Classroom Design Manual

Guidelines for Designing, Constructing, and Renovating Instructional Spaces at the University of Maryland

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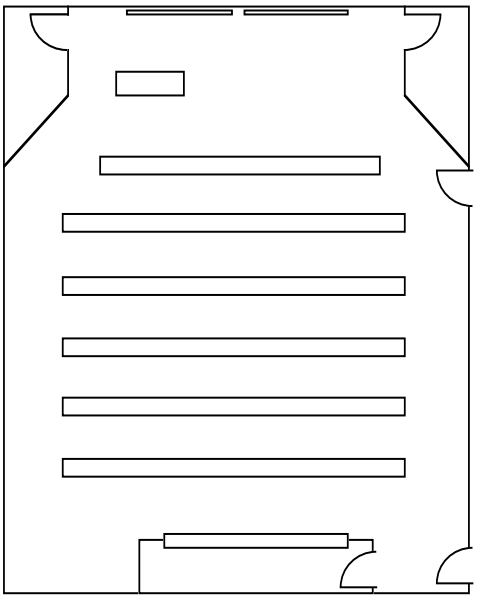

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INTRODUCTION

This, and previous, editions of the *University of Maryland Classroom Design Manual* are based extensively on the 3rd edition of the *Classroom Design Manual* by Allen, Bowen, Clabaugh, DeWitt, Francis, Kerstetter, and Rieck. That manual represents a collaborative effort by experienced professionals from seven major universities to identify the essential design elements of modern, high quality learning environments. In addition, other topics crucial to the provision of quality learning spaces were discussed, including facility programming, management, utilization, evaluation, and planning for future technology. The *University of Maryland Classroom Design Manual* incorporated much of the basic content and modified it to fit the specific practices and requirements of the University of Maryland.

Today, technology and an increased emphasis on undergraduate education have rekindled interest in classroom design. Institutions now invest significant amounts of scarce funds to "bring classrooms into the modern century." Colleges and universities recognize that to recruit and retain good students and faculty, modern and well-equipped instructional facilities are as important as modern and well-equipped research facilities.

A fundamental tenet has guided each of the three editions of this publication. *Students have a fundamental right to a classroom learning environment that allows them to see anything presented visually, to hear any audible presentation free from noises and distortions, and to be physically comfortable (air flow, temperature, furniture, etc.) regardless of the method of instruction used.* Any classroom design plan should first meet these requirements before meeting other needs. Likewise, any existing classrooms that do not meet these basic criteria should be renovated whenever possible or if the problems cannot be adequately addressed, they should be removed from the classroom inventory.

Three categories of classrooms are described: (1) general-purpose classrooms, designed to house 75 or fewer students and typically have at least 350 square feet and a minimum capacity of 20 students; (2) seminar rooms, which are smaller in capacity and area and often have a table and chairs arrangement; and, (3) lecture halls, designed for larger classes and typically have fixed seating. Separate guidelines have been prepared for each type of classroom; however, it is important to remember that the lines between them are not absolute and require some interpretation based on individual facilities and applications.

The guidelines and definitions emphasize instruction type and design characteristics, and *do not conform* to the standards and definitions of the Higher Education General Information Survey (HEGIS), the Classification of Instructional Programs (CIP), or any other published standards of room classifications.

This book is designed to serve as a guideline to help the University account for the wide variety of factors that go into making an effective classroom learning environment. Classroom design encompasses an enormous number of variables and adaptations must fit the specific institutional needs, mission, and culture as well as comply with applicable state and local codes.

Well-designed classrooms do not occur by chance. An attitude must be fostered among faculty, students and administrators that reinforces the idea that classrooms are the responsibility of everyone. While offices, conference rooms, laboratories, and other spaces typically have their own advocacy group or responsible department, general classrooms are institutional resources that belong to everyone. For this reason, in addition to using these guidelines to direct the improvement of instructional spaces, the University has assigned the role of advocacy to a specific group on campus, the Teaching Facilities Committee (TFC). That group includes faculty, technology support personnel, facilities staff, scheduling office staff, and administrators who are concerned about the quality of instructional space on campus.

CHAPTER 1
THE PLANNING PROCESS

INTRODUCTION

Good classroom design begins with good classroom management, organizing the various campus units responsible for all aspects of classrooms to work together effectively, and establishing policies that encourage cooperation and teamwork. Only with a collaborative organizational approach to planning will classrooms be designed to facilitate the instructional mission. This means that the focus of all classroom design efforts must be the users, both students and faculty.

- Design of classrooms should meet the true needs of the teachers and students who will use the room rather than simply replicating what was done on previous projects or making compromises that have a negative effect on the quality of the learning environment;

- Support should focus on providing faculty with better assistance for using technology in classrooms not just providing more and better technology;

TEACHING FACILITIES COMMITTEE

At the University of Maryland, the Provost appoints a Teaching Facilities Committee (TFC) which is responsible for developing policies and procedures governing use and development of classrooms at College Park. Membership on the TFC is diverse and includes representatives from various units which have a vested interest in classrooms, including faculty.

When working on specific facilities, a mix of individuals from the various disciplines using those facilities must be involved as well as representatives from the Scheduling Office and those units responsible for supporting the classrooms after they are built or renovated. This insures that adequate consideration is given to the different types of instructional methods and learning environments of those using the facilities as well as careful consideration of appropriate campus standards.

DESIGN STANDARDS AND CLASSROOM IMPROVEMENTS

This manual offers current standards for the design of instructional spaces at the University of Maryland. Periodic reviews of classroom facilities are done to identify deficiencies and develop plans for any needed upgrades or improvements.

The TFC develops classroom improvement plans that identify the rooms to be renovated or newly constructed, the estimated cost for each room, the estimated timetable for implementing the plan, and a funding strategy.

Since enrollment is usually lower during the summer and winter session, most renovations occur during these limited windows of opportunity. Careful consideration must be given to determine how many rooms can be taken out of service at the same time.

Prior to the design for the renovation or construction of instructional spaces, program requirements are developed for each project. The program statement serves as a means to communicate requirements to the designer and a guideline to assist the planning team in reviewing drawings. Program requirements are based on these design standards and the specialized requirements for the individual project being designed.

CLASSROOM MANAGEMENT

Classroom inventory information is provided by the Scheduling office. Accurate information about the current classroom inventory and utilization rates of various classrooms is an essential part of good classroom management. Before planners can determine what is needed to meet the institution's instructional needs, they must first understand what classrooms exist and how they are currently used.

Common start times and day rotations are important in making effective use of all classrooms. Exceptions to a common time and day schedule should be permitted only if the course requires no classroom space that can be used by other units, and creates no scheduling conflicts for students who wish to enroll in additional courses.

CLASSROOM SUPPORT

The University of Maryland provides both centralized and decentralized support for classrooms. In general, the centralized units provide services which are more sophisticated or that benefit from economies of scale. Local support units in colleges and departments generally provide routine, day-to-day support or services which are specific to a particular discipline. Representatives from the local units participate in the Classroom Support Project (CSP) Operating Committee to provide a way to coordinate activities and provide more seamless service to users.

Many new instructional technologies are more complex to set-up, use and maintain than traditional audiovisual instructional equipment. Local support staff assist and train faculty and student users as well as do initial troubleshooting of the equipment.

In addition, faculty often need more in-depth professional development opportunities, such as adequate time and access to skilled support staff and equipment to revamp existing materials and develop new and innovative instructional materials that will integrate technology effectively into their teaching/learning activities. This type of support is provided by groups such as OIT and the Center for Teaching Excellence.

LIFE CYCLE FUNDING AND RESOURCES FOR TECHNOLOGY

All institutions feel pressure to keep pace with new technologies. Maryland, like most institutions, seeks a balance between keeping abreast of the latest technological innovations and increasing access so that technology is available broadly enough that it can be integrated into the entire academic program of the institution. The TFC regularly reviews and recommends funding for ongoing operational support as well as classroom improvements and upgrades.

CHAPTER 2
FACILITY DESIGN ELEMENTS

INTRODUCTION

The discussion of classroom design guidelines must begin with a few general principles about the location of classrooms and the structures that contain them. This chapter emphasizes the design guidelines common to all types of instructional spaces. For specific guidelines on general purpose classrooms, lecture halls, and seminar rooms, refer to Chapters 3, 4, and 5.

SITE AND SPATIAL RELATIONSHIPS

Classrooms should be placed on the lower floors of buildings to provide better student access and more convenient instructional support services. A building with mixed functions (classrooms, offices, and/or laboratories) should separate the classroom core from other functions.

Classrooms should be separated from noise-generating activities inside or outside the building. To reduce external noise, sound buffers must separate classrooms from areas such as streets, parking lots, housing areas, plazas or other areas where students gather, recreation sites, athletic fields, trash pickup sites, and loading docks. To reduce internal noise, classrooms should be isolated from building mechanical systems, elevators, restrooms, vending areas, and other noise generating areas.

BUILDING ENTRANCES

To reduce the impact of exterior noise and temperature differences, all building entrances should have two sets of doors, one from the outside into a vestibule and a second from the vestibule into the building.

The main criterion in determining where to locate building entrances should be the direction(s) from which students and other pedestrians approach the building. Entrances should be near classrooms to limit the distance students must travel through non-instructional areas to reach classrooms. Large numbers of students walking through hallways can disturb classes already in session. Larger capacity classrooms should be located closest to the building entry.

Local building codes should be only one of several criteria that should determine the number and location of building entrances. Equally important is to plan for a flow of students between classes that is double the capacity of the rooms served by an entrance. Students often arrive for class at the same time students are leaving the classroom.

If classrooms must be located on upper floors, the stair towers and the doors into stair towers must accommodate the number of students who may leave and arrive at the same time.

DOORS

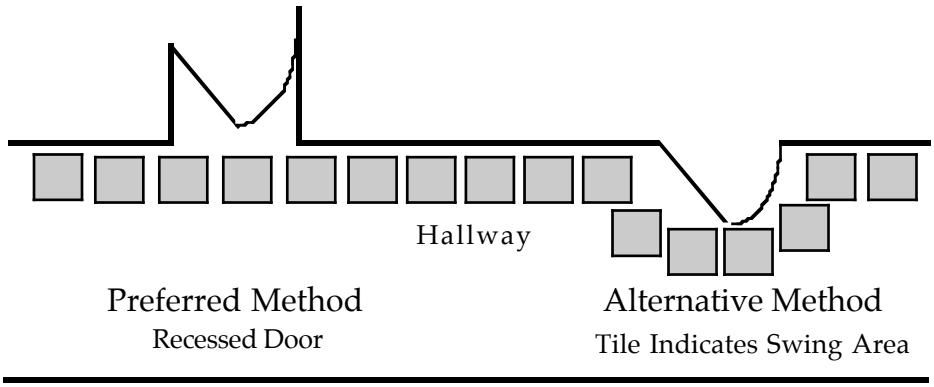
All classroom and lecture hall doors should be a minimum of three feet wide and should have a vision panel in order to prevent injury when being opened. Vision panels should contain shatter-resistant glass that is tinted to reduce light transmission. The area of the glass should not exceed 100 square inches. The base of the vision panel should be no higher than 42 inches above

the floor, and the top of the vision panel should extend at least 62 inches above the floor. All classroom doors should have levers (not knobs) for easier use by people with disabilities.

The doors should be equipped with hardware that results in a slow and quiet closure to a tight sound seal when fully closed. To facilitate traffic flow, the doors should be capable of standing open during the change of classes. All exits from classrooms and lecture halls should conform to prevailing codes regarding panic hardware for use in case of emergencies. Door opening force, hardware, width, thresholds, and maneuvering clearance should conform to ADA standards (See APPENDIX A).

If locks are installed in the doors, they should be deadbolt locks which are card-activated, not push button. Doors should not contain ventilation louvers because they permit transmission of sound and fumes. Kick plates installed on the egress side of doors will protect them from bumps and scratches.

Doors should be located to minimize congestion problems in the hallway when classes are changing. When possible, doors should be recessed into the room so that the door does not swing into the hallway. If it is necessary for the door to open into the hallway, some kind of visual identification (such as the tile pattern in the floor) can be used to indicate the amount of space that the door will occupy when it swings open. Doors should not swing into the primary flow of traffic. This will minimize the danger of someone in the hallway walking into the leading edge of the door.



VENDING AREAS

Vending machines should not be located in the lobby area outside a lecture hall. Vending areas should be placed in remote locations away from classrooms, preferably in an alcove or other similar location that will minimize congestion and noise when students use the machines.

The vending area should have trash/ recycling containers in the immediate area of the vending machines. Any trash/recycling containers in the lobby area should complement the interior decor of the lobby area.

RESTROOMS

Restrooms should be located on each floor, and the capacity of the restrooms should be calculated according to the number of students in the area during class change time rather than to the capacity of the classrooms. To prevent noise transmission, in no case should there be a

common wall or ceiling between any classroom and the restrooms. In new construction, each public and common use toilet room shall be accessible to persons with disabilities.

Lecture halls often are used for a variety of activities in the evening which means that access to restrooms is needed. Restrooms should be so located in the building that they can remain open in the evening, even if the remainder of the building is closed.

DRINKING FOUNTAINS

Preferably 50 percent of all, but at least one drinking fountain per floor, should be accessible and should be located on an accessible route.

TELEPHONES

A public telephone should be located in a visible area near the lobby or entrance area of the building. The telephone should be located near lecture halls and installed so that they do not obstruct the normal flow of traffic through the lobby area. The telephone should be accessible to persons with disabilities, equipped with a variable volume-control feature for people who are hearing-impaired and located at an appropriate height for persons who use wheelchairs.

