ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of
The College of Fine and Applied Arts
in Candidacy for the Degree of
MASTER OF FINE ARTS

DESIGN FACILITY UTILIZING VDTs

By

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August 6, 1989

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LIST OF ILLUSTRATIONS

I. STATEMENT AND THESIS PROPOSAL

After spending a great deal of time in the Computer Graphics area, located on the third floor of the Rochester Institute of Technology ("RIT") College of Fine and Applied Arts, I determined that there were serious problems in the design of this space. The room's layout, including lighting, seating and workstations, is the result of purchasing equipment and simply placing it in a space as opposed to following a predetermined design for the area.

The goal of this project is to develop a computer environment, conducive to maximizing efficiency and productivity while minimizing user discomfort and environmental distractions.

To accomplish this goal, research into the area of ergonomics (workstations and seating), lighting, and materials was conducted. Additionally, a student user survey was distributed to determine the needs of the users. A business survey was conducted to evaluate current interior design strengths and weaknesses of video display terminal ("VDT") environments. The design process focused on Rooms 3496, 3500, and 3510, with Room 3509 receiving minimal attention to detail because of its size and its proposed function as a technician's area. The proposed floor plan and reflected ceiling plan place an emphasis on maximizing the VDT users' comfort and efficiency, bringing together people, environment and task in a harmonious relationship.

II. INTRODUCTION

The impact of computers on our work environment increases every year. As technological progress propels the computer into a greater variety of business settings, it is imperative to scrutinize the environment housing the video display terminal ("VDT"). Martin, as quoted by Kleeman, states:

> A Video Display Terminal is installed in an office somewhere in the country every 13 minutes. . . . There's one VDT for every twenty desks right now [October 1981], and by 1990, there will be one for every three desks. . . . The number of desks will be increasing, too. . . . This part of the labor force [office workers] is growing at the rate of 2% annually and already numbers nearly 50 million people.[1]

With the number of VDT users increasing at such a rapid rate, it is impossible to ignore the technological impact of VDTs on the office environment.

VDT's are not adaptive to office settings designed for traditional office tasks. People performing traditional tasks would not be required to stay in a designated area for a prolonged period of time; they would be typing, filing, producing copies, and interacting with others on a regular

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[1]Walter B. Kleeman, Jr., "The Office of the Future," in Behavioral Issues In Office Design, ed. Jean D. Wineman (New York: Van Nostrand Reinhold Company Inc., 1986), 252.

basis. Now VDT users may be at their workstations for hours at a time with very little need to leave and perform what was once considered a traditional task. This lack of movement often results in physical discomfort and helps to emphasize the need for re-evaluating the environment housing the VDT. It is strongly suggested that operators leave the VDT for ten to fifteen minutes out of each hour to help alleviate physical discomfort and possible monotony.[2] To fully realize the advantages of the VDT and ensure operator comfort, the design of VDT workspaces was analyzed. Workstations, seating, lighting, noise and floor plans were studied to optimize operator comfort.

> In terms of dollar outlay over the 40-year life cycle of an office building, 2-3% is generally spent on the initial costs of the building and equipment; 6-8% on maintenance and replacement; and 90-92% is generally spent on personnel salaries and benefits. These data suggest that if an investment in physical planning and design could be made that would favorably influence organizational effectiveness and therefore reduce personnel costs, total life-cycle costs could be substantially reduced.[3]

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[2]Department of Health and Human Services, Public Health Service/Center for Disease Control, HHS Publication No. (CDC) (Atlanta: Center for Disease Control, 1980), 308.

[3]Jean D. Wineman, ed., Behavioral Issues in Office Design (New York: Van Nostrand Reinhold Company Inc., 1986), xiii.

With figures such as these, it is impossible to ignore the economic benefits and improvements in employee welfare and productivity brought about by the redesign of interior spaces.

III. Survey Results

From the outset of this project, I considered it crucial to have feedback from the users of the Computer Graphics area. People should have input into the working environment design so as to obtain maximum benefit while at their workstations. A survey of the computer graphics user groups was conducted in order to obtain student input on the current computer area. Anthropometric questions were not posed during the survey nor were economic considerations a factor in redesigning the area. In the computer graphics area, hardware from several manufacturers is present, namely Intergraph, Genigraphics, IBM, Artronics and Autographix, along with two major seating options and a variety of existing work surfaces. It is acknowledged that some students were enrolled in more than one class. Therefore, they were exposed to several hardware, workstation and seating configurations within the computer graphics area, leading to survey results dependant on the equipment and location.

Results from the sixty-eight respondents were compiled and taken into consideration in redesigning the Computer Graphics area. The groups surveyed comprised five students using the VDT's primarily for word processing, fourteen students for Graphic Design and forty-nine students for Interior/Industrial Design. The results are presented in Table 1, below.

TABLE 1. --VDT STUDENT USER SURVEY

QUESTION	RESPONSE				
1. When using a video display terminal (VDT), how many hours per use do you spend?	1 - 2	3 - 4	5 - 6	>6	NR
	26	32	6	2	2
2. What is your primary use of the VDT: Word Processing (WP), Graphic Design (GD), Interior/ Industrial Design (ID)?	WP	GD	ID		
	5	14	49		
3. Do you feel that the present workspace area is adequate to accommodate your needs?	YES	NO	OTHER		
	21	46	1		
4. Do you feel that the workstation and VDT are at an appropriate height for user comfort?	YES	NO	NR		
	57	9	2		
5. Is the seating comfortable for the length of time you are at the VDT?	YES	NO	DE-ON CHAIR		NR
	31	20	16		1
6. Do you consider the noise level too high with the present room arrangement?	YES	NO	DE	NR	
	18	46	3	1	
7. Is the lighting level too high, too low, or adequate for comfortable viewing of the VDT?	HIGH	LOW	AD	NR	
	24	4	37	3	
8. Does the present room arrangement allow distractions that you find detrimental to completing assigned tasks?	YES	NO	AD	NR	
	36	29	1	2	
9. Do you feel the current room arrangement is the most effective for teaching software applications?	YES	NO	NR		
	16	48	4		
10. If your answer to Number 9 was "No", what would you consider an appropriate room layout?	ROWS	CLUSTERS	OTHER	NR	
	8	19	15	10	

KEY: NR = NO RESPONSE   AD = ADEQUATE   DE = DEPENDS

In order to observe current VDT environments in industry, several local companies were examined, ranging in size from eight employees to over one thousand. The goal was not to survey every individual, but to obtain an on-site examination of workstations, seating, lighting, and floor plan to determine current practices.

Taking these results into consideration, and integrating the standards established by the American National Standards Institute ("ANSI", February 4, 1988), a design was developed to enhance the computer area and improve operator comfort. RIT is considering the implementation of the Creative Design Electronic Media Center, to be housed in the present computer area. The Center will serve as a national center for the use of interactive electronic media in visual communications and will provide educational, developmental, and commercial services to academic institutions, business, industry and government.[4] Therefore, the Computer Graphics Area was approached as more than a temporary working environment for the students; it was viewed as a showcase for the progressive technology offered by computers.

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[4]"Creative Design Electronic Media Center" 1989 Informational document published by Rochester Institute of Technology.

