI), certificates, and digital signatures

- Authorization and Access Control—the means of establishing and enforcing rights and privileges allowed to users; technology components include encryption, security protocols, firewalls, virtual private networks (VPN), and directory-based authentication and authorization

- Administration—the functions required to establish, manage, and maintain security; technology components include domains, zones, registration authorities, key recovery, and key escrow

- Audit—the process of reviewing system activities, enabling the reconstruction and examination of events to determine if proper procedures have been followed; technology components include vulnerability tools, monitoring and filtering tools, intrusion-detection software, backup and recovery tools, and virus protection software

- Network-penetration testing uses tools and processes to scan a network for vulnerabilities. Performing penetration tests regularly helps uncover network security weaknesses that make data or equipment vulnerable to Trojan horses, denial-of-service attacks, or other intrusions.

- Monitoring and filtering tools verify and monitor any networked device and send immediate alerts via audible alarm, message, e-mail, or third-party software when a connection fails.

- Intrusion-detection software completes tasks such as file-integrity checking. It is difficult to infiltrate a system without altering a system file. A file-integrity checker computes a checksum for every guarded file and stores this information. At a later time, the new checksum can be computed again and tested against the stored value to determine if the file has been modified.

- Backup and recovery tools schedule ongoing backups of critical files. Regular backups are vital because it is impossible to guarantee the safety of any data that exists in only one place.

- Virus protection software tools should not only scan and detect existing viruses, they should also protect against additional infection and provide the options to clean, replace, or remove infected files. Utilities can repair boot sectors that have become infected by viruses; this is particularly important when the viruses cannot be removed by reformatting the hard disk.

Effective local security is critical to the successful implementation of the testing initiative and technology integration. At a minimum, *all* divisions should have some type of firewall protection between their networks and the Internet. One area of particular concern is protection against *denial-of-service* attacks against a division's Internet connection. Each division must ensure that its firewall solution and ISP protect against these types of attacks.

When implementing new technology components or new configurations of existing components (e.g., firewalls, content filters, monitoring tools, virus protection, etc.), it is necessary to ensure compatibility with online SOL testing software *prior* to administering SOL tests. Minor changes to network or workstation software and hardware can have significant impact on the ability to successfully administer online SOL tests. Network and workstation tests for compatibility and connectivity are highly encouraged *prior* to administering online SOL tests in order to avoid any unintended consequences that could impact student SOL testing. Current recommended configurations and guidelines for hardware and software are provided in the Virginia Online Testing Technical Guidelines at http://www.doe.virginia.gov/VDOE/Assessment/Online/. These guidelines should be reviewed prior to each online SOL test administration (fall, spring, and summer test administrations) and when a change in a network environment or desktop environment is being considered and evaluated.

3.4.3.2. Data Retention (Storage and Archiving)

On December 1, 2006, a new federal law went into effect requiring schools, businesses, and other organizations to archive all e-mails, instant messages, and other digital communications produced by employees. *Preserving Paper and Electronic School Records*, an information brief published by the Virginia Department of Education, offers suggestions on how divisions should attend to records retention and is located at http://www.doe.virginia.gov/VDOE/Technology/OET/info_brief_records.pdf. Divisions should ensure that all data systems can archive data based upon requirements established by the Library of Virginia. Please contact your division's records management specialist for additional information on the Library of Virginia requirements.

The *Educational Technology Plan for Virginia: 2003-09* requires divisions, as a representative action, to maintain networks that utilize data-recovery software. Divisions must work with technology providers to conduct periodic security audits and develop security policies and procedures that meet their needs. Production databases should be tested periodically for recoverability, according to requirements for their use and preservation. Divisions should consider the backup of metadata along with data. Production databases that support mission-critical applications

should be recoverable to a point-in-time and point-of-failure. Databases requiring 24/7 availability should have a high-availability strategy, such as failover, mirroring, and/or online backups.

3.4.4. Data Quality

Increasingly, educators recognize the link among effective teaching, efficient schools, and quality data. As a state agency, the Virginia Department of Education collaborates with district data coordinators to establish procedures for data collection and reporting. A volunteer task force of the National Forum on Education Statistics developed a "Forum Guide to Building a Culture of Quality Data" for schools and school districts and is located at http://nces.ed.gov/forum/pub_2005801.asp. The guide covers "common principles that can increase the likelihood that data will be secure, accurate, and useful." High-quality data should inform decisions about different educational technologies and help determine the impact of technologies on teaching, learning, and administration.

All software tools or packages that create files or data stores should use a format based on an underlying open or de facto standard—or provide the capability to export to such a format. Database software implementation should adhere with all local security, confidentiality, and privacy policies. Newly deployed database technologies should support Java Database Connectivity and Microsoft connectivity technology, such as Open Database Connectivity or Object Linking and Embedding Database. Production databases should be tested periodically for recoverability, according to requirements for their use and preservation.

3.4.5. Health, Safety, Efficiency, and Ergonomics

Computers are probably the most ubiquitous type of machine in today's work and learning environments. Although they generally are clean, quiet, and safe to use, improper interaction with and positioning of the equipment can lead to health problems such as eyestrain, repetitive stress syndrome, and backache.

Before designing the safest and most effective ergonomic environment, determine the type of computer, purpose, and normal usage times. If different people use the computer for a few minutes each, ergonomic design may not be the first priority. However, for workstations where individuals may spend an hour or more at a time, a few sensible tips can help achieve an ergonomically proper environment, such as proper positioning of the person and equipment, the use of document holders, and regular breaks. Users should also look away occasionally from the screen and blink several times to refresh their eyes when staring at a computer monitor for more than 15 minutes (Hedge, 2007).

Several alternatives to standard input devices and software can ease strain and offer ergonomic alternatives. These include digital pens, voice-recognition software, keyboard control pedals, joysticks, touchpads, voice-activated mice, eye-tracking systems, specially designed keyboards, wrist rests, and other products. Be sure to choose a research-based product that is comfortable for long periods of use.

Table 4 shows how various environmental aspects can be organized to create the right ergonomic conditions for a safer learning and work environment.

Table 4. Ergonomic Recommendations for Computer Use

Environment	Health & Safety Considerations	Ergonomic Recommendations
VDU (visual display unit)	• Avoid discomfort caused by reflective glare and eyestrain • Protect eyes against moisture loss	• Take adequate breaks regularly • Adjust the monitor's contrast and brightness • Focus regularly on a distant object • Use an antiglare screen • Adjust the screen height so the top is at eye level • Position the screen in a downward viewing angle
Keyboards	• Prevent wrist strain, which can develop into RSI (repetitive strain injury)	• Use a wrist rest • Type with your wrists floating above the keyboard • Keep your elbows relaxed • Keep the mouse at the same height as the keyboard
Seating	• Neutral body position	• Keep your hands, wrists, and forearms in a row, straight, and almost parallel to the floor • Keep your head and torso in line with your head, bent forward slightly, facing towards the front and balanced • Ensure your shoulders are at ease with your upper arms, hanging normally to the side • Ensure your elbows are close to the body and bent between 90 and 110 degrees • Support your feet with a footrest or by relaxing them on the floor • While leaning back or sitting in a vertical position, support your back fully with a firm hold on the lumbosacral area • Ensure the seat is well padded to support your hips and thighs • Ensure your knees and hips are almost the same height, with your feet slightly forward

3.4.6. Division Acceptable Use Policies

All Virginia public schools are required to have an educational technology plan that aligns with the *Educational Technology Plan for Virginia: 2003-09*. These individual school plans must include policies defining acceptable use of computers and the Internet. In addition, superintendents must submit divisionwide acceptable use policies biennially to the Department of Education for compliance review. Legislation approved by the 2006 General Assembly and signed by Governor Kaine added a requirement that each division acceptable use policy must include an Internet safety component.