BUILDING DIRECTORY

A directory that identifies classroom locations should be provided at each entrance along with a directory of other programs and activities located in the building. If multiple corridors lead away from a point of entry to a floor, directional signs should indicate the location of classrooms. Refer to APPENDIX A, for signage accessibility requirements.

SIGNAGE

Signage in and around a classroom should be kept to a minimum and should be coordinated with other signs and with the general decor of the area.

All classrooms should have a room identification number on the wall next to the door. These numbers should be accessible to and meaningful to all students in accordance with local code. There should be information located inside and outside each classroom regarding how to report problems with physical facilities and with equipment in the classroom.

When movable seating is used, the capacity of the room should be prominently posted within the room. This will assist the staff in maintaining the proper number of seats in the room.

FINISHES

Color and Reflectance Values

The selection of color and the reflectance values of finish materials must be considered for all classrooms. Painted surfaces should be a light color, and should have a durable finish to allow washing. A soft matte finish marks easily, is difficult to clean, and, therefore, should be avoided.

Special care must be given to rooms where televised instructional activities will originate. Light blue and gray are good choices for these areas. In addition, all finishes should be non-glare.

The reflectance value of paints, vinyl coverings, laminates, and other finish materials should be selected to enhance ambient illumination and the illumination at working surfaces. The following values are recommended by the Engineering Society of North America:

SURFACE REFLECTANCE VALUES

Ceilings	80 percent or higher
Walls	50 to 70 percent
Floors	20 to 40 percent
Desktops	25-45 percent

In addition to reflectance, work surfaces should have a matte finish. Reflectance values can be found in selection charts and samples.

A person's eyes move toward the brightest object in its field of vision. Thus, lighting should highlight what is most important to see--the task at hand. The desk surface should contrast from the paper, book, or computer screen where the task is performed.

Floors

The floor in the general classroom should be vinyl or rubber tile and should have a smooth surface. Industrial grade, stain resistant carpet is rapidly becoming in classrooms because it provides valuable acoustical properties to the room, and because it is increasing durable. If carpet is installed, consideration should be given to its effect on the acoustics in the room. Where movable seating is to be used, acoustical advantages of carpet should be weighed against the maintenance costs produced by the wear and tear resulting from the moving furniture.

The floor covering should be a medium to light color and should contain some kind of subdued pattern or fleck to break the monotony and to make it less likely to show dirt and stains. A four-inch cove base should be installed around all of the walls.

HALLWAYS

The design of buildings that contain classrooms should recognize that students will be in the hallways or public areas while classes are in session. This means that built-in or permanently affixed seating should be provided. If there are no seats, students will sit on the floor, interrupting traffic flow through the hallways. The lower portion of the hallway walls should have a very durable surface because of normal wear and tear. Sound-absorbent material may be applied to the upper portion of hallways to provide for control of sound in these public areas.

Any changes in floor elevation in a hallway should make provisions for wheelchair and equipment passage through the use of a ramp. Gently sloped ramps (1:20 or less in slope) are typically easier for persons with disabilities to negotiate than steeper, although more direct routes. Ramps must not exceed one foot rise in twelve feet of run and handrails are required if the run exceeds 72" or rise exceeds 6". Level landings are required every 30' of run and wherever a ramp changes direction. See APPENDIX A for a more complete discussion of accessibility requirements.

The floors of hallways should be smooth to minimize noise and to facilitate the movement of equipment carts and wheelchairs. Floors also should have a nonskid surface, especially near the outside entrances.

To improve acoustics and create visual interest, a variety of materials and colors should be used in hallways and other public areas.

Trash and recycling receptacles should be available near the door of each classroom. Receptacles should have a large opening and be large enough to accommodate trash generated between scheduled collection times.

It is recommended that a pencil sharpener be conveniently located in or near each classroom and be securely mounted with tamper-resistant screws.

EQUIPMENT STORAGE (AV Closets and Projection Booths)

Adequate and secure storage for all types of instructional equipment may be needed near the classrooms. This storage should be accessible from the hallway and not require entering through another classroom. Any classroom located on a floor that is not accessible by an elevator should have storage provided for portable instructional equipment and cart(s).

For lecture halls with installed technology, an AV closet of at least 50 SF may be needed at the front of the room to house the equipment rack as well as carts, cables, etc. Depending on user needs and design requirements, some rooms may need larger closets or two closets at the front of the room and/or a projection booth may be needed at the rear of the room.

Special considerations must be given regarding security of any equipment that is permanently assigned to a general classroom. All equipment should be firmly secured and clearly marked in a way that makes the identification difficult to remove.

DESIGNING TO ACCOMMODATE INDIVIDUALS OF VARIOUS SIZES

Anthropometrics, the comparative study of human body measurement, should be considered when designing classrooms to make certain that furnishings and equipment will be suitable for the persons for whom the space is intended. Generally, when designing for institutional use, equipment and furnishings should accommodate the "tallest and the smallest" persons; that is, everyone within the 5th to the 95th percentiles. This means that five percent of the population will be too small to be comfortable, and five percent will be too large to be comfortable. According to Panero and Zelnik in *Human Dimension & Interior Space, A Source Book of Design Reference Standards,* classrooms should be designed for the 5th percentile females (104.5 pounds and 60 inches) to the 95th percentile males (215.4 pounds and 74.3 inches). To establish which percentile to use for each dimension, use the following guidelines.

- To define clearance areas (lines of sight, aisles, seat widths, thigh clearance, etc.), use the 95th percentile.

- To establish vertical-grip reach, heights of equipment, seat height and depth, and placement of audio-visual equipment and controls, use the 5th percentile.

- To define lines of sight, pivot movements and positions, the limit of visual field in the horizontal and vertical planes should never be exceeded. The design should account for normal line of sight, limit of color discrimination, and the actual limit of visual field.

To accommodate larger individuals, it is desirable to provide a variety of chair widths and put the wider ones along the aisles.

ACOUSTICS

Good listening conditions (i.e. a quiet room) depend on four basic factors:
- the amount of noise entering the room from outside sources
- the loudness of various sound sources within the room (with or without amplification)
- the distribution of sound to all parts of the room
- the fidelity and clarity of the sound (lack of reverberation, distortion, etc.)

Perhaps the single most important factor related to good acoustics is the absence of noise from external sources since this interferes with sound created within the room. Even a room with good internal acoustical properties and sound systems can't overcome extensive noise infiltration.

Walls

Walls in classrooms and lecture halls should have a minimum sound transmission class (STC) rating of 50. All walls must extend to the floor above or to the roof construction, and not stop at the ceiling. This will reduce noise transmission as well as improve security.

Higher STC ratings and special wall-construction details must be included whenever classrooms must be located adjacent to, above, or below restrooms, mechanical rooms, elevator shafts, athletic facilities, or other sources of high noise levels or where the classroom function generates a significant amount of noise, such as a music room.

Concrete masonry units may be used as structural walls, but may have to be covered with another finish in order to provide proper acoustics.

Folding walls should not be used in classrooms because it is difficult for a folding-wall to maintain adequate sound separation between classrooms over an extended period of time.

Ceiling

Sound must be loud enough to be heard by people sitting in the rear of the room as well as those in the front. The ceiling is the most critical element inside the room in assuring effective distribution and appropriate volume of sound throughout the room. The ceiling should act as a sound mirror, reflecting sound downward to blend with the direct sound. This is why the ceiling should include significant amounts of hard surfaced material. Too many classrooms and lecture halls have ceilings composed entirely of sound absorbing acoustical tile that offer little or no sound reflection. This leads to a significant and undesirable difference in volume and distribution of sound within the room.

The surface of the ceiling must be designed to accommodate the required acoustical properties of the room. The area of the ceiling that should be covered with acoustical tile is related to ceiling height.

CEILING SURFACES

Ceiling Height	Proportion of Acoustic Tile
8 feet clearance	40 to 50 percent
10 feet clearance	50 to 60 percent
12 feet clearance	50 to 60 percent

These numbers presume the use of Noise Reduction Coefficient (NRC) .55-.65 tile in a ceiling suspension system. The acoustical tile should be arranged in horseshoe configuration around the perimeter of the room, with the opening at the front and the rest of the ceiling a hard material such as gypsum board or plaster.

Reverberation in smaller classrooms is normally not a concern, although it can be critical in larger rooms and lecture halls. If a reverberation problem exists, applying a small amount of acoustical material to the walls in the rear of the room may provide sufficient deadening.

Insulation from Mechanical System Noise

The mechanical system supporting classrooms should generate a background noise of no more than NC 35. To achieve this, the HVAC system requires careful design, competent installation and balancing, and regular maintenance. Factors that influence the design of a quiet operating system include air handlers or fans located away from the classrooms; low velocity of air within the room; and proper sizing and acoustical treatment of ducts, returns, and diffusers.

Inadequate or improperly sized mechanical systems often cause acoustical problems for classrooms. Budget constraints and cost-cutting measures may be short-sighted and create conditions where HVAC systems must be turned off so that students can hear. This requirement must be communicated to the design engineer to ensure proper air circulation and duct sizing. Often, less expensive high velocity, small duct mechanical systems create noise problems that go undetected until it is too late. Large, oversized ducts create lower velocity and higher air volume so that air is dispersed quietly over the entire room rather than blasting out of small vents.

If low structural ceiling heights prevent large duct work, consider raising the ceiling as high as possible and installing mechanical ducts in the top of the side walls. Side wall duct systems generally limit the distance cool air can be distributed, however, and are used primarily in smaller classrooms.

In rooms with ceiling mounted video projectors, microphones, or other equipment, the duct work needs to allow for installation in the proper location.

Utility Boxes

When classrooms share a common wall, electrical receptacles or other utility boxes should not be installed back-to-back with similar receptacles in the next room. Off-setting the boxes will reduce sound transmission between rooms.

ACCESSIBILITY

Doors

At least one set of entry doors to every facility should be power activated using both a high (approximately 42" above finished floor) and a low (approximately 6" above finished floor) for persons with limited upper body mobility. In some cases, interior doors may also need to be power activated if the door opening pressure is great (higher than 8.5 lbs. force). In many cases, door closures can be adjusted to decrease the door opening pressure. Installation of magnetic devices that hold interior doors open and are connected to a building fire alarm system is another method of providing accessibility.

Accessible Routes and Fire Safety

An accessible route must connect accessible building or facility entrances with all accessible spaces and elements within the building or facility. Accessible routes should also serve as a means of emergency egress or connect to an accessible area of rescue assistance. (Areas of rescue assistance are not required in buildings that have a supervised automatic sprinkler system).

Each area of rescue assistance should contain a method of two-way communication and should be marked with appropriate signage. Areas of rescue assistance should be located within a smoke-protected and fire-protected area of egress.

Where audible alarms are required by life safety codes, visible alarms must be provided which signal the same areas that are required to be signaled by the audible alarms.

Signage

Public entities must provide signage at all inaccessible entrances to each of its facilities that directs users to an accessible entry or to a location with information about accessible entities. Tactile maps or prerecorded instructions may be useful to persons with visual impairments.

The Americans with Disabilities Act Accessibility Guidelines (ADAAG) gives specific guidelines for the design of raised and braille characters and pictorial symbol signs. The legibility of printed characters is dependent on the viewing distance, character height, ratio of the stroke width to the height of the character, contrast of color between character and background, and print font. Instructions on mounting location and height also are specified Section 4.30 ADAAG.

Where permanently installed assistive listening systems are required, signage is needed that indicates the availability, including the international symbol of access for hearing loss.

Environmental Issues

Due to many medical situations, which will be referred to collectively as cardiopulmonary medical problems, fresh air or clean re-circulated air must be provided for classrooms. This means that windows and fresh air intakes for the buildings and classrooms be located away from loading docks, mechanical areas, exhaust vents, roadways, and other sources of potential irritants.

Persons with allergies often have problems with chemical aromas, including carpet glue, paint, and roof tar. Use of these in or near general classrooms should be minimized whenever possible, and adequate "airing out" time must be provided before scheduling classes in the rooms.

Flickering of fluorescent lights can trigger seizures in persons with epilepsy and other neurological disorders. Regular inspection and/or replacement of ballasts and tubes can help eliminate this potential problem.

LIGHTING

Due to the increased use of media and technology in classrooms, the design of easy-to-use, adjustable lighting systems is more important than ever.

Lighting should be designed in accordance with the Illuminating Engineering Society's and the National Electrical Code's current recommendations. In addition, lighting should be designed to meet the special program requirements for each instructional space. For example, the control of light has become increasingly important as more technology is used in classrooms. Although adequate lighting levels can be achieved through a variety of approaches, it is essential that all instructional spaces have a range of lighting possibilities, from a comfortable level for reading and seeing the chalkboard to sufficient darkening at the projection screen to accommodate various types of projection while still permitting enough light in the seating area for notetaking.

Although low light levels are often acknowledged as a problem, too much lighting also can create difficulties (e.g. glare, reflection, eye strain, etc.).

When lighting is reduced during projection, some type of lighting may be needed in the presentation area for the instructor (such as podium light) but care should be taken to insure that the light does not spill onto the projection screen. Special lighting on technology controls or equipment racks also may be needed as well as provision for lighting a sign language interpreter for hearing-impaired students (see APPENDIX A).

Attention should be paid to the maintenance of the lighting system. If bulbs burn out frequently and are not replaced the system won't work as required. Therefore, all other things being equal, fluorescent lights are generally preferable to incandescents because they last longer. In any case, bulbs should be easily accessible for replacement when they do burn out. Because lecture halls often have high ceilings, the design of the ceiling lighting should recognize the need to regularly change bulbs. Bulb_changing is often difficult in a facility that may be heavily used and that may require special equipment to reach the high ceilings, so lighting designs should attempt to ensure a long lifetime of the bulbs.