IV. DESIGN CONSIDERATIONS

A. Floor Plan

The existing third floor plan of the computer graphics area fulfilled the function of housing the VDTs, but did not provide the faculty and students with an area amenable to performing required tasks. Figure 1 depicts the existing area with its completely open arrangement and lack of division between user groups. This leads to distractions when a faculty member is attempting to instruct a class and students at different workstations are attempting to complete their assigned projects. As the survey results in Table 1 indicate, the majority of respondents found the present room arrangement allowed for distractions and was not the most effective for teaching software applications.

Focusing on these problem areas, and utilizing feedback indicating a preference for VDTs arranged in clusters according to task, led to the proposed floor plan (Figure 2). The desired goal was the separation of VDTs into areas segregated from the distractions of users at other workstations while allowing users with similar projects to interface. The proposed floor plan achieves this goal while increasing the number of workstations from the existing twenty-nine to the proposed thirty-seven workstations.

Faculty members of the Computer Graphics Department desired an increase in the number of Macintosh II workstations in Room 3510, from five to ten, to allow for future growth. The Macintosh IIs receive a great deal of use and in the proposed floor plan were separated into two clusters to accommodate the expansion. All cluster groups of the same manufacturer are separated from circulation areas and other cluster groups by 82 inch high partitions in order to reduce distractions from adjoining areas. Within cluster groups of the same manufacturer (See Figure 2), 60 inch high partitions were used between VDTs that were placed back-to-back to reduce operator distractions for these users, but a 30 inch partition was used in the middle to allow visibility (Macintosh II and PGP/Artronics - Figure 2), enabling faculty to communicate with students at adjoining clusters.

Autographix, Room 3510, received a less generous space allocation due to the lighter use of this equipment, typically only one quarter out of a year. Students still have adequate worksurface to perform tasks, but the equipment does not use as much floor space as the equipment used during all four quarters. It is recognized that faculty members will not be able to instruct large groups within the allotted area, but will still be able to give personalized attention as needed. A recommendation for group lectures and demonstrations will be made later in this paper when discussing the conference/lecture area in Room 3500.

Relocation of the IBM PC workstations was considered mandatory; the current location by the entry into Room 3510 makes distractions inevitable (Figure 1). There, workstations are completely exposed to a continuous flow of traffic by those entering and exiting the room. In their place would be the lockers, relocated from Room 3500, used by the Graduate Computer Graphics students to store supplies. Placing the IBM PCs in a cluster gives them an identifiable work area with far fewer distractions. The proposed IBM PC cluster was also located adjacent to the new Intergraph location because of the similarity between user groups, a majority coming from the Interior/Industrial Design program.

Intergraph equipment was relocated from Room 3496 to Room 3510 and placed in a fixed area in order to control environmental conditions. Autographix, Macintosh II, PGP/Artronics, and IBM PCs do not require as stringent environmental control as does the Intergraph. Many major corporations are installing computers in various locations that are able to communicate with each other in order to improve efficiency and reduce costs. Rising costs of travel (airfare, hotels, meals, etc.), unproductive man-hours while traveling, and inaccuracies in dissemination of information (one person taking notes and distributing to others) are making it more attractive for companies to link workgroups by computer. Xerox Corporation's Palo Alto Research Center ("PARC") is an excellent example of the development of this technology. PARC's Intelligent Systems Laboratory created an environment for computer work groups called Colab, with the Colab workstations connected over an Ethernet network.[5] With this concept becoming a reality, establishing an independent area for the Intergraph equipment allows faculty of different departments to simulate industry conditions. The College of Fine and Applied Arts Intergraph workstations are already linked to the Intergraph workstations located in the College of Engineering, opening up the possibility of interdepartmental projects. Designers and engineers work together on many projects in industry, and should begin experiencing collaboration while in college.

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[5]Kelly Shea, "For times when two heads are better than one," Computerworld (March 14, 1988): 2.

B. Design Plan

Removal of the Intergraph equipment from Room 3496 allows the Genigraphics and related hardware to have a dedicated workspace in that room. Partitions are used to create a vestibule and a private PGP/Genigraphics area used primarily by graduate students, to reduce distractions and create a more productive teaching/learning situation. Genigraphics hardware requires environmental control and by creating a dedicated space, lectures can be given in this room to groups with a common goal.

The conference/lecture room, Room 3500 (Figure 2) as proposed, will take on a more formal appearance as well as serving fewer functions. Currently, Room 3500 is used as the graduate students' room, lecture room, conference room, drafting room; it contains lockers for storage, a lunch room complete with sink, and a general meeting area. With the shortage of classrooms in which lectures can be held, it is recommended that Room 3500 become a conference/lecture room. A locker area, drafting area, and kitchenette were created in Room 3510 (Figure 2) providing the students and faculty with the same facilities previously found in Room 3500, while not detracting from the appearance of Room 3510. This would allow for removal of the sink, lockers, and drafting tables from Room 3500 and provide a larger lecture area.

An even more impressive environment would be created through utilization of the School of American Craftmen's Woodworking and Furniture Design Program. Students could be contracted to design and build storage cabinets, tables, pedestals for slide and movie presentations, and a conference table. The conference table should be of a sectional design that, when separated, forms a 2 foot-6 inch by 24 foot table to be placed against the wall, opening up the floor space for chair arrangements during lectures. Demonstrations of various equipment capabilities can be improved by transporting a VDT into this area and then projecting the demonstration onto a screen. Lectures often have more impact when twenty to twenty-five students are not crowded around a twelve inch monitor trying to see what is being discussed.

The addition of a technician, stationed in Room 3509, would improve efficiency and security and add to the overall professionalism of the computer graphics area. Presently this room is used to house a VDT, manuals and miscellaneous articles related to the computer graphics area. The much-needed technician would be a person capable of coordinating maintenance of the equipment, helping with software problems and assisting faculty members. Locating a technician in Room 3509 would make that person easily accessible to students and the technician's visibility would discourage less-qualified users from attempting to tamper with the equipment.

C. Detail Considerations

In the design, application of accent trim, flooring, and window coverings were used to bring Room 3510, Room 3500 and Room 3496 together as a cohesive unit. The present scheme is lacking in interest and does not provide a stimulating environment. It is too institutional in appearance for the image this area should project. If the Creative Design Electronic Media Center is to serve as a consulting, research and production unit to outside education, business, industry and government, it should have greater appeal to its constituents.

All of the businesses surveyed used color to enhance the environment. From Figures 3, 4, and 5, it can be seen that a two tone color approach was adapted for Rooms 3496, 3500 and 3510. A darker, less reflective finish was used on the part below the wooden fluorescent cove with a lighter, more reflective finish above. Fabric-covered partitions, to be used as tack surfaces, of the same color as the lower wall section (Figures 3 and 4) were specified. Use of these colors creates a more pleasing visual environment, but not so bold as to become distracting. The Illuminating Engineering Society (IES) Lighting Handbook recommends reflectances of 40 to 70 percent for partitions, 50 to 70 percent for walls and 25 to 45 percent for furniture.[6]

Wooden floors were selected for Rooms 3496, 3509 and 3510 to give a richer appearance and reduce the chance of electrostatic discharge to equipment. From the companies visited and from research conducted, no standard flooring material was found to be preferred. Wood accent trim for fluorescent coves, window coverings (Figure 3) and furniture (Room 3500) was another design element used to unify the area. Conference/lecture room 3500 (Figures 2 and 5) remains carpeted in order to reduce noise during presentations and meetings, and to retain a more business-like appearance.

