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ABSTRACT

A study of 120 students selected from the user populations of four music education computer laboratories was conducted to determine the applicability of current ergonomic and environmental design guidelines in satisfying the needs of users of educational computing workspaces. Eleven categories of workspace factors were organized into a questionnaire encompassing 59 items, each representing a specific factor. Each factor was rated with a 5-point Likert-type scale ranging from 1 (poor) to 5 (excellent). Significant differences were found in user ratings across the four facilities as well as individual workspace factors. Analyses reveal a trend toward user satisfaction with workspace factors designed in accordance with ergonomic and environmental design guidelines. Appendices include a glossary of terms, the study instrument, study data, student comments, and an equipment list of general workstation configurations of each lab. (Contains 67 references.) (GR)

Boston University

School of Education

Dissertation

A USER ASSESSMENT OF WORKSPACES IN SELECTED MUSIC EDUCATION COMPUTER LABORATORIES

by
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A USER ASSESSMENT OF WORKSPACES IN SELECTED MUSIC EDUCATION COMPUTER LABORATORIES

(Order No.)

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Boston University, School of Education, 1995

Major Professor: Dr. Gerald F. McVey, Professor Emeritus of Education

ABSTRACT

This study investigated the applicability of current ergonomic and environmental design guidelines developed for computerized offices and other non-educational settings to the needs of users of educational computing workspaces. The specific setting chosen was college-level music education. A total of 120 subjects, selected from the user populations of four music education computer laboratories at an internationally recognized music college, participated in the study.

An additional goal of the study was the validation of user feedback as an important source of information for the development and improvement of educational facilities. The study also intended to show that the interior and workspace factors of the learning environment are important to users, and should be seriously considered by the designers and administrators of similar educational facilities.

The facilities were selected for their similar equipment, task orientation, and user populations, but differing workspace specifications. Each workspace factor was measured with appropriate instrumentation and methods to determine the extent to which its specifications were in accordance with the guidelines. Eleven categories of workspace factors were organized into a questionnaire encompassing 59 items, each representing a specific factor. Users rated each factor with a 5-point Likert-type scale ranging from 1 (poor) to 5 (excellent).

Statistical analyses using the Kruskal-Wallis and Friedman tests revealed significant differences in the user ratings across the four facilities as well as individual workspace factors. A comparative examination of the ratings was conducted to determine the extent of user satisfaction with specific workspace factors, and which specifications appeared to be preferred by the users. The combined analyses revealed a trend toward user satisfaction with workspace factors designed in accordance with ergonomic and environmental design guidelines. Discrepancies are noted as well, in that users expressed satisfaction with some workspace factors that were not in accordance with the guidelines. Implications for computer workspace design in music and other specialized higher education environments are further discussed.

Table of Contents

List of Tables

List of Figures

CHAPTER 1
Introduction to the Research Problem

1-1. Problem Statement

This study was an investigation of the applicability of current ergonomic and environmental design guidelines to educational workspaces which employ computer-based technologies. Its purpose was to determine whether guidelines pertaining to office environments and other non-educational settings can contribute to a satisfactory learning and working environment from the viewpoint of users of educational computing facilities.

Specifically, the setting was one that supported the education of musical artists at the college level. This context provided a perspective on a unique application of technology in education as well as the needs of a unique user population. Both workstation and ambient environmental factors were investigated, namely the immediate workstation furniture and equipment as well as the surrounding interior elements of room space, acoustics, lighting, thermal conditions, and air quality. An attempt was made to determine the extent to which current guidelines are applicable to college-level music education workspaces, and if additional or alternative guidelines should be considered for this context. Implications for other specialized educational applications are considered as well.

Building upon similar research in the assessment of educational facilities (McVey 1979; Bethune 1991), this study employed the users as evaluators of their learning environment. It was designed to reaffirm the fact that users, when given an opportunity, will reliably identify specific environmental and ergonomic factors as acceptable or unacceptable to the task at hand, and that such factors are important to them.

In addition to a comparison of user assessment data with established ergonomic and environmental design guidelines, each of the facilities under investigation was compared with each other to determine which facility and which environmental and ergonomic elements (design specifications) are perceived as most favorable to users.

1-2. Background

With technological innovations becoming commonplace in today's higher education institutions, students and teachers alike now have access to an impressive array of tools for learning and productivity. Many of these innovations are based on the personal computer, which in its modern form has proven itself amenable to virtually every academic discipline. The most common applications of computers in education occur in such institutional areas as academic computing centers, learning resource facilities, libraries, and specialized classroom laboratories. Within these areas, equipment is generally configured into individual workstations consisting of a personal computer augmented with various peripherals and features designed to support a specific task.

In spite of the increasing sophistication and versatility of today's computer-based educational technologies, there remain, however, more *basic* issues surrounding their use, namely elements of the built environment such as room space, furniture layout and design, acoustics, lighting, and HVAC. Modern computing technologies employed to support innovative educational programs are often enclosed within unsuitable interior environments that hinder the performance of both students and equipment. It is not unusual to see computer rooms created out of existing classroom spaces or other locations without modification. Systems may be placed on regular writing desks, or fitted to library carrels without the appropriate forethought. Seating may be inadequate in terms of user adjustability and comfort, or at worst no more sophisticated than the plastic chairs found in a regular classroom. Lighting systems in these spaces, once sufficient for reading, writing, and viewing the blackboard, now cast a distracting glare on computer screens. The expanse of the new equipment suddenly renders room space inadequate, and noise and heat levels increase without compensation. In almost cyclical fashion, new solutions pose new problems.

Even when there is an opportunity to literally build from the ground up, these issues are often ignored:

> Improving the design of the physical environment has enhanced workers' health, safety, and productivity in a wide variety of jobs. Imagine, though, settings in which thousands of people daily try to integrate complex new information and tasks while being hampered by inadequate work space, lighting, air quality, or noise reduction.
>
> Imagine further that significant human factors research for these settings is virtually non-existent; that both new construction and renovation efforts assign little

> importance and few resources to improving the settings, relying instead on designs that are decades old. This scenario is routinely played out in lecture halls and classrooms on college campuses worldwide (Caldwell 1994, p. 30).

The effects of these environmental factors on human performance, cognition, perception, health, and personal satisfaction has long been a subject of investigation in the fields of ergonomics, human factors engineering, and environmental design. These fields have established themselves on the research and design of spaces, equipment, and surroundings to fit the myriad human interactions that take place between them with the goal of improving productivity and well-being in a variety of occupational settings. Yet, the inherent principles of these fields are, by all appearances, virtually untested and undeveloped in educational settings.

Though Caldwell's statement refers to classrooms and lecture halls, it is believed that these problems extend into educational computing environments as well. Research pertaining to workspaces incorporating computer technology has focused largely on office environments and other non-educational settings, and published standards for their design have been compiled that reflect the empirical findings of such studies (Salvendy 1987; ANSI/HFS 1988; IES 1989; Woodson 1992). While much of this information has been incorporated into literature pertaining specifically to the design of computer-based workspaces for education and training, studies conducted within actual educational environments appear to be scarce. Where the environmental assessment of educational facilities *has* been successfully conducted, the situation involved more traditional instructional formats, such as classrooms and lecture halls (McVey 1979; Bethune 1991; Caldwell

1994). It can be reasonably assumed that spaces designed for independent learning activities pose a different and more varied set of problems.

Though the lack of distinction between office and educational workspaces may not seem problematic on the surface, there are considerable differences underlying their respective functions. Some writers on the subject of computer workstation ergonomics call for design criteria that considers the specific tasks and users, rather than adherence to a single set of standards (Kroemer 1987; Povlotsky and Dubrovsky 1988). Higher education institutions provide technological support for a variety of subject matter, incorporating resources for such general applications as wordprocessing and computer-assisted instruction as well as specific equipment configurations for such disciplines as engineering, fine arts, and biomedical sciences. Each of these applications is likely to share a number of common environmental requirements as well as present differences unique to their respective domains.

Within the fine arts domain, music has been one of the most receptive of recent advances in technology. Professional and educational applications of computers and other digital media have changed the way musicians learn and create music. At the college level, learning resources and other support systems for music students must be designed around both instructive and productive activities for the development of musical skills. An individual workspace in this situation will be configured to provide practice in essential aural skills, tools for the creation of musical compositions, and perhaps *general* applications such as wordprocessing and spreadsheets for personal productivity.

Accommodating this range of activity can be a complex undertaking. In addition to a personal computer system, a workspace designed for this purpose usually includes an electronic music keyboard (synthesizer), audio recording equipment, headphones, a reading/writing surface, and perhaps other specialized peripherals as deemed appropriate (Figure 1-1). Configuring this array of equipment and surfaces within a limited usable space is not as straightforward an effort as designing a simple wordprocessing station, and often results in a less than optimal positioning of equipment. Even when user comfort and convenience is an expressed design goal, it is difficult to achieve at every point. Individual items on the workstation are also likely to feature complex banks of controls. It can therefore be assumed that support for the tasks to be performed in this situation will require different criteria than what has been established for offices, as well as more *general* learning tasks. Additionally, the learner population in question is likely to differ significantly from office workers in work habits and attitudes by virtue of their discipline.

With respect to office environments themselves, Kroemer (1987) writes:

> Successful design of the office workstation requires proper consideration of several interrelated aspects. These include anthropometry and biomechanics of the operator; individual differences and preferences; varying work tasks and work habits; and the need for change and variations. A person working with a computer will assume work postures and perform activities that are determined by the specific work task, e.g. text processing, data filing, or CAD. Posture and activity are also influenced by the specific

> workstation conditions which include furniture, the environment, and the equipment used. All of these need to "fit" the person and the task (p. 1006).

Similarly, the conception of an effective and appropriate learning environment must be derived from an understanding of the tasks to be supported as well as the users (learners) who will be engaging in these tasks.

Figure 1-1: Student seated at music workstation. Note the accommodation of computer system, music keyboard, and worksurface.

One methodology for determining what constitutes an effective environment for working or learning is an assessment of observable human performance, such as the effects of various environmental factors (i.e. noise, illuminance) on specific tasks, behaviors, or perceptual skills (Laguisa and Perney 1974; DesRosiers 1976; Kyzar 1977; Baron 1990; Pekkarinen and

Viljanen 1991). Another is the employment of instruments designed to represent a direct assessment of an environment by the users themselves. User assessment methodologies, also known as *post-occupancy evaluations*, have their origins in the field of psychology in the evaluation of architecture (Cooper 1971; Francescato et al 1975; Sommer 1983), but have also been successfully conducted in workplaces (Carayon et al 1987; Rohles et al 1987; Hedge et al 1989; Vietch 1990; Boubekri et al 1991) as well as educational facilities (McVey 1979; Bethune 1991; Caldwell 1994).