As divisions increase the integration of technology into instructional programs, they must ensure that the technologies and devices mentioned in these guidelines comply with their acceptable use policies. The Superintendent of Public Instruction has issued guidelines to divisions regarding Internet safety-related instructional programs. These guidelines are available in PDF format for duplication as needed at http://www.doe.virginia.gov/VDOE/Technology/OET/internet-safety-guidelines-resources.pdf. The Department has issued companion documents relating to integrating Internet safety into curriculum and instruction which can be found at http://www.doe.virginia.gov/VDOE/Technology/OET/internet-safety-guidelines.shtml. The Department also has compiled additional resources relating to implementing the legislation which can be found at http://www.doe.virginia.gov/VDOE/Technology/OET/internet-safety-related-resources.pdf.

3.5. Evolving/Emerging Technology Considerations

3.5.1. Supercomputers

Supercomputers were introduced in the 1960s and designed primarily by traditional companies such as IBM and HP. In recent years, supercomputers have been created by connecting a number of desktop machines in parallel to harness the power of all the linked machines. Schools have started to assemble machines in small cluster formations to create their own supercomputers. This *cluster* approach helps break down and run problems simultaneously.

3.5.2. Grid Computing

Grid computing is an emerging model that can perform faster operations. It takes advantage of multiple networked computers to model a virtual architecture that distributes process execution across a parallel infrastructure. Grids use the resources of many computers at separate sites, connected by a network (usually the Internet) to solve large-scale computation problems, use computing resources efficiently, and conduct educational research. School systems and other organizations should consider grid computing to utilize existing resources more efficiently or improve the efficiency of school data processes and other functions.

3.5.3. Internet2/National LambdaRail/SEG-P

Internet2 is a nonprofit consortium of universities and corporate sponsors that work with advanced technologies to develop future Internet applications and increased bandwidth capabilities. It is the foremost advanced networking consortium in the United States, with an access capacity from 1.5 Mbps to 622 Mbps.

Internet2 created a private network for education and research known as the Abilene Network. It advances Internet2's goal of facilitating and enabling the development of advanced network applications, services, and content that enable routine collaboration on instructional, clinical, and/or research projects, services, and content.

The consortium also invested in National LambdaRail (NLR), a high-speed national computer network developed by research institutions that runs over fiber-optic lines. National LambdaRail is the first transcontinental Ethernet network. Led by the research and education community since 1996, NLR provides both leading-edge network capabilities and unique partnership opportunities that facilitate the development, deployment, and use of revolutionary Internet technologies. NLR is similar to the Abilene Network but allows for more experimentation. National LambdaRail is a university-owned network, while the Abilene Network is a university-corporate sponsorship. This university ownership of NLR ensures the research community unprecedented control and flexibility to meet the most advanced network application requirements and provide the resources demanded by cutting-edge network research. The network bandwidth of NLR is on OC192.

Any organization that subscribes to or uses Internet2 services through the Abilene gigaPoP, direct connection, or any other route is considered an Abilene Participant. Abilene provides high-performance networking for data traffic among participating gigaPoPs, regular members, and other organizations whose connectivity benefits U.S. higher education. Abilene Participants fall into two categories. *Sponsored* participation includes two classes: Sponsored Individual Institutions and Sponsored Educational Group. The Sponsored Educational Group Participant (SEG-P) is allowed expanded access to Abilene for state and regional education networks through sponsorship by Internet2 university members. State and regional networks may include nonprofit and for-profit K-20 educational institutions, museums, libraries, art galleries, or hospitals that require routine collaboration on instructional, clinical and/or research projects, services, and content with Internet2 members or other sponsored participants.

As of March 2006, 35 state K-20 networks participated with SEG-P. Virginia school divisions connected to the Internet through Network Virginia can access Internet2/NLR resources through the SEG-P program, provided the school infrastructure has sufficient bandwidth. To participate, a minimum connection capacity of T1 should be available directly to the network containing the individual PCs that will be accessing Internet2/NLR. See Appendix B for educational applications.

3.6. Other Considerations

3.6.1. Teacher Involvement in Technology Planning

Research on classroom integration of information and communication technologies has found that technology, in and of itself, does not directly change teaching or student learning (Grégoire, Bracewell, & Laferrière, 1996). One of the necessary factors for the effective application of technology is involving teachers in technology planning. Teachers serve as the *frontline* implementers of technology integration. Their buy-in to building-level and divisionwide technology planning is essential to the successful implementation of strategies for increasing and improving technology integration. Teacher feedback from past professional development is vital; their continual feedback and participation in future professional development planning helps ensure the activities adequately meet the needs of teachers. Teachers, by their positions, are part of an instructional team in a school; consequently, they should be part of any technology planning team aiming to make a positive impact on instruction and learning. A local technology plan—fully aligned with the *Educational Technology Plan for Virginia: 2003-09*—should be developed by a technology committee comprising those responsible for implementing the plan, including teachers.

3.6.2. Developing Technology Literacy: TSIP, Computer/Technology SOL, NETS

The development and continuing improvement of teacher technology literacy skills is necessary for technology to be a useful tool in the instructional process. In January 1998, the Virginia Board of Education approved the Technology Standards for Instructional Personnel (TSIP). The regulations (http://www.doe.virginia.gov/VDOE/Compliance/TeacherED/tech.html) help ensure that instructional personnel in Virginia master and demonstrate competency in technology consistent with the computer/technology SOL for students.

One of the goals of Title II Part D of the *No Child Left Behind Act* (Enhancing Education Through Technology) is that every student be computer literate by the end of the eighth grade. Each Virginia school division is responsible for developing an assessment instrument to determine student computer literacy. Standards have been developed at the state and national levels to assist in this effort. The computer/technology SOL identify and define the progressive development of essential knowledge and skills necessary for students to access, evaluate, use, and create information using technology. Computer/technology proficiency is not an end in itself but lays the foundation for continuous learning and computer literacy. The focus is on learning *using* technology rather than learning *about* technology. The standards are available in a PDF and Microsoft Word file format located at http://www.doe.virginia.gov/VDOE/Superintendent/Sols/home.shtml.

The National Educational Technology Standards (NETS) were developed by the International Society for Technology in Education for three levels of technology users. The NETS-A identifies knowledge and skills that every administrator needs to know about and be able to do with technology. The NETS-T covers standards related to what teachers should know about and be able to do with technology. The NETS-S provides standards as guidelines for planning technology-based activities in which students achieve success in learning, communication, and life skills.

3.6.3. Digital Conversion

On February 17, 2009, broadcast television will undergo a major change as all stations switch to digital transmission and abandon the analog signal that has sent television signals to American homes, schools, and businesses since the 1930s. Not since the introduction of color television in 1953 has there been such a significant change in the technology that sends commercial and public television signals all over the country. With this new technology, the broadcasting industry can free up valuable airwave space to provide exciting new options for television viewers, the most anticipated of which is high-definition television (HDTV). A 2008 information brief (VDOE, 2008) addresses additional implications for school divisions regarding digital conversion. The information brief can be viewed at http://www.doe.virginia.gov/VDOE/Technology/OET/info_brief_digital_conversion.pdf.