General Room Lighting

For general room lighting, a level of 50-60 footcandles should be provided at all student stations within the room and at the instructor area. General lighting should be uniformly distributed throughout the room, with no noticeable pooling or hot spots. This general room lighting should be provided using fluorescent fixtures that are banked or zoned to provide appropriate control. In rooms with very high ceilings, care needs to be taken to insure that lighting from fluorescent fixtures does not spread out too much and wash out the projection screen.

Generally, 2' x 2' fixtures are preferable to 2' x 4' fixtures, especially in small and medium size rooms, because they make it easier to get even light levels, to allow for separate light zones and control, and to accommodate all the other items that must fit into the ceiling grid (e.g., sprinklers, projectors, speakers, microphones, ducts, etc.). Diffusers in light fixtures should be nonreflective.

Note-Taking/Dimmable Lighting

For notetaking during projection, it should be possible to reduce the lighting to 5-20 footcandles over the seating area with all direct light eliminated from the instructor and projection screen areas (i.e., an object held in front of the projection screen should not cast a shadow on the screen).

Since most rooms now have high output projectors, it may be possible to zone and control non-dimming fluorescent lighting to provide adequate light levels. In these situations, the lights should be zoned (front and back) so that the front zones (instructor area and screens) can be controlled separately from the lights over the seating area. And in the seating area, the tubes in a multi-tube fixture can be controlled separately to provide different light levels. For example, if a 3 tube fixture provides 50 footcandles of light at the student work surface, turning off two of the three tubes in fixtures over the seats can reduce levels to 16 2/3 footcandles.

Some rooms, especially larger ones, may need more flexible lighting control (i.e., where faculty will use media requiring lower light levels, such as slides, or the instructor area has special requirements). Traditionally, this has been done by providing two types of lighting. General room lighting was provided by fluorescent fixtures. During projection, the fluorescent lighting was turned off and dimmable incandescent lighting over the seating area provided sufficient light levels for note taking. Now that dimmable fluorescent systems have improved and provide better control (i.e. 1% dimming) the incandescent systems are no longer needed. Whichever type of lighting is used, the lighting level should be even over the entire seating area with no pooling or hot spots, and light should not shine on the projection screens (i.e., should pass the shadow test).

Illumination of walls should be minimized to reduce reflection.

Controls

Room lights should conveniently be controlled from the teaching area, along with any lights that are capable of being dimmed during projection, as well as chalkboard lights. The number of switches required to control the lighting should be kept to a minimum and should be clearly labeled. As much as possible, how to control the lights should be readily apparent to anyone unfamiliar with the room. Standardization of lighting controls among instructional spaces is recommended. In addition, illuminated switches make it easier for users to locate lighting controls in a darkened room.

Switches for turning the general room lights on and off should be provided at every entrance to the room.

In rooms with more sophisticated audiovisual equipment installed, such as lecture halls, a lighting control system may be used that interfaces with the room's media control system. In these instances, preset scenes shall be programmed to accommodate various media.

Chalkboard/Marker Board Lighting

Currently, projection screens are being installed off-center (sometimes two screens are installed) so that the chalkboard can be used at the same time as material is being projected. This requires that the chalkboard be illuminated without any light spilling onto the projection screen.

Illumination of the chalkboard or marker board should be 10-15 lumens distributed uniformly across the entire writing surface. The lights over the writing surface should be controlled in separate sections to permit illumination of a portion of the board while one projection screen is in use. Proper selection and installation of the board lighting and/or baffles should ensure that the lamps in the fixtures will not be visible to students seated in the front rows. In addition, the fixtures should not interfere with raising/lowering the screen(s). Board lighting should not cast any light on the projection screens. Whenever possible, this should be achieved by placing the lighting behind the screens (between the screens and the chalkboard) and sitting directly on the top edge of the board. This requires that the lighting have a narrow profile so the screen doesn't need to be too far forward. In cases where the nature of the screen mounting precludes this, lighting fixtures should be selected that sufficiently control the spread of the light so that no light spills over onto the adjacent projection screen.

Specialized Lighting

For rooms where video recording or distance learning systems may be used, careful attention must be paid to the design of the lighting system. Lighting levels may need to be enhanced for quality television imaging and lighting must be controlled to ensure that projected images are not washed out by the room lights, that direct view monitors don't produce glare, and that the instructor area has sufficient, even lighting.

Ambient Light

Ambient light within the room (from hallways, signage, and other sources) should be controlled so that it is far away from the projection screen and is not a visual distraction. Emergency exit lighting should be self-luminous on a dark background and should conform to code requirements.

Emergency and Aisle Lighting

Emergency lighting and exit signs should conform to local codes and be self-illuminating. These should be located so they do not interfere with the image on the projection screens (they should pass the shadow test) or provide visual distraction to the audience. Emergency lighting should be wired so it only comes on in emergencies, even if it uses fixtures that are controlled as part of the normal room lights.

Three common methods of providing egress or aisle lighting include: 1) using small thin tubes or strips at the edge of the aisles and steps (such as used in airplanes and movie theaters), 2) using fixtures that are incorporated as part of the fixed seating that is next to the aisle, or 3) narrow beam spots that are mounted in the ceiling and shine down onto the aisle.

Wall Lighting

Lecture halls often have high walls and it may be desirable for aesthetic or other reasons to have some type of wall fixtures that illuminate the walls. Fixtures that project light down are preferred over those that bounce light up so that it reflects off the ceiling. Wall lights should be dimmed along with the lights over the seating area. Any wall lighting that disperses light so that it has an adverse effect on projection must be able to be turned off during projection.

HEATING VENTILATION AND AIR CONDITIONING

The circulation of air is a critical factor in all instructional spaces. Poor air circulation causes students to feel drowsy and not alert. Careful selection of duct sizes, air handlers, and fan units can achieve effective combinations of proper air flow and quiet operation of mechanical systems in classrooms and lecture halls.

The heating, ventilating, and air-conditioning (HVAC) system must provide adequate air changes per hour in conformance with current standards of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). The recirculation of air within the building should not be done in such a way as to result in hall noise entering the room.

Air ventilation units should not blow a strong volume of air directly on the seating area or on the instructor area. Since it takes very little air flow to cause projections screens to move, there should be no ducts or intakes close to projection screens. The air circulation system in the room should be able to be used at all times separately from any HVAC system that may be operated only seasonally. In rooms where ceiling mics are installed, careful attention must be paid to insure that air ducts don't blow directly on mics and produce extraneous noise.

The temperature range should be maintained within 68-75 degrees Fahrenheit, with relative humidity at 50 percent, plus or minus 10 percent.

No building should be designed so that the windows and doors are essential for temperature control within the building. Ideally, each classroom should have a temperature-sensitive monitoring device within it and that device should be tied to a central monitoring system maintained and overseen by Operations and Maintenance staff. Response to abnormalities detected by such a monitoring device should be a number-one priority at all times because of the lack of any other method of circulating air, especially in rooms without windows.

The acoustical considerations in determining volume of air-handling noise should include, in addition to the background noise level, any vibration considerations that would generate additional noise. (See Acoustics section, Chapter 2).

Air intakes for classrooms should not be located in or near loading docks, trash receptacles, or areas of high vehicular traffic outside the building. Additionally, air exchanges inside buildings should isolate air circulated in classrooms from air circulated in laboratories and other areas capable of producing odorous or hazardous airborne contaminants.

The system servicing classrooms should operate independently of any system(s) servicing other functions within the same building.

The installation of low-velocity ceiling fans will provide air circulation, an important element in all classrooms, but especially in rooms that are not air conditioned. The mounting location of the ceiling fans must not interfere with projected images or equipment.

Technology can make special demands on the buildings in which it is installed. For this reason, new construction (as well as renovation projects) requires special attention to the design of the electrical and the heating, ventilation, and cooling (HVAC) systems so they will meet the requirements of the equipment that will be installed. This often means specially conditioned or additional electrical circuits, increased number of air exchanges, year-round temperature and humidity control, low-noise ducts and air returns, etc. Renovation of individual rooms can present special challenges, especially when building mechanical systems are not being replaced. In those circumstances, even such simple measures as installing ceiling fans can improve conditions until major renovations can be made.

Routine maintenance of building mechanical, electrical, and plumbing systems is critical. It is particularly important for the HVAC system ducts to be cleaned and the air flow balanced regularly. These measures not only benefit the users, but they prolong equipment life and reduce maintenance costs since many types of equipment are especially sensitive to environmental conditions.

ELECTRICAL, TELECOMMUNICATION, & AUDIOVISUAL SERVICES

Because technology needs change rapidly, attention should be given to installing cable management systems (conduits, cable trays, etc.) that are flexible and have spare capacity for future growth. This will make it easy to upgrade and expand wiring without the need for major renovation.

Electrical

All electrical services should be protected from surges and spikes. Electrical outlets should not be controlled from a wall switch that could be confused for a light switch.

In both new construction and renovations, provision should be made for a minimum of 20 percent, with a recommended 40 percent, future increase in the need for electrical services in classrooms. This includes additional capacity in the breaker box for future use.

Wall outlets should be mounted 18-24 inches above the floor. In rooms where student furniture will be wired, it may be advisable to install raceway around the perimeter of the room or outlets in floor boxes to allow easy installation. In cases where extensive technology installation is anticipated for each student station, consideration should be given to using a low-profile raised floor. This will make it easier to make upgrades or reconfigure the room.

Even if technology is not installed when a room is built or renovated, electrical service should be provided in appropriate locations to allow for easy installation in the future--the ceiling for future projection, camera, and wireless communication capability. Specifically, each projector location will need a separate, dedicated circuit in the ceiling. Each potential camera location needs a duplex outlet near the ceiling. If electric screens are being installed, electrical service to

the screen locations is required. Each equipment rack location needs a separate dedicated circuit. If there's an AV closet, in addition to the separate circuit for the rack, at least one convenience duplex outlet is needed near the door. Electrical outlets should be provided in the front of the room for convenient connection of overhead projectors and other equipment.

There should be no elevator motors, compressor motors, blower motors, or other types of equipment on the side of the power transformer that feeds classroom or lecture hall circuits.

Telecommunications

All telecommunications wiring should adhere to the latest campus standards developed by the Office of Information Technology. The central feed conduit or cable tray from the telecommunications closet to each classroom should make provisions for voice, data, and video. Attention should be given to the HVAC needs of these telecommunications closets because of heat generated by the equipment.

All conduit, trays, and cabling should be clearly labeled at all termination locations so that a knowledgeable person who has never seen the installation before can identify the services in the room. Anytime an empty conduit is installed, it should contain a pull wire.

Every classroom should be connected to campus network for voice, data, and video communication. At a minimum, this includes three voice/data jacks and a campus cable tv jack near the equipment rack. In rooms where student use of laptops or other technology is anticipated, wiring to each table or seat may be required as well as provision in the ceiling for installation of wireless networking capability.

Audiovisual

Conduit, raceway, or cable tray shall be installed from the equipment rack location in each classroom to all locations where equipment will be installed that must be connected to the rack (projector ceiling locations, screens, speakers, instructor area equipment/inputs, lighting control system, cameras, ceiling mics, wireless mic antenna, assistive listening transmitter, etc.).

All low-voltage connections should be separated from the electrical circuits to the room through separate conduit or separate channel within a raceway or cable tray. These services include control and signal cables for audio, video, data, and voice feeds. These circuits should not be tied to ground.

TECHNOLOGY

An institution's commitment to provide and support the use of technology in classroom instruction triggers a series of complications to good classroom design. Integrating modern technology into general purpose classrooms and large lecture halls involves more than simply installing the necessary equipment. A host of related issues must be addressed if the technology is to function properly and support instruction in meaningful and appropriate ways.

Standardization

The use of electronic technology in the classroom must be as "user friendly" as possible. One way to accomplish this is to establish a standard layout and placement of all control panels

and equipment. Standardization facilitates use by faculty who teach in numerous rooms, troubleshooting and maintenance by technical staff, and the interchange of components.

Standardization also reduces training time and costs for both the users and the support staff, and it frequently results in lower equipment prices due to quantity purchases. The location of light switches and equipment and screen controls should be as standard as possible from room to room and each should be clearly labeled. Portable equipment and interfaces that require user hook-up can be made easier if equipment is the same (or similar) and by identifying cables and connectors with labels or color coding.

Security

Classrooms that house equipment are designed to provide for maximum security and at the same time to be convenient to access by the user. Security measures include marking equipment (both externally and internally), using security cables and devices, and installing equipment in racks using University-standard security screws and rack doors. AV closets and projection booth have standard door locks that use key cards. Portable equipment is attached to carts and kept in secure storage closets.

Video And Computer Projection Systems

Classrooms should be designed to accommodate both video and computer generated (or electronic) displays. In general, the same room conditions specified for optical projection (light control, screens, sound, etc.) apply to video and computer projection.

Determination of the most appropriate type of display or projection system to use depends on room and audience size, and the type of visual materials used. For showing video, a large monitor/receiver (27”- 40”) may be adequate in seminar rooms, while large screen projection devices are most suitable for standard size classrooms and lecture halls. For computer images, a video/data projection system is generally more effective regardless of room and audience size.

When a monitor/receiver needs to be movable, carefully evaluate equipment for safety considerations. Monitors/receivers mounted on carts tend to be top heavy and can cause serious injury or damage if they are not designed, built, and/or used properly. The International Communications Industries Association (ICIA) has established standards regarding carts used to move portable monitor/receiver equipment to and from classes. It is recommended that these standards be followed. If a monitor/receiver is wall or ceiling mounted, it should be secured and tilted down for easy viewing. If the set is mounted over an aisle, the lowest part of the mount should be at least seven feet from the floor or it can be mounted on a cane-detectable cabinet or rack in the corner. Special attention during installation is needed to avoid glare from lights and windows.