The McVey (1979) study compared five media presentation classrooms in a university setting utilizing a Likert-type questionnaire designed to measure user ratings of specific environmental and display system factors. Two of the classrooms were categorized as "environmentally coordinated" (pp. 122-123) in that their design specifications reflected published environmental design and human factors engineering guidelines. Users evaluated specific attributes of their learning environment: thermal features, viewing sector, visual display systems, lighting, color and reflectance, seating, desks, acoustics, and audio systems. The results of the study established that the subjects preferred the environmentally coordinated media presentation rooms in that the factors rated as most acceptable were in accordance with current guidelines. An additional outcome of the study was the validation of users as reliable evaluators of their learning environment.

Bethune (1991) modified and successfully applied McVey's methods and instrumentation to a user assessment of university lecture halls. User ratings of environmental and display systems factors were compared with the published recommendations of ergonomists and architects to determine which set of standards were most appropriate for lecture hall design. The results of this study indicated that users preferred the recommendations of ergonomists over those proposed by architects.

Both of these studies were conducted in what might be regarded as more *traditional* instructional situations, namely lecture and presentation. However, their application of user assessment techniques to the validation of design standards appears to offer a model extendible to learning environments dedicated to self-directed activities.

1-3. Rationale for Study

Considering the proliferation of technology in modern education, it is becoming increasingly important to design educational facilities that are not only conducive to its use, but humane as well. Information is available to assist those responsible for the design and management of these environments, but the source of this information is derived from non-educational settings, and under significantly different working conditions than is encountered in a learning situation. A given set of criteria may not be universally applicable, as the quality of the task to be considered, as well as the characteristics of the users themselves, are likely to bring a number of factors to bear on the situation. "The nature of good human factors engineering is to tailor the specifications for the unique work situation of interest." (ANSI/HFS 1988, p.3).

In response to the need for documented research on individual workspace design standards conducted within an actual educational context, this study endeavored to develop a perspective that has not been addressed in previous studies and texts pertaining to office environments. It was designed to aid in the establishment of specific workspace design criteria for computer-based music education settings, as well as other learning environments incorporating specialized technology. It was an attempt to bridge the literature by either extending, revising, modifying, negating, or affirming established ergonomic standards to the extent that they are more applicable to educational facility planners, designers, and administrators charged with the development of technological resources. Commercial applications of the findings might also assist product developers in the design of supportive furniture and hardware systems for use in a variety of educational contexts.

By employing users as evaluators of their learning environment, the findings build on previous user assessment studies (McVey 1979, Bethune 1991), thereby contributing to the continual updating of literature pertaining to educational facility planning in general as well as methodologies in post-occupancy evaluation. These evaluations also help to determine which interior environmental factors are most important for a particular user group and task, thereby suggesting a priority for design specifications.

1-4. Research Questions and General Hypotheses

This research focused on answering the following questions: 1) Are current ergonomic and environmental design guidelines appropriate for designing computer workspaces for music education that are satisfactory to the users?; 2) Are the workstation and surrounding interior factors of a learning environment important to users, and if so, what specific factors are most important for this particular application?; 3) What design specifications are most favorable to users in this context? and 4) Can users, in this specific context, reliably and accurately evaluate the efficacy of their learning environment?

To answer these questions, the research strategy was designed to investigate the following general hypotheses:

1. Current ergonomic and environmental design guidelines for computerized offices and other non-educational settings are applicable to the design of workspaces in music education computer laboratories.

It can be reasonably assumed that many of the ergonomic and environmental design guidelines examined in research on computerized offices and other settings can be applied to educational computing environments. The application of similar guidelines have also been shown to relate to user satisfaction in other educational settings, such as classrooms and lecture halls (McVey 1979; Bethune 1991). There is, however, the possibility that the functional aspects of a learning environment, particularly one that is dedicated to a specific class of activities, may require additional or alternative design specifications. Differences in tasks performed, equipment configuration, and user characteristics within a specific context may not be addressable through the application of a single set of criteria.

In this study, as in the McVey (1979) and Bethune (1991) studies, the appropriateness of the guidelines was determined by asking the user. Applicability was examined in two parts: the overall relationship of the users' assessment of the workspace to the established guidelines; and 2) the extent of user satisfaction with specific ergonomic and environmental factors in the workspace.

An acceptance of this hypothesis supports the position that the application of current ergonomic and environmental design guidelines is appropriate for workspaces for college-level music education computer laboratories, and will produce workspaces that are satisfactory to users. A rejection of this hypothesis indicates that these guidelines are not appropriate for this particular application, and that alternative or additional design specifications may need to be considered in order to create a satisfactory learning and working environment for this context.

2. *The ergonomic and environmental factors of a learning environment are important to those who use it.*

McVey's (1979) research on media presentation classrooms determined that students consider such interior environmental factors as acoustics, thermal conditions, visual display systems, and lighting as important elements of a learning facility (p. 121). To assess the face validity of these elements, McVey included an item for each category of his questionnaire that provided student evaluators with the opportunity to rate the subjective importance of a particular environmental factor on a 10-point scale. Table 1.1 shows the results of this face validity analysis, listing each factor in order of importance.

TABLE 1-1: Face validity from McVey (1979) p. 130

Section	Mean	SD
Viewing Locations	7.41	1.61
Visual Display Systems	7.40	1.48
Acoustics	7.22	1.80
Seating	7.11	1.91
Thermal	7.03	1.61
Lighting	6.69	1.92
Audio Systems	6.06	1.78
Desks	6.35	2.06
Color & Reflectance	5.98	2.05

McVey's study was conducted in a large group (310) lecture hall/auditoria media presentation environment where students participate in the role of audience. The current study examined educational facilities designed for self-directed activities. An acceptance of this hypothesis would further support McVey's findings and extend them to individualized learning environments. In the case of acceptance, however, it is expected that the priority of the items will differ for this particular application.

3. Users are able to reliably identify acceptable and unacceptable ergonomic and environmental factors in their learning environment.

McVey (1979) and Bethune (1991) concluded in their respective studies that students are reliable evaluators of their learning environment. McVey writes:

> ...given the proper instrument, students are capable of reliably evaluating environmental and display system factors relative to their particular learning environments. (p. 131)

An acceptance of this hypothesis would further extend the validity of the user assessment methodology utilized by these two studies to a different educational context.

1-5 General Definitions

For the purposes of this study, a *workspace* is defined as follows: 1) the equipment and surfaces within close proximity to the user, configured into a workstation; 2) the furniture and chairs supporting the equipment and the user; 3) visual, acoustical, and thermal conditions in the section of the room where the individual workspace is located 4) interior architectural features including elements whose purpose appears to be limited to providing an aesthetic value to the space, and 5) ancillary elements including personal space, convenience, and resources available to provide support to the user.

The following eleven environmental variables are investigated and discussed in this study:

Seating - postural support for listening, viewing, reading, writing, and operation of music keyboard; ease of weight adjustment; ease of movement within the workspace; seat height; ease of access and egress; range of adjustment.

Desks - size of writing and work surfaces; desk height; inclination of writing and work surfaces, and their appropriateness for reading, writing, viewing, and other operations involved in independent learning activities. Appropriateness of distances between all other workstation elements and supportive educational tools and devices. Comfort and efficiency of viewing and manual operations; range of adjustment of desk components; knee and leg room.

Viewing locations - monitor placement; sight lines to the top and bottom of the display; viewing angles; visual comfort; viewing accuracy; minimum and maximum viewing distance; adjustment.

Computer screen image quality- image brightness and resolution; legibility; color or gray scale rendition; ease of operation; adjustment; size; appropriateness of display for a specific task.

Music and Audio systems - quality of recording equipment, electronic keyboards, and headphones; ease of operation.

Lighting - illumination for paper-based tasks; amount and uniformity of lighting; absence or presence of disabling glare; luminance contrasts in the visual field.

Color and reflectance - appropriateness of room's color scheme; visual distractions; task - surround contrast; absence or presence of viewing reflections.

Acoustics - ambient noise level and spectrum and its effect on the range of activities performed by the occupant, including communication between instructor and class and between students where required by the educational program; ability to hear other students and activities; noise isolation.

Thermal conditions - temperature and fresh air exchange; air velocity at workstation; relative humidity.

Technical Support - Availability and quality of support personnel and manuals designed to familiarize the users with workstation equipment and software.

Other - room aesthetics; personal space; seating configuration; book, coat, and hat storage.

These variables were derived from the McVey (1979) and Bethune (1991) studies, with additions and modifications deemed appropriate to an individualized music learning environment.

1-6. Summary of Chapter 1 and Overview of the Study.

This study addresses a specific and unique application of instructional technology within the fine arts domain: *computer workspace design for college-level music education.* It attempts to determine whether current ergonomic and environmental design guidelines, as currently documented and applicable to office workspaces and other non-educational settings incorporating computer-based technologies, can provide a learning environment that is satisfactory to users requiring specific technological solutions. It also seeks to support the evaluation of educational facilities by the users themselves, and that users regard the interior factors that comprise their learning environment as important enough to merit serious consideration by designers and administrators.

The unique context of this study employs similar methodologies developed first by McVey in 1973 (as reported in his 1979 study) and reapplied by Bethune (1991). As in these previous studies, specific categories of environmental factors are examined, with the necessary modifications and additions implemented to adapt to the parameters of this study.

Chapter 2 contains relevant literature in the fields of ergonomics, human factors engineering, environmental design, and other pertinent disciplines for each of the workstation and interior factors to be addressed in this study. Chapter 3 contains a discussion of the methodology to be used in gathering environmental and user assessment data and subsequent comparison to the standards presented in the literature. Chapter 4 provides a detailed description of the collection and subsequent analysis of the data. A discussion of the results of the study is found in Chapter 5. Implications and recommendations for the design and improvement of similar facilities, user assessment methods and further research are delineated in Chapter 6.

CHAPTER 2
Literature Review

2-1. Overview of the Literature

The core source used in this study is the *American National Standard for Human Factors Engineering of Visual Display Terminal Workstations* (ANSI/HFS 1988). General references from the field of human factors engineering, such as *The Handbook of Human Factors* (Salvendy 1987), which features writings by various experts, and the *Human Factors Design Handbook* (Woodson 1992), are also presented and compared for their contributions to design guidelines for computer workstations, their individual elements, and/or the surrounding work environment. Writings by ergonomists such as Bennett (1977), Grandjean (1982), and authors of selected field studies are reviewed for their general and specific applicability to the focus of this study. Other writings and texts in the fields of educational facilities planning, engineering, architecture, industrial medicine, environmental design, and environmental psychology further contribute to the overall presentation.

These sources are presented as a view of the *total workspace*, consisting of the local workstation area, elements of the surrounding interior environment, and other factors considered to contribute to a pleasant and efficient workspace. The rationale behind this approach, as opposed to one that treats the workstation solely, is that no workstation exists independently of an environmental surround. Therefore, all elements of the workspace, namely the furniture, equipment, and the working environment, are conceptualized as an *integrated system* (ANSI/HFS 1988, p. 41).

