THE STUDY OF CRITERIA FOR VISUAL AIDS PRESENTATION IN SELECTED STUDY AREAS

By

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THE STUDY OF CRITERIA FOR VISUAL AIDS

PRESENTATION IN SELECTED STUDY AREAS

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NOMENCLATURE

Dx	The maximum distance a viewer may sit from the screen and still see all the detail.
Dn	The minimum distance a viewer may sit from the screen and comfortably see all the detail.
W	The screen width.
θ	The maximum side viewing angle: in a horizontal plane at the center of the screen between the projection axis and a person located as remotely to one side of the screen as he can possibly be and still comfortably see all the detail on the screen in proper brilliance.
$\frac{Dx}{W}$	The dimensionless ratio of maximum seating distance to screen width (when each is expressed in the same units of measure).
$\frac{Dn}{W}$	The dimensionless ratio of minimum seating distance to screen width.
OP	Opaque projector.
OHP	Overhead projector.
LAN	3 1/4" x 4" slide (Lantern) projector.

CHAPTER I

INTRODUCTION

The student body in schools and colleges is growing more rapidly than the existing space for learning in today's classrooms and laboratories. There must be a way to increase the facilities to accommodate the growth. The solution is: increasing the efficiency of use of existing space to make room for more students, or using instructional aids as a tool for more effective teaching.

The Problem

Within the next decade there will be twice as many young people attending schools and colleges as there are at the present time. Along with this rise in enrollment there will continue to be an increase in the cost of operating, building, and maintaining institutions.

In the past few years the idea of the new aids and media for education has been the subject of much discussion. Primary interest has centered on the new educational philosophy and the effectiveness of new teaching techniques. Yet schools are being built today which do not take full advantage of the new teaching methods and new media. Classrooms still follow the typical pattern dictated by out-moded and conventional uses.

Purposes of the Study

Audiovisual materials have become an increasingly important tool in education. The growing importance of audiovisual education in the schools has brought various recommendations from experts in different fields concerning audiovisual programs. Learning spaces must be fitted to the audiovisual program and economically employed to handle the expanding needs of curriculum, staff, and student body.

This report will be an investigation of planning factors for a large group learning space and also a small one, associated with the development of visual aids facilities. The author's study began in exploring design factors for a lecture room, and this room will be checked within the context of a pilot program of an upper secondary school in Thonburi, Thailand.

CHAPTER II

VISUAL INSTRUCTION AIDS IN LEARNING SPACES

Concepts of Learning Spaces

The design of the facilities in which aids and media are fully utilized in the teaching-learning process is quite different from those for the conventional classroom. The optimum use of instructional aids and media requires new concepts of space types and their design.

The concepts of their functions are these:

> The professor is provided with a variety of technical devices which he may call on as desired to present supporting material, aid his presentation, or carry the burden of instruction. These devices may be brought into the instructional process by the push of a button or may be activated by a preprogramming punched tape or card. The combination of devices and the duration of use of each one during a presentation are unlimited.[1]

Spaces which are provided for visual instruction aids should have facilities that can be used in combination during one period of instruction. For example, as an experiment is televised from a laboratory and received in a room, a slide showing the ultimate result of the experiment may be held on a projection screen for comparison. Or, an outline developed by the teacher may be projected on one screen by the overhead projector, while an adjacent screen shows a motion

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[1] Alan C. Green, "Criteria for Collegiate Environment," Progressive Architecture, Vol. 42, (November, 1961), p. 176.

picture amplifying the points on the outline.[2] The teacher is in control of all of these devices. The design of the instructional facility must support this process.

According to a new idea of teaching, there are three types of spaces which are used together: (1) the large group and small group learning spaces; (2) productive spaces; and, (3) access and review spaces.[3]

The Large Group and Small Group Learning Spaces

These spaces serve the instruction process. In some ways, they resemble conventional lecture rooms. The fundamental consideration should be the provision of an appropriate condition for the teaching-learning process. The requirement for seeing and hearing is important because the area of visual attention may be vast and spread across the front of these rooms.

Large group learning spaces, big enough to hold 125 students, are equipped with rows of auditorium seats with arm rests. They are customarily provided with overhead screens, microphones, tape recorders, and chalkboards. Connections for closed-circuit television are also available.[4]

The small group learning spaces are large enough to seat from twenty-five to thirty students in tablet arm chairs or other seating

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[2]Ibid.

[3]James W. Brown and Kenneth D. Norberg, Administering Educational Media (New York, 1965), p. 40 - 51.

[4]Ibid.

types. Projection screens, chalkboards, and tape recorders are provided. Television should be installed in this room.[5]

Productive Spaces

Production facilities cover that wide range of spaces which must be provided for the production of the instructional materials used with the aids and media.[6] These include: the production of slide and film materials; audio tapes and records; film loops and strips; slides for both the slide projector and overhead projector; production of graphs, charts, and other art works; assembly of demonstration apparatus and models; and the origination, distribution, and control of instructional television.[7]

These spaces combine production of materials and fixing of equipment. These are: media specialist's office, work room, storage space, and studio and control room for closed-circuit television.

The Access and Review Spaces

The access and review spaces are the places where the material used during the course of presentation should be made available to the student for review and further study. This facility incorporates the library-type function of collecting, cataloging, and distributing films, slides, kinescopes, tapes, and other materials. These, along

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[5] Ibid.

[6] Department of Audiovisual Instruction of the National Education Association, Planning Schools for Use of Audiovisual Materials (Washington, D.C., 1958), p. 54.

[7] Alan C. Green, "Criteria for Collegiate Environment," Progressive Architecture, Vol. 42 (November, 1961), p. 176.

with book material, extend the range of student review, initial study, and individual exploration.[8]

These spaces combine reading and study areas for group use of library and reference materials; individual and group listening to tapes and recordings; informal reading; individual and group screening of films, slides and film strips; and the conduction of small group conferences.

Media

To design a large group audiovisual instruction facility, one must first understand the media involved. The study of the equipment, of the techniques used to convey messages, and of the limitation of such equipment is essential.

Projected Materials

All projectors utilize the principle of light and shadow. An intense light is directed on or through the material to be projected and focused on the screen. There are three types of optical systems in common use today: the direct, the indirect, and the reflected.[9] Each of these has its advantages and its limitations.

Direct Optical System

The types of projectors are the slide, filmstrip, and motion picture projectors. The optical system includes a light source,

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[8]Ibid.

[9]Robert E. DeKieffer, Audiovisual Instruction (New York, 1965), p. 34

reflector mirror, condensing lenses, aperture, and objective lense.

(1)<u>Slide projectors and slides</u>. Among the most commonly used slide projectors are the 3 1/4 x 4, 2 1/4 x 2 1/4, and the 2 x 2 projector. Slide projectors are easy to set up and to operate. In setting up a slide projector, the lamp is turned on and the objective adjusted, after plugging the electric cord into an outlet. A slide is then inserted upside down into the slide carriage, pushed into the projector, and any slight focus adjustments are then made.

There are several automatic and semiautomatic slide projectors on the market which can be used in schools. Their major advantage is that they permit the speaker at the front of the room to project the pre-arranged slide material by remote control.

All slides are valuable materials to the classroom teacher. They are inexpensive to make or purchase; they can be used in any sequence that the teacher deems advisable; and they can be stored in a small area in the classroom.

(2)<u>Filmstrip projectors</u>. The filmstrip projector is the most widely accepted and used projector in schools today. It has the same basic parts as the 2"x2" projector: lamp, reflector mirror, condensing lenses, aperture, and objective lenses. The lamps in these projectors range from one hundred watts to twelve thousand watts, and are equipped with a blower fan to keep the elements and film material cool.

A filmstrip is a strip of thirty-five millimeter film on which individual slides or frames appear in vertical sequence. It provides the teacher with a well-planned and well-organized visual presentation which is usually complemented by brief, written explanatory remarks on each frame.

(3)Motion picture projectors. Motion picture projectors are a mechanism for projecting images which appear to move on the screen as in real life. It is a device which can be directed by switches and manipulated in any way which will be of the greatest value in the learning and teaching situation. It can be started, stopped, and run forward or backward at the discretion of the teacher.

The optical system of the sixteen-millimeter motion picture projector is identical to all other direct optical system equipment. It has a light source, a reflector mirror, condensing lenses, an aperture, and object lenses. Films for the sixteen-millimeter projector are of two types: silent and sound.

The motion picture has found a place in training and education because of its unique characteristics. It shows motion not only at normal speeds, but it can be slowed down during the original photography to allow the viewer to study more rapid processes in greater detail. The action can also be speeded up, which is often desirable for study and research.

Students can learn factual information, motor skills, and concepts from motion pictures; so, they may develop the skill of problem-solving more rapidly.

Indirect Optical System

These projectors, also known as overhead projectors, might be considered as special-purpose projectors. Although their function is slightly different from that of direct optical system projectors, the arrangement of component parts is similar. As with all projectors, the size of the aperture, and the arrangement and size of the lense systems control the size of materials which can be projected. Some overhead projectors will accommodate 2"x2", 2 1/2"x2 1/4", and 3 1/4x4" slide material. The larger projectors will accommodate tranparent materials from seven to ten inches square.

The overhead projector provides the classroom teacher with many advantages. First, the equipment must be located in the front of the room, which allows the teacher who is using it to face the class, thereby maintaining constant eye contact with students. Second, the brilliant light source, concentrated at a short distance, makes it possible to use the projector under normal lighting conditions. This provides students with the opportunity to take notes. Third, the teacher controls the material, which eliminates the necessity for a projectionist. Fourth, because the aperture is in a horizontal position, the teacher can point out specific items on the slide material, marking with pencil or ink.

Reflected Optical System

This optical system, used for projection equipment, is the reflected variety. This category includes the opaque projector, which can project such opaque materials as a flat picture cut from a magazine, a picture of colorful cotton material, the leaf from a tree, or a wrist watch laid flat.

