DOCUMENT RESUME

ED 398 921 IR 055 979

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TITLE	Designing the Electronic Classroom.
PUB DATE	95
NOTE	12p.; In: The Internet--Flames, Firewalls and the Future. Proceedings for the 1995 Conference of the Council for Higher Education Computing Services (CHECS) (Roswell, New Mexico, November 8-10, 1995).
PUB TYPE	Guides - Non-Classroom Use (055) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Classroom Design; Cooperative Learning; Costs; Design Requirements; *Electronic Classrooms; *Facility Planning; Furniture Arrangement; Guidelines; Human Factors Engineering; Standards; Teacher Student Relationship; Teaching Methods; Technological Advancement
IDENTIFIERS	Building Codes; *Equipment Needs; Interactive Systems

ABSTRACT

In an increasingly technological environment, traditional teaching presentation methods such as the podium, overhead, and transparencies are no longer sufficient. This document serves as a guide to designing and planning an electronic classroom for "bidirectional" communication between teacher and student. Topics include: (1) determining whether to construct a new facility or renovate an existing one; (2) building codes and standards; (3) outfitting the lab, including selecting furniture, arranging desks, chairs, white boards and screens, lighting, walls, acoustics, environmental controls, and accessories; (4) electronic equipment, including selection of projection equipment with considerations about motion video, portability, image quality, and cost, rear versus front projection, integrated control systems, monitors, and wiring; (5) software; (6) security; (7) estimating costs; and (8) managing the classroom. (Contains 20 references.) (Author/SWC)

DESIGNING THE ELECTRONIC CLASSROOM

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Why Electronic Classrooms?

In libraries, we have largely relied on one-on-one interactions with patrons and software demonstrations to groups to teach patrons to use our electronic resources. In large classrooms, the traditional methods of teachers have included the podium, overheads and transparencies. However, relying solely on these methods is no longer sufficient in an increasingly technological environment. Simply demonstrating software to a group of patrons will not make them *information literate*. It is the hands-on experience that transforms class content to mastery.

The basic lecture format in large classrooms has long been criticized for its impersonal nature and the tendency to suppress student participation. There is an emerging focus on the student-teacher relationship and the importance of collaboration in the learning process. Technology is being used to foster the "bidirectional" communication between teachers and their students. Librarians and teachers need to keep pace with these changing educational methods if they are to maintain an influential role in the learning process. Electronic classrooms can provide an environment for accomplishing this.

However, technology should not be added for its own sake. When evaluating the addition of an electronic classroom to your facilities, be sure to ask yourself, "can the goals for my classes be better accomplished using this technology?" If so, the following paper will provide you with a starting point for designing and planning your electronic classroom.

New Facilities or Renovations?

Begin by determining the specific intended uses of the lab as this requires specific considerations in the design process including location, furniture, hardware and software. Decide if it will be used for short instruction sessions, courses for credit, or computer resources for students, for example. It is also advisable during the earliest stages to either hire a consultant or involve others with expertise in the many specialized areas of facility planning, areas such as HVAC (heating, ventilation, air conditioning), computer systems, electrical systems and teaching with technology. Consider organizing a committee with representatives of interested groups, such as the computer center, physical plant or teaching faculty as they can provide insights and serve as advocates in the planning stages.

You will need 700-1200 square feet for the classroom to accommodate 20-30 computer stations. In older library buildings, bibliographic instruction rooms are often renovations of small, unused corners and were not designed with technology in mind. This is also true in many older teaching facilities. Consequently, if you are renovating, you will be limited by your own circumstances and the financial resources available for the project.

Traffic flow should influence the decision to renovate or construct a new facility. Electronic classrooms should be arranged with traffic at the rear. If possible, they should be close to the entrances of buildings so that students coming and going do not disturb other classes in session or, as in libraries, disrupt other activities.

Building Codes & Standards

For a bibliography on the codes and standards applicable to electronic classroom design, see Clabaugh, et al. (1993). Often, it is ADA standards which prompt questions. According to the standards, "accessible and reasonable accommodation is mandated in new construction and facility renovation unless the cost of the addition or renovation becomes an undue hardship." (Duggan, 1994, p.25) *Undue hardship* is difficult to define but may be understood as constituting a portion of the budget so significant that completing the project with the remaining resources is impossible. If the same resources are available in other locations in your institution to people with disabilities, you may not be required to meet all ADA specifications (Duggan, 1994). You can consult the Uniform Federal Accessibility Standards (UFSAS) or the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for specifics. Also, there are often state mandated codes to which facilities must adhere.