The following excerpt from Grandjean (Salvendy 1987) illustrates the implications of such an integrated system, and why the ergonomic design of such systems are central to research in the field:

> ...*a VDT operator is tied to a human-machine system.* His or her movements are restricted, his or her attention is directed toward the screen, and his or her hands are fixed to the keyboard. Operators are more exposed to ergonomic shortcomings, to inadequate lighting conditions, and to uncomfortable furniture. They are more sensitive to visual strain and to unsuitable desk levels that cause constrained postures. Such circumstances call for Ergonomics and that is how this science has found its way into the office world. (p. 1360)

As indicated at the end of this excerpt and throughout Chapter 1, the focus of the study of computer workspace ergonomics has largely been on office environments, and the majority of the literature reviewed here will come from that perspective. In keeping with the focus of this study, an attempt is made to view those aspects of the literature that appear to have the most significant implications for educational computing environments.

2-2. Workstation Elements

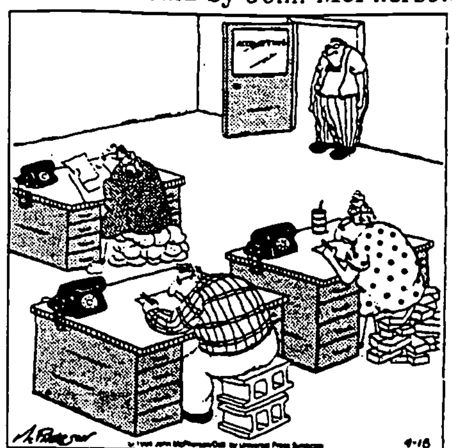
The following paragraphs review standards and research regarding the user's immediate working environment, specifically the seating, worksurfaces, visual display, and equipment support systems. The goal of effective workstation research and design is the thoughtful integration of physical and spatial elements to support the user in the performance of tasks in an atmosphere of health, safety, comfort, and convenience. To supplement this section, Table 2-1 on page 22 provides a comparative listing of recommendations by ANSI/HFS (1988), Woodson (1992) and Grandjean (Salvendy 1987) to compare with other cited references.

2-2a. Seating

Seating is the veritable center of a workspace, and thereby one of its most essential elements. It is acknowledged that the design of a seat influences immediate user comfort as well as the way one interacts with the rest of the workstation's furniture and equipment (Bennett 1977; ANSI/HFS 1988). Seating has also been identified as the most frequent source of health-related symptoms by office workers, regardless of whether or not their job functions entailed the use of VDTs (Prezant and Kleinman 1987). Table 2-1 includes the structural elements of seating as recommended by the three sources.

Though recommendations differ, there appears to be agreement between the three reference texts and other sources (Christinaz and Knirk 1987; Tougis and Nordin 1987; McVey 1988) that workstation chairs should be designed for user adjustability. Tougas and Nordin (1987) state that the chair should be the first component of the workstation to be operator adjustable, followed by the desk. Commonly recommended is a "waterfall" contour at the seat's front edge to relieve pressure at the underside of the thigh. It should also be noted that the sources universally recommend that the seated person's feet should be able to be placed firmly on the floor, or on a support surface such as a footrest if circumstances require.

CLOSE TO HOME by John McPherson



Corporate manager Hank Clemmer firmly believes that a comfortable employee is a lazy employee.

Figure 2-1: Task-based office seating. ©1994 John McPherson / Distributed by Universal Press Syndicate. Printed in *The Boston Globe*, 19 April 1994.

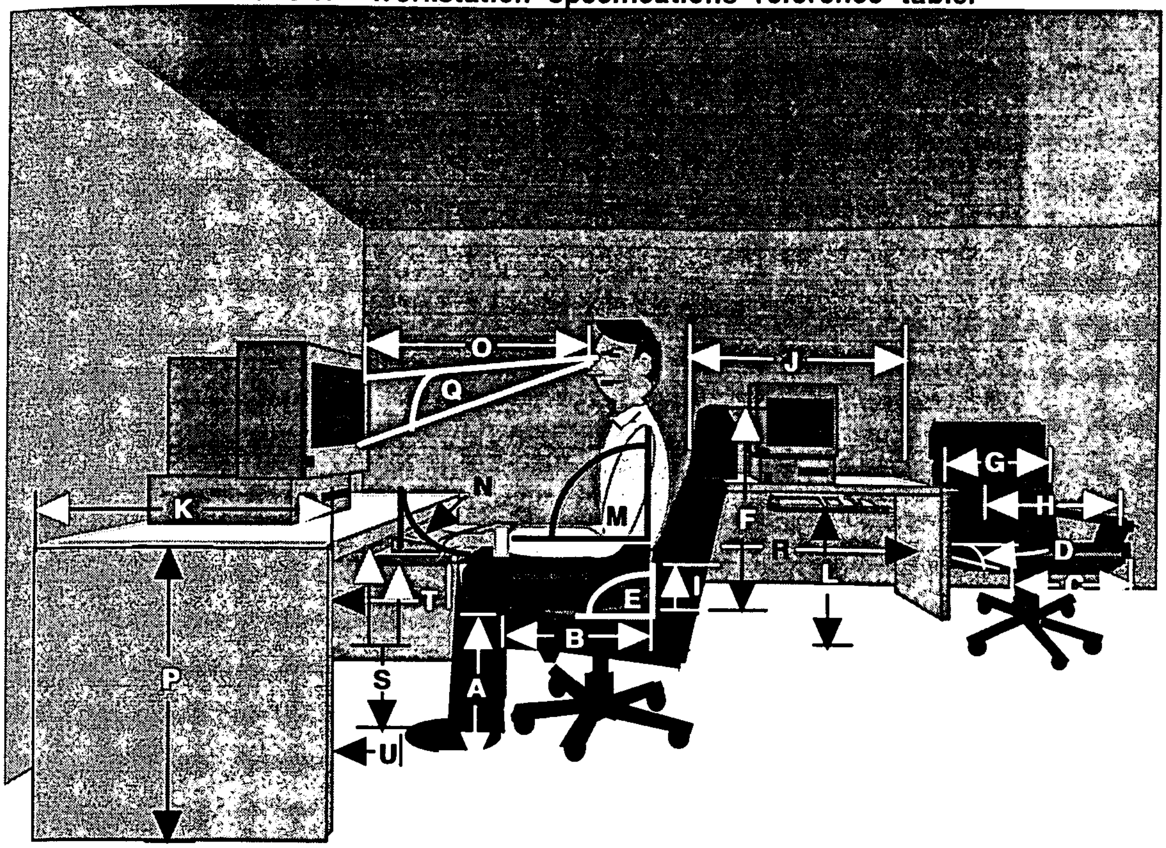
There has been considerable debate concerning the user assuming an upright posture at the workstation vs. leaning back in a workstation chair. Some sources endorse users sitting upright for desk-based tasks (ANSI/HFS 1988; Bridger 1988; Fruedenthal et al 1991; Sauter et al 1991). Others question this standard, claiming that people should be able to vary their posture (Kroemer 1987; Tougis and Nordin 1987), and that the most commonly observed posture at VDT workstations resembles that of a car driver (Grandjean in Salvendy 1987, p. 1389). "This is understandable," writes Grandjean, "who would like to adopt an upright trunk posture when driving a car for hours?" (p.1388). Grandjean justifies this further:

> A backward leaning posture is justified since it allows a relaxation of the back muscles and decreases the load on the intervertebral discs. The traditional office chairs with relatively small backrests are not suitable for a VDT workstation (p. 1394).

Grandjean (1982) also cites a 1962 study he conducted in which the sitting postures of office workers were observed. Commonly observed postures included sitting in the middle of a chair, leaning on the backrest, and leaning forward with arms rested on a table. Figure 2-3 is a candid photograph of students in an educational resource center that lends further support to these observations. Though the illustrations and specifications in ANSI/HFS (1988) appear to assume an upright position, they nevertheless states that "...a well designed chair will provide comfort for static posture as well as allowing for freedom of movement" (p. 52).

Figure 2-2: Two commonly observed seating postures assumed by students while listening to tapes at an educational resource center.

Table 2-1: Workstation specifications reference table.



Dimension	ANSI/HFS (1988)	Grandjean (1987)	Woodson (1992)
Seating			
A - Height	16.0-20.5 in. (40.6-42.0cm)	13.0-22.0 in. (32.0-55.0cm)	15.0-18.0 in.(38.0-46.0cm)
B - Depth	15.0-17.0 in. (38.0-43.0cm)		16.0 in.(43.2 cm)
C - Width	18.2 in. (45.0 cm) minimum		19.0 in. (48.0 cm)
D - Pan angle	$0 - 10^0$		5 degrees
E - Seatback /pan angle	$90\text{-}105^0$	$90\text{-}120^0$	105^0 (10^0 free pivot)
F - Backrest height	no specific recommendation		15.0-18.0 in. (38.0-46 cm)
G - Backrest width	12 in. (30.5 cm) minimum		
H - Armrest distance	18.2 (45cm) minimum		
I - Lumbar support	6 -10in.(15.2-24.4 cm) abv seat	4.0-8.0 in.(10-20) abv seat	
Worksurface			
J - Width	sufficient for equipment and task		32.0 in. (81.0 cm)
K - Depth	sufficient for equipment and task		24.0 in. (61.0 cm)
Keyboard			
L - Support surface ht.	23.0-28.0 in. (58.4-71.1 cm)	27.5-33.4 (70.0-85.0 cm)	
M - Arm angle	$70\text{-}135^0$	90^0 observed avg posture	
N - Slope	$0\text{-}25^0$		
Video Display			
O - Viewing Distance	12.0 in. (30.5 cm) minimum	19.6-29.5 in. (50.0-75.0cm)	
P - Support surface ht.	position within viewing angle Q	35.4-45.2in.(90.0-115.0cm)	
Q - Viewing angle	$0\text{-}60^0$ below horiz. line of sight	$+2$ to -26^0 observed	
Clearance Envelopes			
R - Leg clearance width	20.0 in. (50.8 cm) minimum		
S - Leg clearance height	26.2 in. (66.5 cm) minimum	23.6 in. (60.0 cm) minimum	23.0-28.0 in. (58.4-71 cm)
T - Depth at knee level	15.0 in. (38 cm)		
U - Depth at toe level	23.5 in. (59.0 cm)		

2-2b. Desks

Ideally, a workstation desk should be viewed as more than the sum of its surfaces and moving parts. It should effectively integrate worksurfaces and/or supportive hardware for reading and writing as well as support surfaces for essential equipment, such as the visual display (computer monitor) and keyboard. Also considered within the desk area is the *clearance envelope* for leg room under the workstation. The desk should allow the user to comfortably reach and operate workstation equipment, view display and hardcopy, write, make necessary adjustments to all components, and still comfortably fit into the rest of the available space. Adjustability appears to be widely recommended, as Grandjean (Salvendy 1987) contends that "a VDT workstation without adjustable keyboard height and distance of the screen is not suitable for continuous work with a VDT" (p.1394).