4. Building-Level Instructional Technology Systems

Administering an effective technology infrastructure requires a working knowledge of divisionwide requirements. In addition, building-level technology managers often are responsible for maintaining the infrastructure, procurement of peripherals and software, and physical security. The following should guide administrators and information technology personnel when designing and maintaining building-level instructional systems.

4.1. Computer Lab and Library Media Center

4.1.1. Computer Lab Design

A computer lab creates the potential need for specialized equipment depending upon its use as either a general computer lab or a modeling/design lab. A general computer lab requires multiple computer workstations with access to the building network. If space or workstations are in short supply, no more than two students should be assigned to a workstation. A typical computer lab should accommodate anywhere from 15 to 30 workstations and include four to six printers. A modeling/design lab may require access to specialized equipment such as computer-controlled robots and controllers. For flexibility, labs should be designed to accommodate virtual teaming between rooms, schools, and outside educational facilities. All lab technologies should be configured consistently with labs found in appropriate industries (e.g., electronics, medical).

4.1.2. Library Media Center Design

The library media center may be considered a general access point for technology resources for teachers and students. Adequate space in the circulation area should allow for outlet connections and network access for computerized circulation systems with bar scanning capabilities and a printer. The availability of computer

workstations for students and teachers is necessary for electronic catalog access, client or Web-based electronic research subscriptions, and other resources. The number of workstations depends upon available space. The infrastructure should include cabling that allows for the addition of workstations or wireless access points. Planning for maximum workstation configuration is essential so that voice, video, data, and power connection paths are properly identified.

4.2. Hardware

4.2.1. Clients

Simply speaking, a client can be defined as a single computer. A number of devices can function as clients; but, from a school's perspective, desktop computers are the most familiar type of device. Desktop computers can be connected as clients but possess the processing power to run applications without a server. As part of the Web-based SOL Technology Initiative, each school must achieve a maximum client ratio of five students to one computer. Current minimum workstation requirements are documented in the Virginia Online Testing Technology Guidelines available at http://www.doe.virginia.gov/VDOE/Assessment/Online/.

Table 5 includes recommended computer specifications for classroom instruction. Due to the ever-changing nature of computer technology, these specifications are based upon information available at the time of publication. More current specifications may be available. Please check periodically with computer manufacturers and the state procurement contract documents on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

Table 5. Current Recommended Computer Specifications for Classroom Instruction

	CLIENTS	MONITOR
Good	Intel® Core™ 2 Duo Processor E6300 (1.80GHz, 2M, 1066MHz FSB) 2.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 80GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy Internal Audio Speaker 24X CDRW/DVD Combo	17-Inch Analog Flat-Panel LCD Monitor
Better	Intel® Core™ 2 Duo Processor E6600 (2.4GHz, 2M, 1066MHz FSB) 2.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 250GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy External Audio Speaker 24X CDRW/DVD Combo	19-Inch Analog Flat-Panel LCD Monitor
Best	Intel® Core™ 2 Duo Processor E6700 (2.66GHz, 2M, 1066MHz FSB) 4.0GB DDR2 Non-ECC SDRAM, 667MHz, 2DIMM Integrated Video, Intel® GMA3000 Keyboard: USB USB 2-Button Entry Mouse with Scroll Boot Hard Drives: 750GB SATA 3.0Gb/s 1.44MB 3.5 Inch Floppy External Audio Speaker 24X CDRW/DVD Combo	19-Inch Analog Flat-Panel LCD Monitor

Additional features include the following:

- Easily accessible ports
- Multiple USB ports
- Firewire ports

4.2.2. Peripheral Devices

Classroom teachers, instructional assistants, and students often will be required to use peripheral devices in connection with teaching, learning, and classroom management. A basic knowledge of the available devices and their functionalities can help teachers effectively integrate technology into the curricula. In addition, this information may be useful when designing and maintaining an instructional technology system at the classroom level.

Printers

The printer choice largely is dependent on the purpose or job, as different technologies are capable of different levels of image/text quality and print speed; some technologies are inappropriate for certain types of physical media, such as photo paper or transparencies. Classroom printers can be attached directly to computers. Computer labs generally share one or more printers accessed via a network; networked printers optimally have a higher print speed than classroom printers. Special projects requiring a high degree of color resolution or high volume print quantities may need specialty printers.

Typically, ink jet printers are appropriate for printing color-intensive graphics, and laser printers are best for printing text documents due to their fast print speeds. However, some color ink jet printers can print fast without tearing paper or using excessive amounts of ink.

There are several specifications to consider when assessing the image/text quality of printers. Resolution is a widely used specification that refers to the number of dots per inch (dpi) that can be printed horizontally and vertically. A high-resolution printer is capable of printing more detailed images and text than a printer with a lower resolution. Print speed measures the number of pages generated per minute (ppm); however, printer manufacturers often determine these speeds by printing basic text documents at the lowest-quality settings (draft mode) on plain paper. Users should expect to experience half the print speed that manufacturers report.

Before making a purchase, you should also examine printed text and images. Different text fonts should be legible, fully formed with no fuzzy edges, and crisp. The tops and bottoms of characters should be correctly aligned from one row to the next. The letter openings (counters) should be well rounded; if not, the printer may be using too much ink. When assessing image quality, three characteristics should be considered: color accuracy, sharpness, and dynamic range. In assessing color accuracy, the inside areas of images should be dense and evenly shaded. Transitions from dark to light colors (gradient) should have smooth transitions instead of distinct bands (color banding). Images should show balanced color saturation as opposed to overly saturated colors or washed-out areas. Image sharpness can be judged by looking for crisp outer edges with smooth corners. For the dynamic range, there should be clear details in highlighted and shadow areas.

The cost of consumables such as ink and paper should also be considered. Typically, ink jet printers cost less than laser printers, but ink jets contain smaller cartridges that have to be replaced more often. Therefore, the total cost of ownership may be lower with a laser printer. The printing cost per page should be calculated in determining the total cost of ownership. This is determined by dividing the cost of a cartridge by the number of pages it can print; for example, if a $40 cartridge can print 800 pages, the cost per page is five cents ($40/800=.05). A multifunctional device that provides copying, printing, scanning, and faxing capabilities may provide the lowest overall cost of ownership by eliminating the expenses of purchasing and maintaining multiple pieces of equipment.

For more information, review the state procurement contracts for printers on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractSearch.cfm?mode=keyword.

Monitors

Monitor specifications are described in terms of screen size and quality. The screen size refers to the diagonal length from one corner of the monitor box to the other. A stated screen size of 17″ normally results in a viewable area of only 15.1″.

- Average entry-level PCs usually come with a 17″ monitor, which is adequate for most general-purpose applications.
- Larger 19″ or 21″ monitors may be appropriate for video editing or advanced graphics work (e.g., multipage layout).
- Teachers of students with special needs may want to consider larger monitors.

3-D displays, such as virtual reality environments, can be generated by using a 3-D display device with a computer. There are several devices for generating 3-D displays, but the most common are LC (liquid crystal) shutter glasses and HMD (head-mount displays). 3-D displays offer an alternative environment for students to experience and learn a variety of subject matter via interactive simulations, models, etc.

