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ABSTRACT

This publication offers aid for North Carolina schools in planning new and renovated facilities to accommodate technology. It is a supplement to the North Carolina Public School Facilities Guidelines and should be used in conjunction with the STS-1000 Telecommunications Wiring Guidelines and the North Carolina School Technology Plan and other materials listed in "References for Further Reading" at the end of the publication. The emphasis of the STS-1000 is on network infrastructure, and the emphasis of the North Carolina Instructional Technology Plan is on the use of technology in schools and the specific equipment to support those uses. The material presented in this publication has different emphasis--that of building needs to accommodate this technology equipment. The publication addresses: space, electrical, and cooling requirements for personal computers; computer and keyboarding labs; media centers; special use, computer aided design and drawing (CADD), graphics, and vocational labs; distance learning and information highway labs; administration areas; other uses of technology in schools; network wiring systems; head-end and file server rooms; and distributed wiring closets. (EV)

E. Brumback

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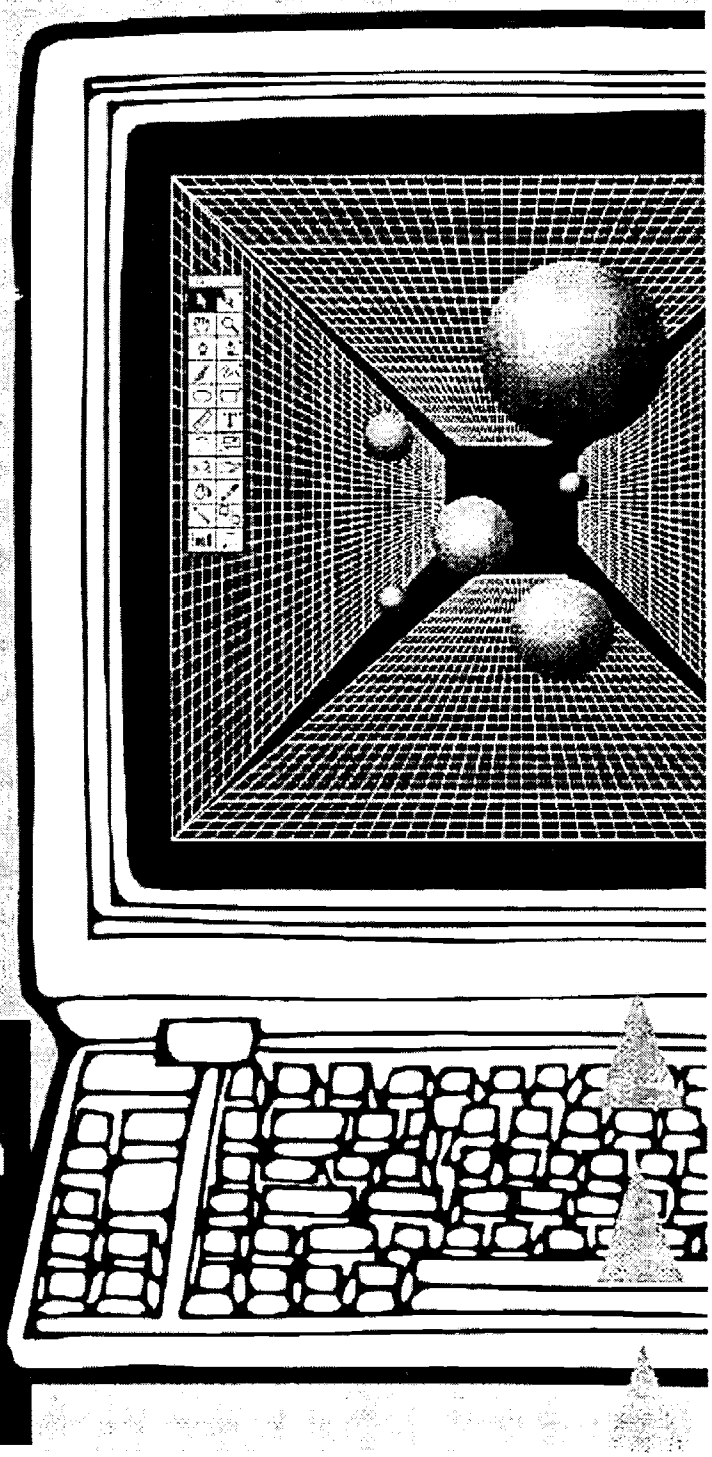

Impact of Technology on School Facility Design

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Foreword

School administrators, teachers, parents and students are well aware of the implementation of technology in our schools. Computer labs, individual classroom computers, networks, integrated communications, video systems and other types of technology are being installed or upgraded in schools statewide. The cost of this technology is significant, not just for the equipment itself, but also for training of staff in its use and the maintenance and upgrade of hardware and software as the technology rapidly advances.

This technology, of course, impacts the building's physical facilities. Classrooms need to be larger to accommodate new equipment, additional rooms and closets are required to support the technology and the new equipment places increased demands upon electrical and air-conditioning systems.

This publication is offered as an aid in planning new and renovated facilities to accommodate this new technology and is a supplement to the North Carolina Public School Facilities Guidelines. It is a resource that can assist design professionals and school administrators to plan facilities that effectively meet the evolving needs of public schools in North Carolina. We hope you find it useful.

Phillip J. Kirk, Jr., Chair
State Board of Education

Michael E. Ward, State Superintendent
North Carolina Department of Public Instruction

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Introduction

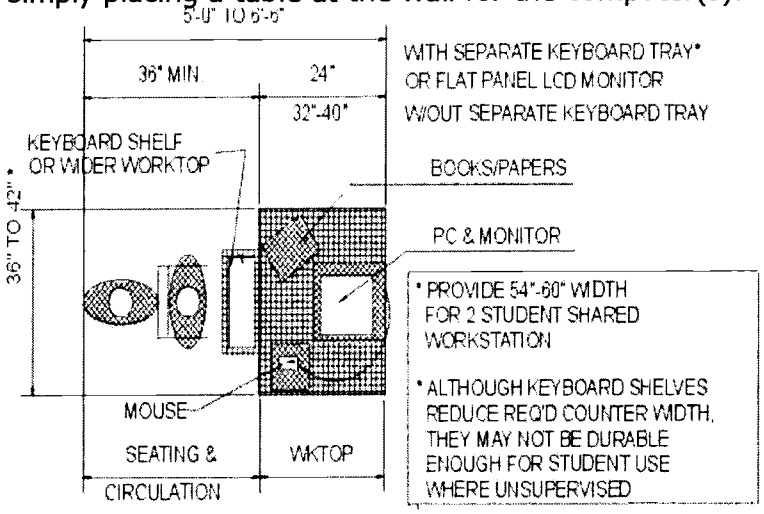
For over two decades, the use of personal computers has pervaded our society. Their value as a tool for information management, science, mathematics, graphics and business is now widely recognized. With this technology has come a new and different set of spatial and environmental constraints that must be recognized and incorporated into our buildings to allow the effective use of this equipment. Spaces that once were designed for pen and paper, chalkboard and lecture are not the same as those that are needed for microcomputers or integrated voice, data and video communications.

This publication should be used in conjunction with the STS-1000 Telecommunications Wiring Guidelines and the North Carolina School Technology Plan and other materials listed in "References for Further Reading" at the end of this publication. The emphasis of the STS-1000 is on network infrastructure and the emphasis of the North Carolina Instructional Technology Plan is upon the use of technology in schools and the specific equipment to support those uses. The material presented in this publication has a different emphasis -- that of building needs to accommodate this technology equipment.

Many types of equipment, building systems and innovative ways of teaching or communicating can be included under the broad label of "technology." Aspects of technology in schools include such items as classroom-to-administration intercom systems, master TV systems, telephone and voice mail, personal computers, integrated communication systems, energy control systems, fire alarms, security systems, etc. Many choices are available to school systems for these types of technology; however, this publication deals primarily with the impact of personal computers and their interconnectivity. Future publications are planned that will examine other aspects of technology, as well as modifications resulting from future advances in technology.

Space Requirements for Personal Computers

The addition of one or two computers within a traditional classroom often has little, if any, impact upon traditional classroom size. They can usually be accommodated on existing countertops, sometimes by removing a cabinet below for kneespace, or by simply placing a table at the wall for the computer(s).



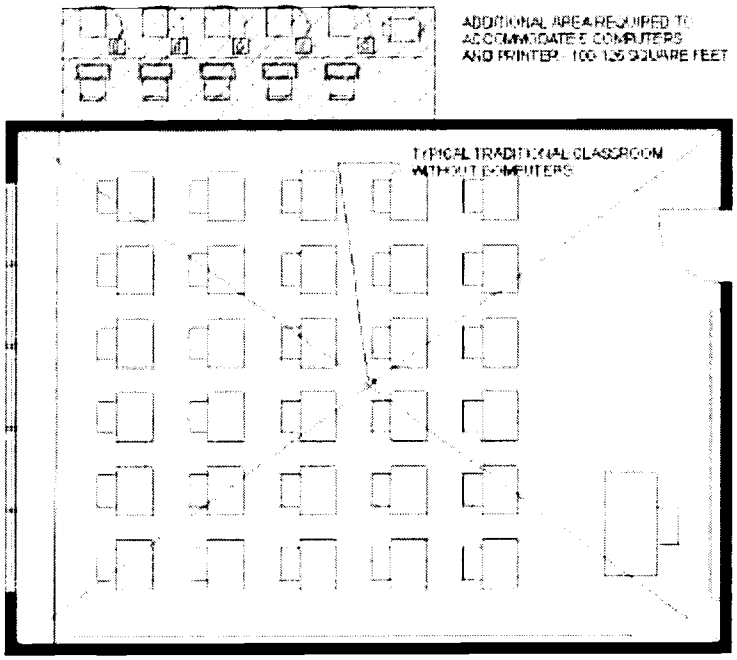
Space requirements per workstation
15 sf to 21 sf plus printer space

More than two or three computers in a classroom, however, can have a significant impact upon spatial needs. Many elementary and middle school regular classrooms are being equipped with five student computers, plus a workstation for the teacher. Even more are often planned for math, science or vocational classrooms. Each of these workstations require between 15 and 20 square feet. This allows space for the computer and monitor, keyboard, mouse and space for books or papers to use in conjunction with work on the computer, as well as space for a seated user and minimal circulation. Single printers and file servers would need about the same amount of space. We can assume that the teacher's computer would be located at his or her desk and require no additional space; however, five student computers and a printer occupy about 100-125 additional square feet. With careful design, limited space savings can be realized by sharing some existing circulation area with that required for computer circulation. When planning new regular classrooms, the room size should be increased by 10%-15% to accommodate these workstations. Spaces, such as computer and business labs and other similar classes with large numbers of computers, require substantially more space to accommodate increased circulation, teaching areas and other functions.