Where worksurface dimensions are concerned, ANSI/HFS (1988) recommends no dimensional specifications other than the following:

> The worksurface and both keyboard and display support surfaces (if they are separate) shall be sufficient to accommodate the VDT components necessary to perform the task and have the room necessary to support other task-dependent items, such as hard copy (p. 51).

Table 2-1 provides a listing of the recommended dimensions for the components of a VDT desk, including keyboard and display support surface heights. The clearance recommendations listed in Table 2-1 are the minimum

ANSI/HFS requirements necessary to accommodate the 95th percentile male (see Appendix F).

2-2c. Keyboards

The keyboard most widely used at VDT workstations is an adaptation of the one developed by C.L. Sholes in 1873, and commonly referred to as the "QWERTY" layout. Its wide-spread acceptance is a function of its common usage, and was based on certain limitations of the mechanical typewriter and the ability to transfer existing keying skills from one machine to another (ANSI/HFS 1988 p.35). Cursor keys, a "mouse," and/or trackball are recommended for text processing applications (p. 36). Generally, these amenities are provided either separately or in combination with most modern computing equipment.

The keyboard's placement within the workstation must allow the user to assume the recommended arm angle ranges (Table 2-1). This is a function of the height and slope of the keyboard support surface. ANSI/HFS (1988) acknowledges that keyboard slope is a matter of personal preference (p. 37). As a general guideline, they recommend that the keyboard slope be between 0 and 25 degrees (p.37). In their reference to research findings (Armstrong et al 1984), however, they suggest that keyboard slopes be limited to a range between 0 and 15 degrees, since wrist extension beyond 15 degrees has been concluded to be associated with *carpel tunnel syndrome.*

2-2d. Visual Display Viewing Locations

A VDT user typically views the computer monitor as well as printed materials in the performance of tasks. Therefore, in addressing viewing locations within the context of workstations, *visual display viewing locations* will refer to the placement of the computer monitor as well as the placement of hardcopy, as opposed to *video display systems* which refer to the computer monitor only.

Leed and Leed (1987) identify 5 factors for proper placement of any visual display: 1) the *size* of the display; 2) the *height* of the display; 3) the viewer's *distance* from the display; 4) the viewer's *angle* from the display; 5) the viewer's *need for sharp detail*(p. 234). The standard method of measuring computer and video screens in the United States is by inches diagonally across, and display sizes of 5 - 25 inches are common. Computer monitors incorporated into educational workstations for individual use generally range from 13 - 16 inches with larger displays (16 - 21 inches) used for critical graphic applications such as CAD/CAM or desktop publishing. Group presentations of computer-based media may utilize monitors up to 42 inches.

There is considerable variability in the literature as to the appropriate viewing distance range of a VDT screen (see Table 2-1). The ANSI/HFS (1988) standards establishes a *minimum* of 12 inches (30 cm). Research by Jaschinski-Kruza (1988) concluded that users found video displays placed at 50cm (19.6 in.) to be too near and more conducive to visual strain than a distance of 100cm (39 in.). Later research by Jaschinski-Kruza (1990) observed a preferred viewing range of 50 - 81cm (19.6 - 32 in.) when subjects were free to adjust the screen. An analysis of research findings on user-preferred workstation settings by Grandjean (Salvendy 1987) revealed a composite viewing distance range of 44 - 96 cm (17 -38 in.). Grandjean's actual recommendations are listed in Table 2-1.

The height of the display directly affects the user's viewing angle. A display that is too high or too low relative to the observer's normal line of sight will cause the user to hold the head in a strained position for an extended period of time. Bennett (1977) cites the 1973 research of Crouch and Buttolf, which concluded that positions from 0^{0} to 15^{0} below the horizontal were judged by student subjects as the best viewing angles for visual displays. As the viewing angle went above the horizontal, it was judged *immediately* as poorer. Bennett describes this as the "front pew" effect:

> It has been frequently noted how churchgoers avoid the front pews. Although some have interpreted this phenomenon as avoidance of close confrontation with God's representative, it is more likely caused by the discomfort suffered when looking upward. The muscles in the back of the neck are compressed when the head is tilted backward (p. 48).

Bennett continues to explain how the placement of signs high enough to be unobscured by furniture often go unnoticed by people, who generally walk with their heads naturally facing forward or tilting downward (p.48). User preference for declined viewing angles at VDT workstations has also been observed by Kroemer (1987). In McVey's (1979) study of large group media presentation rooms (i.e. lecture halls and auditoria), viewing locations had the highest rating of importance to students. Grandjean's observations of users at VDT stations (Table 2-1) showed preferred angle ranges of +2° to - 26° from the horizontal. ANSI/HFS (1988) makes the following general recommendation for screen height location in terms of the its relationship to the seated user's primary viewing area:

> The height of the display support surface shall permit the entire primary viewing area of the display to be located between zero and 60 degrees below the horizontal plane passing through the eyes. (p.49)

The user of a computer workspace must often view both the VDT and paper-based documents related to the project at hand. Though it had been commonly assumed in ergonomic guidelines that viewing distances to the screen and hardcopy should be the same, Jaschinski-Kruza (1990) found that visual strain was no greater when they were at different viewing distances. Accordingly, there is sufficient room for user preference in screen and document placement. It is generally agreed, however, that documents should be placed within the same visual plane and viewing angle as the computer screen (VDT Ergonomics Committee 1993).

2-2e. Video Display Systems

A workstation's video display system, or monitor, should be readable to the user within recommended viewing distances. One of the attributes of a monitor considered by many to be most conducive to its readability is its *resolution*, defined by ANSI/HFS (1988) as "... a measure of its ability to display the smallest discernible details" (p. 17). According to this source, a visual display system's resolution should be quantified by the *Modulation Transfer Function Area* (MTFA) method, which has been shown to positively correlate with visual performance. However, this method is presently accepted for monochrome displays only, and there is presently, according to this source, no accepted method for the evaluation of other commonly used displays, such as color and grayscale.

It should also be noted that at the publication time of many of the source texts, most computer workstations were equipped with *negative polarity* displays utilizing light characters on a dark background. Many educational institutions, in their pursuit of user-friendly software packages, multimedia, and other graphic intensive applications, have utilized *positive polarity* displays that feature dark characters and graphics on a light background. Earlier research found no difference in visual comfort or performance as a result of screen polarity (Zwahlen and Kothari 1986), though a more recent study found positive polarity screens to be ergonomically more appropriate as well as more appreciated by users (Taptagaporn and Saito 1990).

Another characteristic considered to be important in an effective visual display system is luminance (photometric brightness). The luminance of visual displays is measured in either *candelas per square meter* (cd/m^2) or *foot-lamberts* (fL). ANSI/HFS (1988) recommends a minimum luminance of 35 cd/m^2 (10fL) for either the character or the background, whichever is higher (p. 19). Screen luminance as a visual factor within the total VDT workspace is discussed in Section 2-3b. ANSI/HFS (1988) further recommends employing precautions to avoid glare on computer displays from luminous sources. These precautions may be in the form of swivel bases that help the user position the display away from sources of glare, or anti-reflective coatings or faceplates for the screen.

2-2f. Spatial Considerations

Since space requirements for computing environments will vary considerably among contexts, there are no specific recommendations from the source texts. General recommendations for classroom spaces are typically 15 - 25 square feet per person (Lord 1977; McVey 1988). When considering the inclusion of a workstation, it is generally recommended that there be enough room for the required equipment and relevant support surfaces, and enough space for the user to perform tasks with efficiency and safety (McVey 1988). As workstations are usually equipped with movable chairs on casters, row spacing should provide a minimum of 36 inches between stations to provide freedom of movement within the workspace and access between rows, and 42 inches if an instructor is to personally monitor student activities at a workstation (McVey 1991).

2-3. Interior Environmental Elements

2-3a. Lighting

Lighting solutions for computer environments are particularly complex in that they must be designed to control unwanted glare on VDT screens while providing sufficient illumination for the paper-based tasks commonly performed in these areas. Lighting is but one aspect of the luminous environment of any workspace, and part of a collective balance of general illuminance levels, window light control, and surface reflectance and contrast. All of these aspects must work together to provide a visual environment that facilitates learning and productivity without being distracting, tiring, unpleasant, or otherwise inadequate to the task.

The literature pertaining to lighting discusses illuminance levels in terms of two units of measure, *footcandles* (FC) and *lux*. While many of the sources appear to use these units interchangeably, the most recent engineering texts such as those published by the Illuminating Engineering Society (IES 1989) use lux. For the purposes of reader convenience and to maintain consistency throughout the study, both units of measure will be presented. Conversion factors are presented in Appendix B.

There is some variability in the literature with regard to recommended lighting levels for computer workspaces. ANSI/HFS (1988) considers 200 to 500 lux (19 to 46 FC) to be normally sufficient for VDT workspaces as measured on the work area of the worksurface (p. 11). Christinaz and Knirk (1987), while citing a 30-75 footcandle range for general classroom activities, contend that when VDTs are used, lighting levels should be based on the readability of associated materials and the surrounding area, and warn that adherence to raw footcandle standards will not in themselves ensure sufficient or efficient task illumination (p.229). Grandjean (1982) explains in further detail:

> Specifications for lighting levels can be no more than general guidelines, and other circumstances must be taken into account in any particular situation. For example:
> (a) the reflectivity (colour and material) of the working materials and of the surroundings;
> (b) the extent of difference from natural lighting;
> (c) whether it is necessary to use artificial lighting during the daytime;
> (d) the age of the people concerned. (p.271)

The varying recommendations for lighting VDT workspaces are in part due to the need to maintain a balance between the lower level requirements for viewing the VDT, and the higher requirements of hardcopy tasks. Ruck (1989), an architectural text, recommends a low overall room illuminance of about 300 lux (28 FC) with supplementary lighting at each workplace for a local illuminance of 500 lux (46 FC). Research by Taptagaporn and Saito (1990) found lighting levels of 500 lux to be appropriate for work with positive polarity displays. The Illuminating Engineering Society (IES 1989), like Grandjean (1982), takes into account the visual environment, worker characteristics, and occupational requirements:

> In order to establish the illuminance target value within the appropriate range, the following factors must be considered; the age of the workers (older eyes require more illuminance), the speed and/or accuracy required, and the reflectance of the task background (IES 1989, p.4).