CD and DVD Drives

CD drives—standard on PCs—read or write data on a compact disc. It is defined by its speed (e.g., 16x, 48x). DVD drives can read both CDs and DVDs. A DVD can hold more than 25 times more data than a CD in higher-density multilayer storage format. Educational software is available in DVD and CD formats.

Speakers, Microphones, and Headsets

Most computers come with either built-in or external speakers. External speakers can enhance the sound levels of a computer or classroom projection device. For computers that lack built-in microphones, external microphones or USB headsets may be used for audio input. In a computer lab setting, headsets can control sound from multiple computers simultaneously. Inexpensive *headphone splitters* can allow two sets of headphones to be accessed on one computer.

Projection Devices

Projection devices enhance teacher and student presentations in classrooms and computer labs. While classroom projection devices can be as simple as an overhead projector or a computer-based LCD (liquid crystal display) or DLP (digital light processing) projector, wall-mounted flat-panel screens can enhance an auditorium or lab setting. When choosing a projection device, consider its ANSI lumens, resolution, and lamp life. For projecting detailed data and graphics onto a 60-inch diagonal screen, a projector with 300-400 ANSI lumens and a resolution of at least 1024 x 768 is preferred (Projector Central, 2007).

Electronic Whiteboard

An interactive whiteboard is a peripheral device that requires a computer to generate the display either directly or via a projector. Operating directly as a large room display, the end user might use built-in software to capture notes written on the whiteboard-like surface and/or control the computer (click and drag), markup (annotate a program), or use optical character recognition (OCR) on the computer-generated image displayed from the whiteboard and/or touch-screen surface.

The interactive whiteboard is connected to a computer through a wired medium (e.g., USB, a serial port cable) or a wireless connection such as Bluetooth. There are different types of interactive whiteboards including electromagnetic, infrared optical, laser, ultrasonic, and camera based. These are available with three forms of imagery:

- Front-projection whiteboards have a video projector in front of the whiteboard.
- Rear-projection whiteboards have a projector located behind the whiteboard; some are self-contained, with the projector and the whiteboard in a single cabinet.
- Add-on systems attach to an existing monitor, such as a large flat-screen monitor.

Considerations for an interactive whiteboard include room design, room size, controllable lighting, and the desired interactive features. Approved state contracts for interactive whiteboards and other peripheral devices can be invaluable resources during the selection process. These state contracts can be reviewed on the VITA Supply Chain Management Web page at http://www.vita.virginia.gov/procurement/contractDetail.cfm?contract_id=2804 http://www.vita.virginia.gov/procurement/contractDetail.cfm?contract_id=2806.

At the time of publication, Smart Inc., which produces a full line of interactive whiteboards, had a grant program for K-12 entities located at http://smarterkids.org/k12/index.asp.

Scanners

Inexpensive flatbed scanners often can meet basic classroom scanning needs, such as generating student handouts. A low-resolution scanner works well for scanning text or data; however, for accurate OCR (optical character recognition), a high-resolution scanner and OCR software are necessary. Photographs or other detailed graphics may require a 600 x 600 dpi (dots per inch) scanner. The higher the dpi resolution, the better the resulting image will be. Combination flatbed/automatic document-feeder scanners with a fairly high page-per-minute feed rate may be more appropriate for administrative use.

Cameras

Digital cameras can enhance the teaching and learning process. Two resources for guidance on the purchase of digital cameras are Kathy Schrock's *Teacher Helpers Guide to Digital Gadgets—Digital Cameras and Camcorders in the Classroom* (http://school.discovery.com/schrockguide/gadgets.html) and Keith Lightbody's *Digital Cameras Enhance Education* (http://www.zardec.net.au/keith/digcam.htm). In general, the purpose of the digital camera will determine its necessary features. Professional-quality images for art or graphics classes may require cameras that have the following: exposure controls such as aperture and shutter priority, choice of metering modes, bracketing, and lens attachments. A camera with a resolution of seven megapixels or higher should be used to take images that will be printed or require retouching. Always consider factors like focus control, flash modes, ease of use, file-download format, file-storage capabilities, and compatibility with USB ports.

Personal Response System

A personal response system is also called a classroom response system or an audience response system. The system comprises hardware and software that collect and display student input to teachers' questions. The system can use an infrared or radio-frequency signal sent to a receiver attached to a teacher's computer; the necessary components are a student keypad, receiver, computer, and software.

Voice Amplification Systems

Voice amplification systems have been used as assistive technologies for students with hearing impairments for years. This technology can facilitate all facets of teaching and learning by lessening the strain on a teacher's voice and helping students remain attentive and engaged. The system's setting will determine its necessary features. The room dimensions, the presence or lack of acoustical tiles, flooring type, the presence of large fixtures, and other factors must be considered when choosing a voice amplification system.

Computer-Based Microscopes

Computer-based microscopes electronically collect data for analysis during inquiry-based learning. Several models are available; the microscope's purpose will determine its type and features. Table 6 includes some guidelines.

Table 6. Guidelines for Selecting Computer-Based Microscopes

	MICROSCOPES
Good	Digital, 20X-50X zoom
Better	Digital, 20X-100X zoom, USB plug-n-play, digital image capture
Best	Digital, 20X-500X zoom, USB plug-n-play, digital image and video capture, LED illumination, Save file format: BMP, JPG, AVI

Sensors (Probes)

Sensors and probes electronically collect data as a part of inquiry-based hands-on activities in such curricula as science, mathematics, and technology. Probes are components of *probeware*, which is equipment and software that gathers and analyzes data in real time. Probeware systems interface with a computer, graphing calculator, or self-contained measuring system. The data can be displayed as graphs, tables, meters, or values.

Table 7. Guidelines for Selecting Probes

	PROBES
Good	Temperature sensor with range of -35° to +135°C; displays degrees in C, K, and F
Better	Multimeasure sensor with temperature range of -10° to +50°C; sound level range of 40-90 dBA; light range of 0-5000 lux
Best	Multimeasure sensor including probeware system with temperature range of -35° to +135°C; selectable light ranges of 0-100, 0-10,000, and 0-150,000 lux; sound level of 50-100 dbA, voltage ±24 V, and sound maximum sample rate of 200 Hz

4.2.3. Assistive Technology/Web Accessibility

Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794d), guarantees federal employees with disabilities comparable access to information and data as employees who are not individuals with disabilities, unless an undue burden would be imposed on the agency. This is a mandate for federal agencies that develop, procure, maintain, or use electronic and information technology. School divisions are not required to comply with Section 508 standards. However, the standards were developed to ensure technology accessibility to the public; therefore, divisions should be knowledgeable of the standards as part of their responsibility to meet the needs of education stakeholders and the general public. See Appendix A for additional information on Section 508 standards.

The *Code of Virginia* (Title 2.2 Administration of Government, Chapter 35 Information Technology Access Act, § 2.2-3500–2.2-3503) provides information on the Commonwealth's policy addressing information technology access. The *Code* defines access to mean "the ability to receive, use, and manipulate data and operation controls included in information technology."