An often-used "rule of thumb" for computer printers to workstations is one laser or comparable speed printer for every five to eight workstations, depending upon the type of software being used. Intensive word processing, graphics or slower types of printers may require the installation of more than one printer. The printer(s) should be located within the room; therefore, if one printer for every classroom is provided, some moderate growth in the number of workstations can be accommodated without the need for additional printers. In the interest of economy, many schools purchase inkjet printers for regular classroom use. This may be a false economy, however, because the

cost of inkjet cartridges is high per printed sheet, resulting in a much higher overall cost for inkjets when compared to laser printers. An additional disadvantage is that teachers may be forced to buy additional cartridges using their own money because of extremely low budgets for this type of supplies. It may be prudent to limit or control printer access due to the difficulty in obtaining paper and other supplies.

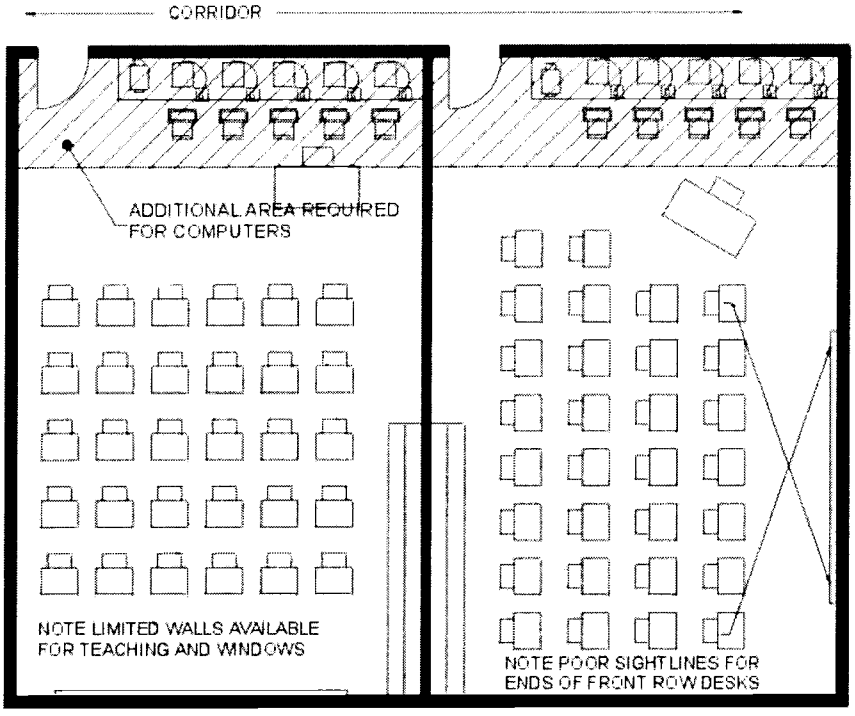
Location of the workstations within the classroom should be carefully considered. Ideally, visibility between the teacher and student should be maintained, as well as the ability of the teacher to view the monitor screen from the normal teaching area. In addition, monitors should be located to prevent direct rays of light from the sun or light fixtures from striking their surfaces and producing glare on the screens. Indirect or parabolic reflector lighting fixtures should be considered to reduce glare in these areas and the use of matte (less reflective) worksurfaces also helps. The workstations should be located away from wet or dusty areas to reduce damage. Chalkboards should not be used due to the damaging dust produced by chalk; markerboards and similar newer types of surfaces are now available at reasonable cost.



Layouts shown on the accompanying sketches assume single-user workstations. Team or cooperative workstations require substanitally more space.

Typical space required for personal computers in a regular classroom

Workstations located along a wall, or extending out from a wall like a peninsula, allow traditional classroom use to continue without the difficulty and expense of underfloor wiring for power and network communications.

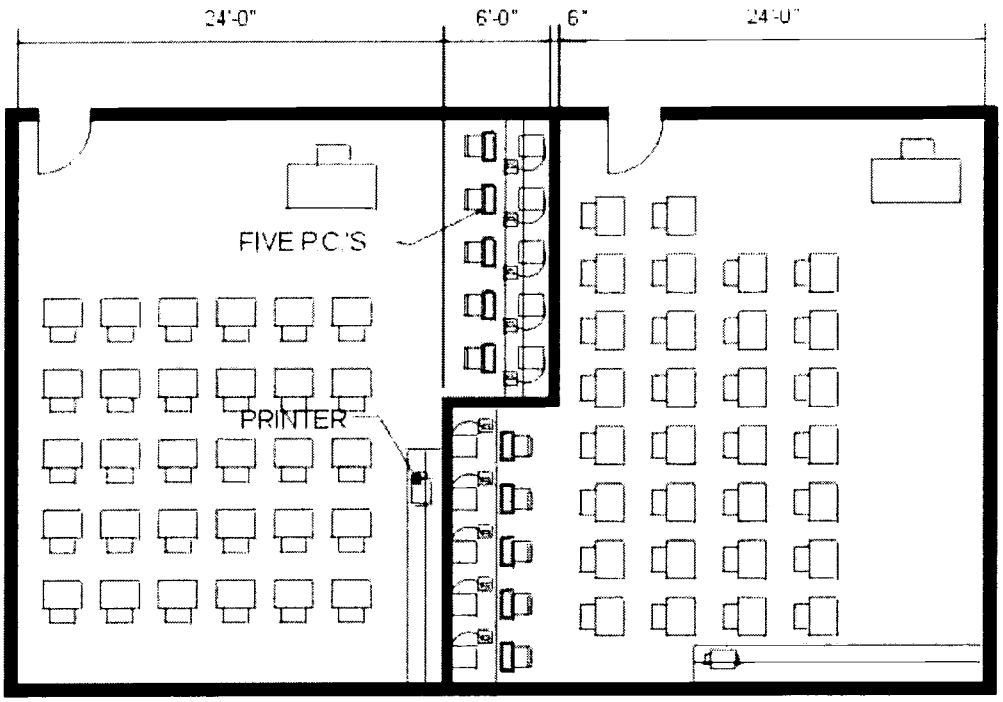


Example with computers along short wall adjacent to corridor

Schemes where the corridor wall is the classroom short wall and computers are placed along this side may result in less overall area increase and less cost for power and network wiring. A scheme of this type, however, may limit teaching walls and furniture arrangement to orientation to a long wall. This could result in poor sight lines for students unless classrooms are wider than 24 feet. Traditional rows of student desks are shown for illustrative purposes only and are not intended to discourage more flexible or innovative teaching arrangements.

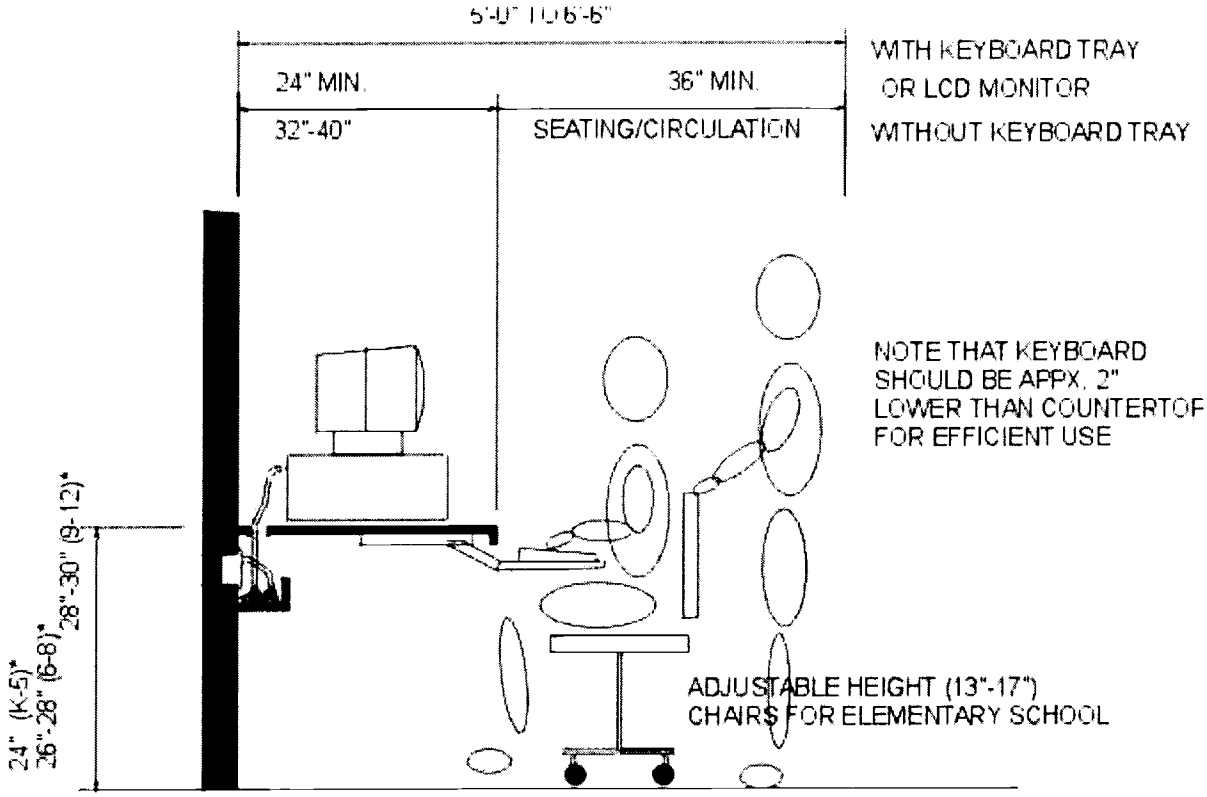
The possibility of separate, shared computer labs between adjacent classrooms is sometimes discussed as a way to reduce costly computer resources. This approach may be shortsighted as more and more computers are introduced into the classroom. Further considerations include the loss of teacher control over students in a separate space and the loss of space flexibility as technology and educational philosophy change in the coming years. Although simple rectangular rooms are probably best for overall future flexibility, a pair of alcoves or niches between classrooms may be a reasonable compromise, especially if the separating walls are constructed for possible reconfiguration as needs change. See the accompanying sketch.

Non-structural classroom dividing wall to create computer niches (different wall arrangement may be desirable in the future).



Computer niches between classrooms

Issuing "laptop" computers to all students is often discussed as a potential future goal. As laptop computers become more durable, obtain increased battery life, and lower in cost, their use may emerge as a trend. Their benefits are access by all students and the ability to take workstations home for assignments or independent work. These units have their own requirements which are likely to be very different from those of desktop workstations. Individual student desks will need to be larger, in order to accommodate this piece of equipment, along with the traditional books and papers. In addition, network connections will be necessary at each student's desk. It is also likely that "docking stations" with connection to full-size monitors for specialized work will be necessary. The current trend of installing full-size workstations could possibly allow their conversion to docking stations in the future.