To arrive at the appropriate illuminance level, the IES recommends an *illuminance selection procedure* (IES 1989, p.4). For an up-to-date office, for example, a three-tiered range of 200-300-500 lux (19-28-46 FC) is established. The target illuminance value within this range is then selected according to the weighting factors listed in Table 2-2. These factors are added or subtracted, with totals of -2 or -3 indicating the use of the lower value, and +2 or +3 indicating the use of the upper value. Otherwise, the middle value is appropriate. Accordingly, a modern office with workers over 55 years of age, critical speed and accuracy requirements, and a task background reflectance of 30-70% will yield a weighted value of +2, indicating the appropriateness of an illuminance level of 500 lux. The illuminance range may be extended (i.e. 500-750-1000 lux) if a significant amount of time is spent on more critical visual tasks.

Table 2-2: Weighting factors to be considered in selecting illuminance within a range of values. Adapted from IES (1989, p. 4)

	Weighting Factor		
Task and Worker Characteristics	**-1**	**0**	**+1**
Workers ages	Under 40	40 - 55	Over 55
Speed and/or accuracy	Not important	Important	Critical
Reflectance of task background	Greater than 70%	30 - 70%	Less than 30%

One of the most detrimental effects of improper lighting system design is glare, which can impede both the comfort and performance of the occupant of a workspace. Even where lights or reflections are not so bright as to be debilitating, they can still distract the occupant of a workspace through the natural tendency of the human eye to be drawn to brighter sources in the visual field. This effect has been the subject of an investigation which concluded that reinforcing the brightness of classroom visual aids resulted in greater student attention (Laguisa and Perney 1974). Where a controlled reinforcement of brightness patterns might be viewed as a *positive* application of the principle, it is where brightness patterns are *not* controlled that are a potential source of performance problems in a computer environment.

Numerous sources recommend locating equipment or arranging the room so that bright sources are not seen by the VDT user as direct glare or reflections on the screen (Figure 2-3). Additionally, ceiling lights should be shielded with 45 degree parabolic lenses (Figure 2-4) to deflect glare out of the

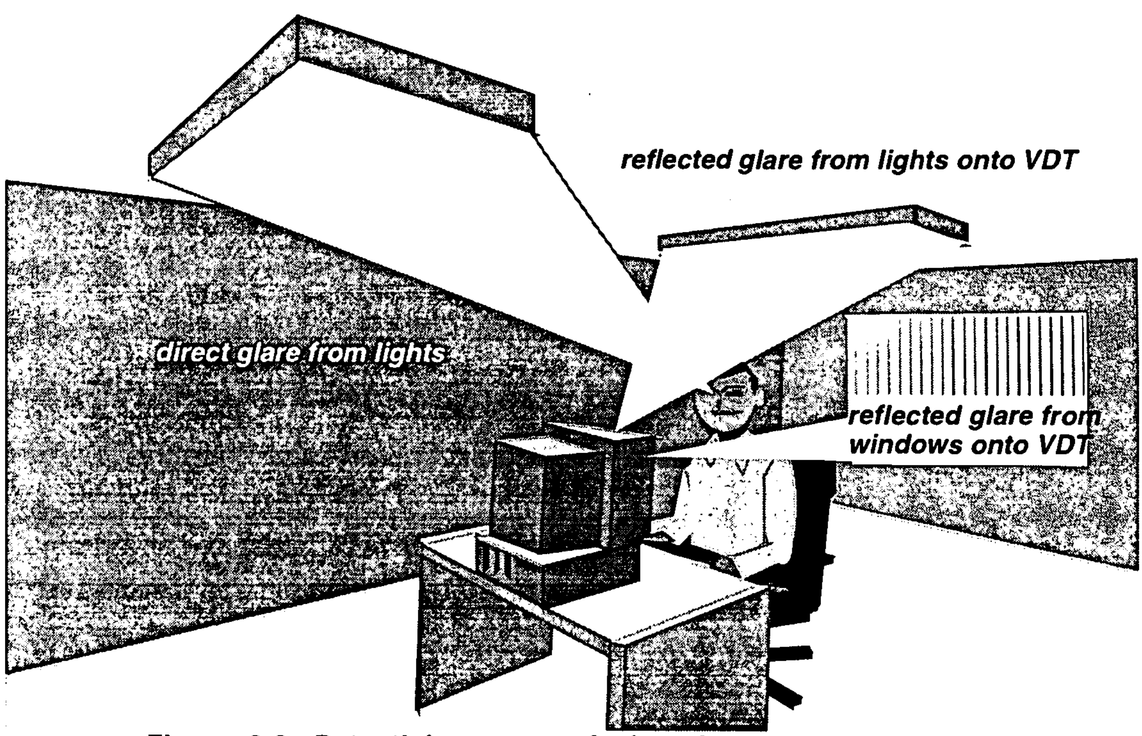


Figure 2-3: Potential sources of glare for the VDT operator.

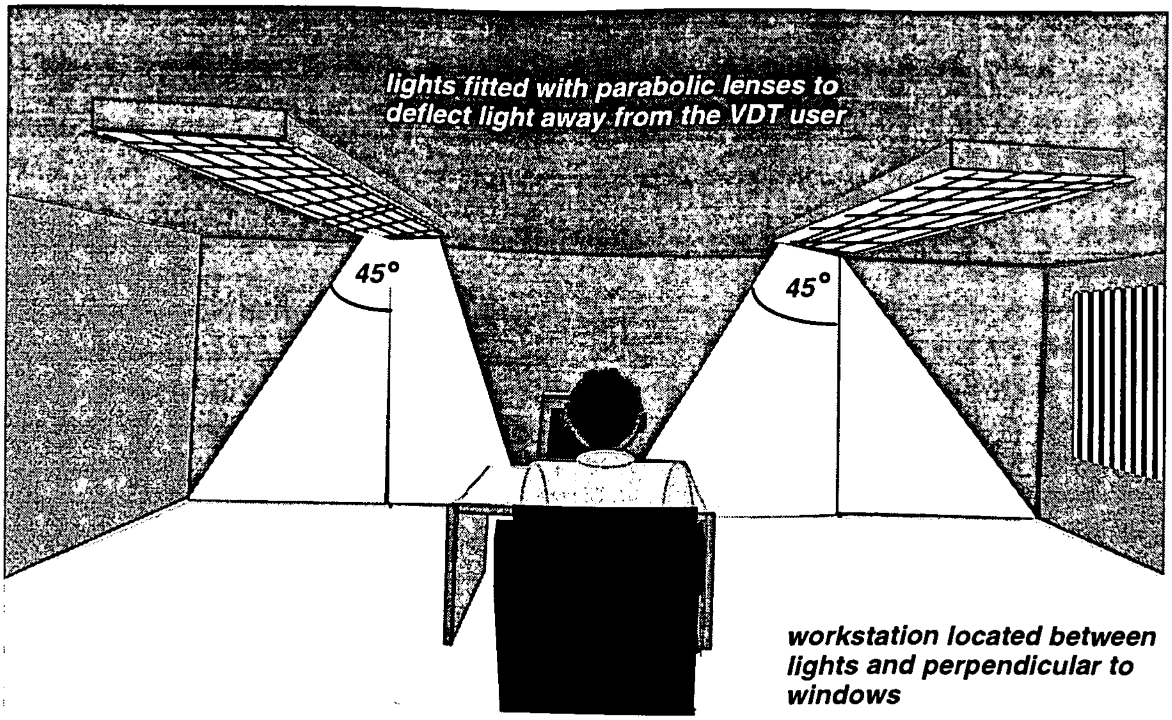


Figure 2-4. Workstation placement as recommended by Grandjean in Salvendy (1987), ANSI/HFS (1988), IES (1989), and others.

visual field and off worksurface areas (Grandjean 1982, 1987; ANSI/HFS 1988; IES 1989; Woodson 1992). Of particular note are lighting systems that direct and diffuse light upward towards a reflective ceiling (Figure 2-5). Computer workers in offices equipped with these systems have reported less problems with glare, fewer eye problems, better productivity, and higher satisfaction (Hedge et al 1989). Woodson (1992) recommends using indirect lighting systems only in areas where reading or other critical tasks are not required. Grandjean (1982) agrees, stating that indirect lighting is not suitable for workrooms unless supplemented with extra light over the workplace (p.265).

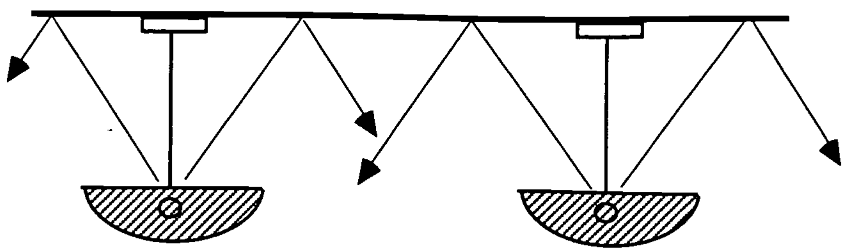


Figure 2-5: Indirect lighting uses the ceiling to reflect light downward. Adapted from Woodson (1992)

Differing opinions and criteria regarding the *color* of luminaire most appropriate for computing environments are seen in the literature. Specific lighting types have been found to influence both cognition and behavior among the occupants of a space (Baron 1990), while other findings have proven otherwise (Boray et al 1989). There has been a popular trend towards the use of full-spectrum fluorescent bulbs, which approximate the lighting quality of natural daylight, as opposed to warm white or cool white bulbs. Research, however, has found no performance or perceptual advantage of one type of fluorescent luminaire over another (Boray et al 1989). Though incandescent lighting has been popularly assumed to be the best solution where room aesthetics is an issue, research has shown that occupants of a space perceive incandescent and fluorescent as equally pleasant (Bennett et al 1985). Where cost-effectiveness is the deciding factor, fluorescent is the luminaire of choice given its long life and low energy consumption (Leed and Leed 1987). Woodson (1992) states that the selection of lighting color should consider the appropriateness of the task at hand, as well as the actual seeing conditions desired.

Windows are often considered a disadvantage in computer and other media facilities because of the limited control of unwanted light, heat, noise, and vandalism they present. It is generally recommended that where windows are present, they should be fitted with shades or louvers to regulate the amount of light and heat that enters the room (Christinaz and Knirk 1987; McVey 1988). When carefully utilized, windows can also contribute to an effective lighting solution, as well as to the overall pleasantness of a space. Allowing a moderate amount of sunlight into a workspace, for example, has been shown have a relaxing effect on office workers that is beneficial to the performance of tasks requiring a high degree of concentration (Boubekri et al 1991). Current trends in energy conservation for office environments have led to the design of *integrated lighting systems* that combine natural daylight with interior lighting. The utilization of exterior light enables less resources to be directed to electric lighting. Design considerations for integrated systems, however, must take into consideration the size and shape of windows as well as utilizing electric lighting with color rendition compatible with daylight (Ruck 1989, p. 103 - 108).

<u>2-3b. Color, Reflectance, and Contrast</u>

The attributes of color, reflectance, and contrast work together to provide additional quality to the visual environment. Though each can be viewed on its own terms, their inherent relationship to one another is evident. Therefore, they will be presented together in this section to further illustrate this relationship.