Assistive technology consists of any technologies that help students read, write, speak, see, get around, move, or play. Educational and assistive technologies give students with disabilities greater possibilities to master content and organize and control their behavior. Assistive technologies offer adaptations and modifications to help students with disabilities participate in the general education curriculum to varying degrees. The following list addresses some of the most common issues people with motor disabilities face; note that many more types of technologies exist—this is just a sampling:

- It is often easier for a person with a motor disability to operate a trackball mouse than a standard mouse. For example, it is easier to manipulate a head wand or mouth stick with a trackball mouse. Someone with hand tremors also may find this kind of mouse more useful because once the cursor is moved to the right location, there is less danger of moving it accidentally while trying to click on the mouse button. In addition, people with hand tremors potentially could manipulate the trackball mouse with their feet.

- Due to its simplicity and low cost, the mouth stick is one of the most popular assistive technologies (though the word *technology* may be a bit of an overstatement). In many cases, a rubber tip at the end of the mouth stick gives the tip better traction; a plastic or rubber feature at the other end is inserted into the mouth. People without use of their hands could maneuver a mouth stick to type and perhaps manipulate a trackball mouse, depending on their control of the mouth stick and patience level.

- A head wand is similar to a mouth stick, except the stick is strapped to the head. Head movements make the head wand type characters, navigate through Web documents, etc. Fatigue can be an issue when a lot of keystrokes are required.

- People with very limited mobility can use a single-switch access. For this tool, a switch is placed to the side of a person's head. The person can control the computer by moving his or her head and clicking the switch. Special software on the computer interprets the clicking action and allows the user to navigate through the operating system, Web pages, and other environments. Some software facilitates typing by using an auto-complete feature that tries to guess what the person is typing and offers choices of different words.

- An adaptive keyboard can be useful for people who lack reliable muscle control in their hands. Some adaptive keyboards have raised, rather than lowered, areas between the keys, which allow people to slide their fingers into the correct position. A person with tremors or spastic movements could benefit from this type of keyboard. Keyboard overlays can achieve the same results. In some cases, adaptive

keyboards come with specialized software with word-completion technology, allowing the person to type with fewer keystrokes; this is significant since typing can be rather laborious.

- Eye-tracking devices allow individuals with limited or no control over their hand movements to navigate through the Web with only eye movements. Special software allows the person to type and may include word-completion technology to speed up the process. These systems can be expensive—usually several thousand dollars—so they are less common than less-sophisticated devices such as mouth sticks and head wands.

- Touch screens allow users to interact with computers by touching the display screens. They often project infrared light beams across the screen surface. When a person's touch interrupts the beams, an electronic signal identifies the location on the screen. Software interprets the signal and performs the required operation.

Several typical pieces of computer equipment also can assist people with disabilities, including **headphones** with stereo output and volume controls; a digital **microphone**, which allows students to control their input and interact with voice recognition software; and **scanners**, which should be used with scan- and read-type software. *Note: It should not be assumed that assistive technologies and additional computer equipment will be compatible or allowable for online SOL testing. Inquiries should be directed to the Virginia Department of Education's Office of Test Administration, Scoring, and Reporting at (804) 225-2107 or via e-mail at student_assessment@doe.virginia.gov.*

In addition, *Web accessibility* is important when considering assistive technologies. *Web accessibility* refers to a wide range of user agent devices, not just standard Web browsers. This is especially important for people with visual impairments. To access standard Web browsers, some users require special software or devices, such as a voice-activated browser function, touch screen, or simplified language interface. Design for accessibility is a subcategory of good design for usability.

Web accessibility allows people with disabilities to perceive, understand, navigate, interact with, and contribute to the Web. These tools also benefit older people with changing abilities. Web accessibility encompasses all disabilities that affect Web access, including visual, auditory, physical, speech, cognitive, and neurological disabilities. When developing and setting up access to online resources, schools should allow for resources by individuals with disabilities from school and home.

Organizations, companies, and consultants increasingly offer *Web site accessibility audits*. These types of system testing identify accessibility problems and provide guidance on correcting these issues. There are several options for auditing Web site accessibility:

- Automated tools can identify some of the problems.

- Technical reviewers who are knowledgeable in Web design technologies and accessibility can review a representative selection of pages and provide detailed feedback.

- User testing, usually overseen by technical experts, involves setting tasks for ordinary users to carry out on the Web site and reviewing the resulting problems.

Each of these methods has strengths and weaknesses:

- Automated tools can process many pages in a relatively short length of time but can identify only a limited number of accessibility problems.

- A technical expert review can identify many problems, but the process is time consuming; plus, many Web sites are too large to allow for a review of every page.

- User testing combines elements of usability and accessibility testing and helps identify problems that might otherwise be overlooked; however, it needs to be used knowledgeably to avoid basing design decisions on one user's preferences.

Ideally, Web site accessibility audits require a combination of methods.

Web Content Accessibility Guidelines 2.0 (WCAG 2.0) (http://www.w3.org/TR/WCAG20/) offers various recommendations for making Web content more accessible. These guidelines make content accessible to a wider range of people, including those with blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech difficulties, photosensitivity, and combinations of these. Following these guidelines will make Web content more accessible to the vast majority of people, including older users.

These guidelines, however, cannot address the needs of all people with disabilities. WCAG 2.0 success criteria are written as testable statements that are not technology specific. Separate documents provide additional guidance about specific technologies and general information about interpreting the success criteria. WebXACT is a free, online service that tests single Web pages for **quality**, **accessibility**, and **privacy** issues. This service, known also as "Bobby," is a comprehensive tool designed to aid Webmasters in creating standard compliant and increasingly accessible Web sites. "Bobby" tests Web pages using guidelines set in the Web Access Initiative (WAI) established by W3C—World Wide Web Consortium—and Section 508 guidelines. Appendix A provides additional information on Web accessibility.

Another consideration is Universal design—the development of products and environments that can be used by as many people as possible without the need for adaptation or specialized design. It allows students to access content using their strongest learning modality; for example, text can be adapted in print and digitally for a lower reading level with graphics that add clarity or the text could be read aloud via a computer. For additional information on Universal design, go to www.cast.org.

4.3. Software

4.3.1. Educational Software

Educational software helps teachers and students in any learning environment maximize the power of the computer. Hundreds of educational software titles are available, but not all are suitable for school use. Most educational software can be divided into two categories.

Content-free software is the more flexible of the two categories. It allows teachers and students to create their own content, such as word-processing and graphics programs, that support the user's creativity. Table 8 lists a series of tasks that could be adapted to open-ended software.

Table 8. Content-Free Software Tasks and Software

TASK	SUGGESTED SOFTWARE TYPE
Writing	Word-processing or desktop-publishing program (e.g., Word, Textease)
Writing a musical score	Score-arranging software (e.g., Sibelius)
Editing a digital photograph	Image-editing software (e.g., PhotoShop)
Brainstorming, essay planning	Concept-mapping software (e.g., Inspiration)

Content-rich software typically comprises multimedia content (e.g., graphics, video, sound, animation) presented in a very structured way. Content-rich software ranges from teaching basic number concepts and explaining complex mathematical equations to analyzing strategic military movements during World War II. Table 9 lists a series of tasks that could be adapted to content-rich software.

Table 9. Content-Rich Software Tasks and Software

TASK	SUGGESTED SOFTWARE TYPE
Reinforcing basic number concepts	Drill-and-practice mathematics program (e.g., Millie's Math House)
Exploring electrical concepts	Science simulation program (e.g., Exploring Science)
Retrieving information	Multimedia encyclopedia (e.g., Encarta)

4.3.2. Hosted Applications

Hosted office applications may offer several benefits over standard software packages. Some applications provide a stand-alone service such as a single word-processing or presentation application. Application service providers (ASP) may offer an entire suite of hosted office applications integrated among their own services.