* FOR H/C K-5 STUDENTS PROVIDE 26" HIGH SURFACE W/ 24" KNEE CLEARANCE
FOR H/C MIDDLE & HIGH STUDENTS, PROVIDE 28"-34" SURFACE WITH 27" HIGH KNEE SPACE

Design of furniture and casework to manage and conceal the tangle of computer wiring has become increasingly important. Not only are the numerous cables unsightly, tampering or inadvertent pulling, tugging or tripping on wires can damage equipment or connectors and can be hazardous to users. Modern furniture and casework can be specified or designed to provide built-in, concealed wiring paths and raceways. Grommets in countertops, as well as built-in outlets for both power and communications, can easily be installed in most furniture and casework and will reduce the amount of exposed wiring to acceptable minimums. Should "wireless" networks become an economic and bandwidth reality, network connections at individual student desks would no longer be required.

Electrical Requirements for Personal Computers

Personal computers can require substantial amounts of electrical capacity. When a typical desktop workstation with a full-sized monitor is equipped with optional accessories, such as CD- ROM/DVD, sound cards, extra hard drives, and an allowance for a laser printer, it is capable of drawing over 400 watts (or more) of electrical power. With consumption at this level, no more than three to six computers/monitors (depending upon actual consumption) should be connected to a single 20 amp circuit. For a typical classroom, with six computers and a printer, one to two circuits for computer/ printer use comprised of two or more duplex outlets per workstation should be installed. This is in addition to a circuit for the TV and other circuits for convenience outlets around the room. It is no longer necessary to separate computer receptacles from general purpose ones, however, computers should be protected with surge suppression.

Newer computers typically come equipped with a power supply rated at 120 to 200 watts output (input = 180 to 300 watts) plus that consumed by the monitor and other externally powered peripherals. It is highly unlikely that all accessories would be running simultaneously. Computer manufacturers indicate that actual typical consumption is about half of this capacity, or 90 to 150 watts. Typical CRT monitors may be a different story. Their power consumption varies from 100 to 240 watts depending upon model and manufacturer. The newer, flat panel LCD screens use substantially less energy; 30%-50% less than their CRT counterparts. Although more expensive initially, these units may pay for themselves in reduced need for electrical service capacity, reduced HVAC equipment size and the associated energy usage for electricity and cooling. As LCD monitor costs come down, we can expect this pay-off period to become even shorter. A small laser printer suitable for a single classroom typically will consume 250 to 300 watts of power when printing. This, too, must be included in calculations for electrical capacity and cooling capacity. Typical calculations may look something like this:

Using Newer LCD Monitors

Equipment	#/Classroom	Wattage/Unit	Typ. Usage Factor	Design Wattage
PCs	6	300 200W Output/.67eff	0.5	900
LCD Monitor	6	60	1	360
Laser Printer	1	275	1	275
Misc ext. Accessories	Allowance			150
Total/Classroom				**1685**
1685W/120v=14A ~ One 20A (80% loading) Circuit for 6 PCs + 1 Printer. Provide 2 circuits for PCs and general purpose.				

Using Current Typical CRT Monitors

Equipment	#/Classroom	Wattage/Unit	Typ. Usage Factor	Design Wattage
PCs	6	300 200W Output/.67eff	0.5	900
CRT Monitor	6	230	1	1380
Laser Printer	1	275	1	275
Misc ext. Accessories	Allowance			150
Total/Classroom				**2705**
2705W/120v=22.5A ~ One and one-half 20A Circuits (80% loading) for 6 PCs + 1 Printer. Provide 2 to 3 circuits for PCs and general purpose.				

Computers can also generate high levels of electrical harmonic distortion. This can cause problems when numerous computers are installed. Special considerations such as oversized neutral wires, separate, equally sized neutral for each circuit and specially designed transformers with a higher "K" rating should be specified by an electrical engineer when implementing significant numbers of computers.

Laptop computers require substantially less electrical capacity. If operated on battery power alone, the only electrical capacity needed is for battery recharge, which is nominal. Even when directly plugged in, laptops use a minimal amount of power. Realistically, several full-size monitors as an alternative to the laptop screens should be provided for graphics work. These monitors could probably use the general purpose receptacles found in most classrooms.

File servers should have uninterruptible power supplies (UPS) to let them power down safely in the event of a power loss from the local utility company. It may be more cost effective to place all file servers on the same circuits, backed by one common UPS, rather than separate UPS devices for each file server.

All computers should be on circuits that are equipped with surge suppression. This can be accomplished either with stand-alone surge suppressors or by protection of the circuit at the panelboard.

Ideal placement of power and network outlets is wihtin a solid wall so that cords and cables can be effectively managed. Workstations located in the center of the room on tables or casework are much more difficult to supply with power and network communications. When freestanding workstations are installed, they must be supplied either from overhead by the use of power poles, from floor mounted receptacles, low (table height) knee walls or furniture with built-in wire management capability. Knee

walls are the preferred choice, but they limit flexibility in furniture arrangement and future alteration of the space. Power poles and certain types of floor receptacles have even more significant disadvantages.

Power poles and surface-mounted raceway (wiremold) are both considered "temporary" solutions and should only be considered in remodeling projects where routing of wiring in inaccessible existing walls is cost prohibitive. Power poles that provide feeds from above the ceiling to desk or floor height tend to become easily damaged because they are light in weight and non-structural. Likewise, surface-mounted raceway is light in weight and easily damaged or vandalized. Both of these are often knocked loose from their anchorages at the floor, wall or ceiling, resulting in electrical hazards. In addition, they are usually considered unsightly and disrupt the view between students, teacher and teaching walls. In large installations with many poles, this can become an especially significant problem.

Floor receptacles are available in two types; so-called "tombstones" that consist of a small electrical box that rises up from the floor about 6" to 8" and the recessed type that, when closed, is flush with the floor. With both types, cords are subject to being kicked loose or broken inadvertently due to their usual placement under furniture. The "tombstone" type also severely limits furniture arrangement because it is a severe tripping hazard unless located under or immediately adjacent to furniture. The recessed type is more flexible because it can occur in circulation areas (when not in use) without hazard; however, it is even more susceptible to inadvertent dislodging or breakage of power cords. Some types of recessed boxes also include a cord-locking mechanism that improves the installation by reducing the danger of dislodging. Because of these disadvantages, floor reptacles should only be considered when no other permanent means of connection is available.

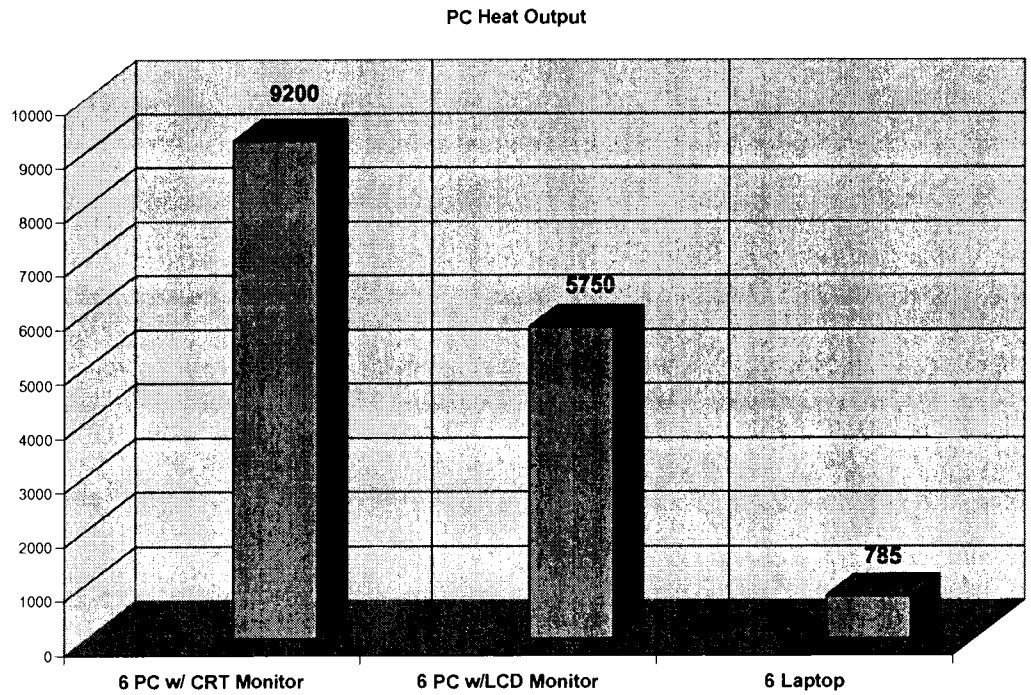
Often, only limited numbers of computers per classroom are initially wired and installed, with plans to add several more per room in the future. In order to reduce the cost of future installation, limit the amount of exposed future wiring, and reduce the time needed to install future workstations yet retain low initial costs for wiring and cabling, a prudent school system will install empty power and network boxes with conduit during the initial installation. These empty boxes can be wired when needed without breaking into walls, other destruction or unsightly exposed raceway or wires. Empty conduits (with a pull cord) should be stubbed above the ceiling for future access, or, for slightly additional cost, stubbed and capped at the entrance to the main cable trays running down the corridors.

Cooling Requirements for Personal Computers

Like all electrical appliances, personal computers and printers produce heat as a by-product of their operation. With one or two computers located in a classroom, the amount of heat produced is probably negligible compared to the normal heat generated by people, lights, infiltration through doors and windows and heat gain through walls and roofs. As we increase the number of computers, however, their added load becomes significant and must be considered. This is true both for new buildings when designing air-conditioning systems and for existing structures where the existing system may become over-taxed.

Computers require a relatively narrow band of temperature and humidity for their operation. If this band is exceeded, they often will stop working unexpectedly, their lifespan may be significantly reduced and/or they may suffer permanent damage. A typical single personal computer may produce over 1,500 BTUH of heat, depending upon the amount of options installed and the type of monitor (including an allowance for a shared laser printer for each six workstations).

This computer load translates to ¾ of a ton of air conditioning for six computers with CRT monitors and a printer or ½ ton if using LCD monitors. Small air conditioning equipment is manufactured in logical ½ ton steps (larger equipment, such as for an entire wing, may be in 5- or 10-ton steps). For a typical classroom with a two- to three-ton air-conditioning load without computers, this can mean an additional ton of air conditioning equipment for six computers.



The "green" or "energy star" computers, monitors and printers advertise substantially lower energy consumption and heat output. This is true, but only when the computers are not being used. These computers go into a "sleep" mode with very low energy consumption when the keyboard or mouse has not been used for a specified period of time. Unfortunately, heating and cooling systems must be designed for the worst-case scenario -- that of when all the computers are in operation.