Collectively, the literature seems to portray color as serving a dual purpose in the built environment. One is subjective and reactionary on the part of the occupant (i.e. aesthetic, psychological, physiological). The other is as a reflectant property on a continuum of black (0) to white (1) and the relative percentages of those values. Grandjean (1982) views the planning of a room's color scheme as meriting considerable attention:

> Before starting to plan the colour for a room, there must be a careful consideration of its functions, and who is going to use it. After that it will be possible to plan its colours in relation to psychological and physiological factors. (p. 288)

Bennett (1977), however, takes a less serious view:

> Color is clearly an important part of the luminous environment. However, probably more nonsense has been written about color effects than about any similar phenomena. Many writers confuse their strongly held beliefs with facts. In a large number of research studies carried out over the years, many seemingly contradictory results have been found. Some of this may be due to poor research, but the major reason is probably that many reactions to color are *very small effects.* (p. 104)

In the face validity analysis conducted in the McVey (1979) study, students gave color and reflectance their lowest rating with regard to what was important to them in their learning environment (see Section 1-4, Table 1-1). This would appear to lend support to Bennett's contention.

It is generally accepted, however, that color is important to the perceived pleasantness of a space, and that some colors are more appropriate than others for use in a learning environment requiring quiet concentration, such as a library or computer lab. An accepted general color solution for learning environments are the utilization of neutral tones (i.e. gray, beige, light green) within the visual field and the avoidance of stressful colors, such as saturated blues and reds. Exceptions may be considered for areas that are out of the visual field (walls, floors) or where visual excitement is desired (McVey 1988).

The reflectance properties of color have a significant effect on the visual environment in terms of perceived brightness and pleasantness. Grandjean (1982) states "When deciding upon colours in and around a work place, it is necessary to consider reflectivity" (p. 285). Table 2-3 lists the reflectance values of typical colors and materials.

Along with the appropriate color scheme, the surface treatments of a computing facility's equipment, furniture, and interior elements should provide enough variability in the reflectance of ambient light for a visually interesting environment. However, care must be taken to protect the user against distracting or disabling glare. IES (1989) recommends the avoiding of glossy desktop surfaces, in favor of those with matte finishes:

> A glossy desktop may reflect a mirror-like image of a ceiling luminance or luminaire luminance into the operator's eyes. The result may be discomfort glare or even disability glare; therefore, desk tops and work surfaces should have a matte finish that will diffuse the image. (p.6)

Table 2-3: Reflectivity of colors and materials in percentage of the incident light. From Grandjean (1982, p. 285)

Color and materials	Reflectivity (%)
White	100
Aluminum; white paper	80-85
Ivory; deep lemon yellow	70-75
Deep yellow; light ochre; light green; pastel blue; pale pink; cream	60-65
Lime green; pale gray; pink; deep orange; bluegray	50-55
Powdered chalk; pale wood; sky blue	40-45
Pale oakwood; dry cement	30-35
Deep red; grass green; wood; pale leaf green; olive green; brown	20-25
Dark blue; purple red; reddish brown; slate gray; dark brown	10-15
Black	0

ANSI/HFS (1988) provides specific recommendations for the immediate workstation area :

> The specular reflectance, or gloss, of equipment covers and furniture surfaces shall be 45 percent or less.... (p.14)

Recommendations for surface reflectance values considered appropriate for computer workspaces are shown as a composite illustration in Figure 2-6. Workstation elements (furniture, equipment covers, screen, hardcopy, and keyboard) are adapted from Grandjean (Salvendy 1987) and room elements (walls, ceiling, floor) are as specified in the IES *Lighting Handbook* (Kaufman 1981).

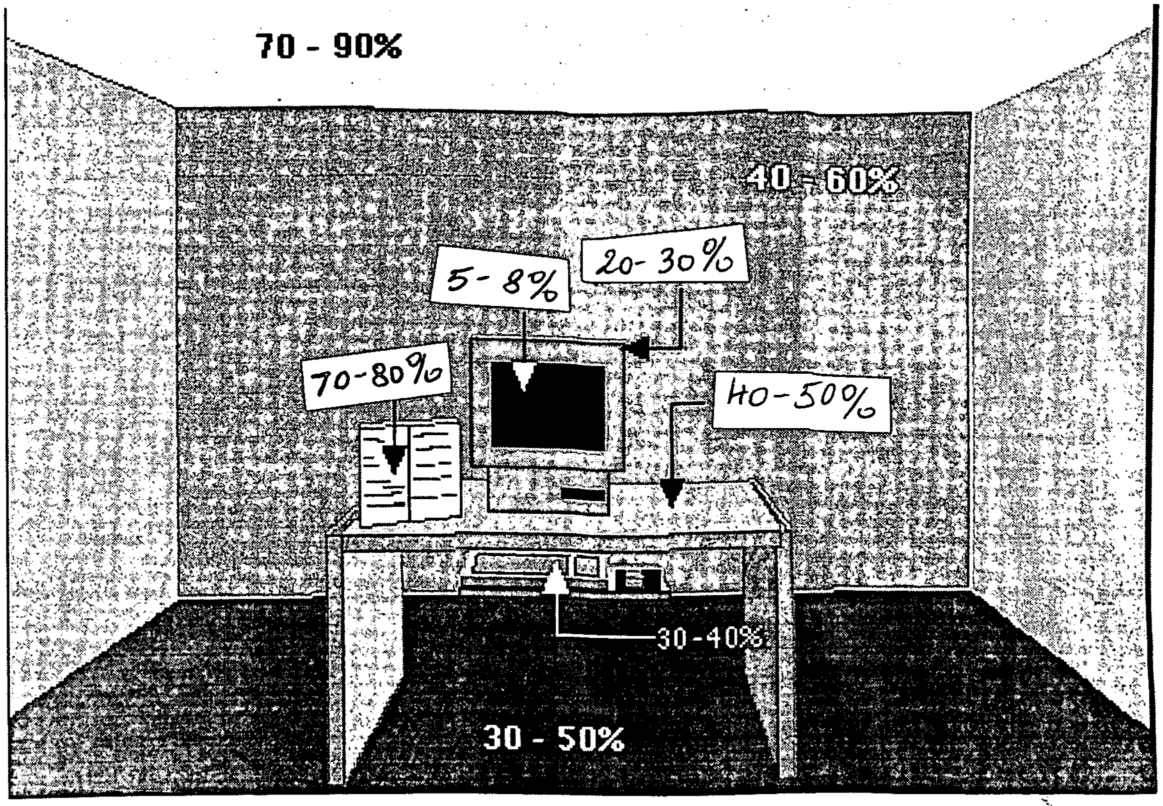


Figure 2-6: Composite reflectance values for computer workspaces. Adapted from IES recommendations (Kaufman 1981) and Grandjean (Salvendy 1987, p.1371).

Surface reflectance and illumination combine to produce the quality of *luminance* in the visual environment of a workspace. Luminance can also be a function of light transmitted *through* a surface, such as a VDT screen or window. Bennett (1977) explains:

> When illumination falls on an opaque surface and is reflected or when it falls on a transparent or translucent surface and is transmitted through it, people see the brightness (or in physical terms the luminance) of the surface.... Luminance equals illumination times reflectance (or times transmittance.) (p. 90)

Earlier writings often used the term "brightness" to describe or directly refer to luminance. Brightness, however, is actually a *perceived*

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phenomenon, and is a subjective reaction to luminance (Halsted 1993). Recent definitions have since endeavored to distinguish measurable physical properties from what is perceived by the occupant. Both terms are used throughout the literature, though the standards they imply are consistent. Luminance levels are often measured and referred to in terms of *foot lamberts* (fL), though the unit of measurement currently preferred by the IES (1989) is *candelas per square meter* (cd/m^2) (see Appendix A and B).

The relationship of the luminance values of adjacent and distant surfaces results in what is termed the *luminance ratio* (or *brightness-contrast ratio* (BCR) as discussed in earlier writings). This is expressed as a quantity of light coming from a given surface in proportion to adjoining and surrounding surfaces within the visual field. These values combine to create the visual task-surround contrast of the workspace. If the contrast is too stark, the viewer's eyes will eventually tire from constant adaptations to luminance levels. In general, a luminance ratio range of 1:3 - 1:10 is recommended (Grandjean 1982; IES 1989; Woodson 1992). Surface areas that are visually adjacent to the task and in the middle of the visual field are especially critical, and should not differ from the task area by more than one-third (1:3). The luminances produced by distant surfaces (i.e. walls, ceilings, windows) should not be greater than 10 times the visual task (1:10). Grandjean (1982) explains further:

> (a) all surfaces within the visual field should be of the same general order of brightness, to avoid dazzle effects;
> (b) the general level of illumination should not fluctuate rapidly because adaptation is a relatively slow process. (p. 122)

Table 2-4 lists the maximum luminance contrast ratios for VDT offices as recommended by the Illuminating Engineering Society (IES 1989). These recommendations are consistent with other general sources (Woodson 1992), as well as verified in educational research on projected images (DesRosiers 1976). ANSI/HFS (1988), however, is critical of present luminance contrast guidelines for VDT environments:

> Published empirical data on luminance differences between sequentially fixated areas that affect performance and comfort of VDT users suggest that earlier strict recommendations of luminance ratios of 3:1 and 10:1 between the task and any other source of luminance in the visual field cannot be justified (Farrell, Lynch, and Bennett, 1986; Kokoschka and Haubner 1985). The balance between the luminance levels of sequentially and frequently fixated areas should therefore be determined in terms of the visual task, considering the highest and the lowest luminance levels, together with the average luminance levels. The balance between the luminance levels within the VDT user's field of view is left to the discretion of an equipment designer or system integrator, with the caution that extreme luminance differences between sequentially and frequently fixated areas, or even only occasionally fixated areas, may produce noticeable performance decrements and discomfort. (pp. 13-14)

Table 2-4: Recommended maximum luminance ratios for VDT offices. IES (1989, p. 2)

Between paper-based visual tasks and an adjacent VDT screen	3:1
Between a visual task (paper or VDT) and adjacent dark surroundings	3:1
Between a visual task (paper or VDT) and adjacent light surroundings	1:3
Between a visual task (paper or VDT) and more remote dark surfaces	10:1
Between a visual task (paper or VDT) and more remote lighter surfaces	1:10

Table 2-5: Illuminance required to produce luminance ratios of 1:3 and 3:1 between various VDT screens and adjacent surfaces. From IES (1989, p. 5)

1	2	3	4	5	6	7	8	9	10
VDT avg screen luminance (cd/m2)	Adjacent surface luminance (cd/m2) for 1:3	Adjacent surface luminance (cd/m2) for 3:1	Adjacent surface reflect. (%)	Illuminance (lux) producing surface luminance shown in columns 2 and 3		300 Lux falls within range of req. illumin.	500 Lux falls within range of req. illumin.	750 Lux falls within range of req. illumin.	1000 Lux falls within range of req. illumin.
			Paper 0.8	20	190				
17	5.8	51	Paper 0.6	30	250				
			Desk 0.45	40	330	Yes			
			Desk 0.25	70	600	Yes	Yes		
			Paper 0.8	60	560	Yes	Yes		
51	17	153	Paper 0.6	80	750	Yes	Yes	Yes	
			Desk 0.45	110	1000	Yes	Yes	Yes	Yes
			Desk 0.25	200	1800	Yes	Yes	Yes	Yes
			Paper 0.8	100	940	Yes	Yes	Yes	
85	28.2	255	Paper 0.6	140	1250	Yes	Yes	Yes	Yes
			Desk 0.45	180	1670	Yes	Yes	Yes	Yes
			Desk 0.25	330	3000		Yes	Yes	Yes

Table 2-5, from IES (1989), further illustrates the integrative relationship between the elements of a computer workstation's luminous environment. To provide the appropriate 1:3 luminance ratio for adjacent task areas, the ambient lighting levels (illuminance) should be coordinated with the luminance of the VDT screen and surface reflectances (pp. 4 - 5).