Many feel that totally covering a window should be a last resort and none of the businesses interviewed totally enclosed windows. However, this was considered justified

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[6]Illuminating Engineering Society of North America, IES Lighting Handbook, (New York: Illuminating Engineering Society of North America, 1987), 5-2.

for Rooms 3510 and 3496. People in industry tend to be at their assigned area for greater periods of time and derive pleasure from viewing the outside. The majority of students (Table 1) spend less than four hours at a time in these two rooms, and the horizontal blinds were observed to be closed to reduce glare, seeming to justify eliminating the windows.

Three of the most popular window coverings are dark film, louvres or mini-blinds, and curtains.[7] All three methods tend to reduce veiling and specular reflections, as well as obscure views beyond the window. Using the window enclosures as a potential design element, instead of employing conventional treatments, was considered appropriate. A fabric face, using the lighter color of the area above the fluorescent cove, was chosen to cover the complete window, and create the feeling of the upper portion springing up from the lower part of the wall. Wooden grids were then placed on the section below the fluorescent cove (Figure 3) to create the impression of the window still existing.

It is acknowledged that covering the windows would eliminate a source of ventilation in Room 3510. Fluorescent

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[7] Martin G. Helander, "Design of Visual Displays," in Handbook of Human Factors, ed. Gavriel Salvendy (New York: John Wiley and Sons, Inc., 1987), 529.

fixtures with air supply/air return (through side slots) or a ceiling-mounted air handling system similar to that currently in place in Room 3496 should be installed to provide ventilation. Horizontal blinds were selected for Room 3500 (Figure 5), using the lighter color of the section above the cove, as the only VDT usage in this room would be for demonstrations.

V. FURNITURE

A. Workstations

Interestingly, only four out of the seven[8] companies visited used adjustable workstations, and the majority of students (Table 1) surveyed felt that the workstations were at an appropriate height for user comfort, though they are not adjustable. This perception could be a result of the short durations of student use. It is recommended that the computer graphics area be equipped with adjustable workstations, not only to help accommodate a wide range of physical sizes, but to make handicapped access easier.

Adjustable workstations allow users to find worksurface heights that are more acceptable to their particular body size and help alleviate any undue strain. This is critical for operators who are working with a VDT for prolonged periods of time. As Grandjean points out, the operators' movements are restricted, and their attention is directed toward the screen, leading to ergonomic shortcomings

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[8]The seven companies surveyed were International Business Machines Corporation (Endicott, New York), Telesis (Rochester, New York), Sax (Rochester, New York), Rochester Products (Rochester, New York), Arctan (Rochester, New York), Xerox Corporation (Rochester, New York), Visual In-Sietz (Rochester, New York). Additionally, Alfred University was visited to obtain an overview of another college setting.

attributed to uncomfortable furniture, such as unsuitable desk levels that cause constrained postures.[9] The workstations should be adjustable to accommodate the clearance envelopes for the 5th percentile female and the 95th percentile male, as specified by the Human Factors Society. Table 2 lists the requirements for depth, width, and height under worksurfaces, with the resulting clearance envelopes illustrated beneath. In addition, the display support surface should be located such that "the top line of the display is not above the horizontal plane through the eyes."[10]

Eliminating the variety of workstations currently located within this area will add greater continuity and improve the overall appearance. Warm gray, with a reflective value of less than 50 percent, was the color specified for all workstations and accompanying tables in Rooms 3496, 3509 and 3510. As Grandjean recommends to designers of VDT workstations, "Select colors of similar brightness for the different surfaces, replace eye-catching

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[9]Etienne Grandjean, "Design of VDT Workstations," in Handbook of Human Factors, 1360.

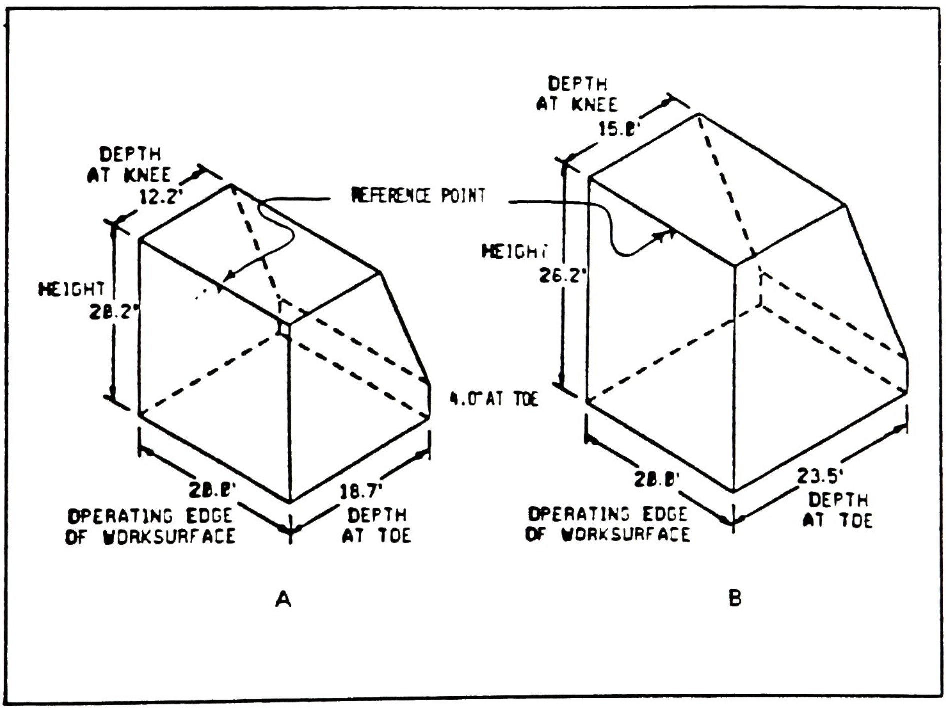
[10]The Human Factors Society, American National Standard for Human Factors Engineering of Visual Display Terminal Workstations (Santa Monica: The Human Factors Society, 1988), 44, 49.

TABLE 2.[11]

Minimum Knee Space Dimensions (cm/inches)

Minimum Knee space	5th Percentile Female	95th Percentile Male
Minimum Depth*		
- Depth at knee level*	31.0/12.2	38.0/15.0
- Depth at toe level*	47.5/18.7	59.0/23.5
Minimum width	50.8/20.0	50.8/20.0
Minimum Height**		
- Adjustable surface	51.3/20.2	66.5/26.2
- Nonadjustable surface		66.5/26.2
*The minimum depth under the worksurface from the user's edge of the worksurface. **From the floor to the bottom of a support surface.		

Clearance envelopes. Minimum clearance envelope for 5th percentile female (A) and 95th percentile male (B).



[11] The Human Factors Society, American National Standard, ANSI/HFS 100-1988. copyright 1988 by the Human Factors Society, Inc., and reproduced by permission, 45.

effects with black and white contrasts, avoid reflecting materials and give preference to dim colors."[12] He further suggests that reflectances (percentages of reflected light with respect to luminous flex) for keyboards be 30 to 40 percent, hard copy 70 to 80 percent, monitor enclosures be 20 to 30 percent, and the monitor 5 to 8 percent.[13]

Workstations with an independent adjustable keyboard support surface are available, adding even greater flexibility for the VDT operator. If these workstations are designated, the ANSI states they shall range in height from at least 58.5 cm to 71.0 cm.[14] It must be remembered that these are the minimum requirements, for Grandjean, Hunting and Pidermann found in their field studies that the range of adjustability should lie between 65 cm and 82 cm.[15] These were not recommended due to the short duration spent by students and in turn the full benefit would not be realized.