Laptop computers use substantially less energy and produce much less heat than standard workstations. A typical battery-powered laptop produces less than 60 BTUH of heat or only about 5% of the amount for a comparable desktop unit and monitor. If laptops become general usage for students and teachers, very little additional electrical or air-conditioning capacity for schools will be required. However, until the problems of ease of loss or damage to these small and expensive units and middle-of-the-room network connectivity are overcome, laptop computers may not see widespread use in the classroom.

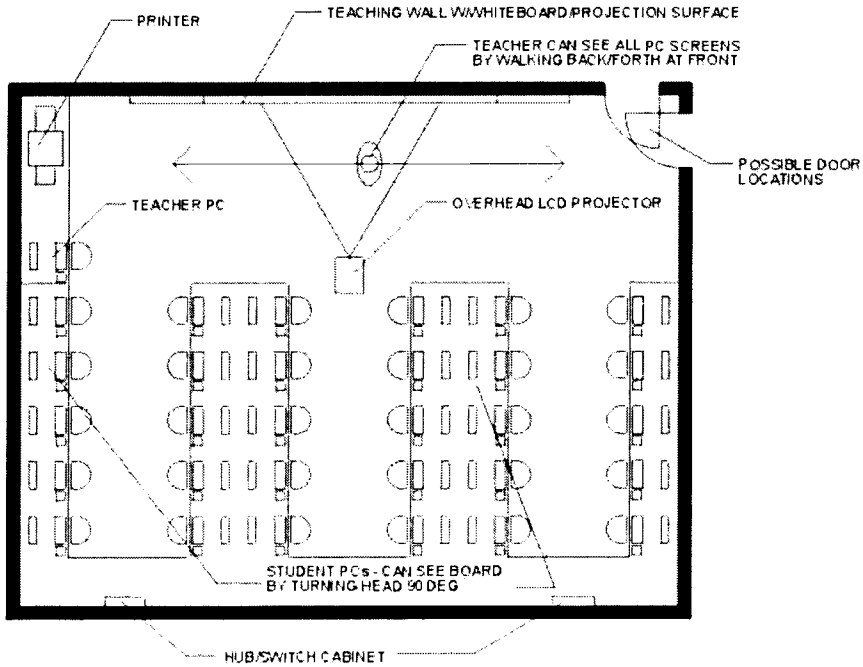
Computer labs where twenty to thirty desktops are installed, will have a cooling load of four to five times that of a typical classroom with only six computers. Because of this high load, it may be prudent to provide cooling for this lab on a separate zone or a stand alone HVAC system (such as a heat pump) for this space.

A final note of caution: too much air-conditioning is, in many ways, worse than not enough. In addition to chilling the air, air-conditioners also remove humidity. If a unit is substantially oversized for its load, it will not run long enough to remove humidity before it reaches the thermostat setting. If that happens, mold and mildew will build up, resulting in very poor air quality issues, potential health risks, and damage to books, papers and room finishes.

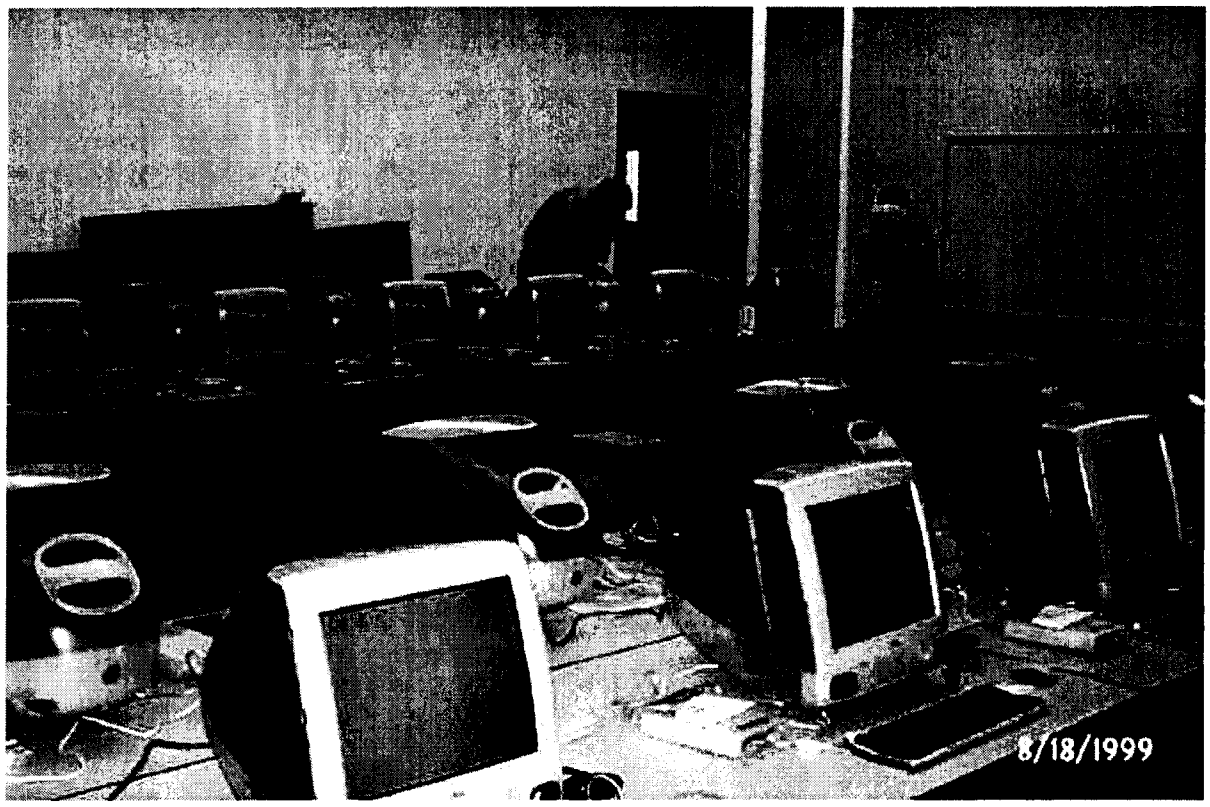
Computer and Keyboarding Labs

Computer and keyboard labs have similar requirements for each computer as regular classrooms. Substantial additional space must be allowed, however, for circulation between banks of workstations, teaching area with marker and bulletin boards, file server and incidental areas. A self-contained computer lab should generally be about 1,000-1,200 square feet (about 40 square feet per workstation), similar to the size of a traditional business or keyboarding lab. Considerations for circulation of teachers among student work stations, student view of markerboards and overhead screens and teacher view of student workstations must be well thought out. With large numbers of computers, it is difficult to manage glare from sunlight unless the room is located with north-facing windows or some means of sun control. Additionally, consideration should be given to the use of indirect or parabolic reflector lighting fixtures to control glare on screens. Printers should be located to provide easy access for all users and should be plentiful enough so that all students can print out that day's work in a short period of time at the end of a class period. To be flexible, a variety of software and hardware should be installed so that specialized projects can be worked on after school hours and work can be brought from home in differing disk formats.

Additional information on planning computer labs can be found in Impact, 2000, Guidelines for Media and Technology Programs[9] Instructional Technologies Division, NCDPI, http://www.ncwiseowl.org/impact.htm



GOOD VISIBLITY COMPUTER LAB
(1,000 SQUARE FEET)



Computer Lab, Glenn Marlow Elementary School, Henderson County, MBAJ Architects
Photo of lab similar to previous sketch.

Media Centers

Media centers are often the central core for technology in schools. Such functions as central head-end rooms for computer networks, central file servers, automated catalogs, CD-ROM stations, modem connections to outside sources, audio/visual interfaces, computer classrooms and regular workstations are often located within the media center and its support spaces. A media specialist is frequently the most highly trained in the setup, operation and maintenance of these systems and thus is often assigned responsibility for them. In a large school or high school, it may become necessary to assign a full-time staff member whose primary responsibility would be the operation and administration of these systems. If a separate staff member is assigned this function, only the media center related aspects of technology need be located within the media center; main network equipment may be located elsewhere.

Within the media center main room, the following types of computers are currently being installed:

Automated (on-line) catalog stations scattered around the entire room, as well as one or more units at the circulation desk for check-in/check-out purposes. The scattered stations should be located in the reference, non-fiction and fiction areas and should be configured to allow printing to conveniently located printers. These units can either be dedicated stations for automated catalog or combined with CD-ROM readers for on-line reference material and/or general purpose workstations.

Green Hope High School , Wake County, NC. 2001 Cherry Huffman Architects

CD-ROM workstations: These units are currently used predominately for reference material supplied in CD-ROM format, as well as for back issues of periodicals. CD-ROM is frequently replacing traditional printed (book) reference materials. Because they are often used for basic reference research, it is important that several workstations be located in the reference area. They should be networked to the other units for flexibility. CD-ROM towers that can access multiple discs simultaneously can be located in the main head-end or file server room

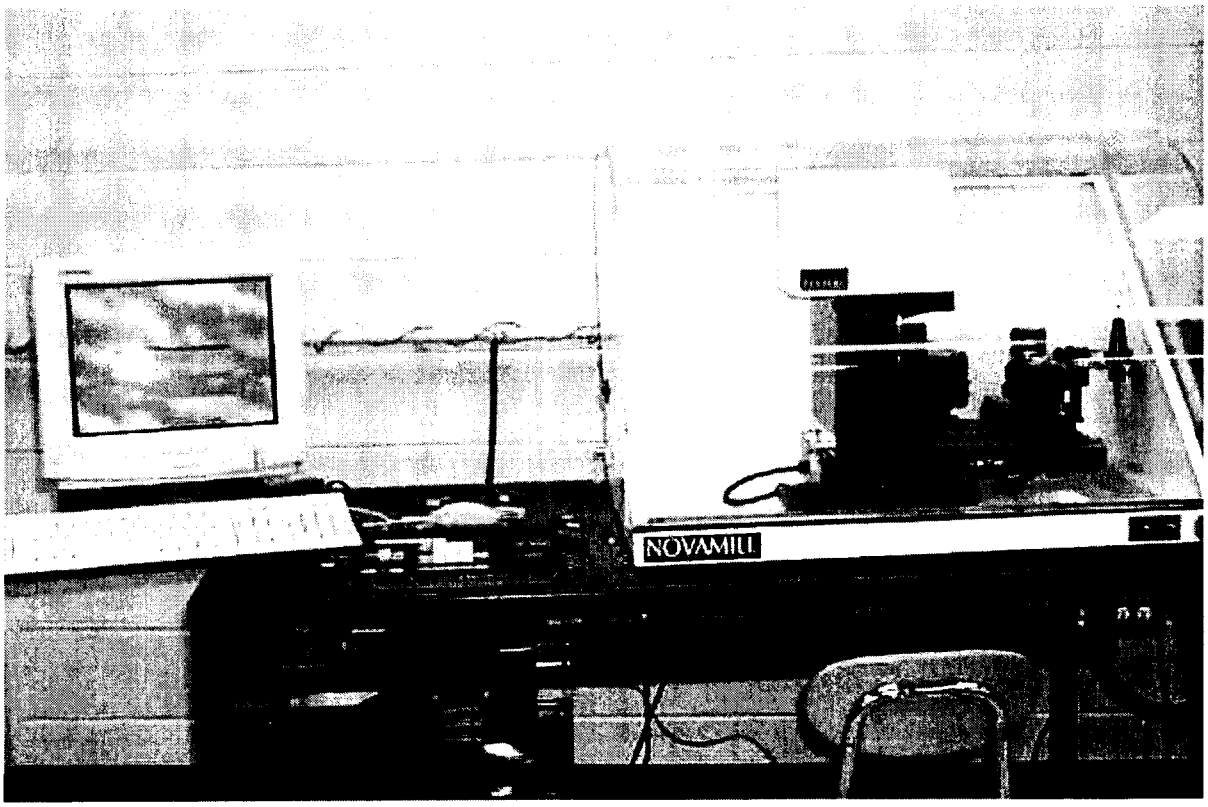
General purpose/Internet workstations: These units should be equipped with word processing, math and other software and networked with Internet access to allow access to the automated (on-line) catalog and CD-ROM units. Several stations should be provided (depending upon the age and number of total students) for the word processing of reports, term papers, research notes, etc. The units should be supervisable by media center staff and could be located away from the main RLV in an alcove or other area.