Projection systems for standard classrooms can be portable or ceiling mounted. For optimum results, control of natural and artificial light is critical. Window cover must be opaque. Room light control must be designed so the projected image is not washed out by ambient light, and to allow for note taking--5 to 10 footcandles over the student area.

Since faculty at the University make heavy use of both video and computer materials in their classes, all projectors are selected for their ability to provide good images for both types of media. Currently, the University uses LCD projectors. (See Appendix B for a list of current standard equipment.). The exact projection distance will depend upon the focal length of the projector lens and the image size required.

Several factors should be considered when mounting a video projector in the ceiling. There must be a grid or beam anchored to the permanent ceiling that is strong enough to support the weight of the projector and, if needed, an elevator lift or pulley system to lower and raise the projector or an above-ceiling mounting device. There must be electrical power and conduit/cable tray running from the ceiling location to the teaching station or equipment rack. Equipment manuals should be consulted to determine the appropriate type of ceiling mounts, conduit size, and projection distances required to meet legibility standards.

Projection Screens

The need for multiple projection screens in classrooms increases as the use of technology in instruction increases. The standard single center screen in the front of the room is increasingly inadequate and faculty members complain that it leaves them with little or no usable board space. The University standard is to provide two projection screens. The exception would be in small rooms where mounting a second screen may not be possible. In such cases, it is best to mount the screen to one side to maximize available board space.

There are two common methods of mounting two projection screens in the front of the room. Regardless of the method, screens should be mounted so they do not block access to light switches and other controls or traffic patterns.

Method 1. Hang two screens side by side across the front wall of the instructor area. If this method is chosen, a minimum of six running feet (preferably much more) of chalkboard should remain exposed when either one of the projection screens is in use.

Method 2. Place one screen in the front of the room and angle the other one across the front corner of the room. Once again, if this configuration is chosen, a minimum of six feet of chalkboard space should be exposed when either one of the projection screens is in use. If the second screen is used primarily for overhead projection, an effective corner screen is a rigid-frame tilt screen, sized specifically to meet the needs of overhead projection. This type of screen is particularly good at minimizing keystoning.

In large rooms with high ceilings, it may be desirable to use the wall above the boards as a screen surface or to mount a framed, snap-on screen on the wall. These options eliminate the delay in raising and lowering the screen as well as any potential mechanical difficulties that might occur with an electric screen. These options are also much less expensive.

In small rooms, manual screens may acceptable but in larger rooms, electric screens with low voltage interfaces are preferred. Three button low voltages switches for the screens shall be located in the instructor area next to the light switches and shall be clearly labeled. All switches

should have an automatic shut off and all should automatically return to neutral when the screen is fully extended or fully retracted.

The most suitable projection screen surface is a matte white finish. This surface, which provides a viewing angle up to 45 degrees to each side of the center line of the screen, accommodates the widest range of room seating arrangements and projected images.

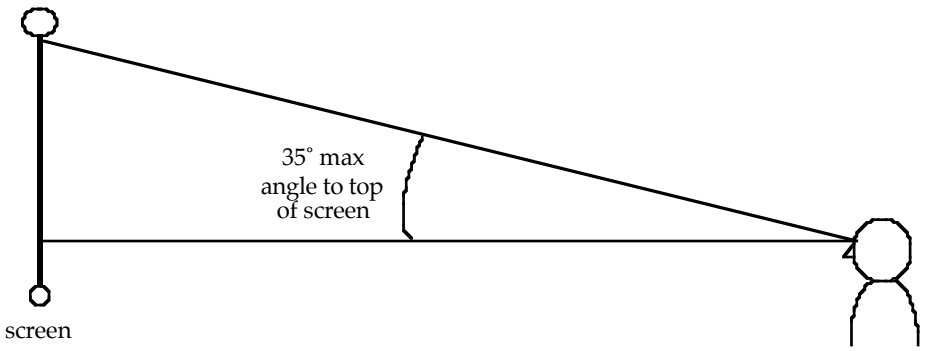
Screens mounted parallel to the front of the room should be mounted with the top of the screen 10 to 12 inches out from the wall to allow clearance over chalkboard lights and map hooks. This distance also provides a means of correcting keystoning (distorted image that frequently results when using an overhead projector) since the bottom of the screen can be pulled back to the wall with a tieback.

Ceiling height is often a key factor in determining screen size. In a non-tiered room the screen should be mounted high enough so that the bottom of a lowered screen is about 45 inches above the floor. In smaller rooms with low ceilings, the bottom of the screen may need to be even with the chalkboard tray (36" above the floor) to provide a large enough image. In larger tiered lecture halls with high ceilings, the bottom of the lowered screen should be no lower than the top of the chalkboard. The screen should not be located near an air exhaust/intake duct since air flow can cause the screen to move.

Another factor in determining the size of the projection screen is the size of the room. Minimum screen width is determined by using the 1 : 4 ratio --the distance from the screen to the farthest viewer divided by 4 equals the screen width. For example, in a room where the farthest viewer is 40' a minimum 10 foot wide screen is needed. If conditions permit, larger screens may be installed because it makes computer text more legible.

The first row of seats should be no closer to the screen than 1.5 to 2 times the width of the screen. This is especially critical in rooms with two screens because the front row of seats needs to be further back so that students can see both screens well.

The top of the screen should subtend an angle no greater than 35 degrees from the horizontal from any seating position. However, some compromises may have to be made in the first few rows of seats to allow sufficient space for chalkboard/markerboard and a reasonable screen size, and yet not have the front seats too far from the front of the room.



Front Screen Or Rear Screen Projection

Front projection screens are recommended over rear projection screens for general purpose classrooms, lecture halls, and seminar rooms. Front projection:

- accommodates a wide variety of projection equipment, including overhead projectors
- costs less to purchase and install
- provides higher resolution and brightness, wider viewing angles, better color fidelity, and better contrast ratios (when used under appropriate lighting conditions)
- requires smaller projection booth size (or none at all)
- provides easier access to and operation of equipment

Generally, rear projection is not recommended for University classrooms because of its high initial cost and the fact that a rear screen can easily be damaged if users are careless or mistake it for a chalkboard. In specialized circumstances, such as rooms used for distance learning or video conferencing, the disadvantages may be outweighed by the advantages, which include:

- provides better rejection of ambient light
- allows higher levels of room lights making it easier to take notes and see the presenter
- lets presenters walk in front of the screen without blocking the projected image or having the projected light shine in their eyes
- provides a more seamless, less noticeable technology environment

It should be noted that if projectors are installed in a rear projection booth behind the instructor area, the booth must be deep enough or a mirror system may be required to achieve the correct throw distance for the projector.

Computers

The University uses two methods of providing instructor computers in classrooms. For classrooms with installed AV systems, computers are installed in the room's equipment rack. For those who bring their own laptops, a cable for connecting the laptop is provided.

In rooms without installed AV systems, carts with computers and portable projectors are often available to take to classrooms.

CHAPTER 3

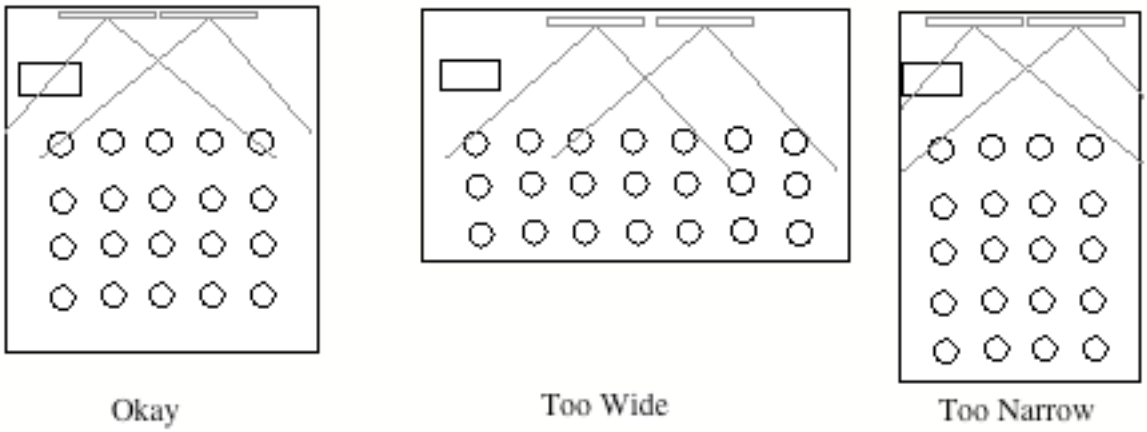
GENERAL PURPOSE CLASSROOMS

INTRODUCTION

As stated in the Introduction, General Purpose Classrooms are defined as those seating 20-75 students and having at least 350 square feet of space. These rooms are by far the most numerous and must be carefully designed and equipped if they are to provide the appropriate learning environment.

DIMENSIONS

Classrooms should be designed so that all students have good viewing angles. Rooms that are too wide or too narrow create wasted space and/or unacceptable viewing angles for projected materials and for the chalkboard. With increased use of projected images, the shape and dimensions of classrooms are more critical than ever before.



There should be no obstructions (such as columns or posts) anywhere in the classroom. The front wall of the room behind the instructor area should have no protrusions into the room so that a chalkboard/ marker board can be installed across the entire wall of the instructor area and that screens can operate without obstructions.

Ceiling heights will vary depending upon the size of the room. The following are suggested minimum ceiling heights that allow for projected images to be seen.

MINIMUM CEILING HEIGHTS

Room Capacity	Optimum	Minimum
20-49 stations	12 feet clearance	8 feet
50-75 stations	12 feet clearance	10 feet

Clear space is needed above the ceiling, away from mechanical and utility systems to permit installation of screens and structural supports for projection equipment installation.

In general, classroom under 75 seats should have flat floors, in both the seating area and the instructor area. Flat floors in the seating area provide greater flexibility when classroom activities involve collaborative learning projects or small group discussions. Raised platforms at the front present ADA access problems, can be a safety hazard, and are not needed in a well-designed room.

ENTRANCES

Rooms with fewer than 50 stations normally should have a single entrance/exit. To facilitate movement of people and equipment, two entrances are preferred, and are required in rooms with a capacity of 50 or more.

If achieving maximum room capacity is an objective, a single entrance at the front of the room will usually provide room for more student stations because entry space is incorporated into the instructor area. However, single entrances from the rear of the classroom reduce the disturbance caused by students arriving late for class. If only one entry is possible, it should be located at the front of the room. This single entrance should be on the side wall rather than the front wall so that it does not reduce the amount of space for boards and screens.

All doorways should facilitate the easy passage of people with disabilities and should accommodate moving equipment into and out of the room.

WINDOWS

If used, windows should be placed away from walls that are near parking lots, exhaust fans, vehicular and pedestrian walkways, and building cooling towers. Many factors, including anticipated types of instructional activities and projected use of audiovisual materials, should be considered to determine whether to include windows in new construction and where to place them when used.

The two primary purposes of classroom windows are aesthetic and environmental. The presence of windows in a room provides visual contact and sensory stimulation with the world outside. All windows in classrooms should be operable so that they can be opened to provide additional air circulation when needed, particularly when the building heating, ventilating and air-conditioning system is not operating adequately. Windows should either raise and lower or open outward (never inward).

Windowless classrooms may be desirable in special circumstances. Advantages include the ease of light control, the elimination of heat loss or gain during periods of extreme temperatures, and the elimination of noise interferences from traffic or other exterior sources.

Architectural design often requires windows on the exterior of a building. If windows in classrooms are a problem, this requirement can be met by locating windows in other spaces (lobbies, hallways, offices, etc.).

Any classroom that does not have windows must be air-conditioned and must contain adequate circulation and outside air exchange. In addition, if there are no windows, extra care

must be given to ceiling height and the use of interior finishes, colors, and decor to provide visual interest to the room.

When windows are installed, particularly on the south side of the building, install tinted glass with a "low E" rating to reduce the heat transfer from the outside to the inside of the room. Double, or even triple, glazed windows will assist in reducing heat transfer and will provide a noise insulation barrier from exterior sounds.

When windows are a desired feature in classroom design, the glass surface should be limited to minimum amounts. All window surfaces should be at the side of the room and not located in the front or rear of the room. The use of clerestory and other types of window panels that admit incidental light can present problems with light control.

WINDOW TREATMENTS

Window treatments should be opaque and should be capable of eliminating all outside light from reaching the projection screen(s) and must be robust enough to resist the abuse of daily use. In general, the University installs horizontal blinds on classroom windows. The blinds should be installed so that they cover the window opening as completely as possible. If horizontal blinds do not provide adequate light blocking, some other type of treatment, such as shades or roller blinds may be needed.

FINISHES

Walls

A chair rail should be installed on the side and rear walls whenever movable seating is used in the room. The surface below the chair rail or chalkboard should be extremely durable. All surfaces must be washable. The finishes used in a classroom should be chosen with the room's acoustical characteristics in mind. (See Acoustics section in Chapters 2 and 4.) Accent colors or design elements should be used to provide visual interest to the room.

Ceilings

For direct lighting, ceilings should be a light color and nonreflective. For indirect lighting, a higher reflective material is required. (See also section on acoustical characteristics of the ceiling.) Because of the increasing number of AV items being installed in ceilings (projectors, speakers, mics, mic antenna, etc., a 2 x 2 ceiling grid is preferred over drywall or plaster which can be more expensive and time-consuming to maintain and repair.