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[12]Grandjean, 1372.

[13]Ibid., 1373.

[14]The Human Factors Society, American National Standard, 47.

[15]E. Grandjean, W. Hunting and M. Pidermann, "VDT Workstation Design" Preferred Settings and their Effects,: Human Factors 25(2) (April 1983): 166.

B. Monitor Screens

Several currently marketed solutions for reducing screen reflection were investigated to determine the overall benefit to the operator. There are disadvantages associated with screen filters and treatments. Neutral density (gray) filters have less character luminescence, color filters (same color as phosphor) have less character luminance as do Polaroid filters, and non-embedded filters become dirty. Micro mesh and micro louver both demonstrate limited angle of visibility. Quarter-wavelength anti-reflection coating is expensive and difficult to maintain, matte (frosted) finish of screen surface increases character edge spread (fuzziness, increased veiling reflections), and CRT screen hold makes it difficult to avoid shadows on screens.[16] It must be acknowledged that each of these techniques also has advantages which in some applications may be justified, but due to the disadvantages, none are recommended for this design. Students often use their fingers as pointers, increasing maintenance, and decreasing screen filter effectiveness even further. It is best to control reflections and glare by proper reflectance values of the environment and lighting.

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[16]Helander, 529.

C. Seating

Well-designed seating is essential, for it is assumed that the operator will perform the tasks while seated as opposed to standing for the complete work day. A chair that offers a positive effect on posture, circulation and spinal pressure is necessary.

Two types of seating are currently available to students in Rooms 3496 and 3510. First is an ergonomic chair with tiltable seat, casters, fixed back, and fabric seat and backrest. The second is a stackable chair with plastic seat and backrest, offering no adjustments or casters. Survey results show that the students found both types of seating acceptable for the length of time they were at the VDT (Table 1). The business survey showed that all companies utilize ergonomic chairs with five-star bases and casters, as recommended by the Human Factors Society.[17]

The proposed design calls for the use of ergonomically designed chairs with controls that are easily accessible to encourage use, five-star bases with casters for mobility, and fabric seats and backrests to allow the body to breathe. The chair should accomodate the 5th percentile female and

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[17]The Human Factors Society, American National Standard, 61.

the 95th percentile male (Table 3). The fabric should have a texture that does not impede shifting of the body, but not so smooth that it is difficult to retain a position. Armrests are optional; some people prefer them while others find that they interfere with lateral movements.

Adjustable backrests are one feature to consider in chair selection. The backrest should adjust backward and forward, up and down. Having the seat back properly adjusted helps to maintain the proper curvature of the spine and possibly reduce the amount of weight on the spine. Maintaining poor posture for extended periods of time could cause deformation of the spinal disks. "Chairs that incorporate seat back angles greater than 105 degrees should have backrests sufficiently high to provide adequate support to the upper trunk, head and neck.[18]

Grandjean, Hunting and Pidermann, in their survey, found that "trunk inclinations approximate to a normal distribution. The 95% confidence interval lies between 97 and 121 degrees; the majority of the subjects preferred

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[18]International Business Machines Corporation, <u>Human Factors of Workstations with Visual Displays</u> (San Jose: IBM Human Factors Center, 1984), 45

TABLE 3.[19]

Anthropometric Values in cm (inches)

	5th percentile female/male	95th percentile female/male
Buttock-Knee Length	51.8(20.4)/54.0(21.3)	62.5(24.6)/64.2(25.3)
Buttock-Popliteal Length	40.9(16.1)/45.0(17.1)	47.2(18.6)/50.5(19.9)
Elbow-Fingertip Length	38.5(15.2)/44.1(17.4)	46.0(18.1)/51.4(20.2)
Elbow Rest Height (sitting)	18.1(7.1)/19.0(7.5)	28.1(11.0)/29.4(11.6)
Eye Height (sitting)	67.5(26.6)/72.6(28.6)	78.5(30.9)/84.4(33.2)
Foot Length	22.3(8.8)/24.8(9.8)	26.2(10.3)/29.0(11.4)
Hip Breadth	31.2(12.3)/30.8(12.1)	43.7(17.2)/40.6(16.0)
Knee Height (sitting)	45.2(17.8)/49.3(19.4)	54.5(21.5)/59.3(23.3)
Popliteal Height	35.5(14.0)/39.2(15.4)	44.3(17.4)/48.8(19.2)
Thigh Height (above seat)	10.6(4.2)/11.4(4.5)	17.5(6.9)/17.7(7.0)

[19]The Human Factors Society, American National Standard, ANSI/HFS 100-1988. copyright 1988 by the Human Factors Society, Inc., and reproduced by permission, 87.

trunk inclinations between 100 and 110 degrees. Only 10% demonstrated an upright trunk posture."[20] VDT operators instinctively prefer a backward-leaning trunk posture and ignore the recommended upright trunk position. An explanation for this can be found in a study conducted by Swedish orthopedists wherein they measured the pressure inside the invertebral disks as well as the electrical activity of the back muscles in relation to different seating postures. Subjects exhibited a decrease of the intervertebral disk pressure and of the electromyographic activity of the back by increasing the backrest angle of the seat from 90 to 110 degrees.[21]

Seat depth should fall into the 15 to 17 inch range, with seats whose depth exceeds 16 inches providing relief to the back of the knee.[22] Frequent changes in the users' position are to be expected, and the seat should permit a majority of the user's weight to be transferred to the seat through the buttocks. A "waterfall" contour on the seat's front edge is also beneficial in reducing excessive pressure behind the knee and under the thigh.

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[20]Grandjean, Hunting and Pidermann, 170.

[21]Ibid., 174.

[22]The Human Factors Society, American National Standard, 60.

An adjustable seat height of 16 to 20.5 inches is recommended in providing operator comfort.[23] It is desirable for the operator's thighs to be reasonably horizontal, lower legs vertical and the feet planted firmly on the floor. Operators whose height is such that the 16 inch minimum is still too great might require a footrest. Selection and placement of a footrest should be such as not to impede operator movement or mobility within the workstation, but still be convenient enough to provide adequate support.

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[23]Ibid., 55.

VI. LIGHTING

Lighting is one area that should be reexamined when converting a workplace from traditional task usage to accommodate VDTs. Traditional tasks in the office environment are usually performed on a flat, horizontal surface with high contrast between paper and printed characters. Generally, these work spaces were designed with uniform lighting levels, which in itself can cause fatigue. However, if workers experienced any discomfort they altered their sitting positions.

Lighting for VDTs must be approached in a different fashion. Users are now confronted with a VDT work surface that is placed in a near-vertical position and is curved rather than flat. This positioning and configuration creates problems with direct glare and reflected glare, as this surface is struck by light rays that would normally go unnoticed if performing tasks at a traditional workstation.