Certain basic features will facilitate access by persons with disabilities. For instance, there should be at least a 5 foot diameter space within the classroom so that wheelchairs can be turned. You may also decide to equip the lab with Braille signs, optical character recognition apparatus, oversized keyboards, joysticks, or assisted listening devices. To foster a learning environment for the visually impaired, choose high-contrast colors and moderate lighting levels.

Some general room standards will be helpful for facility planners in the early stages. If the room will have a capacity of 50 people or less, one door is sufficient. It should have a shatter resistant, tinted glass panel so that no one is injured if it unexpectedly swings open. Doors should not open into the primary flow of traffic. In fact, they should be recessed if into the room if possible. Doors with levers as handles are easier for disabled people to manipulate than doors with knobs.

Air flow and air conditioning requirements are influenced by the ceiling's height. A ten foot ceiling is sufficient in a room designed to hold up to 20 students. For rooms with 20-50 person capacity, plan for a 10 foot ceiling. Larger rooms may require a distance of 12 feet.

Windows should be at the sides of rooms, not the rear or front. Window treatments should block out light and may include venetian blinds, roller blinds, or drapes. If the room will not have windows, you should choose interior finishes and decor carefully so that it is visually appealing and conducive to learning.

Outfitting the Lab

Furniture

Desks: Labs are generally designed for 25-50 people with one or two students to a desk. If your classroom will have two people per computer station, make sure the chairs fit completely beneath the stations. The recommended standard height for desks is 29"-30" but some assert that the best height for using a keyboard and mouse is between 24"-26" (Duggan, 1994). Leg room should be at least 24" and surface space is optimally between 22"-30". Desks should have extended sides and should protect wiring. Cases for disk drives should provide for ventilation and have holes for cords and cables.

Some desks house monitors horizontally, within their tabletops. While this provides more space for note-taking and an unobstructed view towards the front of the room, it may also be prone to glare and difficult to read.

The instructor's station should include the following components: desk, computer stand, monitor stand, and shelves for software and other materials. Task lighting is a useful item allowing the instructor to read notes at the station when the rest of the room has been darkened.

Desk Arrangements: Desk arrangements are largely a matter of teaching style. Planners are encouraged to consult with teachers who will use the facility and to visit other sites during instruction in order to weigh the pro's and con's of various options. A popular configuration is the lining of desks along the perimeter. The advantage to this design is the greater space for traffic flow at the center of the room and the ease with which instructors can walk the room to examine student work. Often, long tables at the center of the room provide additional workspace for students. The disadvantage with this arrangement is that students can not see the instructor without turning away from their monitors.

Traditional forward-facing rows let students watch instructors at the front of the room However, the monitors, unless they are the tabletop type, will obstruct their views. While this facilitates note-taking, it does inhibit traffic flow as students move in and out of their computer stations. Lastly, it is difficult for the teacher to monitor student work while presenting at the front of the room.

Variations on these designs allow planners to utilize limited space and still create effective teaching environments. Horse-shoe or u-shaped seating schemes, double oval schemes, desk cluster schemes, and v-shaped schemes are also possible.

Other labs use a variation on the periphery scheme, placing standard desks in rows at the center. This allows for traditional lecture in the middle of the room followed by hands-on practice on computer stations at the perimeter.

Chairs: Rooms with a capacity under 50 should have movable seating, 10% of which should be offset to the left for left handed people, 4% of which should be wheelchair accessible (Clabaugh, et al.,1993). Armless swivel chairs, adjustable for height and back support, should have casters appropriate for the surface, either tile or carpet, on which they will roll. Using the 0-1-2-3 padding guide will allow you to chose the best chairs for their intended use: for short durations, no padding is required; for 30-60 minutes, use chairs with at least 1" of padding; for periods of 1-2 hours, chairs should have 2" for adequate comfort; anything longer warrants 3" of padding (Coburn, as cited in Duggan, 1994).