The development of this equipment made possible the increase in size of the aperture to 7'x7". The great amount of illumination necessary to reflect an image onto a screen hampered the growth until small fans were added to the equipment to draw off the heat generated by light-wattage lamps to keep the material from scortching. Most opaque projectors will accommodate materials up to ten inches square, including student theme papers, books, magazines, and a variety of objects.

The opaque projector can also be used for enlarging drawings to be traced onto chalkboards or large posterboards. The picture or drawing is placed in the projector, focused on the board, and traced.

Projection Screens

Projection screens are an important part of any projection system, for they reflect the projected image to the eyes of the viewers. Several types of screens are available to schools, each of which has its own advantages. There are also a number of different ways of displaying these screens; for instance, the tripod mount, which can be carried from room to room and set up for projection; and the wall type, which can be rolled down like a window shade when needed. There is also a lace mount on which a screen can be stretched. This type of screen is designed for large auditoriums, where the screen can be raised by ropes into the loft for storage.

There are five major types of screens in common use in schools. These are: matte, beaded, silver, lenticular, and translucent.[10]

(1)A matte screen has a smooth white surface. It is advisable to use a matte screen when the room is wide, because images reflected on

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[10]Robert E. DeKieffer, Audiovisual Instruction (New York, 1965), p. 51.

this type of surface can be seen at an angle of 40° on either side of the screen.

(2)The beaded screen is a matte screen upon which small glass beads have been glued. These beads act like prisms and reflect the projected light more brilliantly. The beaded screen can best be used in a long, narrow room because the reflected light becomes dim if seen at an angle greater than 25° on either side of the screen.

(3)The silver screen was the first to be used in commercial theatres, but lost its popularity for classroom use because of the difficulty in maintaining projection quality.

(4)The lenticular screen combines the advantages of the beaded and silver screens. A silver screen material is coated with a clear, heavy plastic which is pressed into very small corrugated ridges. Light striking the screen is diffused and intensified by these ridges. Manufacturers claim that there is no loss of light at any viewing angle.

(5)Translucent screens are used for rear-screen projection. A projector can be placed behind this type of screen and the projected image seen on the opposite side. Translucent screens are made with a rear screen diffusion layer applied to one surface of glass or durable rigid plastic sheet. Both surfaces are slightly reflective, one is polished, and the other becomes matte by reason of the screen application.

For normal projection with high lumen output projectors, the matte screens are probably most satisfactory if a wide viewing area accommodating the maximum number of viewers is required. When large images are required, the higher reflectance of the lenticular screens and their tendency to maintain good image contrast are advantages to be considered. If the projector has a low lumen output, or if the space is narrow and brightness fall-off at the edges of the viewing area is not critical, then a beaded screen would be best.

Educational Television

Educational television has already become a part of the teaching program in schools since 1953. The Pittsburgh school system was one of the first to broadcast televised programs to assist teachers in their regular classrooms.[11]

As a communication medium, educational television is unique in its ability to bring many aids into the classroom. Every visual aid can be carried by television. Motion pictures, film strips, slides, recordings, drawings, maps, and other instructional devices can be shown. Moreover, it gives schools the opportunity to present original illustrations produced in the living present.

There are two types of television systems which are used in the educational television medium: open-circuit systems, and the closed-circuit systems.[12]

Open-Circuit Systems

Broadcast television makes use of a system by which signals broadcast from a tower and antenna can be received by television receivers within range of the station. A major problem at the outset

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[11] Educational Facilities Laboratories, Design for ETV, Planning for Schools with Television (New York, 1960), p. 21.

[12] James W. Brown and Kenneth D. Norberg, p. 204

is obtaining a channel. Broadcast stations may reach many people in scattered locations. This takes in people who find it inconvenient to go to a school.

Closed-Circuit Systems

The basic definition of a closed-circuit system is that the signal originated must be carried by cable or microwave relay directly from the originating point to every reception point. A continuous and selective physical connection must be maintained between the central point of transmission and all receivers.

Closed-circuit systems do not require the availability of a television channel. They are capable of great flexibility. For example, a system might start with a single camera and one or more receivers in a classroom, and be used to assist science demonstrations. The system could be extended to several classrooms in the same building.

Chalkboards

In the lecture hall, the lecturer requires both chalkboard and projection facilities. Frequently, projected slides are related to subject matter on the chalkboard. It is necessary to illuminate the chalkboard so that it may be viewed simultaneously with the screen. The chalkboard should be installed at student-eye level. In planning for the installation of a chalkboard, careful attention should be paid to the color and reflection qualities of the surfaces to assure the best possible visibility.

CHAPTER III

CRITERIA FOR LARGE GROUP LEARNING SPACES

In the large group learning space, there are the requirements of the lecturer and the requirements of the audience:

The requirement of the lecturer is ease of communication with his audience. Complete control by the lecturer of all appliances for demonstration, projection, lighting and illustration should be arranged with maximum convenience and flexibility.[1]

The ability to see and to hear are basic needs for audiences. Thus, the study of the screen distance for the satisfactory viewing of projected material is essential. Each student must have a clear, unobstructed view of the various display surfaces. A consideration of acoustics is also important. The sound isolation between rooms and from projection equipment must be provided. Absorptive surfaces for prevention of reverberation are essential.[2]

Design for Projected Area

Two basic types of projected systems are the front and rear projections.[3] It is important that the designer become familiar with

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[1] C.J. Duncan, Modern Lecture Theaters (London, 1966), p. 60-67.

[2] Alan C. Green, p. 179.

[3] Renssealaer Polytechnic Institute, New Spaces for Learning, (Troy, New York, 1961), p. 54.

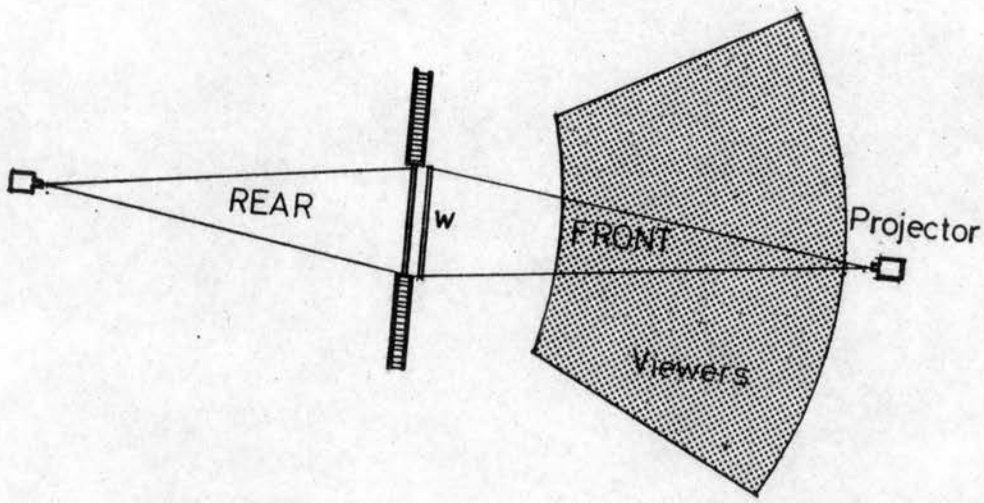

Figure 1: FRONT AND REAR PROJECTION

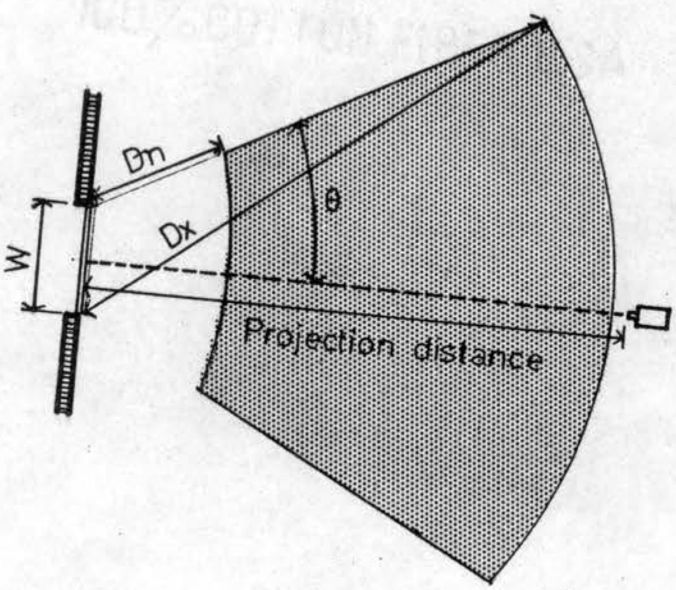

Figure 2: FRONT PROJECTION

the projection means to be employed, and their implication for facilities.

Front projection: both the projector and the viewer are located on the same side of the screen. The image is project to the screen, which reflects toward the viewer (Figure 1).

Rear projection: the projector and the viewer are located on opposite sides of the screen. The image is projected to a translucent screen which transmits it to the viewer (Figure 2).

The distance from the projector to the screen is a function of the focal length of lense and the desired image size, and varies with the type of projector for the front projection.[4] The viewing and edge angles vary with the type of screen used, and also with the throw distance (Figure 3).

The advantages of front projection are:[5]

1. Often equipment already available can be used.
2. If the projector throw distance exceeds the maximum viewing distance, the projector can be located out of the viewing area and space is conserved, since the projection beam occupies the area above the viewer's head.

Disadvantages of front projection are:

1. Light falling on the screen tends to reduce the brightness of the image. This makes it difficult to provide sufficient light for students taking notes.
2. The operating noise of the equipment is a distraction. The teacher casts a shadow on the screen if he stands in front of it to point out details.
3. The heat given off by the equipment is difficult to control unless a projection enclosure is used.

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[4] Ibid, p. 55

[5] University Facilities Research Center, The University of Wisconsin, Space for Audiovisual Large Group Instruction, (Madison, 1963), p. 9.