Because the applications and documents often are hosted remotely, divisions will not need to invest in additional hardware for storage and servers or human resources to install, patch, maintain, and update software. Some hosted office applications are free or cheaper than licensed software packages, which is a cost savings for divisions working with limited technology budgets. Providers of hosted applications do not always offer technical support for installations, patches, maintenance, and application updates. Online forums, wikis, or blogs may be available to assist with hosted applications, but divisions should carefully assess the skill levels of support personnel before selecting hosted applications.

Divisions should look for hosted office applications that can keep the same look and feel as traditional software packages and incorporate the basic functions to create, import, and edit documents. Online spreadsheets may offer basic-to-intermediate formula functions, and word processors may contain common formatting and layout options but provide fewer fonts. Some applications provide a spell checker but not a thesaurus or language translator.

4.4. Other Considerations

4.4.1. Technology Advisory Committee

Every school should have a technology advisory committee, cochaired by the school's ITRT and library media specialist. It should include a representative sample of all school stakeholders including grade levels and academic departments. To assist with goals and objectives, the committee should develop a planning timeline, spelling out clear accomplishments. The roles and responsibilities of the cochair and individual members should be documented carefully. Suggested roles and responsibilities should include the following:

Role of the Committee

- Ensure that technology planning aligns with school and division goals.
- Promote initiatives, communicate expectations, and evaluate plan effectiveness.
- Make recommendations to the principal for distributing media center and technology funding.
- Assess professional development needs and make recommendations for training opportunities.
- Serve as peer coaches and media/technology goodwill ambassadors.

Responsibilities of the Chair (Cochairs)

- Attend grade level departmental or meetings to become knowledgeable about the school curriculum and instructional initiatives.
- Keep up-to-date on available resources, equipment, and trends.
- Plan and prepare for committee meetings and provide agendas.
- Provide the committee with relevant resources and information for consideration or discussion based on current standard selection tools.
- Follow through on any recommendations, directives, or decisions reached by the committee.

Responsibilities of Individual Members

- Provide leadership in implementing and adapting plans and monitor planning processes and results.
- Seek input from teachers and students.
- Participate in the decision making and other work of the committee.
- Support the decisions and actions of the committee.
- Keep faculty informed of actions and recommendations of the committee.
- Assist the ITRT and library media specialists with public relations efforts.

5. Classroom and Media Center Instructional Technology Systems

Teachers are the front line of technology integration in our schools. Incorporating technological tools can help educators meet the goal of *Educational Technology Guidelines: Designing and Maintaining Instructional Technology Systems*, which helps ensure student success by effectively integrating technological tools into teaching, learning, and school management. A basic knowledge of the tools available and their interoperability can help classroom teachers, instructional assistants, and resource personnel meet the needs of their students. The following information should help design and maintain a classroom instructional system that supports technology integration into teaching, learning, and classroom management.

5.1. Classrooms

5.1.1. General Classroom Schematics/Design

When designing a classroom environment conducive to effective technology use, consider the purpose and use of the room. For example, the layout of an elementary classroom with a pod of five computers will differ substantially from a high school that utilizes a laptop cart. Additionally, the size and layout of a legacy room will dictate the number of possible design scenarios. Electricity and connectivity needs will limit the possibilities; a standard personal computer requires at least two 110-volt electrical connections and an Ethernet connection. The following are possible schematics for classroom computer use:

Pods: Grouping computers within the regular classroom can be an effective use of technology. Each workstation should be a minimum of 30 inches wide to allow for a full-size keyboard; if the students work regularly in partners or groups, more space will be needed. When possible, spread the computer stations around all four walls of the classroom to allow collaborative work and encourage learning centers.

Desktop: Placing one personal computer at each desk is essential when privacy and distractibility are issues, such as with online assessments. This is a common computer lab design. In legacy rooms, electricity and connectivity issues often force the desks to be arranged along the walls, which results in students sitting with their backs to the instructor. In rooms designed specifically for computer use, a tiered classroom design allows for more teacher/student interaction. In addition, cables or wires are generally run discreetly (e.g., not across aisles).

Laptop Carts: Portable computer carts add a multifunctional component to regular classrooms; teachers and students can determine the arrangement that suits the lesson needs. Students can work in groups or individually; computers can be arranged in a standard classroom design or in workstations. This schematic requires a wireless access point suitable for multiple connections. Laptop carts have been highly successful for administering online SOL tests.

Individual schools must decide the optimal classroom designs for their technology. They also must consider proximity, placement, and lighting, including the following decisions:

Computer placement: A standard keyboard requires approximately 30 inches of space; more may be necessary if the desk also will be used as a workspace. All screens should be placed approximately 30 inches from the users' eyes. While flat-panel screens require little additional depth, more space must be allowed for CRT monitors. A 15-19-inch CRT monitor requires about 30 additional inches of depth; 21-inch CRTs require 36 inches.

Desk Placement: Aisles between desks should have a minimum width of approximately 36 inches; for wheelchair access, 42 inches is preferable. Staggering desk rows increases width and accessibility. Desks should be placed parallel to windows, when possible, to reduce screen glare. Suitable chairs should be chosen with ergonomics in mind; those with height adjustability and a broad seat and back are ideal.

Printers and Other Peripherals: The location of printers, projectors, VCRs, printer paper, and other miscellaneous supplies must be considered. Space for free-standing or built-in units must be planned.

5.1.2. Working with ITRT

The working relationship between teachers and ITRT is one of the most significant of all the relationships in a school. This relationship, when developed effectively, can have an immediate impact on classroom instruction and student performance through the further integration of technology. For this relationship to be effective and have a positive impact on classroom instruction and student performance, several factors must be implemented properly. One of the most important issues is for the ITRT to understand their roles and responsibilities clearly and communicate them to teachers. The Office of Educational Technology's *Instructional Technology Resource Teacher and Technology Support Positions Handbook* (http://www.doe.virginia.gov/VDOE/Technology/) provides additional guidance on factors that foster a successful working relationship among teachers, administrators, and other school personnel. Effective communication among these individuals can help ensure a maximum positive impact on teaching, learning, and classroom management.

5.2. Evolving/Emerging Technology Considerations

Today, advances in technology and technological applications occur almost more quickly than can be documented. Not only are new products and services available on a daily basis, innovative educators and thought leaders

continue to find new ways to apply existing technologies to teaching, learning, and school management. The following is an overview of devices and applications that may be valuable to educators when designing and maintaining classroom instructional systems.

5.2.1. PDA

Personal digital assistants (PDA) are handheld devices that can serve different functions. Many PDAs can access the Internet or intranet via WiFi, Bluetooth, or wireless wide or local area networks. Software may be downloaded to support functionality; these devices may be used for a wide range of applications, including digital note taking, electronic textbooks, and file sharing. Some school systems have begun to use PDAs as administrative tools or integrate them into classroom learning.

The supported applications and type of connection will determine bandwidth requirements for the devices (Roseberry, 2007). The use of PDAs as classroom or administrative tools should be considered when designing a wireless network.