White Boards and Screens: Some people experience a chemical sensitivity to the ink pens used on white boards. However, they are still preferable to chalk boards since the dust from the latter can damage hard drives and other equipment. Select a board with a white matte finish to minimize glare and maximize the angle at which the screen can be seen in the room. Beaded gain and lenticular screens offer brighter images. However, the trade-offs are their narrower viewing angles and potentials for hot spots. Chose these screens when ambient light will be difficult to eliminate.

Keystoning, or the trapezoidal appearance of images on screens, can be fixed with the adjustable bases on many projectors. If this is not a feature of the unit, you can pull the bottom of the screen outward from the wall. However, while it is sufficient for computer generated images, this approach will distort video images.

Lighting

You should be able to darken the area around the video screen almost completely. In fact, some projectors require a completely darkened room for satisfactory image quality. This, however, makes it difficult for students to take notes. Zoned dimmers are the ideal solution, but they are also the most expensive. A compromise requires positioning some incandescent lights among the florescent ones, so that when the latter are off, there is still light for note-taking. Over seating areas, lighting should generally fall between 50-60 ft. candles and be reducible to 5-10 ft. candles. In labs where there are 50 or more students, extra lighting of white boards at 75 ft. candles will facilitate viewing from the rear of the room.

Walls

When choosing finishes, consider their reflectance values. These can be ascertained from charts and product samples. Since it is possible that items such as chairs and carts may bump walls, you will want to choose finishes for their durability as well.

Acoustics

The Sound Transmission Coefficient (STC) for the lab should be no less than 50 so that students can hear over the hum of the computer equipment, HVAC systems, and other building noises. Carpet will improve acoustics, but static electricity can be a problem in drier climates. While some spray carpets with a carpet guard or fabric softener to combat static, others purchase static-free tiles or linoleum and accommodate for noise by using acoustical tiles in the ceilings. Lab location is another important way to insure acoustical quality of the room. Make sure the lab will not be located near an elevator and that printers are placed in recessed areas or covered.

For larger rooms, you may need to use sound systems. These typically include a microphone, an amplifier, and an equalizer. Some teachers prefer radio microphone systems that allow them to move freely about the room. Another alternative is the cardioid microphone that is suspended from a boom over the instructor's station.

Environmental Controls

Air circulation rates, temperatures, and humidity all need to be controlled for computer functionality and human comfort. An American Society of Hearing, Refrigeration, and Air-conditioning Engineers' (ASHRAE) standard determines the adequate number of air changes per hour for a room. Many recommend ceiling fans in addition to HVAC systems to keep the air moving, especially in smaller classrooms. The temperature should fall between 50-70F degrees, with an optimum temperature for hardware at 65-75F. Humidity levels can range form 20-80Fand will be optimum at 30-50F (Moran, 1987).

Accessories

Other items may be purchased for the lab depending on the type of instruction you intend to conduct there. For instance, in extended classes, footrests, copy holders and task lighting may be useful. Racks for promotional materials, a phone for reporting problems, trash containers, and exit signs are all accessories that should be considered for any lab.

Electronic Equipment

LCD vs. CRT Projection Equipment

The quality of the projected image can ultimately enhance or diminish the overall effectiveness of the lab as a learning environment. Therefore, you could consider the two options, cathode ray tube (CRT) and liquid crystal display (LCD) carefully when choosing a projector. What follows is a summary of some important considerations for making that decision.

Motion Video: Motion video projected through a CRT tends to be more uniform and more resolute than motion video through some LCD units. Ensure that the unit's pixel response time is less than 50 milliseconds for both motion video and computer animation applications. At response times greater than 75 milliseconds, mouse pointers will fade from the screen. Some LCD panels can have rapid pixel response times and display computer animation well, but may not support the National Television Standard Code (NTSC) for video images.

Portability: LCD panels are simpler to set up and more easily transported compared to bulkier CRT projectors which require *convergence adjustments* when they are moved or fall out of alignment. For ceiling-mounted CRT projectors, a ladder is needed to make modifications.

Image Quality: CRTs generally produce brighter images and are more effective in larger rooms or rooms which cannot be fully darkened than LCDs which rely on overhead projectors for light sources. The unit of measure for the brightness of video projection systems is in *lumens* but can be assessed in different ways. The resulting values cannot always be compared. Unless the rating method is listed as American National Standard Institute (ANSI), it is best to test equipment to compare actual brightness. Overhead projectors chosen for use with LCDs should cast between 2,700 and 3,000 lumens (Griffon and Robinson, as cited in Conway, 1994).