Because paper, ink and toner can be very expensive and difficult to obtain in times of tight budgets, printers serving student accessible computers should be under the supervision of and controlled by media center staff.

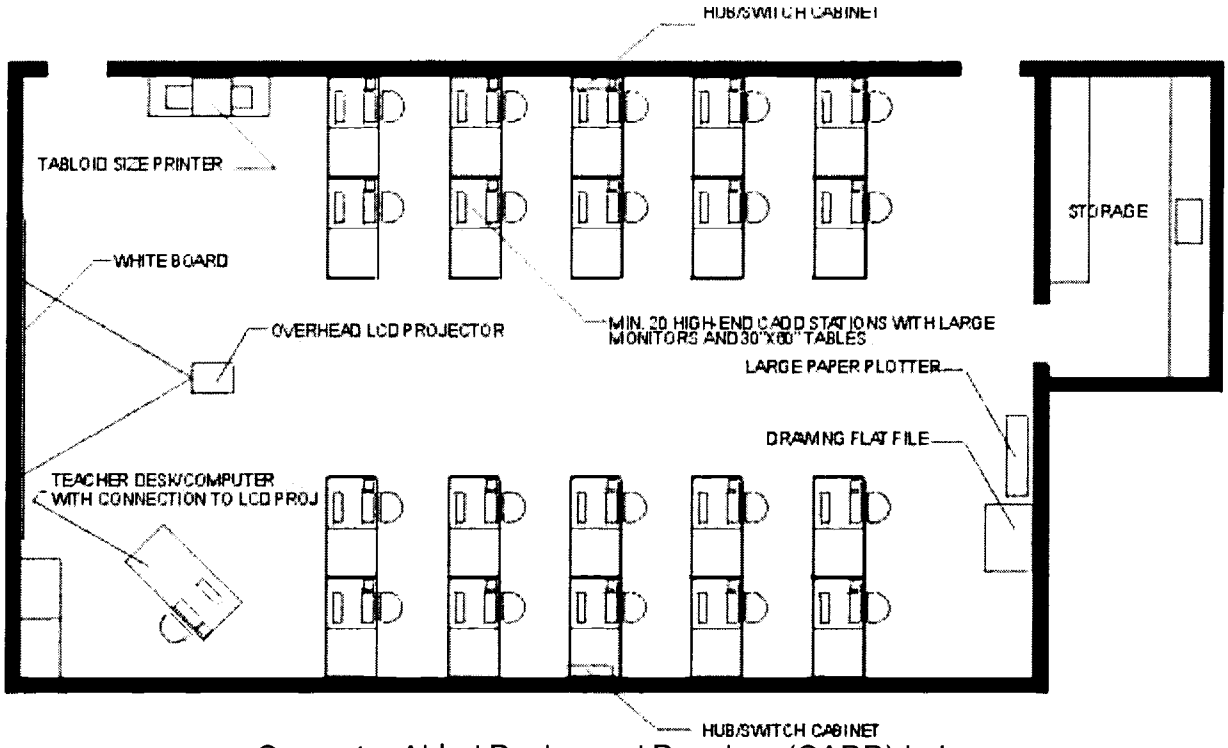
For more complete information, refer to the publication: Impact: Guidelines for Media and Technology Programs[9]

Special Use, CADD, Graphics, Video Production and Vocational Labs

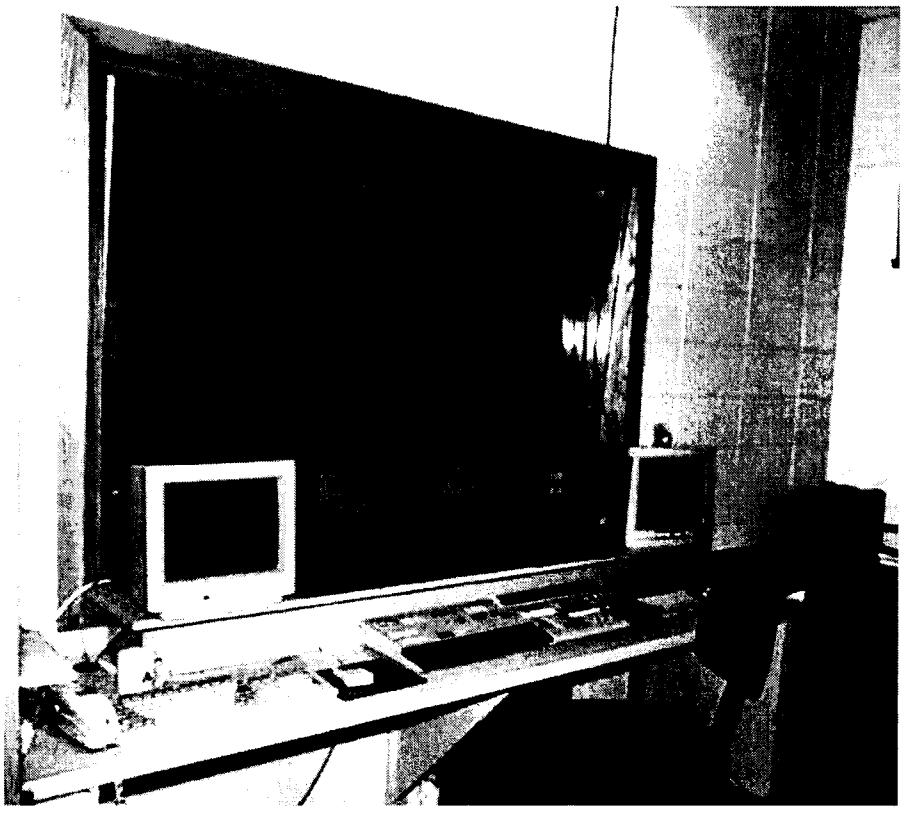
These spaces are specialized and have individualized computer hardware and software. Equipment is often much more expensive and elaborate than average. They include "state-of-the-art" processors, oversized monitors, large hard drives, extensive memory, specialized printers and plotters, robotics, computer-aided machining equipment and specialized software. Because of their high cost and the sensitive nature of this equipment, it is more prone to damage and theft. For this reason, these spaces often need to be tightly controlled by the instructor and equipped with high quality locks. Sizing, layout and physical amenities of the spaces should be modeled after similar uses in private industry or as developed by the educational program for the specific course of study in vocational and arts areas. These workstations should be located away from dirty or dusty areas, often in a separate space separated by glass walls or windows for visual control.



Computer controlled milling machine, Jack Britt High School, 2002, Schuller,Ferris, Lindstrom + Associates Architects, Cumberland County, NC



Computer Aided Design and Drawing (CADD) Lab

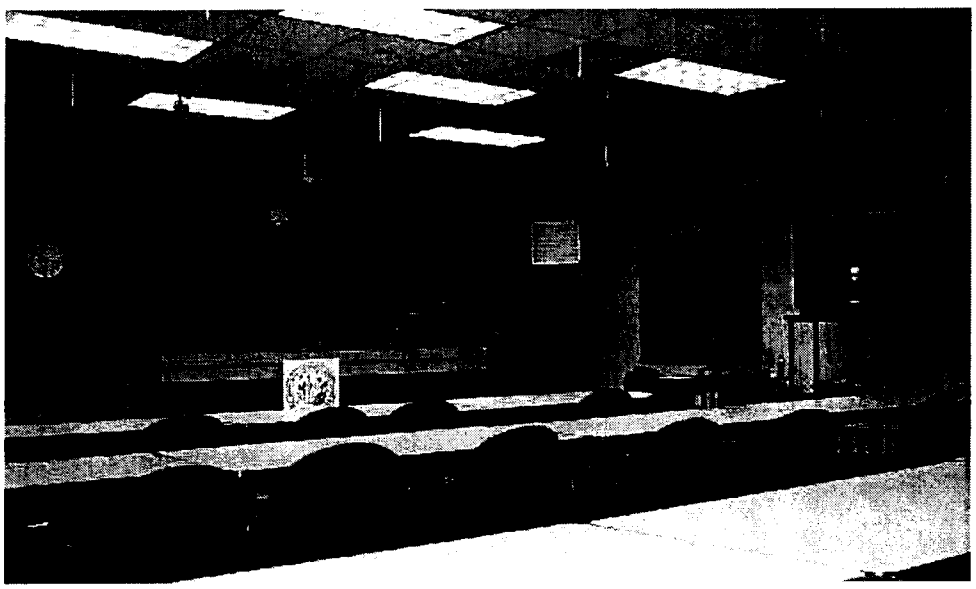


Asheville High School Video Studio Control Room, Asheville City Schools, Padgett & Freeman Architects, PA

Distance Learning and Information Highway Labs

These spaces are designed to provide a classroom setting in which the instructor may be present or be remotely located and interacting with the students via high-speed two-way video, audio (and possibly data) signals. A simple lab could consist of a normal classroom-sized space. A teacher station at the front would include a table with a ceiling-mounted camera aimed down to a flat work surface and another camera pointed toward the student area. Several monitors will need to be built into the teacher station so that the teacher can see and monitor students at remote locations. A third camera would be aimed toward the teacher. Audio signal would be provided by a microphone for the teacher plus one microphone (table mounted) for each pair of students. A sound/speaker system allows voice audio signals from these microphones or from those at a remote learning lab to be heard. Very large wall or ceiling-mounted TV monitors are needed for students to see the instructors and students at remote sites. A separate control booth of 60-150 square feet is preferred. This space can contain the necessary control and monitoring equipment mounted in a rack or other method. If a separate control space cannot be provided, similar square footage for this purpose can be allocated within the lab itself. Normal classroom lighting levels are probably adequate; however, ability to control lighting levels with multiple-level switching or dimming is desirable.