5.2.2. Podcasting/Streaming

Podcasting distributes multimedia files, such as audio or video programs, over the Internet using syndication feeds for playback on mobile devices and personal computers. Streaming refers to media that is consumed (heard or viewed) while being delivered. Streaming is more a property of the delivery system than the media itself. The distinction usually is applied to media distributed over computer networks. Podcasting, streaming, and other Internet-related technologies that send large files (e.g., audio, video, or graphics) have classroom applications. When used on the school network, they need to be evaluated for bandwidth consumption.

5.2.3. Bluetooth

Bluetooth allows wireless personal networks to connect and exchange information among devices such as mobile phones, laptops, printers, and digital cameras over a secure short-range radio frequency (Johnson, 2006). Bluetooth works when two or more devices are in proximity (100 meters or less) to one another and do not require high bandwidth. Other than the device, there is no cost for using Bluetooth technology.

Bluetooth technology has been incorporated into classrooms as a secure communication between teacher and student or administrator. Educators can transfer data and image files wirelessly among devices like laptops, mobile phones, PDAs, whiteboards, and printers. When designing a wireless network or selecting peripherals, Bluetooth applications should be considered. More information on the specifications and applications is available at www.bluetooth.com.

5.2.4. Videoconferencing/Virtual Field Trips

A videoconference uses audio- and video-telecommunications technology to bring people together from different locations for face-to-face interaction or collaboration. A videoconference can involve people in two sites (point to point) or several sites (multipoint). Videoconferencing has gained popularity because it employs key elements of face-to-face interactions while saving time and money. Additionally, a number of vendors provide solutions that allow students to take virtual field trips to places that were previously out of reach of educators and students using videoconferencing technology.

Videoconferencing offers exciting learning opportunities for schools. The purpose or projected use of the videoconference will determine its connectivity needs.

5.2.5. Mobile Phones

The use of mobile phones in education and learning is in its infancy. The main advantage of this technology is portability, which possesses learning benefits outside the classroom. While communication capabilities and multimedia applications are major factors in purchasing a mobile phone, there are other key facets:

- Usability—The handset should be easy to use and the display large enough for readability.
- Battery life—Consider the life span of the battery and the cost of the charger.
- Security—Look for features that discourage theft; examine recommendations and strategies for security.
- Filtering capabilities—Ensure that illegal and harmful content is not accessible from any school-designated mobile phone.
- Monitoring—Review function to determine that phones are used for their intended purposes.
- Additional software—The nature and cost of specialized software will determine whether mobile devices can be converged with other hardware devices. This also has an impact on transmitting to students via mobile devices.
- Policy Issues—Consider whether all functions of mobile phones are appropriate in schools. For example, mobile phones are not allowed during the administration of SOL tests and could result in test security violations.

The management of students' mobile phone use is a timely issue and must be incorporated into schools' Internet safety guidelines and acceptable use policies. Mobile phone issues include the following:

- Bullying through text messaging
- Theft on school grounds
- Cheating on examinations
- Inappropriate adult contact
- Illegal use (e.g., downloading, creating, or sending pornographic images)
- Possible health side effects from over use

5.3. Tools

Several existing tools help divisions and teachers assess educational technology professional development needs and student technology literacy levels. A self-assessment conducted alone or with coworkers by grade level or academic department can help teachers recognize their technology-related professional development needs. Existing tools also can aid teachers in integrating technology into content areas. *Note that the inclusion of the following assessment tools does not imply an endorsement by the Virginia Department of Education.*

5.3.1. TechPOINT

TechPOINT has developed a three-part suite of resources for educators. Its Proficiency Assessments located at http://www.techpt.org/assessments.php can assist with identifying the necessary level of educational technology professional development for teachers. TechPOINT Surveys located at http://www.techpt.org/surveys.php can help divisions determine the attitudes of administrators, teachers, and students toward technology. Another product, TechPOINT Professional Development, located at http://www.techpt.org/pd.php features a combination of online and face-to-face modules.

5.3.2. LoTI

Levels of Technology Implementation (LoTI), developed in 1994 by Dr. Christopher Moersch, is a scale that measures genuine classroom technology use. The LoTI Framework (http://www.drchrismoersch.com/loti.html) breaks down the levels that focus on technology as an interactive learning tool. The goal is not to use technology on individual tasks (e.g., typing a research paper with a word processor, creating a multimedia presentation, surfing the Internet) but to integrate technology to support meaningful problem-solving, performance-based assessment practices and experiential learning.

5.3.3. Technology Integration Matrix

The Technology Integration Matrix (TIM) (http://fcit.usf.edu/matrix/index.html) demonstrates how to use technology to enhance learning for K-12 students. The TIM aids divisions in evaluating the level of classroom technology integration and provides teachers with models of how technology can be integrated into instruction.

5.3.4. Technology Sparks

Technology Sparks (http://www.doe.virginia.gov/VDOE/Technology/OET/technology_sparks.pdf) is designed to ignite creativity in teachers and ITRT who aim to integrate the computer/technology SOL with content SOL. A few apt content SOL are showcased as examples of technology integration strategies for each grade level and subject area in grades six through eight.

6. Appendixes

6.1. Appendix A: Assistive Technology/Web Accessibility

All Web sites were available as of 10 February 2008.

AbilityHub Assistive Technology Solutions (home page)
http://www.abilityhub.com/

ABLEDATA (home page)
http://www.abledata.com/

Burgstahler, S., "Universal design: Process, principles, and applications," *University of Washington*.
http://www.washington.edu/doit/Brochures/Programs/ud.html

Microsoft, *Assistive technology products*
http://www.microsoft.com/enable/at/default.aspx

Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), *Assistive technology*
http://www.resna.org/ProfResources/Publications/ATJournal.php

rehabtool.com (home page)
http://www.rehabtool.com/

Section 508: Section 508 standards
http://www.section508.gov/index.cfm?FuseAction=Content&ID=12

T/TAC Online (home page)
http://ttaconline.org/

Virginia Department of Education, Division of Special Education and Student Services, *Assistive technology*
http://www.doe.virginia.gov/VDOE/sped/AssistiveTechnology.pdf

Virginia Information Technologies Agency:

> *Information technology accessibility standard* (2005)
> http://www.vita.virginia.gov/uploadedFiles/Library/AccessibilityStandard_GOV103-00_Eff_11-04-05.pdf
>
> *I.T. accessibility toolkit* (N.d.)
> http://www.vita.virginia.gov/uploadedFiles/Library/Accessibility/VITAAccessibilityToolkitOverview.pdf
> *Technology assistance for individuals with disabilities* (1992)
> http://www.vita.virginia.gov/uploadedFiles/Library/p92_1.pdf

Web site guideline (2005)
http://www.vita.virginia.gov/uploadedFiles/Library/WebSiteGuideline_GOV107-00_1Eff_11-04-05.pdf

Web site policy (2005)
http://www.vita.virginia.gov/uploadedFiles/Library/WebSitePolicy_GOV105-00_Eff_12-08-02.pdf

Web site standard (2007)
http://www.vita.virginia.gov/uploadedFiles/Library/WebSiteStandard_ITRM_GOV106-01.pdf

W3C:

Web Accessibility Initiative (WAI)
http://www.w3.org/WAI/

Web content accessibility guidelines 2.0
http://www.w3.org/TR/WCAG20/

WebAIM, *Motor disabilities: Assistive technologies*
http://www.webaim.org/articles/motor/assistive.php

6.2. Appendix B: Educational Applications & Wireless Protocols

IEEE 802.11 (Wi-Fi)

The IEEE (Institute of Electrical and Electronic Engineers) formed a group to develop a wireless equipment standard. The 802.11 standard specifies that the upper layers of the OSI model cannot be modified and that WLAN must be implemented on the physical and data link layers.