FURNISHINGS AND EQUIPMENT

All furnishings and equipment should be provided by established manufacturers who can provide parts and service for the anticipated life of the items. For long-life items, such as seating, neutral colors should be used so that they don't looked outdated before they are due to be replaced.

Instructor Area

A sturdy table or desk should be placed at the front of the room as part of the instructor area. This area also should include either a tabletop or free-standing floor podium with a minimum surface of 18 x 24 inches. For universal access, use a height-adjustable podium or a combination of table and podium. There should be a stool or chair available for the instructor. The instructor furniture should be coordinated with other furniture in the room.

Chalkboards/Markerboards

All general-purpose classrooms should have chalkboards (or in special cases, marker boards) across as much of the instructor area wall as possible. The installation of boards on the side or rear walls should be determined by the programs that will use the room and the viewing angles of the students.

The boards should be mounted with the bottom edge of the tray 36 inches above the finished floor. The boards should be four feet in height and have trays under the full width of the board. Seams on the chalkboards/markerboards should be flush. The surface of the chalkboard should be black to provide maximum contrast. In specialized situations, such as lecture halls, motorized board systems may be appropriate.

While markerboards eliminate chalk dust, markers are more expensive and only those made for markerboards should be used since others can permanently damage the markerboard surface. Markerboards will only be installed in special circumstances when the primary users of the room agree to supply markers. In addition, markerboards should not be used as projection screens.

Refer to the Lighting Systems section of Chapter 2 for a discussion of lighting the chalkboard/markerboard.

Tackable and Display Surfaces

A tack-strip approximately two inches wide should be placed above the chalkboard. Unless a special need has been identified, tackboards shall not be provided in classrooms.

A tackboard in the hall, convenient to each cluster of classrooms, may be used to post student announcements and other types of general information. In addition, a tackboard or tack strip may be installed outside of each classroom in the immediate vicinity of the doorway so that room changes and class related items may be posted.

Student Seating Capacity

When determining the seating capacity of a room (regardless of which type of student furniture is used) additional square footage must be allowed for the instructor area including enough space so that the first row of seats is far enough from the screen(s) for good viewing. In addition, the shape of the room is critical. If a room is narrow, then the instructor area will not require as much square footage as if a room is wide. The locations of doors and aisles also effect the amount of space available for seating. In addition, the “station factor” of the proposed seating

can vary depending based on the type of seating selected and whether it's installed in a small room or a large room. Large rooms benefit from economies of scale.

For these reasons, the traditional formula used for figuring room capacities (total square footage minus instructor area divided by station factor) should be considered an estimate and *must be confirmed by doing actual furniture layouts*.

To estimate the number of student stations in a room, take the total square footage of the room, subtract the square footage for the teaching station, and then divide by the number of square feet per type of seating (i.e., movable seating, tables and chairs, or fixed seating). For larger rooms, use the lower number of the station factor range.

ROOM CAPACITY = (Total Sq. Ft. - sq. ft. instructor area) X Station Factor

INSTRUCTOR AREA = width of room x distance to front row of seats

TYPE OF SEATING	STATION FACTOR
Movable Furniture:	
tablet armchairs	15-17 sq. ft.
tables and chairs	20 sq. ft.

TYPE OF SEATING	STATION FACTOR
Fixed Furniture:	
chairs w/ folding tablet arms	12-15 sq. ft.
theater seats w/ folding tablet arms	12-15 sq. ft.
continuous tables	15-20 sq. ft.

Movable Seating

Classrooms under 50 capacity should have movable seating unless there are special considerations. The University has a standard tablet arm chair (see UM Classroom Furniture Standards). The standard chair has a sufficiently large writing surface that is suitable for both right- or left-handed students.

In special circumstances, tables and chairs are desirable because of the additional work space provided to students. However, this arrangement may reduce the student seating capacity of the room when compared to tablet arm chairs. The University has a standard table and chair (see UM Classroom Furniture Standards).

Fixed Seating

Rooms of 50-75 capacity should be evaluated on the basis of intended use to determine whether fixed or movable seating should be installed.

When using fixed seating with a folding tablet arm, allow sufficient aisle space for students to move to the interior of a row while those at the ends have their tablets up. The writing surface on the folding tablet should be at least 150 square inches. Using a variety of seat widths will permit

maximizing capacity and accommodating people of various sizes. Wider seats should be located on the aisle.

Seating for Left-Handed Persons

Both movable and fixed seating should contain a minimum of ten percent left-handed tablet arms or should contain chairs designed to be used by either right- or left-handed people. The left-handed seats in fixed seating arrangements should be along the left side of the aisle when viewed from the instructor area.

Seating for Persons with Mobility Impairments

Stations for students with mobility impairments, especially persons who use wheelchairs, should be provided at approximately four percent of the capacity of the room. In addition, one percent (at least one seat of all fixed seats in rooms of less than 100 capacity) should be aisle seats with no armrests on the aisle side. These stations should be available in a variety of locations within the seating area. To accommodate students using wheelchairs, a table that provides knee space of at least 27 inches high, 30 inches wide, and 19 inches deep should be provided. Another option would be to provide adjustable height tables that adjust from 28 inches to 34 inches above the finished floor. In addition, provisions may be necessary to accommodate companions who assist students with hearing, sight, and mobility impairments. (See APPENDIX A, Designing For Accessibility.)

VOICE AMPLIFICATION

All rooms with capacities greater than 100 shall be equipped with voice amplication systems. Voice amplification may be installed in rooms of <100 capacity, based on outside noise factors, the acoustical characteristics of the room, and any special needs. (See APPENDIX A, Designing For Accessibility.)

PROJECTION

See Chapter 2 for a discussion of projection requirements.

ACCESSIBILITY

Classroom design must insure that the room be accessible to persons with disabilities. Essentially, each classroom should have the following characteristics.

- An accessible route into the classroom is required; thresholds (not to exceed 2 inches), stairs, or other barriers should be minimized.
- In the instructor area, teaching platforms must be accessible by means of a ramp; teaching equipment and room controls also should be accessible.
- Wheelchair stations must be provided so that persons with disabilities are provided a choice of sight lines that is comparable to those provided for persons without disabilities.
- Doorways and aisles must be sufficiently wide enough to allow wheelchairs to pass easily (32" clear minimum, 36" recommended).
- Door hardware should be lever-operated, push-type, or U-shaped to allow easy operation and the force required to push or pull a door should be minimized (i.e., maximum 5 lbf**,** pounds of force, for interior doors). The minimum maneuvering clearance at the pull side of a door is 18 inches.

- Room identification signage should be mounted 60 inches above the finished floor to the centerline of the sign. Characters should be raised, should contrast with the background, and should accompany Grade 2 Braille lettering.

See APPENDIX A for a more complete discussion of accessible design.

LIGHTING SYSTEMS

See the section on Lighting in Chapter 2.

ELECTRICAL, TELECOMMUNICATION, & AUDIOVISUAL SERVICES

In addition to the basic requirements outlined in the Electrical and Telecommunications Services section of Chapter 2, general purpose classrooms often have additional needs.

The number of electrical outlets in the room will depend in part on special functions that may be assigned to the room. In general, rooms below 50 capacity should have at least a single duplex outlet in each side wall of the room, one fourplex outlet in the center of the rear wall of the room, and three outlets in the front of the room (one fourplex outlet located in the center of the front wall and one duplex outlet near each corner). A duplex outlet, data and cable TV jacks are needed adjacent to every AV rack.

In rooms of 50-75 capacity, there should be two outlets evenly spaced in each side wall, three fourplex outlets in the front wall, and two fourplex outlets in the rear. If fixed furniture will be wired for power and/or data, appropriate service connections to the furniture should be provided.

All wall outlets should be mounted 18-24 inches above the floor. In addition, electrical service (and conduits/cable trays) should be provided in the ceiling for future projection and wireless communication capability.

CHAPTER 4

LECTURE HALLS

INTRODUCTION

The three fundamental requirements outlined in the introduction to this book (to see all visual material, to hear without noise or distortion, and to be physically comfortable) are especially important in lecture halls. The complexities of good classroom design increase as classroom size increases. Large lecture halls require more entrances and exits, larger projection screen images, good voice amplification, more complex lighting and audiovisual control, special acoustical design, and greater control of the environment by the instructor. Mistakes and minor problems that often occur in small classroom design are magnified in lecture halls because of the fixed environment and more limited range of instructional approaches.

The issue for many colleges and universities is not whether to teach large classes, but how to create a good learning environment for such classes. Effective classroom instruction can be conducted in large class settings, if the room is designed and equipped properly and if appropriate training and support services exist.

National classification standards (e.g., HEGIS and CIP) define large lecture halls as any classroom with more than 50 seats. As stated earlier, our focus on design and size characteristics alters the standard definition so that a lecture hall is defined as a classroom with seating for 75 or more persons.

As mentioned in Chapter 2, lecture halls should be located on the ground floor near entrances to facilitate the movement of students in and out of the hall.

LOBBY AREAS

Lobby space is an integral part of lecture hall design because of the need to accommodate waiting students. This lobby space should be large enough to allow students to congregate without interfering with the normal traffic flow of students entering or leaving the facility. Also, if the lobby will be used for special events, such as receptions and social gatherings, then lobby areas should be designed to accommodate the large groups in a reception style setting. If the lobby area serves primarily as a gathering and waiting area for students who arrive for class, then the lobby area should be sufficiently large enough to accommodate the passage of students attending consecutive class sessions.

Seating in the lobby area is necessary, and should be placed away from the entrance/exit to the lecture hall to avoid any noise interference caused by normal student interaction. Seating also should be selected with durability in mind and, whenever possible, should be integrated into the overall structure of the building, rather than as stand-alone furniture pieces.

The surfaces and finishes in the lobby area, including the floor and the lower portion of the walls, should consist of durable materials that will survive the large volume of student traffic in the area. Acoustics are critical and measures should be taken, such as installing acoustic materials on the upper portion of the walls, to dampen noise in the lobby area.

The lobby area is one of the most visible and heavily used portions of the building. For this reason, the aesthetics of the lobby become an important interior design consideration. However, pleasing aesthetic design should be balanced against the practical need for durability.

DIRECTIONAL SIGNS

Signage in and around a lecture hall should be kept at a minimum and should be incorporated into the design of the lobby and the lecture hall when the facility is designed. See Chapter 2, Signage.

There should be no tackboards or other surfaces inside the lecture hall although a tackboard should be installed outside each lecture hall in the immediate vicinity of the doorway so that announcements and other class-related items can be posted conveniently.

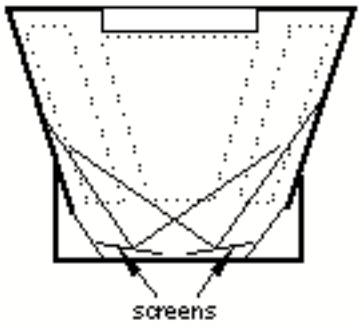
Information should be posted both inside and outside each lecture hall regarding how to report problems with physical facilities and equipment in the lecture hall.

It is essential that information about emergency evacuation of the facility be prominently displayed in the immediate vicinity of the lecture hall.

DIMENSIONS

As the size of the space increases, the complexity of design for that space increases geometrically. It is not a linear process. Design mistakes that may go unnoticed in a small seminar room will be magnified many times in large lecture halls to the point where the space may become dysfunctional.

To provide good sight lines and acoustics, a modified fan-shaped design is often best. In this configuration, student seating can be arranged to provide good viewing angles from all seats. Rooms that are wider will require a much deeper instructor area in order to maintain good viewing angles.



Most larger rooms must be sloped or tiered to provide good sight lines. The slope of the floor in a large room or lecture hall should be no more than 1:12. ADA guidelines state that if a slope extends 30 feet, an appropriate size (flat) landing area must be provided for persons who use wheelchairs. If there is a rise of four inches or less from one row to the next, then the seating in each row should be offset to permit clear visibility to the front of the room. The slope of the floor

in a lecture hall should maximize sight lines. An accessible route within the lecture hall and a choice of wheelchair seating locations are required (see Furnishings).

Some small lecture halls (under 100-student capacity) may have a sloped or tiered floor while some may have a flat floor.

The aisles in a lecture hall should be arranged to provide the maximum prime viewing locations for the audience. Generally, this will mean no center aisle. Building codes must be consulted to determine the number of seats in a continuous row and the distance between rows allowed in the jurisdiction.

There must be no posts or other obstructions anywhere inside a lecture hall that would block the view of the teaching area from any seat.

Ceiling heights will vary, depending upon a variety of factors. The following are recommended optimum ceiling heights, based on the number of student stations within the lecture hall and the appropriate projection viewing guidelines. These guidelines include:

- the screen having an aspect ratio of 4:3
- the bottom of the screen being at the top of the chalkboard
- the distance from screen to farthest viewer being no more than 4 times the screen width
- the distance from screen to first row of seats being no less than 1.5 - 2 times the screen width

OPTIMUM CEILING HEIGHTS

Distance to Last Row	Rear of the Lecture Hall	Front of the Lecture Hall
50 feet	10 feet	17 feet
75 feet	10 feet	22 feet
100 feet	10 feet	28 feet

For acoustical purposes, walls in lecture halls should not be parallel and should have a rough or textured surface.

ENTRANCES

At-grade access should be provided to the front area of large lecture halls which have sloped or tiered floors to accommodate equipment being moved into and out of the room and to accommodate people who use wheelchairs. In lecture halls where there is a sloped or tiered floor, the floor must remain flat at least five feet from the entrance into the room.