More elaborate labs can also be constructed in which flexible space for special productions is provided. Moveable cameras, custom props and specialized sound systems can be installed similar to commercial broadcast studios. These are custom labs; consequently, size and amenities are entirely dependant upon anticipated uses.



NC Dept. of Public Instruction Video Conference Lab

Administration Areas

The full computerization of administration areas is now standard in schools. Student Information Management System (SIMS) has been in place for many years. Secretaries and receptionists use personal computers for correspondence, newsletters, reports and other tasks.

More uses for personal computers in school administration areas are becoming apparent every day. These include access to student records by guidance staff, principals and assistants, interface with energy control systems, Transportation Information Management (TIMS), connections to the central office through a Wide Area Network (WAN), software for scheduling and bell control, homework assignment hotlines, attendance notification and many more tasks. We can expect even more uses of computers with the advent of new and updated software.

The requirements for personal computers in administration areas are similar to those elsewhere in the school. Plans should be made for all staff members to eventually have a personal computer on their desk that is connected to the school-wide network. Printers may be located at convenient central locations, such as workrooms and secretarial areas. Access to the network will enable such features as access to student records and transcripts, shared program materials, accountability analysis and reporting, attendance reporting, electronic mail (Email) within the school, the central office and the Internet, as well as printer sharing for efficiency.

Additional space requirements for personal computers in individual staff offices are minimal. The monitor can be placed on the desktop with the CPU either under the monitor or on the floor adjacent to the desk. Slight additional air-conditioning load will be incurred per office, but if installed throughout an administrative suite, additional air-conditioning tonnage will be necessary based upon the number of units.

Other Uses of Technology in Schools

The use of technology in schools is not limited to education. Many systems have been developed to improve facility management, building maintenance, food service management, inventory/ordering of expendable supplies and other areas.

Energy management and HVAC equipment control technology systems have been extensively developed. Temperature and humidity can be monitored and controlled automatically from a computerized system in the school system central offices. This system can monitor thermostats and control equipment so that large motors or air conditioners do not come on simultaneously, thus "beating the peak" and reducing high electrical demand charges without significantly affecting comfort. Additionally, this technology can monitor the operating efficiency of the equipment itself, alerting the maintenance department when repair or tune-up is required.

Food service systems are available that perform sales (cash registers) accounting, inventory control and even ordering of supplies. These systems improve accounting, reduce errors and allow much more effective management.

Bearfield Primary School, Hertford County, NC TAF Group Architects

Network systems connected to the school system maintenance department allow work orders to be issued from the school principal, vastly improving response time and allowing effective record keeping of problems and repairs. Custodial supplies and inventory can be included, ensuring that supplies are available when needed. Teacher and office supplies can be ordered and inventoried at each school, linked to the central office by Wide Area Networks (WANs) to take advantage of larger purchase orders and effective distribution of appropriate materials to each school.

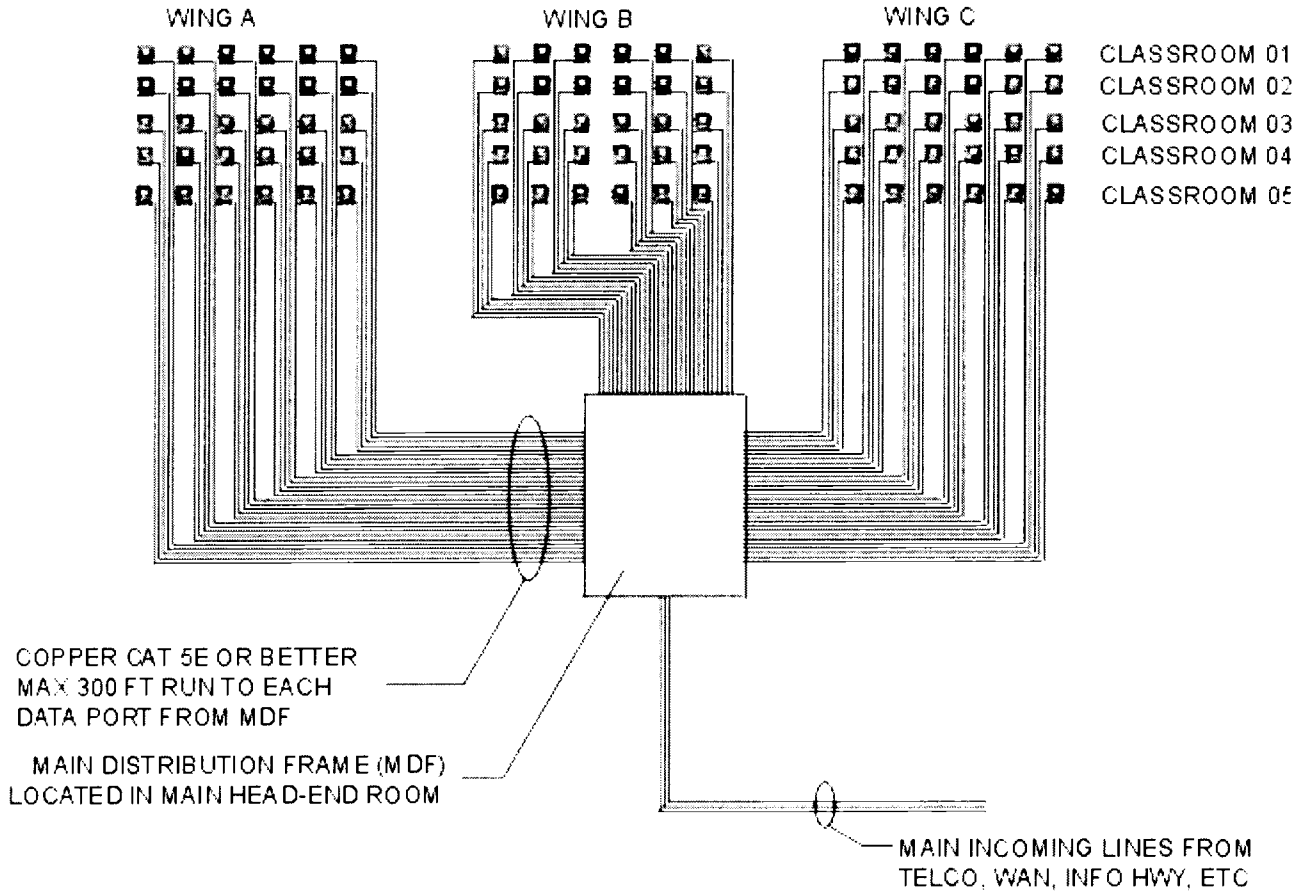
Facility management systems allow tracking of major building maintenance and improvement projects. Major deferred maintenance items, such as reroofing, electrical and HVAC system upgrades, painting, etc., can be scheduled and budgeted years in advance. If the timetable of these predictable maintenance items is known and planned for, funds can be allocated in upcoming budgets without having to contend with "emergency repairs" when boilers age out or roofing becomes "unrepairable."

"Property accounting" drawings and databases of the entire school system can be easily maintained and updated. This information can be invaluable for many departments within the school system. Maintenance departments use plans and databases to perform repairs in specific locations, develop painting schedules, locate underground utilities, schedule deferred maintenance and many other functions. Central offices can use the information to maintain student capacity information and develop long-range plans to accommodate growth in student population and to replace aging facilities. Schools can use their own plans to develop evacuation plans, teacher assignments and maps for new students and visitors.

Network Wiring Systems

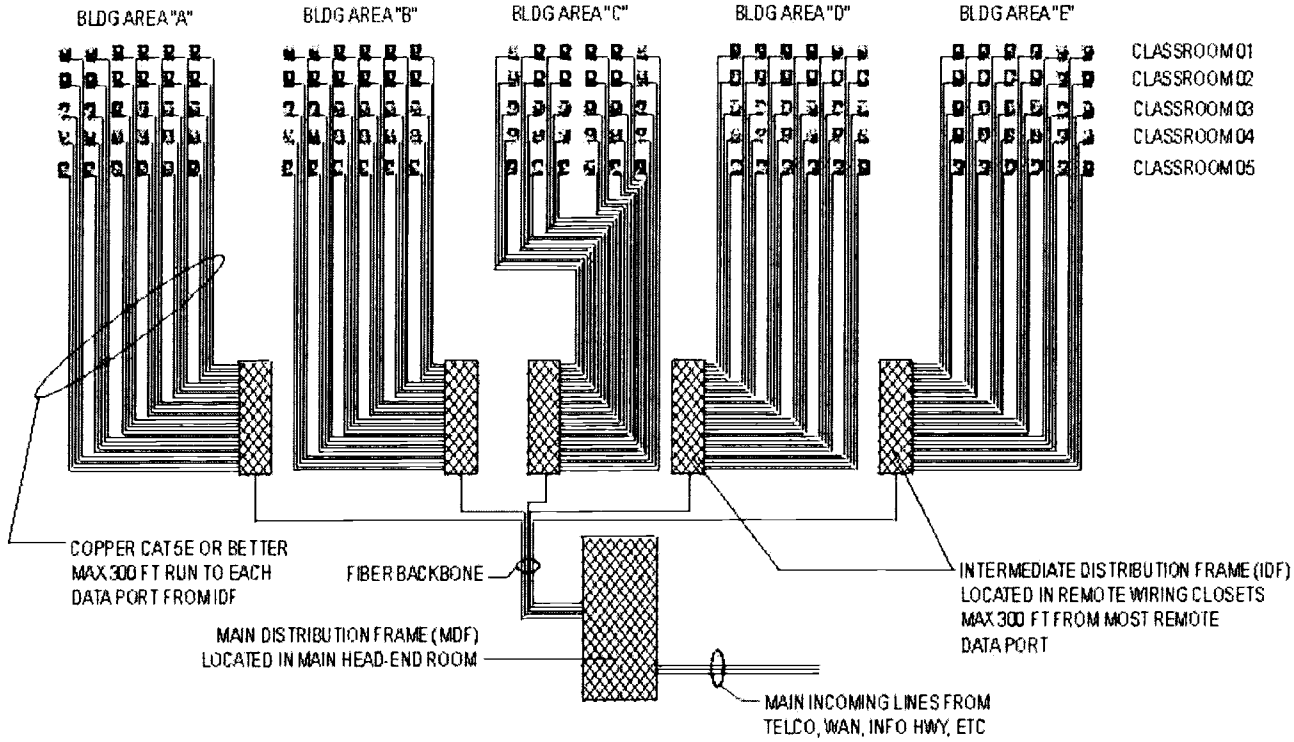
Three major types of network wiring systems are in use, as of this writing. These systems are generally titled, "simple ethernet," "distributed ethernet" and "collapsed backbone."