PROTOCOL	RELEASE DATE	FREQUENCY	BANDWITH
IEEE 802.11	1997	2.4 GHz	1, 2 Mbps
IEEE 802.11a	1999	5 GHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps
IEEE 802.11b	1999	2.4 GHz	5.5, 11 Mbps
IEEE 802.11g	2003	2.4 GHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps
IEEE 802.11n	Expected in 2009	2.4 GHz	540 Mbps

(Sampalli, 2005)

IEEE 802.15 (Bluetooth)

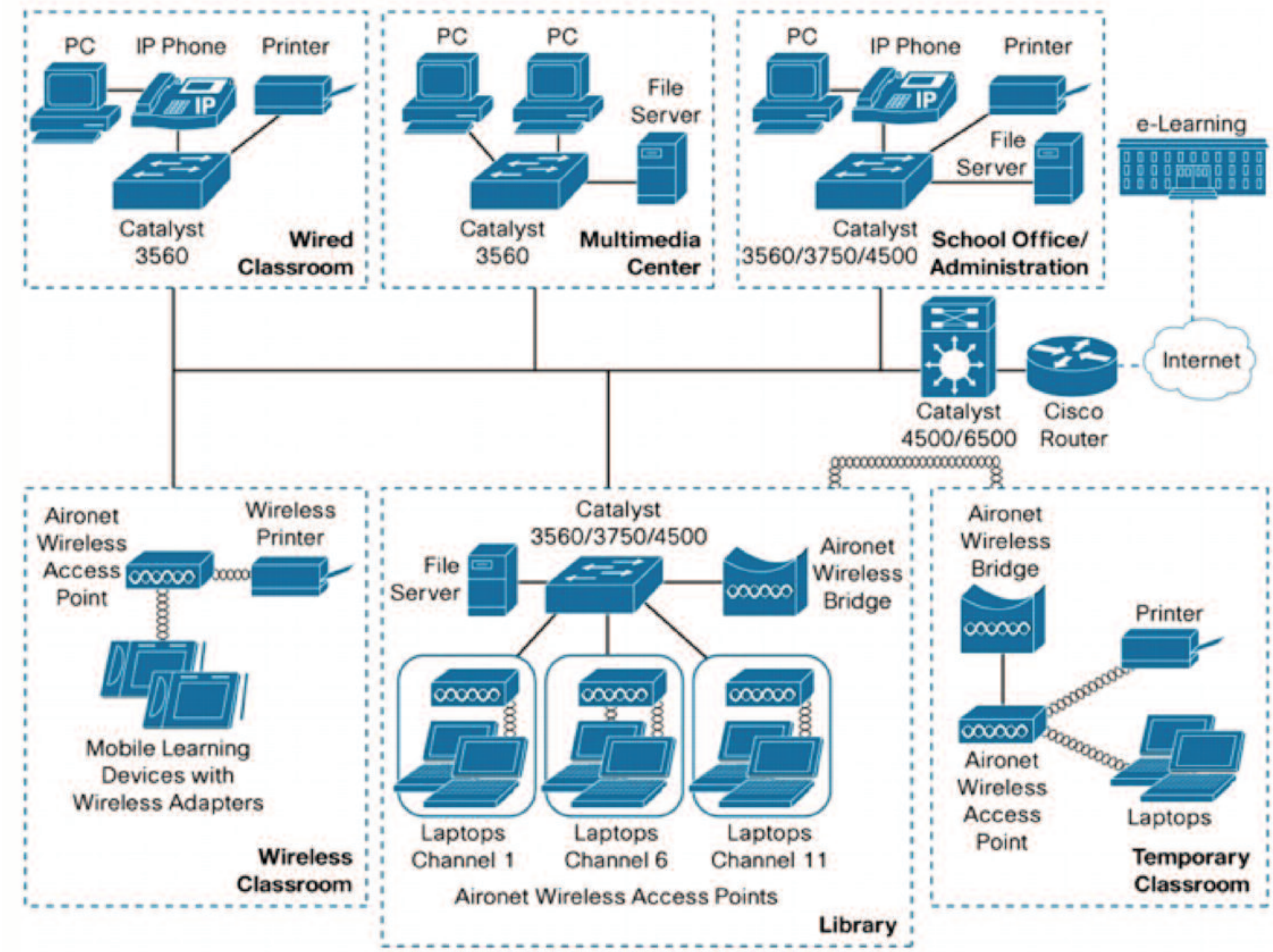
PROTOCOL	RELEASE DATE	FREQUENCY	BANDWITH
IEEE 802.15	1999	2.4 GHz	1 Mbps

(Sampalli, 2005)

Connection Speed and Capacity Chart

CAPACITY	CONNECTIONS	CAPACITY	CONNECTIONS
33.6 K	33,600 bps	T1, DS1	1.5 Mbps
56 K	56,000 bps	T3, DS3	45 Mbps
64 K	64,000 bps	OC3	156 Mbps
128 K	128,000 bps	OC9	467 Mbps
256 K	256,000 bps	OC12	622 Mbps
640 K	640,000 bps	OC48	2.5 Gbps (4 OC12's)
768 K	768,000 bps	OC192	639 Gbps (4 OC48's)

6.3. Appendix C: Network Diagram



7. Resources

7.1. Glossary

Bandwidth	The rate of data transfer, measured in bit/s
Biometrics	The study of methods for uniquely recognizing humans based upon one or more unique physical or behavioral characteristics
Bluetooth	A device that allows wireless personal networks to connect and exchange information among devices such as mobile phones, laptops, printers, and digital cameras over a secure short-range radio frequency
Client	A user; a piece of software that accesses services from a server
Codec	Videoconferencing device that digitizes and compresses incoming and outgoing video signals
Failover	The capability to switch over automatically to a standby system or server without human intervention
IPv6	A network layer IP standard used by electronic devices to exchange data across a packet-switched Internetwork
LAN	Local area network
Metadata	Information (data) about a particular content (data)
Mirror	A direct copy of a data set
Radio Frequency Identification (RFID)	An electronic identification method that relies on data storage devices called transponders to transmit identifying information remotely
Repetitive Stress Syndrome	A condition caused by overuse of the computer, guitar, knife, or any device that demands repetitive motions, which can affect muscles, tendons, and nerves in the arms and upper back
Schools Interoperability Framework (SIF)	A data-sharing specification for schools that enables diverse applications to interact and share data seamlessly

Shareable Content Object Reference Model (SCORM)	A group of standards and specifications for Web-based learning
Total Cost of Ownership (TCO)	An estimate of the direct and indirect costs of a technology investment
Uninterruptible Power Supply (UPS)	A constantly charging battery backup
Voice over Internet Protocol (VoIP)	The routing of voice conversations over the Internet or through any other IP-based network
WAN	Wide area network, often a collection of linked local area networks
Whiteboard	A two-dimensional interactive display device that interacts with a computer desktop and projector
Wireless Encryption Protocol (WEP)	A scheme designed to secure wireless networks and provide confidentiality comparable to a traditional wired network
WLAN	Wireless local area network

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