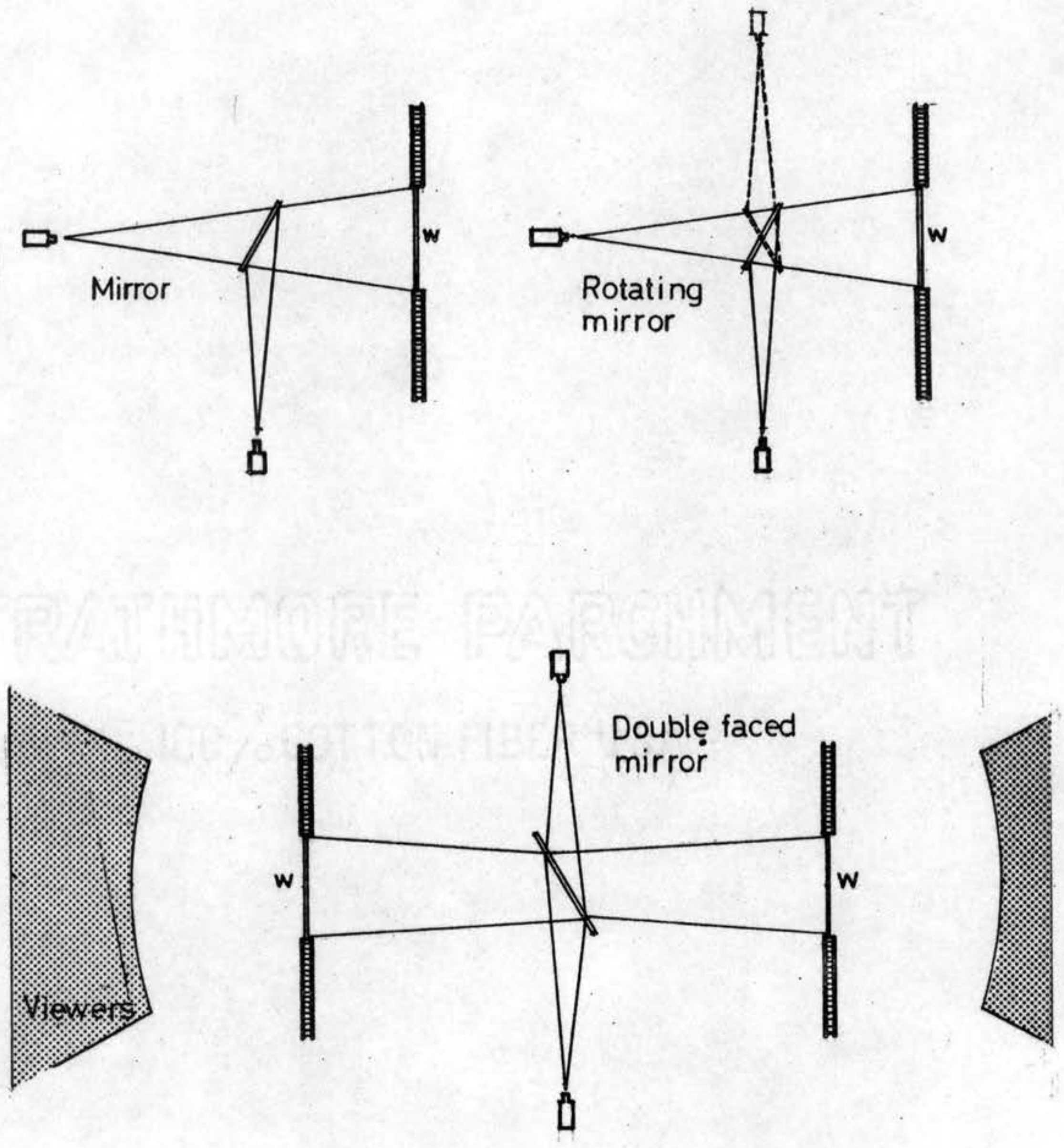

Figure 3: REAR PROJECTION

Rear projection places the projector behind a translucent screen opposite the viewers. The throw distance is a function of the focal length of the projector lense and the desired image size. There are two different systems of throwing:[6] direct throw (Figure 4), and indirect throw (Figure 5).

Advantages of rear projection are:[7]

1. Because room light does not directly interfere with the projection beam, it is possible to provide adequate lighting in the room for note-taking.

2. There is no possibility for student or teacher to interfere with the light beam.

3. With the projection equipment separated from the learning space, the problems of noise interferance are reduced.

Disadvantages of rear projection are:

1. Rear projection requires spaces behind the display area in order to accommodate equipment and projector beams.

2. Since the projector beam is being transferred through the screen, emphasis must be placed on selecting screens with appropriate characteristics.

From these comparisons, the rear projection is better than the front projection when used in the lecture room.

Design Criteria for Projected Area

The appropriate viewing area for display surfaces is a function of the size of the projected images, and is defined by a minimum viewing distance and a viewing angle (Figure 2).[8]

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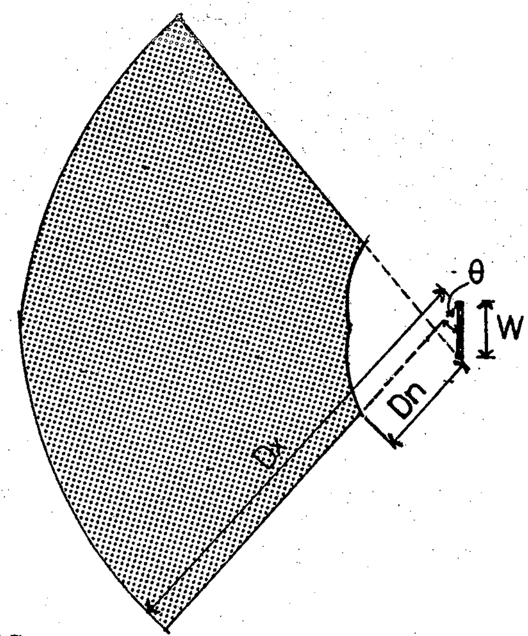
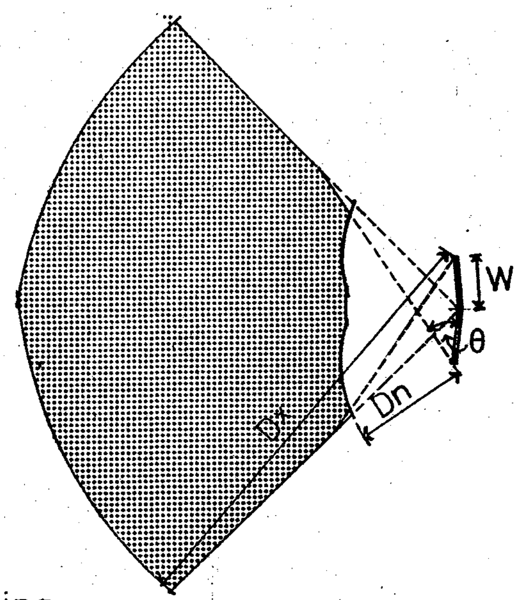
[6] Renssealaer Polytechnic Institute, p. 56

[7] University Facilities Research Center, University of Wisconsin, p. 9.

[8] Ibid., pp. 6 - 8.