2-3c. Acoustics

Acoustical design goals for a computer environment need to address sound levels from a number of sources: 1) noise generated by the equipment within the immediate workstation area; 2) incidental noise in adjacent and surrounding workspaces, such as keyboard noise, conversation, and movement; 3) noise generated by architectural systems (i.e. lighting, HVAC); and 4) the transmission of external sound sources from adjacent rooms or outside of the building. If the facility is also used for training or classroom sessions, an acoustical environment conducive to speech communications must be considered as well. In reference to these issues, ANSI/HFS (1988) makes the following general recommendation:

> The acoustical design objectives for a work space should consider a balance of sound from all sources. The background level should be low enough to avoid interference with activity or speech but high enough to mask intrusive sounds from adjacent spaces. (p. 14)

The effects of noise on human performance is dependent on a number of factors beyond mere volume. Among the attributes of sound are *spectrum* , or the characteristics of a sound in terms of its collective frequencies; *sound pressure level*, perceived as loudness and measured in decibels (dB); and *duration*, or the exposure to the patterns a sound assumes over time (Rosenberg 1989). The interaction of these auditory dimensions will determine how a given sound, at what level and for how long, will influence the performance and comfort of the occupants of a workplace. Jones and Broadbent (Salvendy 1987) further identify four categories of the performance effects of noise : 1) effects of arousal ; 2) effects of lack of control; (3) strategic effects (performance on tasks); and 4) effects on attention (p. 636).

The complexities of these cause-effect interactions within the acoustic environment are evident in the way that studies on this topic have revealed some obvious, as well as surprising results. Kyzar's (1977) study of noise pollution and schools found that traffic noise directly outside of a school building adversely affected the essential instructional processes of communication, concentration, and performance on tasks requiring attention to detail. Loewen and Suedfeld (1992) demonstrated that masking common office sounds with artificially generated white noise resulted in less distraction, lower stress, and better performance, in spite of the fact that the overall sound levels *increased* as a result of the masking. Kjellberg and Sköldström (1991) discovered that the nature of a specific task (manual vs. intellectual) appears to account for only a small part of differing tolerances for noise levels in different workplaces.

Background noise levels are often identified in terms of *decibel levels* (dB) utilizing a scale that approximates the human hearing curve (dBA). Another set of curves used to determine ambient noise levels are the *Noise Criterion* (NC) curves, or their most recent manifestation, the *Preferred Noise Criterion* (PNC) curves. These curves address specific sound pressure levels at specific frequencies. In general, frequencies at the lower end of the spectrum can have a higher sound pressure level than those at the middle and higher end. NC and PNC ratings are considered by some experts to be more reliable overall than overall sound pressure levels as determined by the dBA scale alone. Another convenient application of NC ratings is their direct translation into *Speech Interference Levels* (SIL) to assess the efficacy of speech communications within a space (Woodson 1992).

NC curves were developed and first published in 1957 as a means of evaluating existing noise conditions and to specify design goals for noise control. However, it was found then when noise conforming to a particular NC curve is deliberately generated, listeners perceive the noise as "hissy" and "rumbly" rather than pleasant or neutral. In response to these findings, the *Preferred Noise Criterion* (PNC) curve, an alteration of the NC scale, was established in 1971 (Beranek et al 1971). PNC curves are identical to NC curves at midfrequencies (125Hz, 250Hz, 500Hz), but lower the allowable sound pressure levels in the other frequency bands.

Table 2-6 shows the recommended sound pressure levels of each center octave-band frequency and their corresponding PNC curve. Table 2-7 shows PNC and dBA specifications for steady ambient noise levels for various workspaces with activities similar to educational computing areas. ANSI/HFS (1988) recommends that ambient sound pressure levels in a VDT environment not exceed 55dBA, which approximates PNC-50. This is generally considered the upper limit of acceptability in spaces where quiet is expected (Woodson 1992). Beranek et al (1971) recommends that sound levels not exceed PNC-60 for any office or communication situation.

As shown in Table 2-7, a PNC rating of 30 - 40 (38 - 47dBA) is generally recommended for relatively quiet workspaces such as libraries as well as critical communication areas such as classrooms and conference rooms. Beranek et al (1971) further recommends that sound levels not exceed PNC-35 for classrooms without sound amplification. These levels are especially applicable for a computing facility that is used for live classroom or training applications. Enough of a steady, broadband sound should be present in the acoustical environment of a computing facility to cover up, or *mask*, common and potentially distracting sounds such as typing, writing, page turning, and conversing (ANSI/HFS 1988; Loewen and Suedfeld 1992). While a facility's HVAC and lighting systems should in themselves provide enough background sound for general noise masking, white noise can be introduced electronically through loudspeakers for a more effective noise masking system if the level is not sufficient (McVey 1988; Ramsey and Sleeper 1989). The resultant levels, however, should not exceed the acoustic requirements of the space (Table 2-7).

Table 2-6: 1971 PNC curves and their recommended sound pressure levels per octave-band frequency. From Beranek et al (1971, p.1226)

PNC curve	31.5 Hz	63 HZ	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
PNC-15	58	43	35	28	21	15	10	8	8
PNC-20	59	46	39	32	26	20	15	13	13
PNC-25	60	49	43	37	31	25	20	18	18
PNC-30	61	52	46	41	35	30	25	23	23
PNC-35	62	55	50	45	40	35	30	28	28
PNC-40	64	59	54	50	45	40	35	33	33
PNC-45	67	63	58	54	50	45	41	38	38
PNC-50	70	66	62	58	54	50	46	43	43
PNC-55	73	70	66	62	59	55	51	48	48
PNC-60	76	73	69	66	63	59	56	53	53
PNC-65	79	76	73	70	67	64	61	58	58

Table 2-7: Recommended PNC curves and dBA levels for various workplaces.
Adapted from Beranak et al (1971, p. 1227)

Type of workspace	PNC curve	Approximate dBA
Private or semi-private offices, small conference rooms, classrooms, libraries, etc. (good listening conditions)	30 - 40	38 - 47
Large offices, reception areas. (moderately good listening conditions)	35 - 45	42 - 52
Lobbies, laboratory work spaces, drafting and engineering rooms (fair listening conditions)	40 - 50	47 - 56
Light maintenance shops, office and computer equipment rooms (moderately fair listening conditions	45 - 55	52 - 61

A room's reverberation time (RT) is also a factor in how sound is transmitted. This unit is expressed as the number of seconds it takes for a sound level to decay 60 decibels. Recommendations for reverberation times are usually derived from room size and intended function. A maximum of 1.0 seconds is generally accepted for classrooms (Ramsey and Sleeper 1989), and some sources would place the limit at 0.8 seconds for rooms where speech articulation is an issue (Ruck 1989). Acoustical design considerations for controlling reverberation time require a combination of absorptive, reflective and diffusive surfaces. How these elements are combined depends on the acoustic environment required for the situation. The typical sounds of computer rooms, classrooms, and open plan offices respond well to surface treatments such as carpet, acoustical ceiling tile, and upholstered furniture (McVey 1988; D'Antonio 1989; Ramsey and Sleeper 1989). An additional recommendation provided in Ramsey and Sleeper (1989) is to locate adjacent workers at least 8 ft. apart, if possible, to take advantage of the fact that sound levels drop off with distance. Spacing this generous, however, is not likely to be realistic for educational situations.

Sound isolation is measured in terms of Sound Transmission Class (STC), and represents the transmission of airborne sound from one space to another through their common physical partitions (i.e. walls, windows, ceilings, floor). These partitions should be constructed of attenuating materials and/or arranged in such a way as to prevent transmission. The intended activities of a room determine its STC requirements. STC ratings are properly used in the evaluation of *speech privacy potential* for partitions separating workspaces such as adjacent offices, classrooms, and small conference rooms where their is no amplification, low frequency or impact noise (Ramsey and Sleeper 1989). Table 2-8 provides a listing of the recommended STC requirements for various office and educational spaces as adapted from Ramsey and Sleeper (1989).

Table 2-8: Recommended STC ratings for various spaces. Adapted from Ramsey and Sleeper (1989)

Source room occupancy	Receiver room adjacent	STC requirement between source and receiver
Normal offices, regular conference rooms for group meetings; normal privacy requirements	Adjacent offices and similar activities	50-55
Large general business offices, drafting areas, banking floors	Corridors, lobbies, data processing; similar activities	45-50
School buildings (a) Classrooms	Adjacent classrooms	50
	Laboratories	50
	Corridors	45
(b) Large music or drama area	Adjacent music or drama area	60
(c) Music practice rooms	Music practice rooms	55
Interior occupied space	Exterior of building	35-60

2-3d. Thermal Conditions and Air Quality

Heating, ventilation, and air conditioning (HVAC) in computing environments is concerned with the physical comfort of the user as well as the maintenance of temperature and humidity levels appropriate to the proper functioning of electronic equipment. Though environments with inadequate thermal and air quality are commonly thought to be the most named detractors of learning (Leed and Leed 1987), the actual importance of these environmental factors to users appears to have mixed reviews in the literature. Users in McVey's (1979) face validity analysis prioritized thermal considerations in fifth place among nine environmental features. Prezant and Kleinman (1987) found that issues associated with ventilation were considered less important than seating and noise. Office workers in another study, however, rated temperature as the factor that contributed most to the quality of the indoor space (Rohles et al 1987). Perhaps it is because this aspect of the interior environment is so visceral that it goes completely unnoticed if systems are functioning properly, and the first problem noticed when they are not.