A simple ethernet system can be used in a small facility where all computers, printers and network ports are located within a 300 foot length of cable from the main head-end room. All runs are made from this central head end to each network drop. Recommended cable at the time of this writing is copper CAT 5E. This is typically only possible in a very small school.



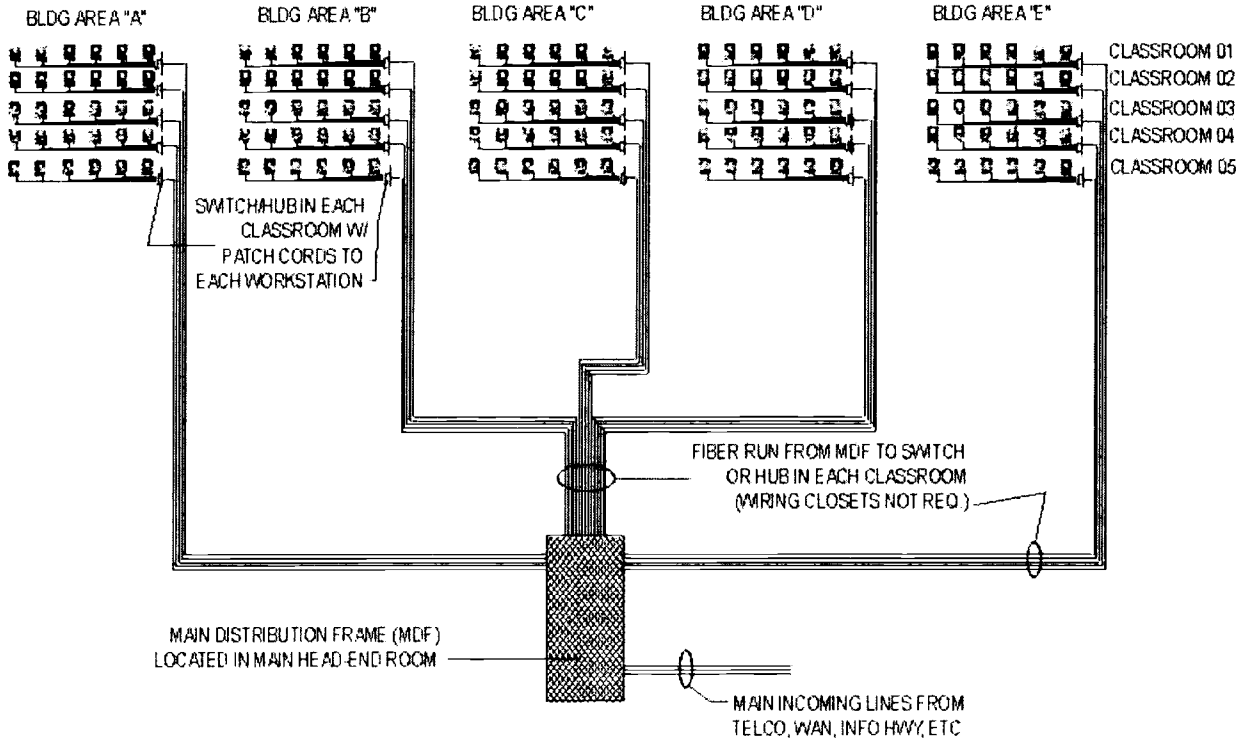
SIMPLE ETHERNET CABLING SYSTEM

Note that all data ports must be within 300 feet of the main distribution frame.
(Only possible in small schools)



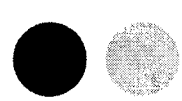
DISTRIBUTED ETHERNET CABLING SYSTEM

Note large number of cable runs.



COLLAPSED BACKBONE ETHERNET CABLING SYSTEM

Note fewer number of cable runs.



A distributed ethernet system is a more commonplace type of system. With this system, a fiber-optic backbone is installed running from the main head-end room to remotely distributed intelligent hubs, switches and routers in wiring closets, situated such that no wiring closet will result in more than a 300-foot run of copper cable to its most remote computer or data port. A separate copper CAT 5E cable (up to 300 feet long) is then run from this distributed wiring closet to each computer/printer/network outlet.

In a collapsed backbone system, remote wiring closets are eliminated, resulting in a cost savings of $6,000 or more just to build the space and provide power and cooling to it. Instead, two strands of fiber-optic cable are run from the main head-end room to a small non-manageable or intelligent/manageable switch/hub located in each classroom. This switch is usually mounted on or in a wall or even above the ceiling. From this point, very short runs of copper CAT 5E cable (often just patch cords) are run to each computer/printer/network outlet. This system results in dramatically fewer number of cable runs, thus achieving cost savings over other systems.

Current cost comparisons of these two systems indicate that a collapsed backbone system costs less than a distributed ethenet when only 2 drops per classroom are installed. As the number of drops increases, a collapsed backbone system becomes substantially less expensive than a distributed ethernet system.

The disadvantage of a collapsed backbone system with an unmanageable or "dumb" switch is that its classroom switch or hub cannot be managed or diagnosed by a network administrator housed at some remote location; however, if all the network connections in a single classroom are lost, the diagnosis is simply that switch/hub has failed, which can be quickly and cost effectively replaced. With the use of the latest, low-cost manageable switches/hubs, this disadvantage is eliminated and this system becomes a "win-win" design.

The advantages of a collapsed backbone system are significant. Because fiber is brought to the classroom, opportunities are great for increased bandwidth, increased network speed and future capabilities. Once optical connections to the P.C. become affordable, the school will be able to take full advantage of this system. Further, addition of more network drops involves simply plugging in a patch cord to an unused port or replacing the switch/hub with one that handles additional ports. Future upgrading of the cabling system is also less expensive because fewer runs of cable are required and new methods of installing fiber-optic cable (pneumatically blown in conduit) are available.

Head-End and File Server Rooms

This is the space or room where major components of the technology and network systems interconnect to each other and to other systems external to the school. Schoolwide network equipment consisting of freestanding racks with hubs, switches, routers, file servers, modems, patch panels, etc. may be located here. Media center functions may be located within this space as well, or located in another room dedicated to that function. Media center equipment may include an automated catalog file server, CD-ROM towers, integrated communications central equipment, MATV equipment, VCRs and other specialized equipment.

Size of the space and extent of electrical and HVAC is entirely dependant upon the amount of planned equipment. It must be air-conditioned year-round. Therefore, a separate air conditioning unit should be provided unless other portions are cooled year round as well. A small school with limited technology may adapt a small portion of the media center workroom for this use. A larger or technologically advanced school may require a separate room of 450 to 800 square feet or more to house all of its equipment. The room should be very secure, with high quality door and window locks and controlled access limited only to those maintaining the system.

If the school is large enough to require a network administrator, the administrator's office space should be combined with or be adjacent to the head-end and main file server area for maintenance purposes.

Special consideration to space should be given in the event a Local Area Network (LAN) now exists or will exist in the future. The minimum ceiling height is 8 ft 6 in. There shall be a minimum of one telecommunications room per floor. Additional rooms (one for each area up to 10,000 square feet) should be provided when:

(1) The floor area to be served exceeds 10,000 square feet, or

(2) The horizontal distribution distance to the workstation exceeds 90 meters (295 feet).

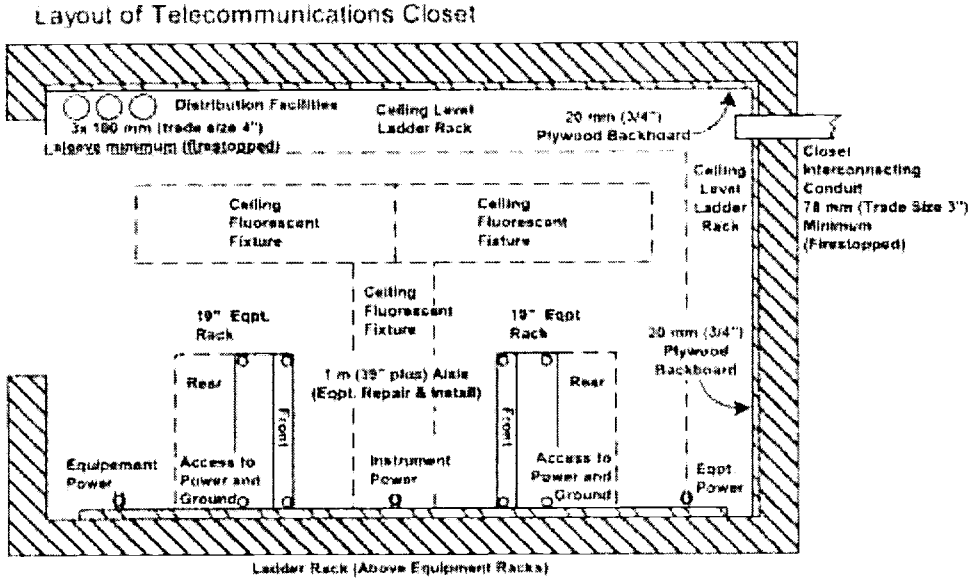
Based on square footage served, telecommunications rooms shall be minimally sized according to the table below:

Serving Area Square Feet	Room Size
10,000	10' x 11'
8,000	9' x 10'
5,000	7' x 10'

(From STS 1000, p 15, NC State Telecommunications Services) [1]

It should be noted that the above space requirements are based upon square footage served and were developed primarily for general purpose office-type spaces, rather than schools. Actual space needed is probably more dependant upon number of data outlets provided, rather than square footage served.

Typical Wiring Closet Layouts



Telecommunications room doors should always swing to the outside!