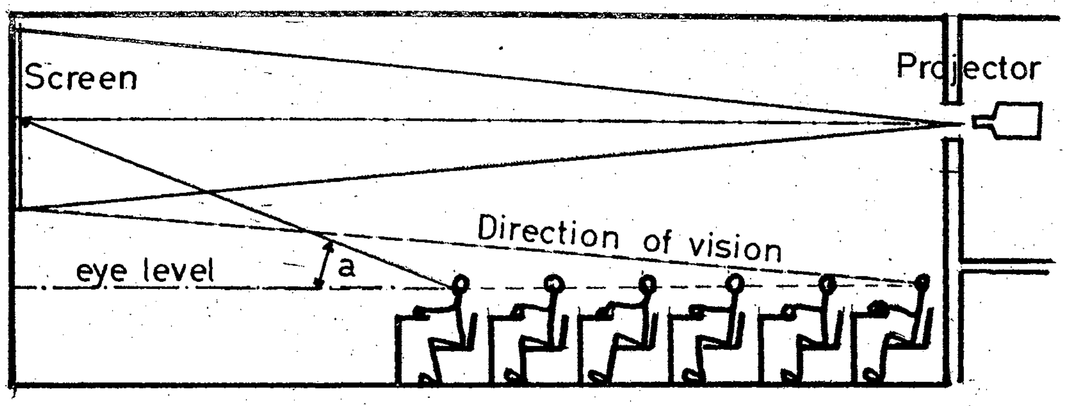


Definition of viewing
area for single image



Definition of viewing
area for multiple images

Figure 4: DEFINITION OF VIEWING AREA
FOR SINGLE AND MULTIPLE IMAGES



a = Maximum Angle of 30°

Figure 5: POSITION OF PROJECTION SCREEN

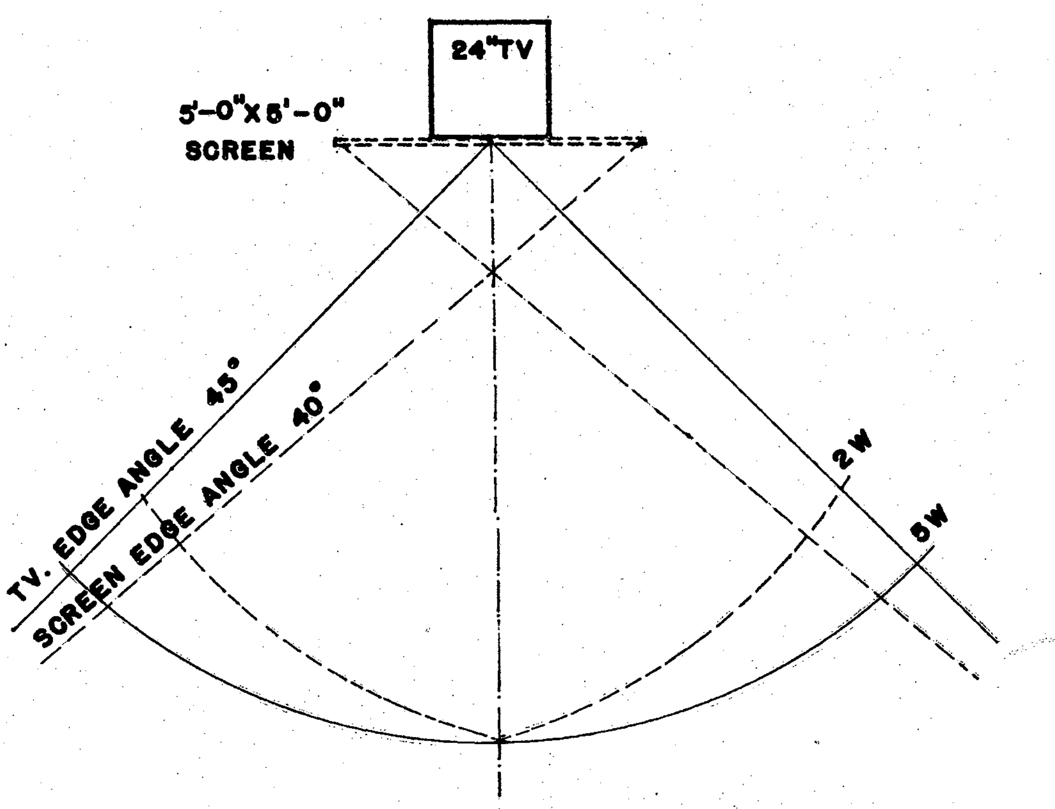


Figure 6: TO COMPARE THE MINIMUM VIEWING DISTANCES OF TELEVISION TO FILM PROJECTION

> These dimensions and angles will not only vary with screen size, but will vary with the type of screens or surfaces, the brightness of the display surface, the duration of presentation, the size, clearness, and contrast of the symbols appearing on the screens, and the need for ready comprehension.[9]

As an example for a matte screen, the minimum viewing distance is 2W, the maximum viewing distance is 8W, and the edge angle is fourty degrees measured from the edge of the image (Table 2). For the multiple images, the determination of the viewing area is more involved (Figure 4). Consideration of the angle of elevation of the eye of the student to the display surface (Figure 5) is necessary for long periods of presentation. The results of an excessive angle are stiff necks and eye fatigue.

These relationships of images size and viewing area have been established, resulting in the definition of a particular viewing area; the actual capacity of the space becomes a function of the seating type and its arrangement.[10]

Using the principles of design presented in Tables 2 and 4, it is possible to graphically solve problems and to achieve good design for varying dimensions, areas, occupancies, screen widths, projection distances, lense focal lengths, and lamp sizes required for the several types of film and projectors that may be used. Examples for these solutions will be presented in Chapter III.

Facility for Educational Television

The use of television for instruction has focused on functional

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[9] Alan C. Green, p. 177.

[10] Ibid.

	FILM	TV
Brightness	10 - 18 Lumens per Sq. Ft.	100 Lumens per Sq. Ft.
Room Requirements	Requires Dark Room	Satisfactory in Normal Room Light
Allowable Incident Room Brightness on Screen	Color: 1/10 Lumen per Sq. Ft. Black and White: 1 Lumen per Sq. Ft.	Shield Light Sources to Avoid Glare (Reflections of Light) on Screen. Requires Background Lighting Around Screen of 10 Lumens per Sq. Ft. Minimum or 1/10 Screen Brightness.
Limitation of Seating Area	Screen Size or Lamp Lumens to Maintain 10 Lumens per Sq. Ft. Limited by Projection Lamp Output.	Limited by Standard Picture Tubes and Manufacturers in Small Sizes Up To 27".

Table 1: COMPARATIVE CHARACTERISTICS OF FILM PROJECTORS AND TELEVISION

MEDIA	SCREEN	MINIMUM VIEWING DISTANCE	MAXIMUM VIEWING DISTANCE	MAXIMUM VIEWING ANGLE, EACH SIDE AXIS
FILM	Translucent of High Grain or Beaded Opaque	2.5W and Not Less Than 6'.	8W	20°
FILM	Translucent of Moderate Grain, Matte, or Ordinary Lenticular Opaque.	2W	8W	40°
TV	Cathode Ray Tube, Phosphorescent.	5W	14W	45°
FILM	Wide-Angle Lenticular Opaque.	2W	8W	50°

Table 2: CHARACTERISTICS OF PROJECTOR SCREENS

requirements for classrooms. It is necessary that students be able to see the television picture properly. So, receivers should be mounted where there is unobstructed vision and good visibility. A maximum and minimum viewing distance is needed as a standard (Table 2). Generally, square rooms are better than long, narrow rooms; but, in the latter case, several receivers may be needed.[11]

The maximum viewing distance and the minimum viewing distance of television are different from film projection (Table 1), because television does not present a fine-grain picture, but an image composed of very evident lines.[12] Television screens because of their curved surfaces, permit the audience to sit as far as 45° (Table 2) to one side of the projection axis.[13] This is called the side viewing angle, and is defined as the angle made in a horizontal plane between the viewer and the center line of the television screen.

The vertical placement of the television image is important for good visibility of the viewing group. For example: for the twenty-three-inch television receiver, the 3' - 0" spacing, using the tablet armchair, requires that the bottom of the television image be eighty-four inches from the floor.[14] All educational material to be viewed on television should be prepared according to standards of legibility. The following maximum distances require these minimum legibility standards:

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[11]Educational Facilities Laboratories, p. 31 - 38.

[12]University Facilities Research Center, University of Wisconsin, p. 4.

[13]Ibid., p. 7.

[14]Educational Facilities Laboratories, p. 32.

Maximum Viewing Distance[15]

8'	12'	16'	20'	24'	28'	32'	64'	128'
1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	2"	4"

Minimum Symbol Size

The similar method, as designed for a projected area, should be used, because the viewing area for television is defined by a minimum and a maximum viewing distance, and also for the edge angle.

For the number of viewers in a small group classroom, using desk and chair and a 4' - 4" spacing, one twenty-one-inch television receiver would be enough for thirty students.

For the number of viewers in a large group classroom, using continuous tables and chairs, four twenty-seven-inch television receivers would be enough for 125 students.

Lighting

The design of lighting systems must be undertaken with the help of an electrical consultant. Light control for teaching and learning requires facilities for regulating both natural and artificial light without limiting or harmfully affecting other essential environmental conditions.

Recommended light quantity levels for school lighting are:

Area	Minimum light level in foot candles[16]
Auditorium	15
Cafeterias	30

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[15] Ibid., p. 7.

[16] Bertram Y. Kinzey, Jr., and Howard M. Sharp, Environmental Technologies in Architecture (New Jersey, 1964), p. 617.

Area (Cont'd.)	Minimum light level in foot candles (Cont'd).
Classrooms	
Art rooms	70
Drafting room	100
Lecture room	
Audience area	70
Demonstration area	150
Shops	100
Typing	70
Corridor and stairways	20
Library	
Reading room	70
Stock	30

Lighting and Projection

In rooms designed for viewing projected images, there are two principal surfaces for the students' attention. They are: the projected image or several projected images, and the writing surface used for taking notes.[17]

There are also other areas in the room that will require illumination as attention is directed to them:[18]

1. The chalkboard.

2. The wall charts and displays, including models and demonstrations.

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[17] Rensselaer Polytechnic Institute, p. 63.

[18] Wayne F. Koppes and others, p. 62.

3. The instructor.

Considered lighting during the projection period:[19]

1. The two principal surfaces during projection are the screen and the tablet surface. They should be of equal brightness. All other surfaces in the room should be of less brightness.

2. During projection periods, the brightness of other surfaces when used, such as chalkboards, lectern, etc., should be about the same as the brightness of screen and tablet areas. When none of these surfaces are being used during projection, they should harmonize with the background.

3. Light on the tablet surface should not cast distracting shadows.

4. The reflectance of the tablet surface itself should be in the fifty-percent to sixty-percent range so as not to distract the attention of the students while taking notes.

5. The student should not be aware of the room lighting within his normal line of vision.

6. It is the most important fact that room lighting be direct and that as little as possible falls on the screen, either directly or indirectly. Such light tends to wash out images on the screens.

7. The room lighting should be capable of being set at different levels to make the tablet surfaces equal in brightness to the various types of projected images. This level will vary with the type of projection being used, the type of screen, and other room conditions.

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[19] C.J. Duncan, p. 104.

Lighting Design

The lumen method is used for designing overall illumination. The light source may be incandescent filament or fluorescent. In general, the filament lamp is preferred when not over thirty foot-candles to thirty-five foot candles are required. For higher levels of illumination, the fluorescent lamp is more satisfactory.

Types of lighting or luminaires that are most suitable for classrooms, offices, drafting rooms, and libraries, in their order of effectiveness are:[20]

1. Luminous ceiling (brightness not to exceed 150 footlamberts in large rooms, and 200 footlamberts in small rooms);

2. Luminous indirect (maximum ceiling brightness not to exceed 350 footlamberts);

3. Totally indirect (maximum ceiling brightness not to exceed 350 footlamberts);

4. Semi-indirect (brightness not to exceed 500 footlamberts in the 0^{o} to 45^{o} zone);

5. Direct-indirect (45^{o} shielding toward line of sight);

6. Flush troffers on 3- to 6-foot centers (bottom of troffers covered with glass or plastic with brightness range of 500 to 1,000 footlamberts to 1,600 footlamberts in 0^{o} to 45^{o} zone);

7. Flush troffers as above on 6- to 8-foot centers (brightness range of 1000 footlamberts to 1,600 footlamberts in 0^{o} to 45^{o} zone);

8. Louverall ceiling (45^{o} shielding toward line of sight);

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[20]Kinzey and Sharp, pp. 617 - 618.