To further complicate the application, ". . . a typical VDT screen's surface consists of polished transparent glass over an aluminum backing, with a phosphor coating sandwiched between the two."[24] Light rays hitting the screen's face or aluminum backing can cause specular reflections capable of totally obscuring the display. These reflections might be caused by the user, a chair, windows, or any other reflective object in the work space. Diffused reflections are caused by light rays hitting the irregular surface of the phosphor coating, degrading visibility by reducing the details of the display and its background.

Developing a lighting plan to address only the problems of direct glare and indirect glare will not be adequate as the VDT is generally located in a workspace where other tasks, which require different lighting levels, are being performed. Many lighting options are available and were analyzed to determine which would be the most beneficial, or if a combination of options would yield the best results. The National Lighting Bureau suggests considering the options of illuminance adjustment, lighting color modification, installation of controls, luminaire relocation, luminaire modification and luminaire replacement.[25]

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[24]National Lighting Bureau, Solving the Puzzle of VDT Viewing Problems (Washington, D.C.: National Lighting Bureau, 1987), 6.

[25]Ibid., 13.

Illuminance adjustment should be taken into consideration if the general illuminance of a work area is too high. Roughly speaking, a VDT workstation need not have levels greater than 75 footcandles ("fc").[26] Recommended differences in luminance between the task area and its immediate surrounding are no greater than 3:1 with no more than a 10:1 difference between the task area and more distant surroundings.[27] It should be noted that no scientific support is available to substantiate these guidelines. If higher illuminance is required to perform a specific task, this should be handled using task lighting and not by increasing the level throughout the area, being mindful that glare results from excessive contrast between the brightness of the task and the general brightness of the surrounding to which the eyes are adapted.[28]

Lighting color modification should enhance the interior and its occupant, not the VDT. Installation of controls leads to greater flexibility, allowing individual users to adjust illumination to satisfy personal needs. Luminaire

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[26]Illuminating Engineering Society, 5-13.

[27]International Business Machines Corporation, 51.

[28]Henry J. Cowen and Peter R. Smith, Environmental Systems (New York: Van Nostrand Reinhold Company, 1983), 136.

relocation is another option made possible by relocatable branch wiring, though whether it is as viable an alternative as the others is questionable. Relocation can impact the overall light distribution of the space, affecting the visual needs of others and the appearance of the workspace.

Luminaire modification and luminaire replacement should be evaluated at the same time; both offer adequate solutions to lighting problems and there would be little cost differential between the two. If extensive modifications have to be implemented, then exploring the deep-cell parabolic-louvered luminaire as a replacement could be justified. Some consider this the best lighting for VDT areas.[29]

A complete lighting modification was deemed necessary when evaluating the current lighting plan. Many students considered the lighting level too high, whereas the majority felt it was adequate for the amount of time spent at the VDT (Table 1). Businesses surveyed generally maintained much lower lighting levels, 10 fc to 40 fc, for their operators than RIT's lighting level of 100 fc in room 3510. General illumination of 20-40 fc, well within the IES guidelines, should be provided from high quality (no veiling

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[29]National Lighting Bureau, 19.

reflections), controlled brightness luminaires, with supplemental task lighting where necessary.[30]

The most noticeable problem area in Room 3510 is where overhead fluorescent light is provided at uniformly high levels throughout. Such lighting may create glare, with consequent headache and eyestrain; it is aesthetically uninteresting if not unpleasant and it is wasteful of energy because it produces more light than is needed.[31] It should also be noted that in June of 1988, the Suffolk County, New York legislature passed the nation's premier bill requiring employers to take responsibility for eye and health-related problems of VDT operators, placing even greater emphasis on proper lighting design and operator welfare.[32]

Focusing on lower lighting levels and reduction of glare led to the proposed reflected ceiling plan (Figure 6). Architectural coves (Figures 6 and 7) are designated in areas illuminating the VDTs, for they provide the

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[30]Mitchell Kohn, "Lighting Offices Containing VDTs," Lighting Design and Architecture (December 1988): 9.

[31]Peter Ellis, "Functional, Aesthetic, and Symbolic Aspects of Office Lighting," in Behavioral Issues In Office Design, ed. Jean D. Wineman (New York: Van Nostrand Reinhold Company Inc., 1986), 225.

[32]Peter Engle, "Encroaching laws will make proper VDT ergonomics a must," Contract (October 1988): 27.

opportunity to hide lighting equipment which, in turn, can illuminate and accentuate architectural details and provide indirect illumination from the ceiling and walls.[33] In order to capitalize on the indirect lighting, a more reflective matte finish, approximately 70%, was used on the walls above the fluorescent cove. An even higher reflective matte finish is recommended for the ceiling (90%). This will help to soften shadows by providing light from many directions. High-reflectance matte finishes on room surfaces become effective secondary light sources and materially reduce shadows by reflecting a significant amount of diffused light into shadow areas.[34]

To simply provide a horizontal plane for a ceiling detracts from the goal of providing a stimulating environment in this application; to end the design at a well planned floor layout is inappropriate. Recesses are used in room 3510 (Figures 6 and 7) to designate circulation areas and VDT clusters, as well as integrating the fluorescent coves into the architectural details. Circulation areas, and the Intergraph room, are equipped with 2 foot-0 inches x 2 foot-0 inches fluorescent fixtures and parabolic louvers

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[33]Illuminating Engineering Society, 5-4.

[34]Ibid., Section 5, 7.

to prevent uncomfortable glare by limiting the light output at angles greater than 50 or 60 degrees from vertical in the case of fluorescent luminaires.[35]

Fluorescent coves were used exclusively in Room 3496 (Figure 6) to provide illumination, combined with a recessed ceiling over the circulation area for interest. The same finish requirements as in Room 3510 were specified to reduce shadows and glare. A more conventional approach was taken in the conference/lecture Room 3500 due to it being a smaller area with the possibility of seating arrangements and functions changing frequently. Providing a lighting scheme that allows for varying luminance is recommended. This can be accomplished by the installation of separate controls for the different fluorescent banks.

Task lighting to illuminate hard copy at the workstation (Figure 7) is left to the discretion of the operator. Task lighting which would secure to document holders and limit the effects of transient adaption and disability glare, should be made available to the students. The IES recommends that luminance ratios should not exceed:

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[35]Ibid., 5-6.

Paper-base task to VDT screen	1 to 1/3
Task and adjacent dark surroundings	1 to 1/3
Task and adjacent light surroundings	1 to 3
Task and more remote darker surfaces	1 to 1/10
Task and more remote lighter surfaces	1 to 10.[36]

The task light in this design would be a high intensity discharge "point source" luminaire, one that limits the light output at angles treater than 45 degrees.[37]

Designing a comfortable workstation and environment for the VDT operator will help provide the necessary conditions to improve productivity. Ignoring the operators' working conditions on the premise that they were adequate or standard to perform traditional tasks is shortsighted and could lead to employee health problems and lawsuits.

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[36]Ibid., 5-14.

[37]Ibid., 5-6.

II. NOISE

Acoustic noise is another area of concern from an engineering as well as human factors standpoint. The Human Factors Society believes that VDT workspaces should not be subjected to sound pressure levels greater than 55 dba, excluding noise generated by the user.[38] The Occupational Safety and Health Act regulations set level standards that vary from 90 dba for operators with eight hours of exposure per day to 115 dba for those with .25 hours or less per day.[39] Clearly, sound levels acceptable to the medical profession are considered too high from the human factors viewpoint. Eliminating all white noise, ambient or background noise, is also undesirable as such sounds not only help to muffle unwanted noise, but a complete lack of ambient noise could be disconcerting. Alternatively, if the ambient noise exceeds the 55 dba level, it could have an adverse affect on productivity, creating speech interference and unwanted distractions.