Active matrix is a newer technology used in CRTs for more rapid response and higher contrast in color displays. Additionally, CRTs can have either *fixed* or *variable convergence lengths*. The former indicates that the image always appears at a fixed distance from the projector. Consequently, the screen must always be positioned at the same distance from the projector and the image size cannot be varied. In CRTs with variable convergence lengths, moving the projector forward and backward reduces and enlarges the image on the screen.

Another important consideration for CRT units is the range of *scanning frequencies* the projector can accept from the computer. Different computers and video equipment have different scanning rates. One convenient alternative is a multi-scan video projector that automatically adjusts to the correct frequency from the computer. Projectors with lower frequencies can be adapted for use with higher frequency computers by attaching a converter that lowers the signal to the projector's range, but the image quality and resolution capacities of the computer will be diminished in the display.

Cost: LCD panel and overhead projector are generally priced between five and seven thousand dollars while low-end CRT projectors start at nine thousand, a price that does not reflect the cost of installation. The choice between LCD and CRT technology should not be made simply on the basis of cost, but with regard for how and where it will be used.

Rear vs. Front Projection

Rear projection allows the positioning of a teacher in front of the screen without blocking the image projection and is effective in rooms where ambient light can hamper image clarity. However, the appropriate distance of the projector to the screen must be allotted or mirrors and lenses must be carefully utilized to duplicate the distance. Rear projection systems can be purchased as single units to avoid using extra space or mirrors, but they tend to be bulky and do not enhance the 50% viewing angle generally afforded by this type of projection system.

Front projection tends to offer a wider viewing angle if appropriate screens are used. Also, computer-generated text will be brighter and have greater resolution. Some front projection systems can be mounted from the ceiling to maintain an open path from the projector to the screen. It will not be necessary to climb a ladder for making adjustments if a unit with a remote control is purchased.

Regardless of the direction of projection, the distance between the farthest viewer and the screen should be no greater that six times the screen width. Some recommend reducing the distance to no more than four times the screen width. They anticipate that changes in projection technology will advance more sophisticated applications of electronic projection (Clabaugh et al., 1993) and, presumably, produce images with levels of detail that can only be appreciated at closer distances.

Integrated Control Systems

Integrated control systems can facilitate the use of various projectors, videocassette players, computers and lights from the instructor's station. These can be either configurable software, such as AMX, Video Director, or Creston control systems, or can be programmed microcomputers which display a series of menu choices when the instructor begins. Much of the software allows instructors to set up individual profiles they can reuse later. A system now being marketed by Extron has been designed to "control all room technology functions and to provide a Knowledge-Based Help System that automatically pages a technician when help is required" (Conway, 1994).

Monitors

Studies on emission rates from video display terminals (VDTs) have not confirmed health risks, but some researchers have suggested that exposure to extremely low frequency (ELF) and very low frequency (VLF) radiation may cause diseases such as leukemia and brain tumors. Monitors should emit no more than 2.5 milligauss (measured by a gaussmeter) at a distance of 20 centimeters. Since no official standard exists at this time, many computer manufacturers conform to this guideline, established by the Swedish National Board for Measurement, known as MPRII. (McKimmie and Smith, 1994). "[Emissions] are especially significant in laboratories where 20-30 machines are in use at one time. Wise administrators will investigate available research and standards concerning these waves and work to mitigate their effect." (Ross, 1992)

Wiring

Two types of wiring will be necessary for the lab: network cable and 110 volt alternating current wire. Lay network cable so that rooms need as few feet as possible since increased distances between computers and servers slow data transmission and often necessitate additional equipment to enhance efficiency. Networks should not be located in high voltage areas. Sensitive ethernet cables will be best protected beneath the floors, though sub-floor utilities are costly and difficult to access for maintenance. Raceways, conduits, and boxes fastened to the floor create uneven surfaces and make moving equipment troublesome. Locating wiring within the walls is most preferable.

An adequate number of outlets, mounted 18"-24" inches from the floor, should be available in the lab. It has been suggested that an additional 20-40% be added to accommodate for future needs (Clabaugh, et al., 1993). The lab should withstand the simultaneous start-up of all machines. Dedicated lines are essential for servers and other heavy equipment, but are not required for each computer (Ross, 1992). Include several circuits, one for the instructor's station, one for each group of ten computers, one for overhead lights, one to turn all student monitors on or off at once from the instructor's station, and extras for expanding as needed.