Primary entries for large lecture halls should be in the rear section of the room, with doors placed in the side walls rather than the rear wall whenever possible. This reduces the amount of light reaching the projection screen when the doors are opened during class. Another solution is to use light traps, two sets of doorways that trap light from entering into the lecture hall when the doors are opened.

There should be double doors at each entrance, with each door being a minimum of three feet wide. If it is necessary to have a center post between the doors, it should be removable to facilitate the passage of large pieces of equipment.

It is important that the doors swing open into the lobby area in a way that does not obstruct the efficient flow of traffic to and from the lecture hall. When possible, doors should be recessed into the room.

WINDOWS

Lecture halls require excellent light control. This can be accomplished by eliminating windows (except for the vision panels in the doors) or by having shades that completely block the light. If windows must be preserved as an exterior architectural element, glass panes can be replaced with mirrors or other opaque material or the entire window opening can be covered on the inside with some type of decorative/acoustic panel.

FINISHES

For information on color and reflectance values, refer to Chapter 2.

Floors

Resilient, nonskid vinyl or rubber tile is a good choice of floor covering for lecture halls. If carpeting is used, it should be installed only in the aisles, entry, and instructor area, not in the student seating area. In lecture halls where science demonstrations occur, tile should be used in the instructor area. Because it is difficult to prohibit students and faculty from bringing food and drink into classrooms, only industrial grade, stain resistant carpet should be installed since it is easier to maintain and clean. If carpet is used, its effect on the acoustics of the room should be considered.

Walls and Ceiling

Walls should be constructed of a durable material that is easy to maintain and should be basically acoustically non-absorbent except in those areas of the lecture halls where acoustical treatment is prescribed. The ceiling in a large lecture hall is an important factor in the overall room acoustics. For more details, see the Acoustics section below.

The ceiling should be a neutral factor in the lighting scheme of the room, projecting a light color from nonreflective material.

It is recommended that both the floor treatment and the wall treatment be in light colors with textures and designs used to add visual interest to the room.

FURNISHINGS AND EQUIPMENT

Instructor Area

As the use of media in instruction increases, particularly in large group instruction, a table and lectern are no longer considered adequate furniture for the teaching station in a large lecture hall. Media needs may dictate the installation of a teaching station or podium at the front of the

room that serves as the master control center for the room. Instructors in wheelchairs should be able to access any controls provided.

The teaching station should provide access to a variety of communication and control capabilities, including electrical outlets; voice, video, and data outlets; controls for the lights and the projection screen(s); controls for the voice amplification system, including a microphone; and controls for all equipment built into the room, projection booth, or equipment closet.

The dimensions of the teaching station for a lecture hall should be large enough to accommodate all equipment and controls to be housed there as well as provide space for laying out papers and notes. Ideally, the podium should be adjustable in height or be a tabletop model.

The size and placement of the teaching station are critical. Neither the station nor the faculty member standing behind it should block students' view of the projection screen(s) or the chalkboard/markerboard. If an overhead projector is to be used, it should be able to be positioned close to the teaching station and at a sufficient distance from the screen to provide an acceptable image size.

If the teaching station is to contain equipment that is permanently housed in the room, then it should be constructed of materials and using methods that provide the maximum security for the equipment housed within it.

The chair or stool for the instructor should be of adjustable height in order to make it convenient for the instructor to use all types of teaching devices.

A telephone or voice communications device, connected to the service unit on campus assigned to provide emergency support to the classrooms, should be located either in the podium or in the immediate vicinity of the teaching station.

Storage and Preparation Areas

Consideration should be given to providing secure storage in the immediate vicinity of a lecture hall where instructors can keep materials needed on a repeated basis as well as provide space for the preparation of lecture materials.

Equipment Storage

Adequate and secure storage for all types of instructional equipment must be provided inside the lecture hall. In most cases, this means at least one AV equipment closet at the front of the classroom and in come cases, a projection booth at the rear. Equipment not needed on a regular basis may be stored in a nearby secure equipment room. This storage should be accessible from the hallway and not require entering another classroom for accessibility.

Chalkboards/Markerboards

Special attention should be given to the amount of space available at the instructor area for chalkboard/markerboard and for other visual presentations. The emphasis, particularly in large lecture halls, is usually on the use of projection tools in the place of the chalkboard/marker-board in order to provide for maximum visibility to students throughout the lecture hall. Despite the

increased use of projected media, a chalkboard/markerboard is still essential to effective use of the room and should be permanently mounted in the lecture hall.

See Chapter 2, Lighting Systems, for recommendations on lighting the boards.

Student Seating Area

Fixed Seating

There may be special circumstances when a small lecture hall, 75-100 students, would best be served by the use of movable seating, but in general it is recommended that rooms seating more than 75 have fixed seating. The seating plan should support the anticipated function.

Continuous fixed tables with attached swing-away chairs are the preferred seating in lecture halls. This provides the student with the maximum work area and makes it easy to provide electrical and data connections at each seat. In addition, by removing the swing-away seats in appropriate locations, easy access can be provided for wheelchair users or for larger students using straight chairs. It should be noted, however, that it is necessary to allow more square feet per student station when installing this type of furniture as compared to other types of fixed chairs. Other options include tables with task chairs on casters and auditorium seating with tablet arms. In some cases, it may be advisable to provide a mix of furniture types (I.e. fixed tables in the front plus a back row or two of tablet arm chairs). This allows for comfortable seating for the majority of classes and enough extra seats for some larger groups.

When fixed chairs with tablet arms are used, the tablet arm should have a minimum of 150 square inches of writing surface. The arm also should fold to facilitate passage of students through the rows of seats. If fixed chairs are attached directly to the floor, exposed bolt heads should be covered.

Since the number of seats in each row and the relationship of this number to the aisles is often covered by code requirements, these should be consulted in determining the layout of a room. To protect the wall surfaces from damage, fixed seating should not be located adjacent to walls, especially walls having acoustic panels.

It is recommended that all components of seating carry a minimum five year manufacturer's warranty. Further, the manufacturer should warrant the availability of replacement parts for a minimum of ten years.

Seating for Left-Handed Persons

When installing fixed seating other than tables, a minimum of ten percent left-handed tablet arms is needed. These left-handed seats should be installed on the left side of the aisle when viewed from the instructor area.

Seating for Persons with Mobility Impairments

Seating for mobility-impaired students should be provided in all lecture halls in accordance with federal and state accessibility codes relative to the capacity of the room. Wheelchair stations should be available in a variety of locations within the seating area. In addition, one percent and at least one of all the fixed seats should be aisle seats with no armrests on the aisle side. To

accommodate students in wheelchairs, a table 19 inches deep, 31 inches high (with 29 inches clearance), and 36 inches wide is recommended. (See APPENDIX A, Designing For Accessibility). Provisions may be necessary to accommodate companions who assist students with hearing, sight and mobility impairments.

AUDIO SYSTEM

Voice amplification should be installed in all lecture halls. Where technically feasible, a wireless microphone should be installed with the voice amplification system to allow the instructor the maximum flexibility of movement throughout the lecture hall.

A stereo sound system separate from the voice amplification system should be installed to handle other sound sources. The system should be capable of amplifying the soundtrack of videotapes, films, audiotapes, compact discs, videotape, DVD's, etc. Distribution from the system can be fed into speakers properly mounted on either side of the instructor area.

See APPENDIX A, for a discussion of assistive listening systems for hearing impaired.

PROJECTION

Projection Booth

Many larger lecture halls have a projection booth constructed in the rear of the room. At this time, slide projection is still used in classrooms, and a projection booth provides sound separation between noise of the machine and the audience. In addition, projection booths may serve other needs. For example, projectors with long-throw lenses may be installed there or in rooms equipped for distance learning, the booth is often used as a control room for operating the recording system.

The dimensions of the projection booth are critical and to a great extent will dictate the size. The booth and its projection window must be wide enough that projectors can be lined up perpendicular to the center line of all screens and it must be deep enough for easy passage of people and carts behind the projection shelf where the projectors sit. In addition, allowance must be made for door swings. That means that for projection booths that are used to house distance learning consoles and other functions, the space required may exceed 200 sq. ft. while a booth that houses only a couple of slide projectors, may be smaller.

The wall between the projection booth and the lecture hall should have a window whose lower edge is a minimum of 48 inches above the floor, so that images will be projected above the heads of those seated in the last row of seats next to the window. This window should be angled approximately five percent off vertical to reduce reflections, with the bottom being the extended section.

A shelf should be mounted directly beneath the window and should be just below the bottom edge of the glass. The shelf should be hinged so that it can be folded down and should be divided into two sections so that each section can be folded independently of the other. Several conveniently located electrical outlets are needed near the shelf.

The projection booth should have a speaker to monitor the house audio and voice-amplification systems. The booth should contain a work light designed so as not to shine into the lecture hall. The booth also may include controls for audio, lights, screens, and other built-in projection equipment.

The booth should have adequate ventilation, including temperature and humidity control. The exhaust system should not have a direct connection to the lecture hall.

Security is a major concern, given the amount of equipment installed in some projection booths. All doors should have locks and consideration should be given to additional measures, such as alarm systems or lockable storage cabinets.

The booth should have two doors. A door from the hallway is needed to move equipment in and out of the booth or to allow technicians to enter without disrupting the class. The door should be a minimum of 36 inches wide with no obstruction on the floor. A door from the lecture hall into the booth is needed so the instructor or teaching assistant can enter the booth directly from the lecture hall.

Equipment Closets

Increasingly, users find it more convenient to have equipment at the front of the lecture hall where it is more convenient to the instructor. AV equipment closets often house equipment in racks as well as carts for equipment that isn't permanently installed in the room but is used on a regular basis.

Auxilliary Input Panels

Faculty often want to bring in equipment that may not be used frequently enough to warrant its being permanently installed in a room. An auxillary input panel is needed (with clearly labeled connectors) which makes it easy for faculty to interface additional equipment with the other systems in the room.

Projection Screens

Lecture halls often require multiple screens, the exact number and size being determined by the design of the facility and by the special uses for the facility. The minimum recommended number of screens is two single or one double width screen. These should be mounted above the chalkboard if the design of the lecture hall permits, with the bottom of the screens being level with the top of the chalkboard. The exact mounting height must take into account a variety of factors (ceiling height, how steeply the seats are tiered, etc.) to insure appropriate viewing angles. See also Chapter 2, Projection Screens.

Video and Computer Projection Systems

See Chapter 2, Video and Computer Projection Systems, for a complete discussion of projection.

ACOUSTICS

Acoustics are one of the most important features in good lecture hall design. All surfaces in the room should be studied, shaped and tested integrally with the design of the floor plan so that

amplified voice systems will augment, not replace, the natural voice volume. Acoustical consultants offer valuable services in lecture hall design and the services of an acoustics expert are cost-effective when consideration is given to the consequences of poor design.

Proper acoustical design will isolate the facility from exterior noises and control the background noise level in the room (e.g., mechanical systems noise). Ambient sound levels measured at four feet above the floor at all points throughout the room should have a Noise Criterion (NC) rating of no more than 35.

Most lecture halls require both a voice amplification system and a program audio system. The placement of audio speakers is important in making certain that all areas receive a strong, clear signal from both systems.

The mix of sound-reflectant and sound-absorbent materials must be carefully calculated to control reverberation without creating a sound-deadened room. The appropriate blend of the two sounds (source and reflected) is achieved by controlling reverberation time. There should be no more than about 30 milliseconds difference between the arrival of source sound and reflected sound. As the interval approaches 70 milliseconds, the listener may perceive a separate sound or echo.

Walls

For acoustical value, walls in the lecture hall should be non-parallel, and should have a rough or textured surface. Side walls should be angled away from the instructor area in a fan-shaped pattern to focus sound toward the audience and the back of the room. The rear wall surface should not be parallel to the front wall and should be tilted, textured, or faceted to prevent "slap-back" noise that bounces directly toward the instructor. All walls should have a Sound Transmission Coefficient (STC) rating of no less than 50, and should extend to the floor above or to the roof construction. Most rooms have suspended ceilings which hide mechanical systems, cabling, etc. so walls that stop at the ceiling may allow sound to travel from room to room as well as create security problems.

The front wall that contains the teaching station should utilize hard surface materials. Sound-dampening materials should be applied to the rear and side walls as needed. In many instances, the back wall may need to be 50-100% covered with acoustical absorption materials.

Ceiling

The ceiling is the most critical element in insuring that the sound in the lecture hall is distributed evenly and at appropriate loudness to all portions of the seating area. The ceiling should act as a sound mirror, reflecting sound downward to blend with the sound from the speaker system. To achieve this the ceiling should be sloped or stepped and the majority of the ceiling should be primarily of a hard surface. If the ceiling has too much sound absorbant material, the loudness will diminish at the back of the room.

If some acoustical treatment is needed as part of the ceiling, it should be installed around the sides and rear in a horse-shoe shape, with the front and middle sections of hard-surfaced, sound-

reflectant materials. If needed, acoustical treatment normally will not exceed 40-50 percent of the total ceiling surface.

To enhance the instructor's voice projection, the ceiling should be hard surfaced nearest the instructor, and tilted at an angle from the ceiling to the front wall, similar to the ceiling of an orchestra shell.

Seats in some lecture hall may not be able to receive sounds that are reflected from the ceiling, which is often the case for seats beneath a balcony. In these situations, the sound reinforcement system should include speakers with appropriate sound delay to eliminate the echo effect often experienced in these seats.

Floor

The amount of tile and/or carpet used will have an impact on the acoustics of the room and should be given careful consideration during the design phase of the project. Generally, carpet is used in the front, rear, and aisles of lecture halls and tile under the seating area.

Seats

The acoustical property of the seats should be essentially the same whether they are vacant or occupied.