Existing sound pressure levels established by the Human Factors Society are not exceeded in the computer graphics

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[38]The Human Factors Society, American National Standard, 14.

[39]International Business Machines Corporation, 57

area, even through the students consider the noise level too high with the present room arrangement (Table 1). Establishing cluster groups and a circulation area, most notably in Room 3510, will decrease distractions and group-generated noise from one cluster to another.

VIII. SUMMARY

Organizations, large and small, are recognizing the benefits associated with providing a work environment designed with employees' welfare in mind. To gain the maximum benefits from today's technology VDT operators must be comfortable with their workstations and environment. RIT has the capability to educate students academically and to develop an awareness of and the ability to shape future work environments. Graduates of the Institute can be a major factor in recruiting talented people. If graduates have been dissatisfied with their environment, they can discourage applicants as well. Minoring in Computer Graphics has exposed me to a very capable and talented faculty, but the classroom and equipment need to be brought up to a higher standard.

The student and business survey contributed a great deal of insight to the design of this area. Much information is available on the separate components comprising a VDT environment, but little information exists that ties it all together. It is possible for many combinations to provide a user-friendly environment, but the combinations must be suited to the group spending time in the environment. Therefore, it is strongly recommended that feedback from users be obtained, whether for a classroom or business setting.

VDTs are becoming commonplace in the academic environment as well as in industry. For the existing computer graphics applications, and for the Creative Design Electronic Media Center being proposed, a design was conceived that, in appearance and efficiency, brings education and business closer together. Ergonomic considerations should not be left until a later date; they should be instituted now to afford students and faculty the maximum return on their investment.

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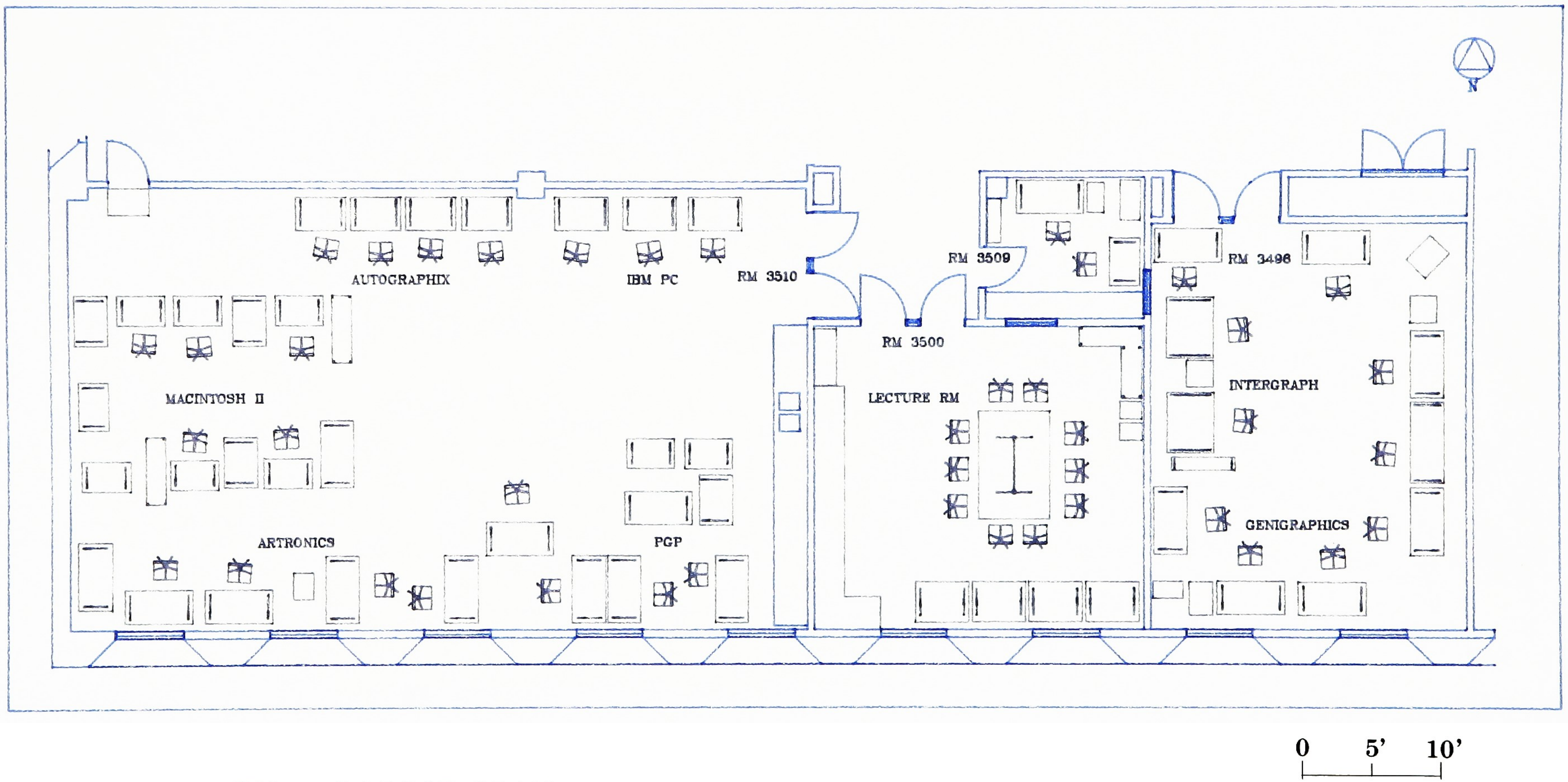