Provisions must be made for power spikes, brown-outs, and black outs. It is not enough to simply equip each circuit with a breaker since cutting the power instantly can cause information loss or disk damage. *Surge protectors* can diminish risks but most systems designers advocate using a UPS (Uninteruptible Power Supply) despite higher costs that range between $300 and $2000. One UPS will serve up to ten computers and will direct power to them during a brown-out. In the event of a black-out, it can keep computers running up to 30 minutes, furnishing time to save work-in-progress and shut down the system (Landt, 1995).

Software

"Lecturware" that facilitates the "bidirectional" flow of communication is being increasingly incorporated onto teaching strategies. This software allows students to ask questions or respond to questions anonymously to their instructors and see the screen image on any screen in the classroom at their own computer station. With some software, teachers can turn off students monitors which may help direct their attention to the instructor at key times. Instructors switch from a computer monitor to the overhead projector, VCR, or a live video camera focused on a real object such as specimen, for example.

It is important to consider the number of simultaneous access points allotted by software licenses so that all students can access the same software together. It is also advisable to keep back-up copies on disk, and for libraries, to have a CD-ROM drive available in case the network goes down during the presentation.

Security

There are six categories of risk to the electronic classroom: fire, disaster, theft, vandalism, copyright, and virus. For fire protection, supply labs with appropriate extinguishers, not water or powder based since these cause extensive damage to computer equipment. Smoke alarms that also register humidity and temperature are good preventative measures. A fire door to last for 2 hours is recommended. Strategies for disaster prevention will vary depending upon the region, but may encompass measures against earthquakes or floods, for example.

Several precautions against theft are available. Steel cables, electronic cables, and alarmed power strips are some examples. A simpler method is to engrave hardware with an identification number. A more difficult form of theft is the cracking of hard drives and removal of expansion boards, video cards and other components. For protection against vandalism, you may decide to invest in more extensive security measures such as alarmed doors and windows, video cameras, motion detectors and card-key systems.

Copyright restrictions are difficult to enforce, but it is important to show a good faith effort towards restricting improper use of licensed resources. Signs should be posted in the lab explaining the users' responsibilities for knowing and complying with copyright restrictions.

Viruses can be easily combatted by ensuring that each CPU have a virus checker which cannot be disengaged when users boot the system.

Estimating Costs

Costs will vary greatly but should factor system support and training expenses. You may choose one contractor for the entire job or may contract to several with expertise in specialized areas. Take advantage of contractors that offer free site surveys when estimating costs. Some of the variations in cost will be due to the types of ceilings, location of cable, and the ease with which components can be hooked up. Also, ask about educational discounts and warranties. Be cautious as warranties may or may not include parts, labor, or temporary replacements.

Establish a plan to cover maintenance and replacement costs. Some institutions are now applying the concept of "life-cycle funding," formerly used with interior furnishings, to equipment. It may also help to create a schedule to resell equipment around the 3-5 year mark in order to realize the maximum benefit from initial investments (Clabaugh et al., 1993).

Managing the classroom

A policies and procedures statement will facilitate classroom management. It should include instructions for scheduling classrooms, providing access to classrooms, and standards for software and hardware support. Early training strategies to assist faculty in making the most of the room's capacities should include an orientation to the basics such as how to boot the system, use the lab according to policy, handle problems with the facility or equipment, find supplies, and use the integrated control systems and application software. Strategies for integrating electronic technologies into the classroom environment is essential for the successful adoption of newer teaching approaches.

Administrators should devise a maintenance plan, a trouble-shooting guide, and an inventory list. A small stock of replacement parts kept nearby can reduce downtime of equipment in the lab.

Promotional campaigns should be utilized to announce the opening dates for the new lab and its services. Publishing a regular newsletter has been an effective method of publicity for some and may assist in enhancing your facility's visibility within the institution.

The impacts of the new classroom should be anticipated. Usually, instruction programs will become stronger and demand for the services will rise. This in turn increases the resources required to sustain the programs. You may find that you have you have met the challenge of designing the electronic classroom so well that you are now challenged by its success!

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