9. Flush troffers with louvered bottom (45° shielding lengthwise and crosswise on the lamp).

Considering the relative merits of incandescent and fluorescent systems, one reaches these decisions:

Incandescent Lighting

Incandescent methods would utilize downlight recessed in the ceiling over the writing surfaces to provide overall lighting. This type of system has proved somewhat less than satisfactory for lighting large group learning spaces where media will be projected:[21]

1. Many lights are needed to give even lighting and to avoid a spot of light on the writing surfaces. This gives a lot of heat, which, when added to the heat already being generated by the occupants of a room, may overload the cooling system

2. The light creates multiple shadows on the tablet surfaces. Their strongly directional character may also cause glare from the tablet surface.

3. The lights are point sources, and serve as distractions during projection; recessing helps, but does not solve the problem.

4. Incandescent lights operate at low efficiency when dimmed.

5. The shorter life span of an incandescent light presents a problem where accessibility for maintenance is difficult.

Fluorescent Lighting

Fluorescent lighting has great potential for large group rooms

[21] Renssealaer Polytechnic Institute, p. 64.

using projected media; its lighting and operating economies are important advantages.

Fluorescent lighting can be controlled at low-level room lighting.

> It has been stated that the iron-cathode lamp can be dimmed. This can be accomplished by customary methods and devices. Tungsten-cathode lamps designed for continuous cathode heating may also be dimmed; the most successful utilize the rapid-start principle. The lamp bulb should be treated with a moisture resistant coating to assure satisfactory starting in high humidity conditions. Special dimming ballasts are required, one ballast for one lamp. Two methods of dimming are available. The electronic method is especially applicable to theaters or auditoriums where fineness of control and flexibility are traditional. The variable-reactance method is simple and low in cost, but does not provide the same degree of smoothness and flexibility as the electronic method.[22]

Lighting for Large Group Learning Spaces

Downlighting is employed for students' note-taking. Light should reach each student from at least four sources. To eliminate specular reflections from notes, the beams from the downlights should be directed toward the front of the room.

Thus, the room is equipped with a dual system: incandescent for spot lights, and fluorescent lights for students' note-taking. For conventional lecturing, both systems are used at a full intensity. For projection and for note-taking during projection, the incandescents are turned off; and, by controls mounted on the lectern, the fluorescents are dimmed to the desired level.

Acoustics

It is apparent that many persons have a responsibility for various

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[22]Bertram Y. Kinzey, Jr., and Howard M. Sharp, pp. 535 - 536.

aspects of noise control problems. Reduction of sound level at the source is frequently an engineer's province. Modification of machinery for quieter operation must be accomplished by the manufacturer. However, the architect should have some acoustical knowledge, in order to cooperate with these people.

The audio-visual program and pupil activity have shown the need for acoustic treatment in all classrooms. Sound from motion pictures or recording may be used in any room in the building. For good use of such equipment within these areas, and to avoid distraction in adjoining spaces, all rooms should be treated to reduce reverberation within the room and also to reduce sound transmission from one room to another.[23]

The noise level objective for schools should be:

Type of Room		Acceptable Noise Levels in Decibels[24]		
	Cycles per second:	125	250	500
Classroom	dB	47	39	32
Auditorium	dB	43	35	28
Cafeteria	dB	62	56	50
Band Practice Room	dB	47	39	32
Choral Music Room	dB	43	35	25

[23]Vern O. Knudsen and Cyril M. Harris, Acoustical Designing in Architecture, (New York, 1965), p. 328 - 333.

[24]Burns Meyer and friends, Acoustics for the Architect (New York, 1957), p. 113.

Acoustics for classrooms are basically concerned with two objectives:[25]

1. The provision of a good hearing condition within a room, by controlling the direction, impact, and duration of sound waves, which are concerned with the absorption and reflection of sound waves within the room.

2. The provision of a good acoustical treatment by controlling unwanted sounds from other spaces, which is concerned with isolation of sound by preventing transmission of sound waves through a barrier material.

Sound Control

The quality of hearing as applied to sounds within the room, is governed by the size and shape of the room, the location and volume and pitch of the sound, and the reflection characteristics of the materials in the room.[26] Reflection depends on the absorptivity of these materials. Hard materials absorb little sound, reflecting nearly all of the sound waves striking them, while soft, porous materials absorb a large proportion and reflect little.[27]

In designing rooms for good hearing, the objective is to dispose the reflective and absorptive materials within the room so that all occupants will receive as nearly as possible an agreeable volume of

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[25]Michael J. Kodares, "Reverberation Times of Typical School Classroom," Noise Control, Vol. 6, (July-August, 1960), pp. 17 - 19.

[26]Vern O. Knudsen and Cyril M. Harris, p. 85.

[27]Ibid., pp. 86 - 87.

sound. Designers have to consider the following:[28]

1. Surfaces relatively close to the sound source should be reflective to amplify the original sound. These are the back of the stage, the ceiling above the stage, and the side walls of the stage.

2. Surfaces behind the audience and facing the sound source should be absorptive to minimize the rebound of sound energy.

3. Ceiling surfaces should be flat planes of reflective materials. Concave surfaces should be avoided because they focus the sound.

4. Non-parallel side walls are preferable to parallel walls. This improves the sound dispersion and tends to reduce the reverberation.

The solutions for the surface materials are: The rear wall of the stage should be built with reflective panels. Wood covering, 3/4 inches thick over framing of sixteen inches center-to-center, represents a construction of minimum stiffness; plaster finishes may be applied in somewhat greater than normal thickness for added stiffness. Lecture room aisles and floors in the seating area should be covered by absorptive materials, such as rubber, cork tile, or linoleum. The walls and the ceiling above the seating area should be covered by acoustical plaster or sprayed-on materials; these materials are comprised of plastic and porous materials applied with a trowel, and fibrous materials combined with binder agents, which are applied with an air gun or blower. Seats should also be covered

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[28] R.N. Lane, "Noise Control in School," _Noise Control_, Vol. 3 (July, 1957), p. 27.

with absorptive materials, such as nylon materials, designed to absorb echoes.

Noise Reduction

Sound isolation problems are concerned with the construction of the walls, floors, and ceilings between spaces.[29] There are problems in the construction of partitions, in particular, due to a lack of adequate isolation and the current interest in lightweight partitions.

Any opening in the construction of sound barriers is a leak, much the same as a leak in water-proofing. Any true barrier to sound transmission must be airtight. All of the sound energy that strikes a void goes right on through.

The sound-isolating properties of a barrier are determined by the mass and inertia of the material.[30] Weight and stiffness are important factors. The best barriers are materials that are heavy. Brick, concrete, or solid-plaster walls are examples.

The solution for the noise isolation is a circular plan of lecture halls. There is a central core, used as the rear projection area, with four pie-shaped lecture rooms. The spaces between lecture rooms, used for teachers' preparation and storage, are placed to provide sound isolation between lecture rooms. Noises from projectors are controlled within the center core. Double doors are used to reduce outside noises.

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[29] Vern O. Knudsen and Cyril M. Harris, p. 226.

[30] Ibid., p. 228.

Seating

The seating must be considered from the start. Functional and economic criteria should be set up. Selection of specific types of seating should be made. Comfort, posture, and the availability of a good writing surface are all important factors in the most effective learning. These general criteria must be satisfied:[31]

1. Good sight lines are essential in rooms where media are projected. To satisfy this requirement in room seating, forty or more sloped or stepped floors must be designed.

2. Location of access aisles should be considered. It would be possible to locate more seats within the optimum viewing area if access were from the sides, rather than down the middle.

3. The cross-aisles should be wide enough to allow easy access to all of the individual seats.

4. The tablet surface should be large enough for note-taking and the use of reference materials.

However, more specific design criteria can be applied in the selection of particular seats and seating types; the prime requirement for seating is that it provide the best accommodations possible to encourage and facilitate the learning process.[32]

1. The provision of a suitable writing surface is a basic essential, whether this surface is provided as a part of the seat structure itself, or as a separate counter unit. The surface should be of ample size to facilitate note-taking concurrently with the use

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[31] Rensselaer Polytechnic Institute, p. 69.

[32] Ibid., p. 69.

PROJECTOR	LUMENS
8mm. movie	100 - 300
16mm. incandescent movie	300 - 500
16mm. arc movie	1000 - 1500
35mm. filmstrip	500 - 700
35mm. slides (general)	500 - 1000
35mm. slides (Selectroslide)	600 - 1200
3¼" x 4" slides	300 - 3000
Opaque 8" x 10"	150 - 300
Overhead 10" x 10"	2000 - 600

Table 3: PROJECTION LUMEN CHART

Close Seating: Auditorium or Theater Seating	Fold-Up Tablets at Rest of Chair or on Back of Seat Ahead	5 to 8 Sq. Ft. per Person
Conference or Seminar Seating	Permanent Arm Rest, Tablet Arm Chairs, or Narrow Tables with Chairs	8 to 12 Sq. Ft. per Person
Cafeteria Seating, Library Seating, Ordinary Classroom Seating, or Classroom Desk and Chair Seating, Listening Lab Seating	Tables with Chairs or Classroom Desks and Seats	12 to 20 Sq. Ft. per Person
Office Desk Seating, Loose Classroom Seating	Full-Size Desk and Chair Seating	20 to 30 Sq. Ft. per Person
Laboratory Spacing, Desk and Reference Tables, Large Drafting Tables.	Lab Table and Stool, Desk and Reference Table	30 to 50 Sq. Ft. per Person

Table 4: SEAT SPACING FOR AUDIOVISUAL PURPOSES

of reference materials. An area approximately twelve inches by twenty-four inches is considered to be desirable. The material used for the surface must be hard, durable, and easily cleaned.

2. The seating unit should provide a conveniently-accessible space off the floor where books may be stored during the class period. This may be an open wire basket or shelf.

3. The seating should provide appropriate postural support, so that the occupant may comfortably view projected materials, watch the instructor, use reference materials, or take notes without being required to repeatedly adjust his position.

4. Dimensions and proportions of the seating unit will be based on the physical characteristics of the average occupant. This applies particularly to the amount of leg and knee room provided, and to the clearance dimension between the occupant and the writing surface.