FIGURE 1. EXISTING FLOOR PLAN

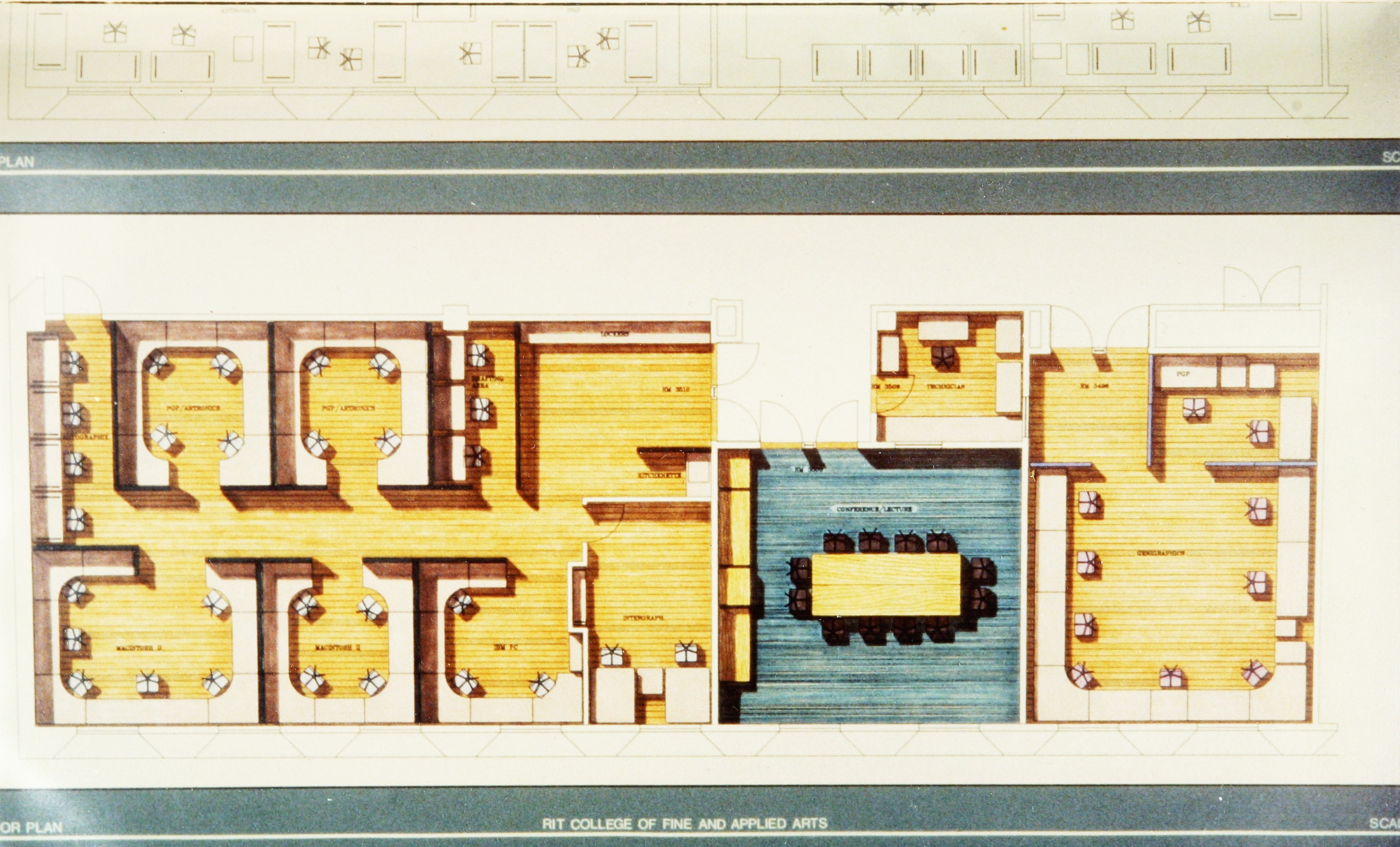

FIGURE 2.. PROPOSED FLOOR PLAN

0 5' 10'