LIGHTING SYSTEMS

Lighting in large lecture halls is a particularly critical element, not only because of the increase in the use of technology in teaching, but also because of the lack of natural light typically available in these facilities. See the Lighting section in Chapter 2 for a discussion of basic lighting requirements.

Because lecture halls often have high ceilings, the design of the ceiling lighting should recognize the need to regularly change lamps. Lamp-changing is often difficult in a facility which may be heavily used and which may require special equipment to reach the high ceilings.

ELECTRICAL AND TELECOMMUNICATION SERVICES

In addition to the basic requirements outlined in the section on Electrical and Telecommunications Services in Chapter 2, lecture halls often have additional needs.

Electrical

The front of the lecture hall should be equipped with a minimum of four duplex outlets distributed evenly across the instructor area. Depending on the design of the room, floor boxes (located right, center, and left) with at least 1 duplex outlet may be needed. If the room has a built-in instructor station, it should contain a quadruplex outlet.

Duplex outlets should be located every 6-8’ on each of the other walls. If the fixed furniture will be wired for power and/or data, appropriate service connections to the furniture shall be provided.

In the projection booth, at least two fourplex outlets should be mounted near the shelf where equipment will be projecting into the room. In addition, two duplex outlets should be located on the wall opposite the projection window.

Telecommunications

If the design of the room includes floorboxes in the instructor area, each floorbox should contain a data outlet.

Audiovisual

If the instructor's teaching station or podium is movable, then floor box connections should be provided at the right, left, and center of the instructor area. The boxes and conduits should be sized to accommodate all the necessary cabling (including spare capacity and pull wires).

Although the specific location of conduits or cable trays will vary depending on the design of the lecture hall, in general, connections are needed: 1) from the instructor area to the projection booth and AV equipment closet, and 2) from the AV equipment closet to the video projector(s), speakers, screens, projection booth, camera locations, mic locations, wireless mic antenna, assistive listening transmitter, instructor area, and lighting control system. Any conduit or cable tray that is installed should have spare capacity and contain pull wires.

For video recording or distance learning capabilities, consideration must be given to camera placements, monitor locations, microphones for student-instructor interaction, etc.

CHAPTER 5
SEMINAR ROOMS

INTRODUCTION

Seminar rooms are designed to facilitate interaction and face-to-face discussion among students and instructor in small classes, usually fewer than 20 students. These rooms sometimes are used also as for departmental meetings or conferences.

Design guidelines for specific considerations such as doorway entrances, hallways, acoustics, finishes, and air ventilation and circulation, etc. are similar to the measures outlined in Chapter 3, General Purpose Classrooms. Refer to that section for advice and recommendations regarding these issues.

DIMENSIONS

The room dimensions should be similar to those of general purpose classrooms but because seminar rooms typically have tables and chairs, the total room area should allow 20 square feet per student station. Long narrow rooms limit eye contact and reduce personal interaction among participants in a class. Ceiling height should be ten feet minimum.

The projection screen or chalkboard/markerboard defines the front of the room. If achieving maximum capacity is an objective, a single entrance at the front of the room will allow the incorporation of the entry space into the instructor area. A single rear entrance reduces interruptions from late-arriving students but will require more space.

Although many seminar rooms have the same installed technology as general purpose classrooms, that may not always be the case. In rooms without installed technology, the front of the room should be large enough to accommodate at least basic AV equipment, such as a computer and LCD projector. It is recommended that a projector used in a seminar room may need to be equipped with a short focal length lens to reduce the distance from the projector to the screen. Faculty also should be aware that placing the projector on the table where students sit may create distracting noise and heat.

WINDOW AND WALL TREATMENTS

Fenestration should be kept to a minimum. All windows must be equipped with window coverings (shades, drapes, venetian blinds) that are opaque and mounted to prevent ambient light leakage around the edges. For more details on windows, refer to the section on window treatments in Chapter 2.

To protect the wall surfaces, wainscot chair railing is often installed in seminar rooms to prevent the backs of charis from rubbing and scarring the walls.

FURNISHINGS AND EQUIPMENT

Movable tables and chairs are the primary furnishings for seminar rooms. The University has a standard table and chair (see UM Classroom Furniture Standards) for use in seminar rooms. A portable lectern (floor or tabletop) should be placed in the room.

MULTIPLE USE CONSIDERATIONS

General purpose seminar rooms that also will be used as meeting or conference rooms may need to have built-in counter space, with lockable storage.

CHALKBOARD/MARKERBOARD

Seminar rooms typically provide a large amount of chalkboard or markerboard space. The boards should be four feet high and mounted to the wall so the bottom edge is three feet above the finished floor. A two-inch tack strip with movable mounting/map hooks should be above the writing surface. Tack boards are not standard and should be placed in the room only if required by the users.

PROJECTION SCREEN(S)

Because many seminar rooms are rather small, they may have a single screen. If users need a second screen and space permits, it is always preferable to mount two screens. The screen(s) should be matte white and mounted so that board space is available when one screen is down.

AUDIOVISUAL EQUIPMENT AND CONTROLS

Often, portable audiovisual equipment is used in seminar rooms so that it can be shared among several locations. The use of technology in instruction has increased, however, to the point that it is desirable to install equipment similar to what is done in other general purpose classrooms. Typically, some type of locking rack/storage cabinet/projection station is provided to securely house equipment.

LIGHTING SYSTEMS

See the section on Lighting in Chapter 2.

ELECTRICAL, TELECOMMUNICATION, & AUDIOVISUAL SERVICES

See the Electrical, Telecommunications, and Audiovisual Services section in Chapter 2.

Seminar rooms are similar to small general purpose classrooms and should have at least a single duplex outlet in each side wall of the room, one fourplex outlet in the center of the rear wall of the room, and three outlets in the front of the room (one fourplex outlet located in the center of the front wall and one duplex outlet near each corner). A duplex outlet, data jack, and cable TV jack are needed adjacent to every AV rack.

CHAPTER 6
SPECIALIZED CLASSROOMS

INTRODUCTION

As more technology is integrated into teaching and learning activities, a need for special adaptations to the general classroom and lecture hall has arisen. This chapter discusses the general design characteristics and features that should be considered when planning the two most common types of specialized learning spaces--distance learning or interactive video classrooms and computer labs/classrooms. The intent of this discussion is to give some basic guidance for designing these facilities with the realization that each room must be designed to meet the unique needs of its users.

DISTANCE EDUCATION OR INTERACTIVE VIDEO CLASSROOMS

Classrooms which are to be used for delivering instruction to distance learners must first be carefully designed general classrooms. Distance education or interactive video classrooms generally display the following characteristics:

- They seat from six to thirty students at an origination site and one or more remote sites.
- They are connected electronically to one or more video, audio, and/or computer telecommunications networks.
- They require additional technical support and training for proper utilization by learners and instructors.
- They allow users to incorporate interactive and other instructional approaches to enhance distance learning activities.

Although distance learning facilities should follow many of the recommendations of the previous chapters for technology usage and space layout, they require additional planning and analysis during their development and construction. All these specialized facilities should start with a careful assessment of their specific goals and objectives, the functions to be provided, and the exact activities to be engaged in by the learners and the instructor.

The following characteristics and features are ones that have been found to be critical in the design of good distance education classrooms.

Telecommunications

The selection and type of distribution systems to be used within and without the distance education classrooms is key to the scope and complexity of the design. Planners should determine the specific technologies (compressed, full-motion video, etc.) that are to be utilized by the distance delivery network as early as possible in the design process. Each of these technologies have specific requirements and limitations that must be accommodated in the facility design (for both the origination and remote classrooms).

Size of Classroom

More space is generally needed in distance learning facilities. From 30-40% additional square footage may be needed to accommodate additional equipment and provide adequate work space for the instructor and students. In addition, extra space may be needed to provide adequate camera angles.

Student Seating and Work Space

A minimum of 18-24" x 30" should be available for each student at tables. If equipment such as monitors or microphones are installed at student stations then 30" x 36" may be needed. High quality movable chairs on castors should be considered for learning activity flexibility.

Space for peripherals (such as FAX machines and recording equipment) should be provided. Extra storage and work counters may also be needed in these classrooms.

Teaching Console and Station

Due to the need for complex technology sources and equipment, the teaching station/console requires special planning and design. Document cameras, computers, viewing monitors, etc., must be easily operated and serviced. A wing-shaped or L-shaped teaching console should be considered. The height of the teaching station should accommodate the presenter both in a seated and standing mode. An adjustable instructor stool/chair will be needed.

Windows

Distance learning rooms should not have windows. The mixture of natural and artificial light in a room with windows can create problems since most cameras balance for one type of light or the other. Mixing the two types of light will mean that colors will not appear true.

Lighting

To provide sufficient light for the cameras, lighting levels should be increased 50-100% over that recommended for general purpose classrooms. Generally, 80-90 footcandles is the minimum needed in the seating area while 100-130 footcandles is preferable for the presentation area. This means that additional lighting may be needed for the presentation area and should be properly placed to improve facial highlights.

Walls

Neutral blues and grays should be used for wall and camera background surfaces in order to improve the video separation of flesh tones in television images. The design should provide a clean visual surface behind the presentation console. The drape or wall area should provide an appealing non-glare backdrop with adequate image contrasts. Whiteboards may present problems because they can create excessive contrast and glare.

Ceiling

The ceiling may need to be higher than a normal classroom to provide sufficient height for lighting instruments, microphones, etc. In addition, higher ceilings will allow cameras to frame shots so that ceiling lights will not be visible, which creates too much contrast for most cameras to get a good image.

Acoustics and Sound Treatment

Sound quality is key to effective communication among distance learning sites and classrooms. Extra acoustical treatment, such as drapes and wall coverings, should be included in these spaces to improve sound quality. It is recommended that reverberation testing and sound engineering be part of the design process of any distance learning facilities. The audio system designer should consider the usage of voice-activated microphones for students and wireless microphones for instructors. High quality audio components, preferably ones specifically designed for use in distance learning applications, should be utilized.

Viewing

Special attention must be taken in the placement, size, and quality of viewing monitors in distance learning classrooms. The degree of eye and head movement by learners should be minimal when moving between monitors and 'live' presenters. The mounting height for screens or monitors must be limited and must provide equal viewing from all seats. This will probably require more and larger display screens than recommended for general classrooms. In some distance learning spaces, small individual monitors for every one or two learners are installed on or within learner work tables.

Front video projection systems are not recommended for distance learning rooms since they create lighting problems for the camera and the images they project are not as bright and clear as with direct view monitors, or even rear screen monitors. Rear projection screens or large monitors tend to work better in this environment.

Technology

The technical requirements of distance education classrooms can be accommodated in two general methods. The hardware can be built into the teaching console and other cabinet areas in the room itself or the technology can be placed in an adjacent control room area. The decision on which method to be utilized should be based on the degree of technical support or staffing generally provided to the users of the classroom. The more technical support staffing that is planned, the greater is the need for separate support/control rooms. If the facility is designed to be operated by the instructor, then special attention must be given to the placement of all controls and their ease of use.

The location and mounting height of cameras and student monitors should provide natural viewing images and eye contact with the other classrooms in the system. 'Birds-eye-views' or high angles should be avoided. The need for special functions such as video production recording activities, computer image development and presenter work/prep areas should be considered when designing distance education classrooms.

Heating, Ventilation, and Air Conditioning

Because of the technology, distance learning rooms may require special heating, ventilation, and air conditioning systems. Year-round air conditioning is recommended to handle the heat and humidity. In all cases, but especially if microphones are to be hung from the ceiling, careful attention should be paid to the placement of air ducts and the velocity of air coming from the ducts.

COMPUTER LABS AND CLASSROOMS

Making computers available for students to use is increasingly important. Although many institutions are encouraging, or even requiring, students to purchase their own computers, there is still a need to provide computer labs or classrooms to support instruction. These computer facilities serve important functions. First, they provide computers that students can use on campus. If students don't carry their portable computers with them, they often do not have enough time between classes to return to their dorm or off-campus housing to use a computer. Second, computer labs and classrooms often have specialized software or peripherals that students may need for class assignments and would be too expensive or require too sophisticated a computer for students to purchase on their own.

For purposes of this discussion, *computer lab* refers facilities where students come to work individually. *Computer classroom* refers to facilities where an instructor can bring a class of students and have access to presentation capability for group instruction. Labs and classrooms share some characteristics and capabilities but there are important differences that should be recognized by facilities planners. It is possible to design a facility to serve both purposes (open to individual students between classes), but when this occurs, the requirements for a computer classroom should take precedence over those for a lab.

Telecommunications

Computer labs and classrooms share a need for good telecommunications capability. To provide access to a wide range of resources, each computer should be networked for file sharing, printing, shared applications, using the internet, etc.

Electrical

Electrical service that provides protection from surges and spikes is crucial. The number of circuits should be determined based on the equipment to be housed in the room with some room for future expansion. An uninterruptable power supply (ups) will be needed for the server and other critical equipment, and if resources allow, for all the computers.

Wiring/Cable Management

The wiring for all electrical and telecommunications services should be carefully planned so that outlets are placed appropriately for the arrangement of the room. All cables should be neatly dressed and covered in moldings or other cable management devices. All cables and outlets should be clearly labeled. Minimizing cable clutter is not only important from an aesthetic perspective, but can reduce unintentional cable disconnections, improper connections, etc. Please note that the arrangement of the seating has a bearing on the accessibility of the cabling (see configurations below). A raised floor allows for more flexibility and keeps cabling out of the way but is expensive.