5. All seats should be accessible without disturbing the occupants of adjacent seats.

Design solution: Since the floor is stepped, fixed seating is the most desirable, and cantilever seating with a continuous table top would be appropriate. Chairs are arranged so that there are fourteen seats to a row. The writing surface area is about 364 square inches per student. The spacing between tables is twenty-nine inches, sufficient enough to permit passage space when a chair is moved in under the table. Seating occupies about 8.1 square feet of floor area per unit.

CHAPTER IV

ROOM DESIGN

In Chapter III, the study of projected areas, lighting, acoustics, and seating are presented. In Chapter IV, the writer would like to show how to design a lecture room. Emphasis will be placed on the viewing area for projected materials.

The student's eye is the most important aspect of the viewing characteristics for film projectors and television. It must be remembered that television and film have entirely different screen viewing characteristics.[1]

Film projections are made from fine-grain films.[2] The practical limit for the closeness at which one can comfortably view the film is determined by the amount of eye-scanning the viewer must do to comfortably enjoy and perceive the field of the film.

Unlike film images, television images are composed of many lines.[3] For this reason, their minimum viewing distance is different (Table 1).

A room developed to accommodate both film projection and television should be built with the consideration of the minimum and

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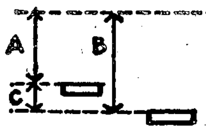
[1]University Facilities Research Center, University of Wisconsin, p. 6.

[2]Ibid., p.6.

[3]Ibid., p.7.

	DIMENSIONS IN INCHES		
	A SEAT TO EYE SHORT PERSON SITTING SLUMPED	B SEAT TO HEAD TALL PERSON SITTING UPRIGHT	C DIFFERENCE
18 - 40 Years Males Females	$26\frac{1}{2}$ $25\frac{1}{2}$	$37\frac{1}{2}$ $35\frac{1}{2}$	11 10
60 - 80 Years Females	24	$34\frac{1}{2}$	$10\frac{1}{2}$
11 - 17 Years Males & Females	$24\frac{1}{2}$	$35\frac{1}{2}$	11
Architectural Handbook	26	30	4

	DIMENSIONS IN INCHES	
	WIDTH 	LENGTH 
Space in Existing Lecture Theaters	18 - 30	30 - 36
Space Required for Large Persons, Posture Changes, and Easy Access	30 - 36	36 - 44

Table 5: DIMENSIONS OF BODY SIZES

and the maximum viewing distance for both images. From Table 1, with a 2W minimum and an 8W maximum, seating distances are not satisfactory for television viewing. A practical answer to the problem is to use the full screen for film projections, and about one-sixth its area for television, in order to hold the same audience at proper viewing distance. For television, the audience would be seated between a 5W minimum and a 14W maximum (Table 2).

A television screen usually has a brightness on the order of one hundred lumens per square foot (Table 1), while a motion picture screen has on the order of ten lumens per square foot (Table 1). The film projection requires a darkened room, while the television does not. Film screens have a narrow angle of effective viewing, as compared to television.[4] Because of their curved surfaces, television screens permit the audience to sit as far as 45^{o} to one side of the television monitor axis.

The Method of Design

From Table 2 and Table 4, solutions for this room design can be divided into two categories. The first of these relates room dimensions, areas, occupancies, and occupied areas to screen width (the characteristics of the type of projection being known). The second category relates screen widths and projector distances to focal length of lenses and aperture sizes, when the desired performance

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[4]Ibid., p.8.

is known. The graphs described here can be used to determine the best way to a design solution.

The first type of design graph is useful in the design of rooms for required occupancies, for adaptation of existing rooms to projector use, or for solving occupancy and area problems. The second type of design graph is useful for solving problems in the selecting of equipment for viewing, knowing the projection distance and screen width, solving for type of projector to be used, focal length of projectors, and knowing the type of visual material to be projected.

Examples

<u>Problem</u>: Design a room for audiovisual vilm presentation using a five-foot-wide matte screen. Solve for the area of the seating sector and occupants.

<u>Method #1</u>: From Table 2, the minimum viewing distance is 2W, the maximum viewing distance is 8W, and the maximum side viewing angle is $\theta = 40^{\circ}$. From Table 4, the seating requires about ten square feet per occupant.

Enter the graph at 8W and then proceed along the diagonal line until it crosses the minimum ratio, 2W; then proceed horizontally to θ equals 40°; next, vertically to the screen width of sixty inches. Then proceed horizontally to the margin where it is seen that the occupied area is about 1,000 square feet. Turning back on this last horizontal line until the path has crossed the

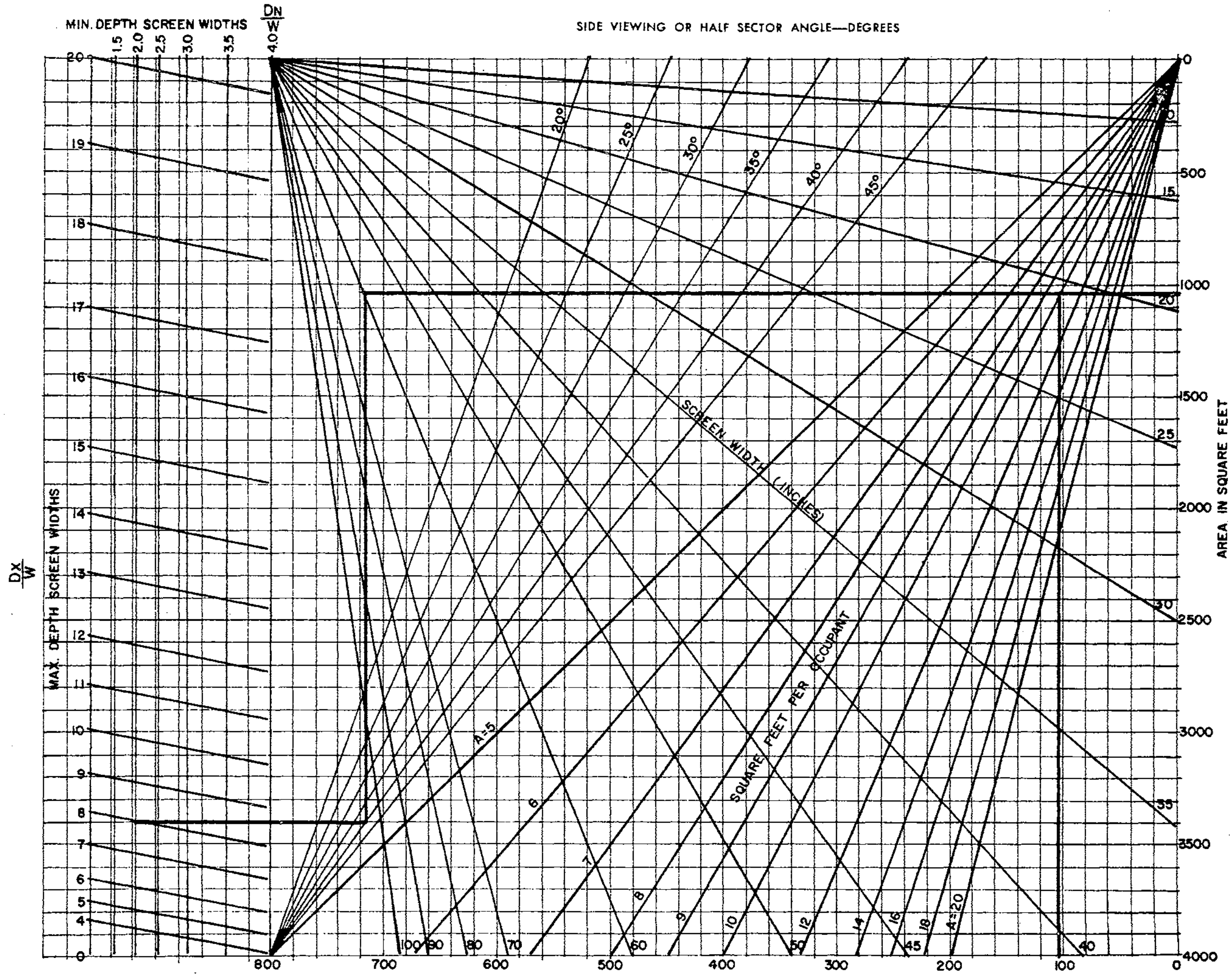

Chart 1. Graph for solving number of occupants, knowing area per occupant $\frac{D_x}{W}$, $\frac{D_n}{W}$, θ, & W.

line where the square footage per occupant was ten, one would proceed vertically to the bottom of the chart where it is seen that the number of the occupants would be about one hundred.

Another way in which this same graph might be used would be for determining the best screen width, knowing the maximum and minimum viewing distances, the side viewing angle, the occupancy desired, and the square footage per occupant required.

Method #2: One would proceed vertically on the graph from the occupancy notation to the square-foot-per-occupant chart; thence, horizontally to the right-hand margin where one can read the probable occupied area. Knowing where this horizontal line is, one would now proceed over to the left side of the graph, following the maximum and minimum space requirements; then he would proceed horizontally to the viewing angle required; thence, vertically to the horizontal line from the occupied area. Where these two lines meet, one can read the screen width required by interpolating between the screen width lines shown on the graph.

Chart 2 relates screen width and projector distance to the focal length of lens required for various aperture sizes. One will know the projection distance when the screen width and type of projectors used are known.