FIGURE 3. PROPOSED ROOM 3510 CLUSTER GROUPS

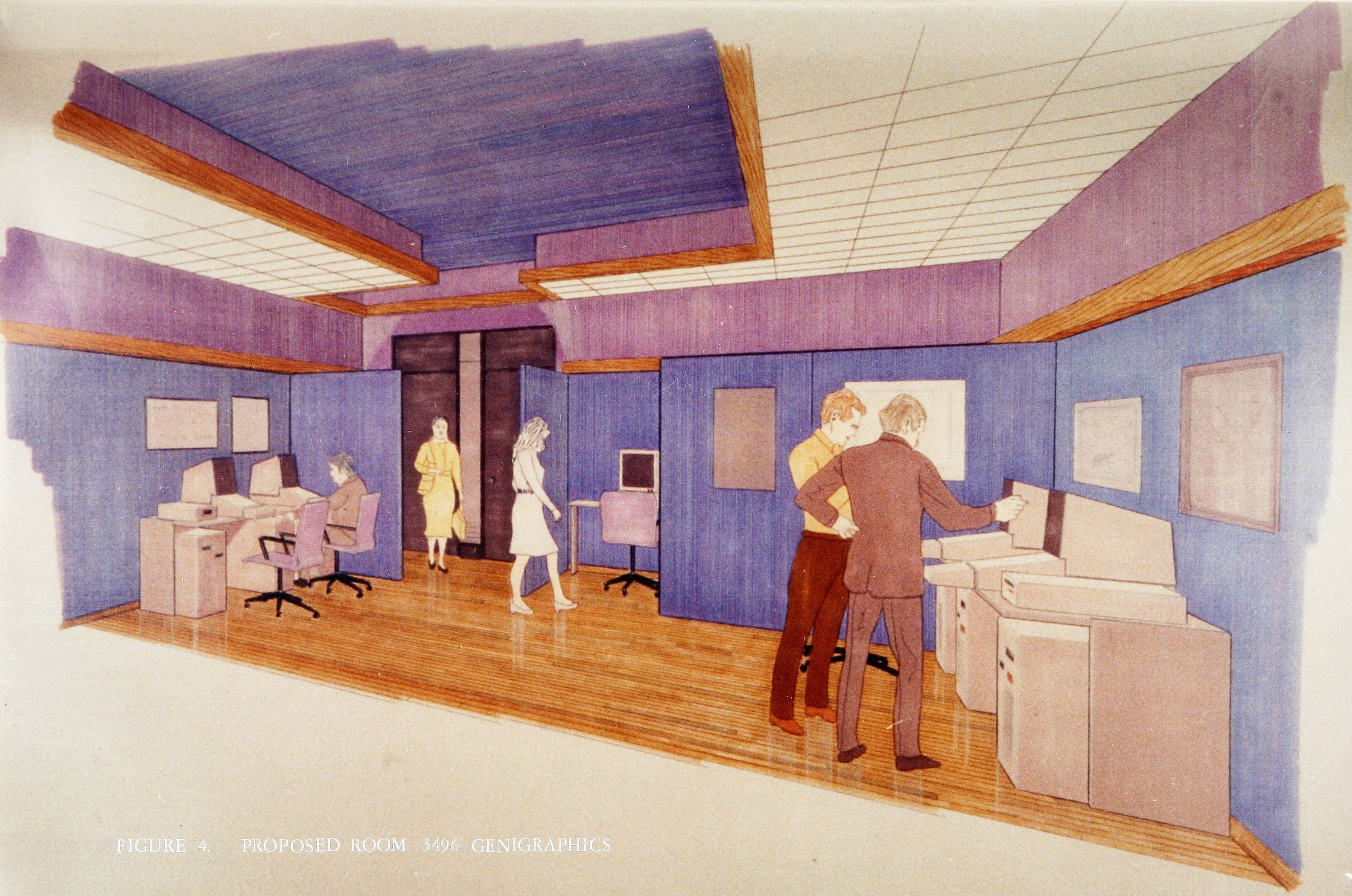

FIGURE 4. PROPOSED ROOM 3496 GENIGRAPHICS

FIGURE 5. PROPOSED ROOM 3500 CONFERENCE/LECTURE

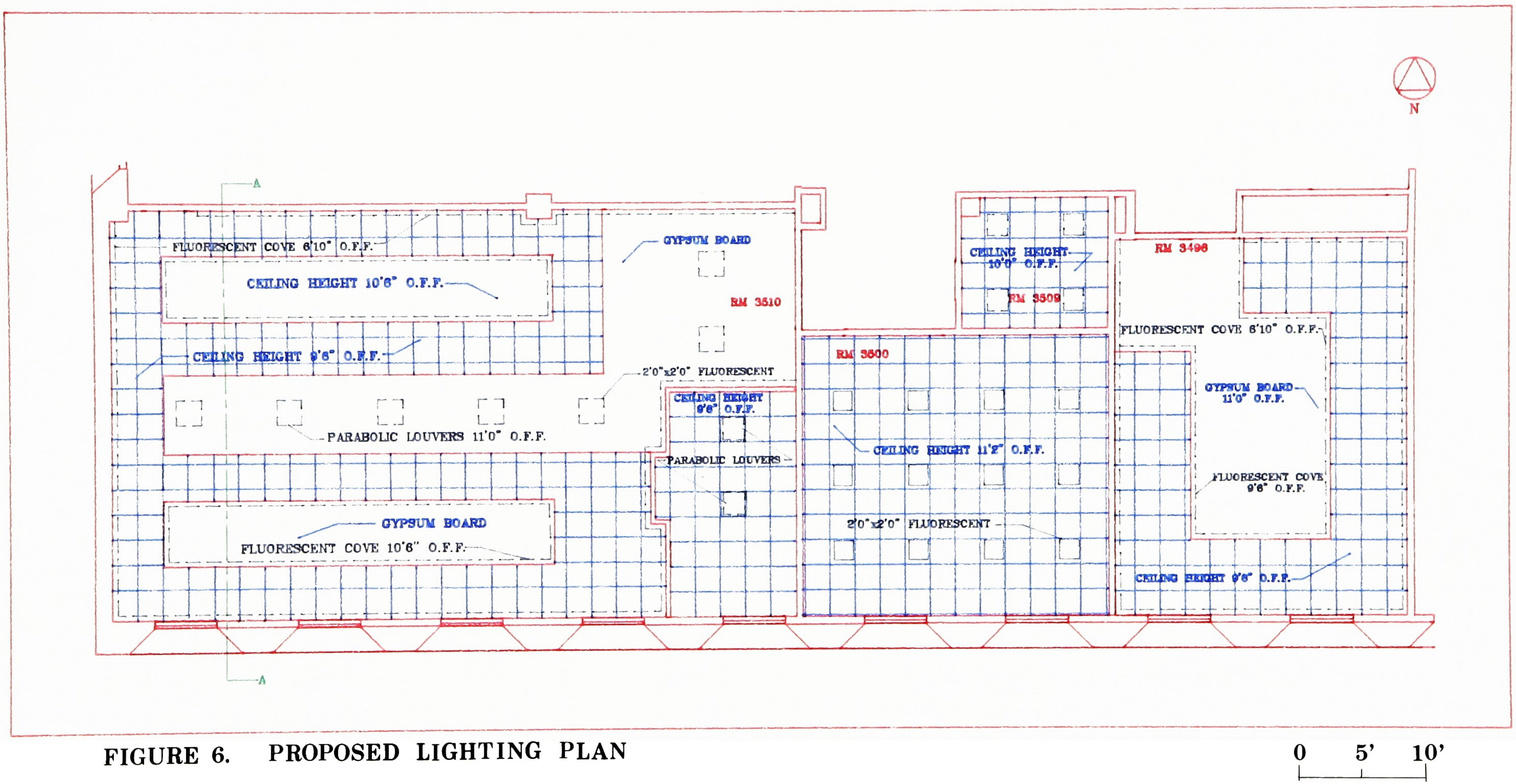

FIGURE 6. PROPOSED LIGHTING PLAN

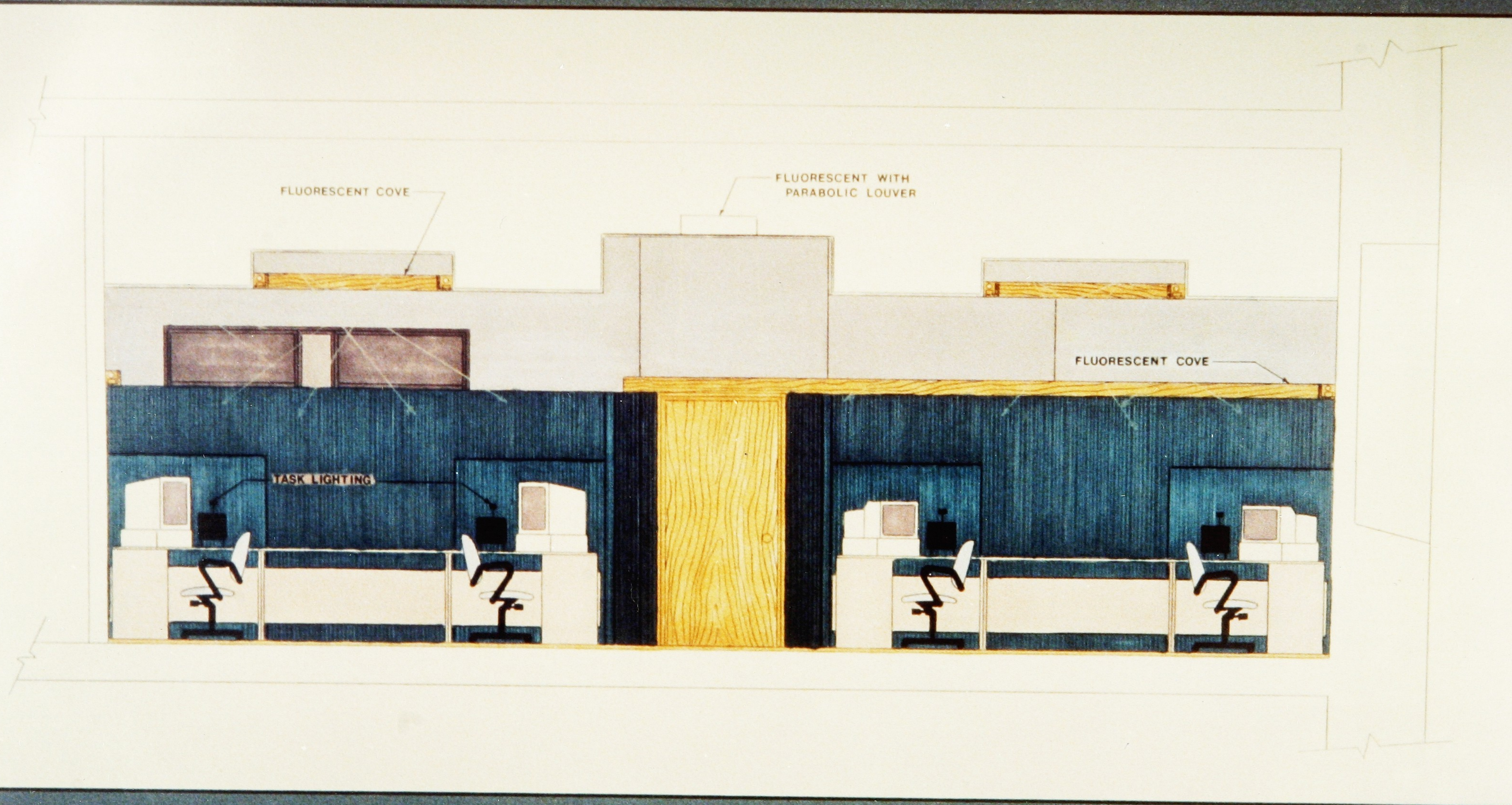

FIGURE 7. SECTION A-A PROPOSED ROOM 3510