Seating and Work Space

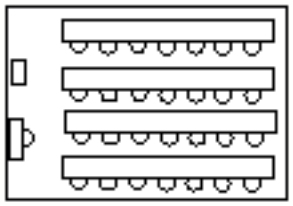
Since students often sit for long periods at the computer, especially in computer labs, it is critical that the seating and furnishings are comfortable. For this reason, padded chairs with casters are preferred.

Each work space must allow sufficient room for the computer and any peripherals, as well as for student notebooks and papers. A minimum of 36" wide may be sufficient for one person, although 48" is preferred. If two students may share a computer, then 48-60" is necessary. The height of the work surface should allow the keyboard to be at a comfortable height for typing (29-31"). The type of furniture can range from computer tables to carrels and must be selected based on the type of activity that will go on in the room.

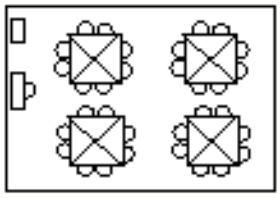
In a computer lab, providing separation among the work areas is more important than in a classroom, where interaction among the students is wanted. For this reason, labs often use carrels with high sides. This not only reduces visual distractions but can reduce noise levels if the sides are covered with a sound absorbing material. In a classroom, carrels with high sides are not appropriate because they block the view of the instructor area and limit student interaction. For a classroom, strong consideration should be given to using tables with recessed monitor wells to improve sight lines.

Since viewing angles and instructor areas are not critical in a computer lab, the individual work spaces can be arranged in a more compact configuration. For a computer classroom, several options are possible and each offers a variety of advantages and disadvantages.

COMPUTER LAB CONFIGURATIONS

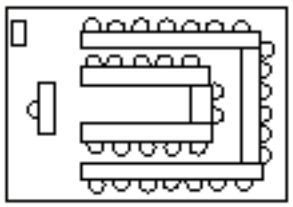


ROWS
Provides a very compact arrangement and has a low station factor compared to other options.

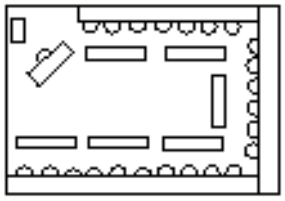


CLUSTERS
Not as compact as rows but provides a more varied and aesthetically pleasing arrangement. Good work spaces that are designed to seat two or more students.

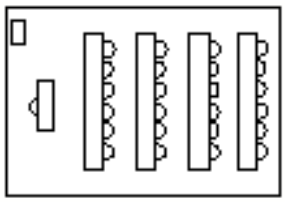
COMPUTER CLASSROOM CONFIGURATIONS



U-SHAPED (IN)
Allows students to see each other but sight lines to projection screen are not good for students in the outside front seats. Can be tiered to improve sight lines in rear rows. Requires more space since the middle is not very usable. Hard for instructor to move among students as they work.



U-SHAPED (OUT)
Students face the wall when using computers and turn inward to face instructor during presentations (computer tables may have L-shaped extension or the room may have movable tables in center). Easy for the instructor to see all student screens and move among them. Easy for students to break into groups or move around. Requires lots of space. Keeps all cables and connectors out of the way.



AISLE
Two side aisles are preferred over one center aisle (which wastes the best viewing area). May need to be tiered to improve sight lines.

The capacity of the room depends on many factors--the size of the furniture, how it is arranged, the amount of other equipment in the room (servers, printers, projectors), storage, etc., For this reason, station factors can range from 20-25 up to 35-40 sq. ft. per person. In some cases, a separate support space may be needed.

Support Space

A separate support space to house servers, support staff, supplies, etc. is desirable. The best arrangement is for the support space to be adjacent to the main room with a connecting door as well as a door leading directly into the hallway. It is even possible to put the computer CPU's in the support space to reduce noise and heat buildup in the student space. This also makes it easy to replace malfunctioning equipment. The initial cost to put CPU's in the support space is somewhat higher since it involves more cabling and a more complicated installation but it makes maintenance easier and less time consuming. If CPU's are located in the support space, sufficient electrical and communication outlets are needed.

Teaching Station

The teaching station in a computer classroom should be carefully designed so it is easy to operate and provides access to all necessary teaching tools. This usually includes an instructor computer and controls for the data projection system, lighting, and any AV equipment installed in the room. Additional capabilities may include a document camera, a system for displaying the screens of student computers, and a video recording system for taping classes or connecting to distance learning systems. A video system can also allow the staff in the support space to monitor the class and deal with problems without entering the classroom.

Ceiling Height

The ceiling height in a computer lab is not as critical as in a computer classroom, where seeing the instructor and screen are important. Also, since computer classrooms sometimes have tiered seating, additional height is needed to avoid a closed-in feeling in the back tiers.

Lighting

In a computer lab, good overall lighting that does not create glare on screens is needed. In a computer classroom, use the same general principles as with other classrooms (see Chapters 2 and 3) but with the additional need to prevent glare on computer screens. If a video recording system is planned for a computer classroom, higher light levels are needed for the cameras (see previous section on Distance Learning Classrooms).

Heating, Ventilation, and Air Conditioning

Given the concentration of equipment found in computer labs and classrooms, HVAC systems should be sized and balanced to handle the anticipated load. Also, year-round air conditioning is necessary to handle the heat and humidity. When computers are located in the classroom, rather than a support room, they generate additional heat and noise. Careful attention should be paid to the placement of air ducts and the velocity of air coming from the ducts so that additional cooling is delivered but without increased air noise.

Acoustics and Sound Treatment

Because computers generate noise (from fans and keyboards), rooms full of computers can be loud. In a computer lab, a very "dead" space is desirable. This means that sound absorbing material can be used throughout (ceiling tiles, wall coverings, floor coverings, carrel walls).

In a computer classroom, however, you need normal room acoustics so that the instructor and students can communicate easily. (See Chapters 2 and 3.) As mentioned earlier, installing the CPU's in an adjacent space can reduce noise. It may be advisable to install a sound reinforcement system if noise is a problem.

Accessibility

A few stations should be adjustable in height or provide 31" clearance to accommodate users in wheel chairs. In addition, printers, scanners, and other devices should be low enough for people in wheel chairs to operate them. Alternative input and output devices as well as specialized software should be available.

APPENDIX A

DESIGNING FOR ACCESSIBILITY

To be useful, thorough, and concise, excerpts are provided from various regulations and publications for barrier-free teaching and learning facilities. However, this section should not serve as a substitute for the complete set of guidelines published in the *Americans With Disabilities Act of 1990 (ADA)*. Designers and planners working on classroom facilities should consult the ADA guidelines, applicable state codes and regulations, and other related materials for more detailed information.

AMERICANS WITH DISABILITIES ACT

The Americans with Disabilities Act (ADA), enacted July 26, 1990, prohibits discrimination against persons with physical and mental disabilities. This means that individuals with disabilities are extended civil rights similar to those now available on the basis of race, color, sex, national origin and religion through the Civil Rights Act of 1964.

The ADA is modeled after that Act and Section 504 of the Rehabilitation Act of 1973. Regarding standards for remodeling and new construction, Title II of the ADA states that, public institutions can choose to follow either UFAS (Uniform Federal Accessibility Standards) or ADAAG (Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities) standards. State supported universities also must comply with their state's accessibility laws.

The term "disability" is defined as a physical or mental impairment that substantially limits one or more major life activities, such as walking, seeing, speaking, or hearing. A record of such an impairment, or of being regarded as having such an impairment, also qualifies under the ADA's definition of disability.

The special requirements of students and faculty with disabilities must be considered when designing and renovating classrooms. Any building constructed or altered after the effective date of the law must comply with the ADA. Rather than requiring a public institution to make each of its existing facilities accessible, the ADA requires that "each service, program, or activity conducted by a public entity, when viewed in its entirety, be readily accessible to and usable by individuals with disabilities." Program accessibility can be achieved by a number of means, such as redesigning equipment, reassigning services to accessible buildings, providing aides, altering existing facilities, constructing new facilities, and other means which provide services in an integrated setting.

In making programs accessible, public institutions need not take action that would threaten or destroy the historic significance of an historic property or that would fundamentally alter the nature of the service activity or program or would result in undue financial and administrative burdens. In these cases, the institution is required to take any other action to provide the required access.

Over 43 million U.S. citizens have physical or mental disabilities. Some persons with disabilities require the use of wheelchairs, crutches, or guide dogs. These visible conditions

require special consideration in the physical design of classrooms, but other less visible conditions also must be addressed. For example, conditions such as hearing loss, limited vision, energy limiting conditions (such as cardiopulmonary disorders), and mental disabilities often are invisible but can impact mobility and academic performance. It also should be noted that disabilities can be temporary or permanent.

The goal of classroom designers is to keep in mind all potential users, including persons with mobility, hearing, vision, and mental disabilities. In this context, the following information regarding the concept of "universal design" for barrier-free facilities is provided.

MOBILITY IMPAIRMENTS

Persons with mobility impairments often have conditions that limit their daily physical activities, such as walking, lifting, reaching, carrying, standing, and sitting. These impairments can range from carpal tunnel syndrome to quadriplegia, from asthma to cardiopulmonary disorders, and many can be energy limiting. In order for persons with mobility impairments to use classrooms and lecture halls, the facilities must be barrier-free. Standards which have been established for reach and rise limits for all persons, including those with differing abilities, can be found in *HUMANSCALE 1/2/3, Section 4 of UFAS, and Section 4.2 of the ADAAG.*

The ADAAG and UFAS differ in the scope of required wheelchair locations in areas of assembly. The guidelines for wheelchair locations vary with regard to room seating capacity from 1% to 6%. For new construction refer to Section 4.1.2 of UFAS or Section 4.1.3 of the ADAAG. For alterations, accessible seating areas may be clustered if technically infeasible to disperse throughout the altered assembly area. "Technically infeasible" is defined for building alterations as unlikely of being accomplished because "existing structural conditions would require removing or altering a load-bearing member which is an essential part of the structural frame; or because other existing physical or site constraints prohibit modification or addition of elements, spaces, or features which are in full and strict compliance with the minimum requirements for new construction and which are necessary to provide accessibility." (Section 4.1.6 of ADAAG)

If seating at fixed tables is provided for persons in wheelchairs, clear floor space and knee clearance should conform to Section 4.32 of ADAAG.

In larger rooms, such as lecture halls, where sloped or tiered floors are required in order to provide acceptable sight lines, accessible viewing positions shall adjoin an accessible route that also serves emergency egress.

Ramps must not exceed one foot rise in twelve feet of run (1:12 ratio), with a maximum rise of 30" and maximum run of 30' for any slope before level landings are required. Level landings (60" in length) must be provided at the top and bottom of each slope, and wherever the ramp changes directions. Handrails should be provided if a ramp run exceeds 72" or the rise is greater than 6". Section 4.0 of UFAS specifically highlights the regulations related to "Accessible Elements and Spaces: Scope and Technical Requirements." Ramps are specified in section 4.8 of the ADAAG.

The teaching station, including the chalkboards, audiovisual controls and projection screens, should be located and designed to be barrier-free.

HEARING IMPAIRMENTS

Over 16,000,000 persons in the United States are hearing-impaired. The traditional approach to improving speech intelligibility during a lecture has been through the use of 'public address systems' terminating in loudspeakers on the walls or ceiling. There are two major limitations to relying solely on these systems. First, while increasing the intensity of the signal is possible with PA systems, such increases in volume often cause distortions due to the combination of the equipment characteristics and the stage and hall acoustics. Second, even within the same lecture hall, the listening conditions can vary considerably in different locations, depending on the various ratios of direct to reverberant sound, changes of wave shape, fluctuations in decay characteristics and variations in sound levels.

A solution to improved sound transmission, particularly for persons with hearing loss, lies in the use of assisted listening devices. The purpose of these devices is to provide functional and effective listening and speaking environments so that people with hearing loss can increase their overall participation in general classrooms and lecture halls. Assisted listening devices supplement the existing loudspeaker system by providing a direct electronic coupling from the sound source to an appropriate amplification device where the signal is then transmitted to good quality, volume-controlled transducers which are located at or very close to the listener's ear canals. Most important to remember is that assisted listening systems provide improved speech clarity, not just volume control.

In cases where interpreters are utilized for deaf persons, consideration should be given to ensuring the visibility of the person signing, especially during reduced lighting presentations.

For new construction, if classrooms or lecture halls accommodate at least 50 persons, or, if they have audio-amplification systems, and they have fixed seating, they must have permanently installed an assistive listening system. In other existing locations, assisted listening systems may be portable or permanently installed. Section 4.1.3.b.(19) of UFAS and Sections 4.1.3(19), 4.33 and A4.33 of ADAAG describes minimum audio-amplification requirements.

Because of the complexity of issues involved, the design and use of classroom amplification systems should include audiologists, electrical engineers, acoustical engineers, audiovisual specialists, and maintenance technicians.

Given the increased amount of pre-recorded and broadcast video programming that is becoming available in closed captioned format, it is suggested that video display devices for use in classrooms be equipped with closed caption decoders.

VISUAL IMPAIRMENTS

Persons with visual impairments frequently have difficulty in classrooms and lecture halls. Instructors often reduce light levels in the seating area and/or the instructor area when projected images or display materials are used. Difficulties also result when light infiltrates projected images, such as sunlight flooding a screen. In addition, energy conservation efforts in recent years

have resulted in a general decrease in illumination levels in public buildings, including schools. A further challenge for persons with low vision is the use of low-contrasting colors, such as using yellow chalk on a green chalkboard.

In order to eliminate barriers for persons with low vision, use as much contrast as possible in image selection. Light levels should not be extremely high or extremely low, since both circumstances can impair vision.

All of these considerations will assist planners in providing barrier-free, universal design for classrooms, seminar rooms and lecture halls.