Method #3: In the design considered, there has been a projection distance of thirty-five feet, and a screen

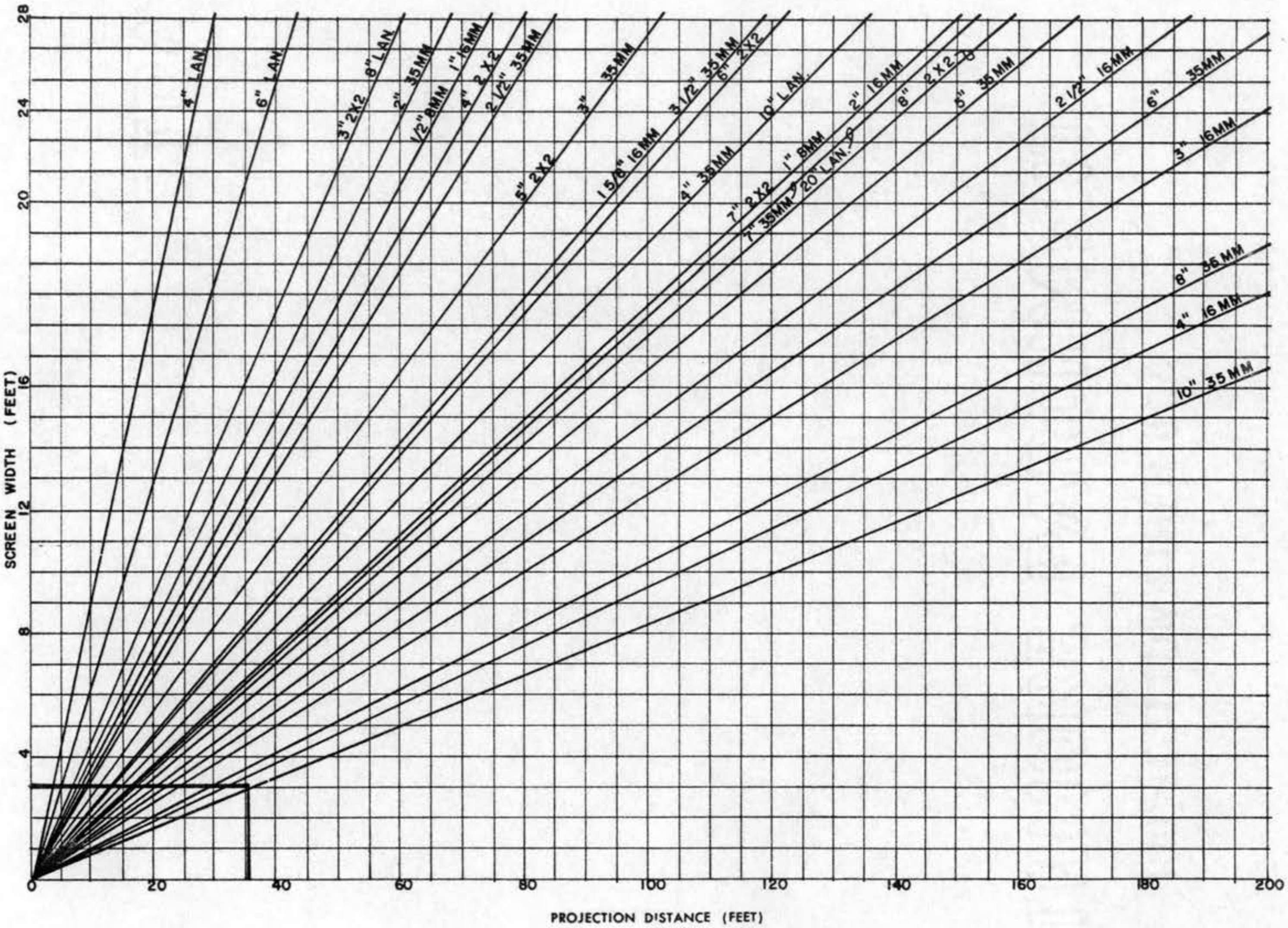

Chart 2. Relation of screen widths, projector distances--to focal length of lenses, aperture sizes.

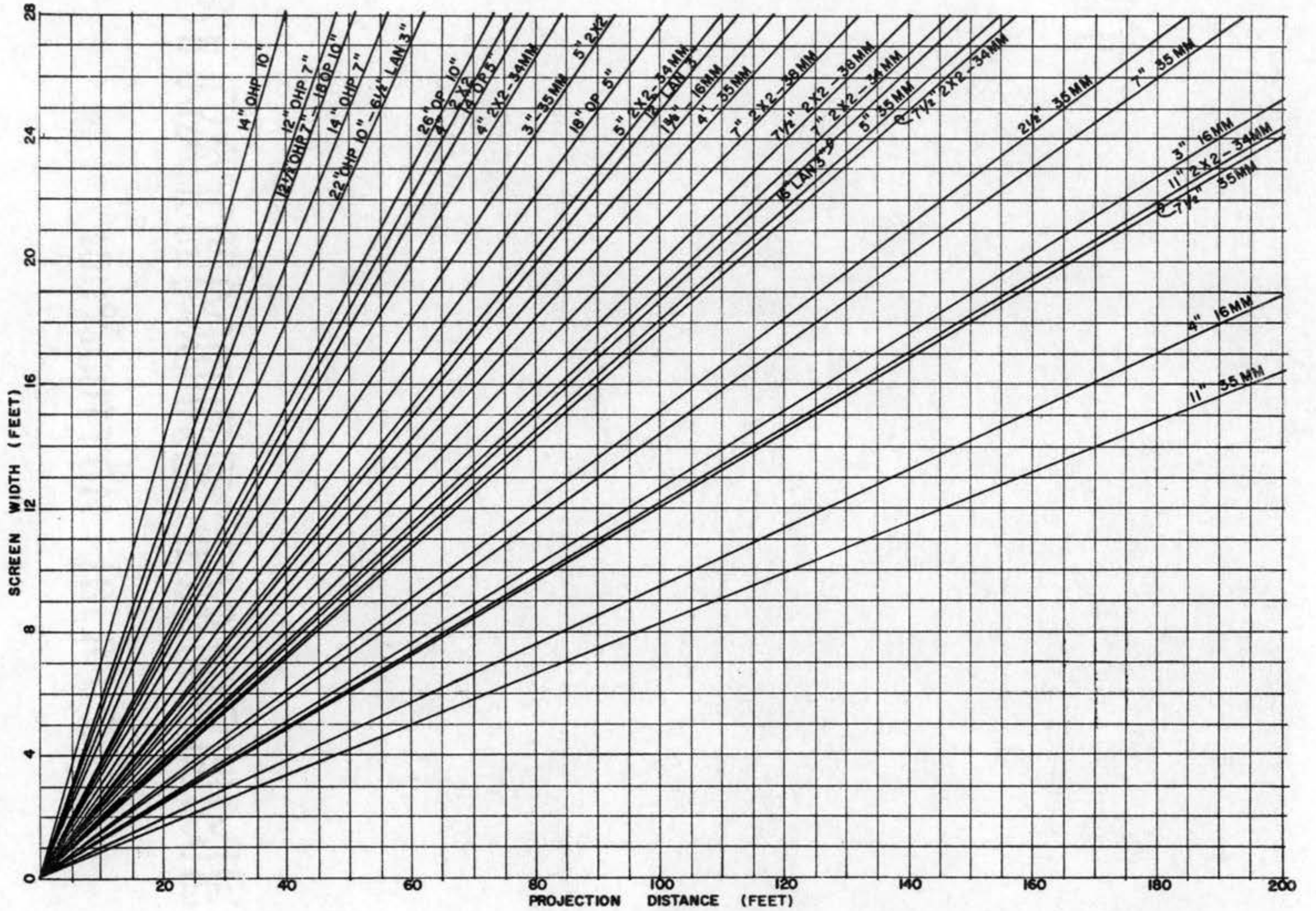

Chart 3. Relation of screen widths, projector distances--to focal length of lenses, aperture sizes.

width of forty inches. For this, one would choose a four-inch focal length lens for sixteen millimeter projection and an eleven-inch focal length lens for thirty-five millimeter projection.

The Large Group Learning Space

Large group learning spaces incorporate many of the features necessary in large spaces to increase their utilization. Three six-foot-wide screens are arranged across the front of the viewing area. These allow the showing of as many as three images simultaneously from the rear-projection area. Below the screens are chalkboards and control panels for lighting and other apparatus.

It will be noted that the two outside rear projection screens are canted at angles of ten degrees to the center screen.[5] This is done to improve the shape of the optimum viewing area which is defined by 40^{o} side angles from the planes of the screens.

The significant feature of this scheme is the use of a central rear projection core, serving four back-to-back learning spaces, because of the advantages of rear projection (Chapter III). From this core, and by using mirrors, three simultaneous images can be rear-projected into each room.

The monitors are to be used for receiving television instruction. Four twenty-seven-inch monitors would provide adequate viewing, and they could be located near the side walls.

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[5]Rensselaer Polytechnic Institute, p. 83.

A seating area, based on optimum conditions for viewing projected images on three adjacent six-foot screens, determines the shape of the room. Approximately 126 students can be accommodated. Access to the room is provided by aisles from the halls. The seating is arranged with a maximum of fourteen seats to a row, which results in two aisles. Since the floor is stepped, fixed seating is desirable; so, cantilever seating with a continuous table top would be appropriate.

Storage and preparation areas adjacent to each room will permit space to be used for lecture demonstrations employing large-scale models and apparatus concurrently with the use of projection facilities.

The Small Group Learning Space

This scheme would be feasible either in a new building or in a remodeled space. A simple rectangular room was used in order to investigate how to utilize typical existing classrooms. Projection screens and a television monitor are located in a corner diagonally opposite the storage area, providing the most efficient use of space.

A stepped floor should be used, in order to permit good viewing. The rear-projection unit, shown in the sketches in Chapter VII, suggests one way in which the screens, monitor, audio, and chalkboards may be organized as an equipment unit. This room accommodates up to thirty students.

CHAPTER V

NORTHERN THONBURI, THAILAND, AS AN EXAMPLE STUDY

Historical Background of Thonburi

The city of Thonburi was the capital city of Thailand in 1767. It is located at latitude 13° 44'N., longitude 100° 30'E., with the altitude being about five feet above sea level.[1] The eastern boundary of this city is connected to Bangkok, the capital city.