Figure 4 Typical Telecommunications Room

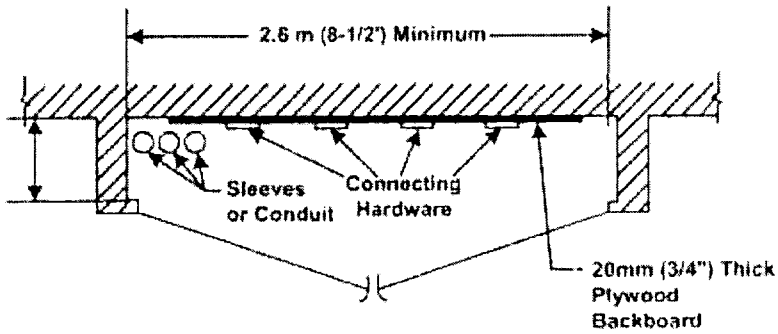
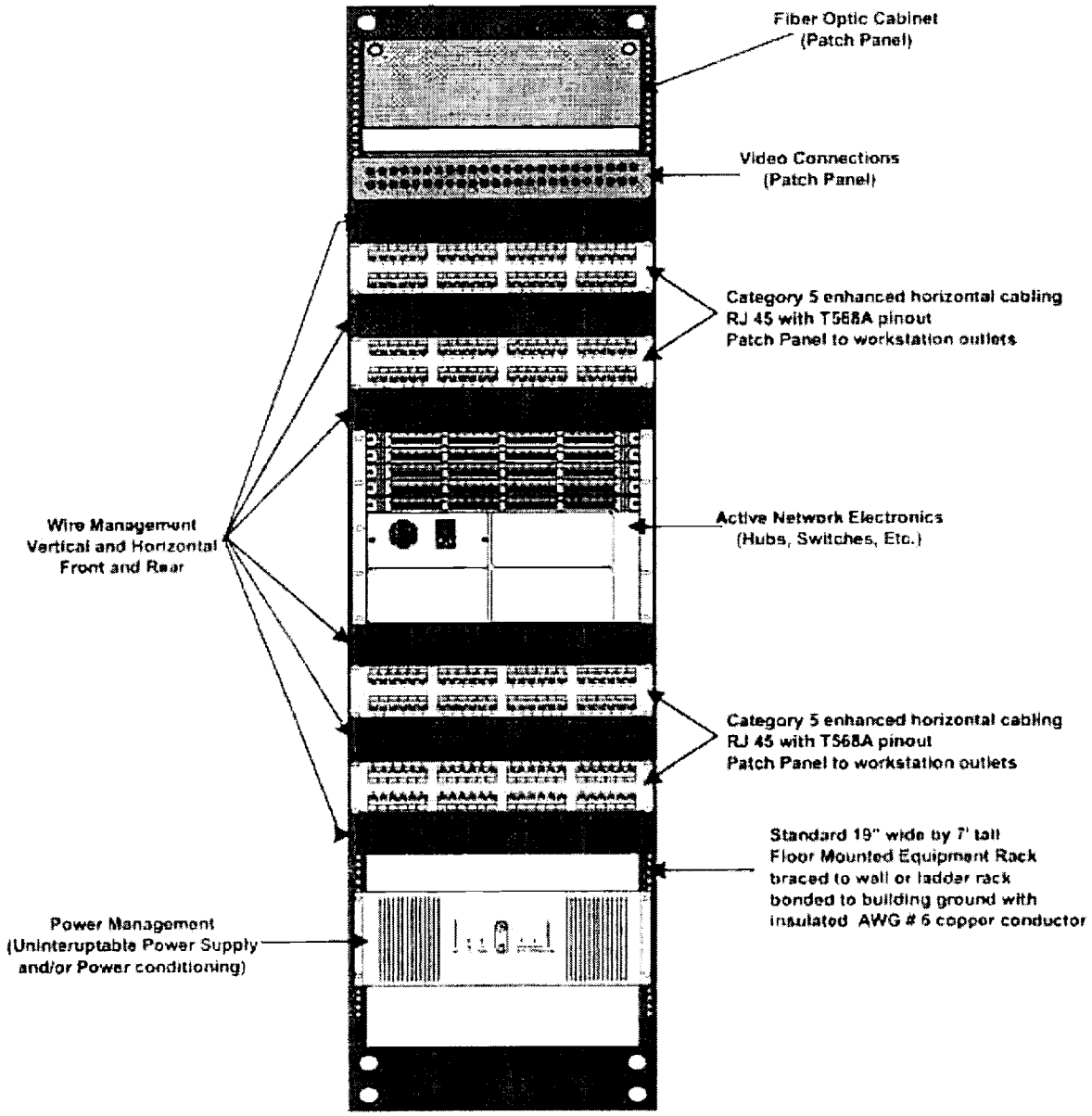


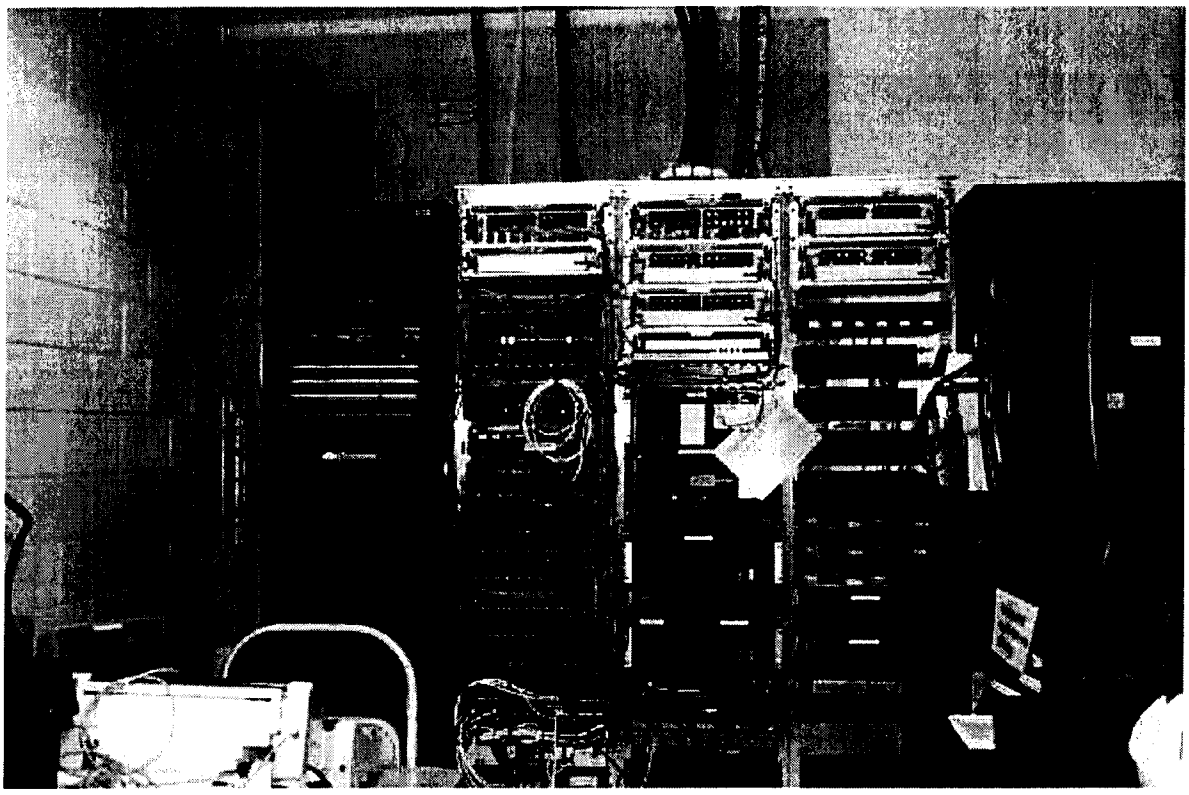
Figure 5 Typical Shallow Telecommunications Closet

(From STS 1000, p 16, NC State Telecommunications Services) [1]

Typical Equipment Rack in Wiring Closet



(From STS 1000, p 18, NC State Telecommunications Services)[1]



Main Head-end Room/Media Technology Servers
Pilot Elementary School, Guilford County, NC,
Moser Mayer Phoenix Associates, PA, Architects

Distributed Wiring Closets

These areas are similar to head-end rooms, but on a much smaller scale. Small rooms dedicated for network wiring connections to house an "Intermediate Distribution Frame" (IDF) need to be established to serve various areas of the school when a distributed ethernet system is used.

Very simple or small systems often utilize a small wiring closet with space on a wall for mounting of connection terminals and hubs. A large piece of fire-retardant treated plywood is usually mounted on the wall for this purpose. Larger or more elaborate systems usually require a freestanding rack system for mounting of equipment, hubs, transceivers, etc. In a simple wall-mounted system, a 5' wide by 3' deep closet for each building wing may be provided; however, as the network grows, a space of this size may not allow the installation of a future rack system and other equipment. More elaborate rack systems may require closets of 70 to 110 (or more) square feet. Number and location of closets is set by maximum length of cable runs and logical zoning of the structure. Distributed ethernet systems with copper runs to each network port require that the closet be no further than 300 feet from the most remote workstation it serves. Some types of equipment placed in these rooms may require that the spaces be heated and air conditioned within narrow limits, but they should be ventilated regardless. Two to six (and maybe more) electric duplex outlets on at least two circuits will be required for equipment. These circuits should be isolated, dedicated for network use, and should be connected to an uninterruptible power supply (UPS) in the event of power failure. STS-1000 Telecommunications Wiring Guidelines is an excellent source of information for wiring, conduit, cable trays and wiring closets.

A Final Word

Because technology is constantly advancing, a publication of this sort cannot remain current.

As new equipment is introduced, its physical and environmental needs and impacts are certain to change from that of the previous generation. New technology can be expected to impact buildings in new ways. Laptop computers may negate the need for additional electrical and air conditioning capacity. "Wireless" networks may significantly reduce or eliminate the need for cable trays and conduit within a building or classroom. Integrated voice, data, and video within a single unit may combine the current telephone, TV monitor and personal computer into a single, portable unit. Many of these concepts are yet to be fully developed and may, or may not, become economically viable in a school environment. In order to accommodate these certain changes in needs in the coming years, we must design our facilities to be flexible, with sufficient space and infrastructure capacity to meet the changes in technology that will be upon us. Rather than attempt to design our schools for the "ultimate technology," we need to design for flexible spaces and systems to accommodate the inevitable evolution of technology

References and Additional Resources

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7. Going VoIP? The advantages of putting your phones on the data network. Essay by Meeks Technology Group. http://www.meeksgeeks.com/mtg2.nsf/Links?OpenPage

8. Going Wireless? Things to consider in making the decision to network using wireless transmission of data. Essay by Meeks Technology Group. http://www.meeksgeeks.com/mtg2.nsf/Links?OpenPage

9. Impact: Guidelines for Media and Technology Programs . Instructional Technologies Division, NCDPI Raleigh, NC . A comprehensive planning guide for school media centers and their associated spaces. http://www.ncwiseowl.org/impact.htm

Photographic Credits

Many thanks to the North Carolina school systems listed below for their invaluable assistance with this publication. Their technology staff proved very helpful with advice and hints about particular aspects of systems that work efficiently, as well as those that tend to cause problems.

Page 13: Glenn Marlow Elementary School, Henderson County, MBAJ Architects

Page 14: Green Hope High School, Wake County, Cherry Huffman Architects, PA

Page 16: Jack Britt High School, Cumberland County, Schuller Ferris Lindstrom + Associates Architects , PA

Page 17 Asheville High School, Asheville City Schools, Padgett & Freeman Architects, PA

Page 18: NC Department of Public Instruction Video Conference Lab, Education Building, Raleigh, NC

Page 20: Bearfield Primary School, Hertford County, TAF Group Architects

Page 28: Pilot Elementary School, Guilford County, Moser Mayer Phoenix Associates, PA Architects

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