> Taksin chose for his capital a new site, Thonburi, across the Chaophraya River from Bangkok. Some of the reasons for choosing a new site for the capital were that Ayutthaya lay in ruins and would have been costly to repair, that Thonburi was believed to be less accessible to invading armies, and that Thonburi, closer to the sea, would be more convenient as a center for profitable overseas trade.[2]

The Economic Framework and Standard of Living

The economy of Thonburi is primarily based on agriculture. Rice and corn are the most important among major crops, followed by fruit and cassava. Over sixty per cent of the population in employment is engaged in agricultural production. Other sources of employment in

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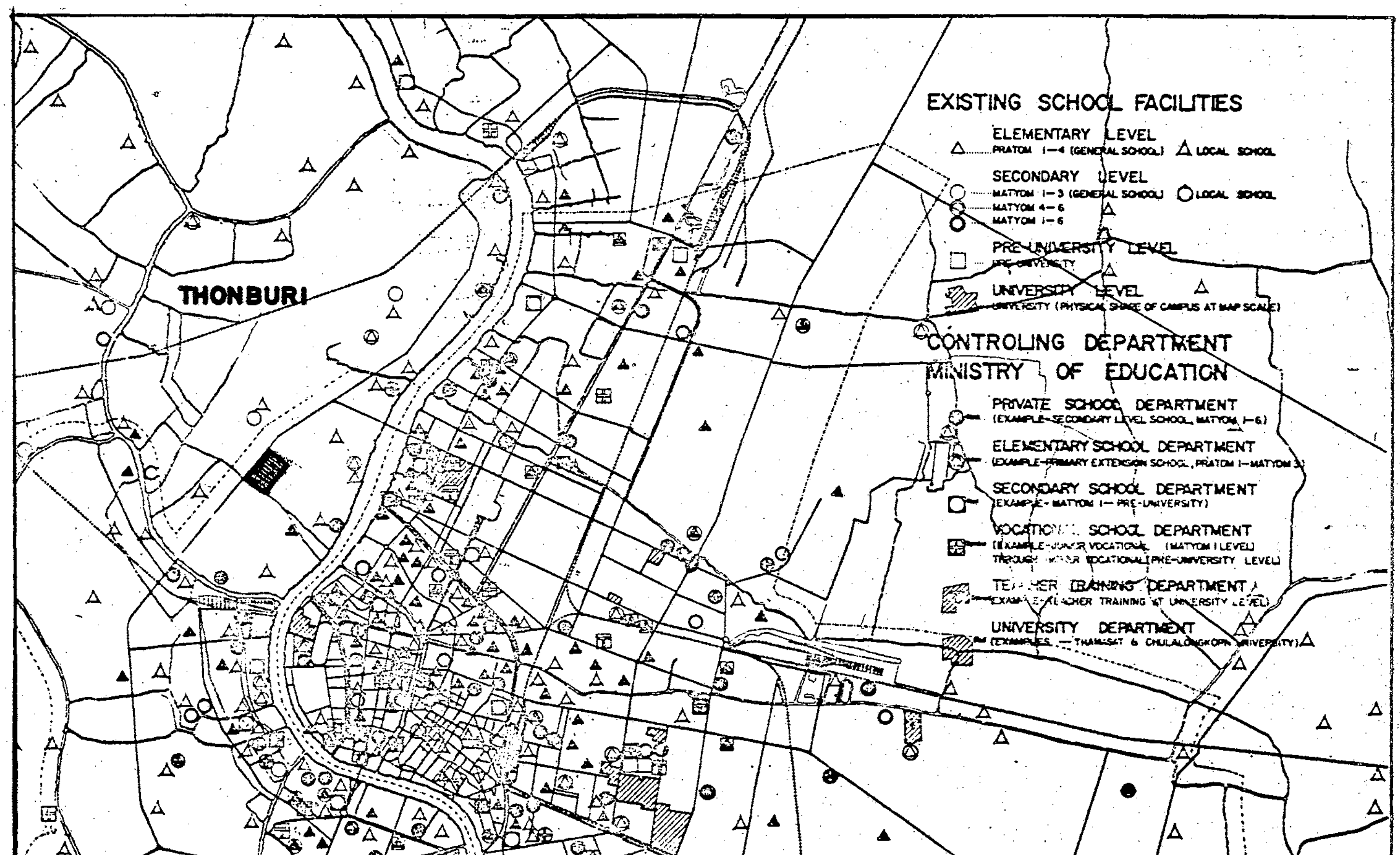
[1]The Ministry of Interior, <u>Maps & Boundaries</u> (Bangkok, 1960), p.4.

[2]Robert L. Pendleton, <u>Thailand</u> (New York, 1962), p. 18.



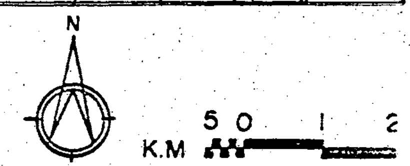


Figure 7: EXISTING EDUCATIONAL FACILITIES

BANGKOK - THONBURI

this area include commerce, manufacturing industries, and labor workers.

The average income of the families in this area is classified as follows: about 51.6 per cent of the families earn less than 6,000 baths a year; about 37.2 per cent earn about 24,000 baths a year; and about 11.1 per cent earn about 60,000 baths a year (20 baths = one dollar).[3]

Population and the Enrollment Project

Enrollment projection is based on the existing secondary school enrollments in this area. The formula for deriving this projection employs statistics on the percentage of students continuing to the upper-secondary level (Pre-University).

At the present time, Northern Thonburi has a population of 75,000.[4] There are six secondary schools which serve about 7,368 students. From the data of the Ministry of Education, thirty-seven per cent of the students graduated from these schools go on to study in the upper-secondary level (Pre-University).[5] Thus, about 2,546 students will graduate each year, and 800 of them will continue to this level. There has been a five per cent yearly increase of students in the secondary level. This means an increase of forty

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[3]Office of the Prime Minister, Household Expenditure Survey B.E. 2505 (Bangkok, 1963), p. 10.

[4]Ministry of the Interior, Population (Bangkok, 1960), p. 17.

[5]Wronski and Sawasdi Panich, Education in Thailand (Bangkok, 1966), p. 33.

students each year. Thus, in the year of 1977, there should be about 1,200 students following the upper-secondary course of study.

The Site and Climatic Conditions

The selection of a site should satisfy two major conditions. It must be within reasonable proximity of the students' family community, and it must be of adequate size to permit the proposed expansion.

The selected site is estimated at 38.4 acres (96 rai). It lies on the Charan Sanitwongs Road and is surrounded by residential and recreational areas. The location is approximately 4.4 miles from the downtown area.

Its existing conditions are: a flat site; water table about 4.5 feet below the existing ground; and dark gray clay for the soil.

Thailand is dominated by the monsoon. Monsoon winds are, essentially, seasonal winds blowing from one direction during part of the year, and from the opposite direction during the remainder of the year. On this basis, four seasons may be recognized: the dry season; summer; the rainy season; and winter.

The average precipitation in this area is fifty inches per year. The bulk of this falls during the southwest monsoon rainy season, from May through October. During the summer, rain usually falls from seventeen to twenty-two days each month.

The main monthly temperature in Thonburi varies from a low of 77^{o} F. in December and January, to a high of 86^{o} F. in May. The highest temperature ever recorded in this area was 108^{o} F., recorded in both April and May; the lowest was 52^{o} F., recorded in December.

Figure 8: SITE SELECTION MAP

The summary of climatic conditions is as follows:[6]

Rainfall:	fifty inches
Wind Direction:	winter - from northeast
	other seasons - from southwest
Temperature:	50^{o} F. to 108^{o} F.
Humidity:	52.2 to 78.4 per cent
Angle of the Sun:	June, 2:00 p.m. - 65^{o}
	December, 2:00 p.m. - 52^{o}
	March, 2:00 p.m. - 23^{o}

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[6]Nimmanuhaminda, "Thai Architecture, Past, Present, and Future," The Association of Siamese Architects (Bangkok, 2508), p. 40.

CHAPTER VI

SUMMARY

Media, as part of the educational system, dictate special considerations for classroom environment. The learning process should not only give consideration to good viewing and listening facilities, but it should also be flexible enough to serve other needs arising from a variety of situations. The necessity for note-taking during an instructional presentation makes a variable system of illumination mandatory. The communication between the lecturer and audience, and the noise from operated equipment dictate a requirement of good acoustics.

The purpose of this tudy was to investigate the design parameters and functional requirements associated with the development of visual aid facilities for lecture rooms. With the rapid growth of student bodies in schools and colleges, the space for learning should be designed to permit the most effective use of audiovisual aids. It is important that, when provided, these spaces be well designed to serve the needs of school staff members and the student body.

For the purpose of this investigation, it has seemed pertinent to introduce two examples of learning spaces, in order to apply it to a pilot school project. Thonburi, Thailand, was used as the location for this project.

Based on the results of this study, it was concluded and summarized that planning a learning space must provide facilities for both students and instructors. Designers should consider the following:

1. Plan shape: The room shape is dictated by minimum and maximum viewing distance and side viewing angles of images.
2. Sectional shape: Consideration of proper reflective planes, for acoustics, angles for ceiling down-lights, is necessary.
3. Projection equipment controls: All controls are located in a master control console at the instructor's lectern.
4. Seating: Fixed seats are arranged because of sloped or stepped floors.
5. Display surfaces: Screens, chalkboards, tackboard, and television monitors are arranged across the front of the room to provide a continuous, integrated information-display surface.
6. Lighting: Lighting is provided by two special, functionally over-lapping systems. The first is a system of dimmer-controlled fluorescent down-lights, which illuminate the student writing surfaces. In the second, accent down-lights are used to illuminate chalkboards and tackboards.

For better results in developing learning spaces, additional information concerning detail of specific equipment is needed. A good area for future study would be to gather detailed data concerning design standards for specific media types. Other studies, such as making experimental learning spaces, used as case studies over a specific period of time, would also be useful.

Finally, it is further recommended that special studies of other learning areas--such as laboratories, libraries, etc.--should be made, for the purpose of improving methods of teaching and learning. It is hoped that this study may provide a basis for such further investigation.

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