The dimensions of thermal comfort are both personal and environmental, and are an interaction of metabolic rate, clothing insulation, air temperature, radiant temperature of surroundings, rate of air movement, and atmospheric humidity (Auliciems in Ruck 1989, p.4). Other combined factors known to influence thermal comfort are such personal dynamics as an individual's knowledge, experience, gender, age, and place of residence, as well as elements of the interior environment apart from the HVAC system, such as lighting and furnishings (Heijs and Stringer 1988). A commonly used standard measure of thermal comfort is the *effective temperature* (ET), which combines temperature and humidity into a single index (ASHRAE 1993). Two environments with the same ET will elicit the same thermal response from its occupants (air velocity being equal), even though individual temperature and humidity readings may be different. Figure 2-7 illustrates this interaction, and the relationship of effective temperature to thermal comfort. The seasonal comfort zones depicted in this chart reflect the differences in summer and winter clothing insulation. Accordingly, effective temperatures should range between 68^0 - 75^0 in the winter and 73^0 - 79^0 in the summer. Though the chart shows a range of humidity levels that would be comfortable to the occupants of a space, a constant relative humidity level of 50% is recommended for computer rooms to protect against the static that may result from dryer levels (McVey 1988). Where computing environments are areas of low physical activity, air velocity should be maintained within a range of 15-25 feet per minute (McVey 1988; Woodson 1992; ASHRAE 1993).

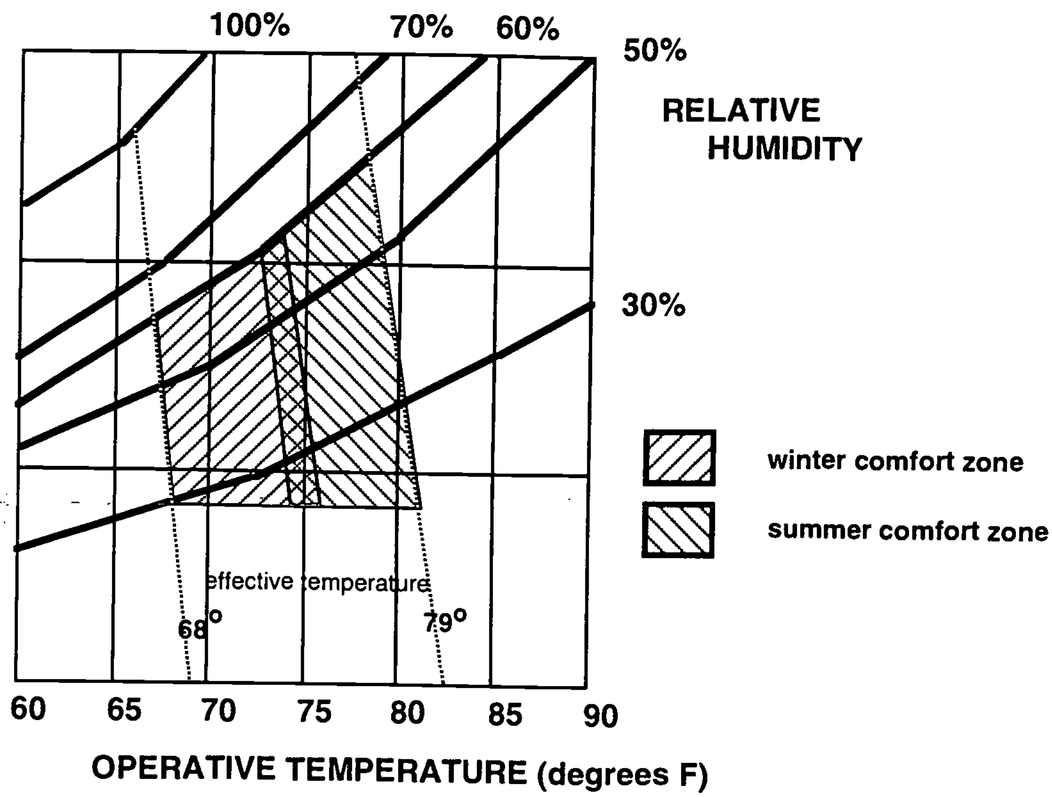

Figure 2-9: Effective temperature and thermal comfort. Adapted from ASHRAE (1993, p.8.13)

Computing equipment itself contributes significantly to the thermal environment. Components generate heat, and are usually equipped with exhaust fans for cooling. ANSI/HFS (1988) recommends the following for the health, safety, and comfort of the VDT user and surrounding workers:

> The exhausting of air from VDT components should be so accomplished as to avoid discomfort to users of the VDT or to others in the vicinity of the equipment.
>
> VDT components **shall** be designed so that forced-air exhausts are not directed toward the operator.
>
> VDT components **shall** be arranged so that forced-air exhausts are directed away from other workers at their work positions.
>
> External surfaces that can be touched during operation **shall** have a surface temperature that does not exceed 50° C (122° F). Surfaces that are intended to be touched during normal operation should not exceed 35° C (95° F).
>
> Heat build-up from equipment under the worksurface (in the area of a VDT user's knees and legs) greater than 3 C (5.5 F) above ambient should be avoided (Ray, 1984; Rohles and Nevins, 1971; Wu, 1975.
>
> (p.15)

2-4. Ancillary Elements

2-4a. Technical Support

Technical support within the context of educational computing generally consists of resident staff who are available to troubleshoot problems and assist users in the effective operation of equipment, as well as documentation in the form of manuals or on-line help. While there are no definitive guidelines as to the appropriate number of support personnel required for a particular situation, it is generally recommended that computer laboratories in schools be supervised and staffed by qualified individuals who are conversant with the software offered, and who can insure the smooth operation of all equipment (Merrill et al 1986). Documentation should be informative and complete, yet be relevant to and focused on the tasks to be accomplished (Duin 1990). The pervasive feeling on computer manuals and other technical documentation, however, is best represented in the following comment:

> Alas, even the best manuals cannot be counted on; many users do not read them. Obviously, it is wrong to expect to operate complex devices without instruction of some sort, but the designers of complex devices have to deal with human nature as it is (Norman 1988, p. 191).

2-4b. Aesthetics and Other Subtleties

Other environmental elements of a learning facility can exert considerable influence on its occupants. Room aesthetics, sense of personal space, user conveniences, and other seemingly non-functional attributes of the facility communicate subtle messages to its users, and contribute greatly to their sense of satisfaction and well-being. An environment for learning, working, or any other purpose communicates *affect* to its users, and influences learning and performance as much as any other aspect of a facility's design. Knirk (1979) views the classroom as a communications medium in itself:

> A classroom itself is a medium of communications. The students react to it. A "hard classroom" with cement or tile floors, with hard plaster walls and ceilings, and with hard surfaced furniture makes a classroom a very *formal* environment. The classroom communicates *affective* data. The student often perceives that he or she can make little impression on it... (p.22)

Leed and Leed (1987) further support this notion:

> Other quality issues include the care, concern, and monetary investment in learner comfort and esteem. First-class facilities subconsciously indicate to the learner, "You are special, you deserve first class," We are proud of you, we are proud of this organization and we are proud you are part of this organization." This type of caring for the learner expressed in the quality of the environment encourages and facilitates effective learning. (p. 4)

Leed and Leed further write that one of the attributes that characterize an ideal learning facility is when "...designers and architects feel the facility meets the needs of the occupants while still meeting aesthetic standards" (p. 5). These standards are is not explicit, and are likely to vary among educational institutions and contexts.

Regardless of the context, it is evident that an environment shapes the activities, behaviors, and perceptions of its occupants. Most learning facilities are designed as "fixed-featured" spaces that are designed around a particular class of activity, whether lecture, concentrated work, or physical activity. Hall (1982) states that "the important point about fixed featured space is that it is the mold into which a great deal of behavior is cast" (p.106). One might therefore consider Hall's concerned observation when balancing human and interior environmental elements in the design of a computing facility:

> As our own technology explodes, air conditioning, fluorescent lighting, and soundproofing make it possible to design houses and offices without regard to traditional patterns of windows and doors. The new inventions sometimes result in great barnlike rooms where the "territory" of scores of employees in a "bull pen" is ambiguous. (Hall 1982, p. 107)

2-5. Summary and Discussion

This chapter contains a review of research, recommendations, and philosophies that have implications for human learning and productivity in environments designed and built for that purpose. While the scope of the disciplines covered implies a difficult and broad undertaking, Bennett (1977) seems to simplify and summarize the language of this review in one short paragraph:

> Design is difficult because it must satisfy several criteria. These design (and evaluation) criteria constitute a hierarchy. First, a space must be safe and healthy. A space must enable users to perform their functions. A design should not cause discomfort. Finally, a design should be aesthetically pleasing. (p.11)

One aspect of the literature that is readily apparent is its focus on offices and other non-educational environments. It also shows, as Caldwell (1994) observes, that significant human factors research is virtually non-existent for educational facilities. Though it is likely that many recommendations presented in the literature are readily transferable, they need to be tested and further developed according to the unique parameters of educational settings and processes. The variability in the literature is not surprising, as people and contexts vary by nature. However, this variability can be utilized to achieve a *specificity of design,* where research findings and their resultant recommendations can be thoughtfully extended or revised when necessary.

What is also evident from the literature is the broad range of disciplines represented, which often operate independently. Consequently, the performance orientation of human factors practitioners and the social, affective, and motivational concerns of environmental designers often do not benefit from each other's work (Parsons 1992). Current research efforts should bridge these disciplines to ensure that environments for learning, whether utilizing high technology or books and blackboards, holistically consider the cognitive, productive, and affective needs of their users, and above all keep them healthy and safe while doing so.

CHAPTER 3
Methodology

3-1. Setting

This study was conducted at the Berklee College of Music, an internationally recognized degree-granting institution of contemporary music education located in Boston, Massachusetts. Berklee's educational applications of MIDI (musical instrument digital interface) and computer-based technologies began with curricular programs in Music Synthesis, Music Production and Engineering, and Film Scoring. These subject areas often require dedicated equipment for specific tasks, and acquiring technical expertise in these tools is a major educational outcome. Since 1989, however, Berklee has further developed computer-based resources and associated technologies for subject areas that are traditionally non-technical in content, such as harmony, composition, ear training, music business, and the liberal arts. The facilities evaluated in this study were designed to support such applications, focusing on instructional delivery (i.e. interactive tutorials, drill and practice) as well as support for academic projects (music composition, wordprocessing, desktop publishing).

The four facilities selected for this study are similar in function and resources, yet different by design. Each was built between 1990 and 1993, and represents a different stage of evolution in the development of such facilities. A general description of each lab is presented in the following paragraphs.

Specific environmental factors of each facility are presented in Chapter 4. A complete list of equipment and specifications are outlined in Appendix G.

3-1a. Facility #1: The Learning Center (LC)

This facility was chosen because it is thought to be the latest in the ongoing evolution of the site institution's computing facilities. It is also the largest and most populated, as this facility serves the entire student population in contrast to the other labs which serve specific programs (Figure 3-1). There are 40 workstations available to students in the main lab area (Figure 3-2),

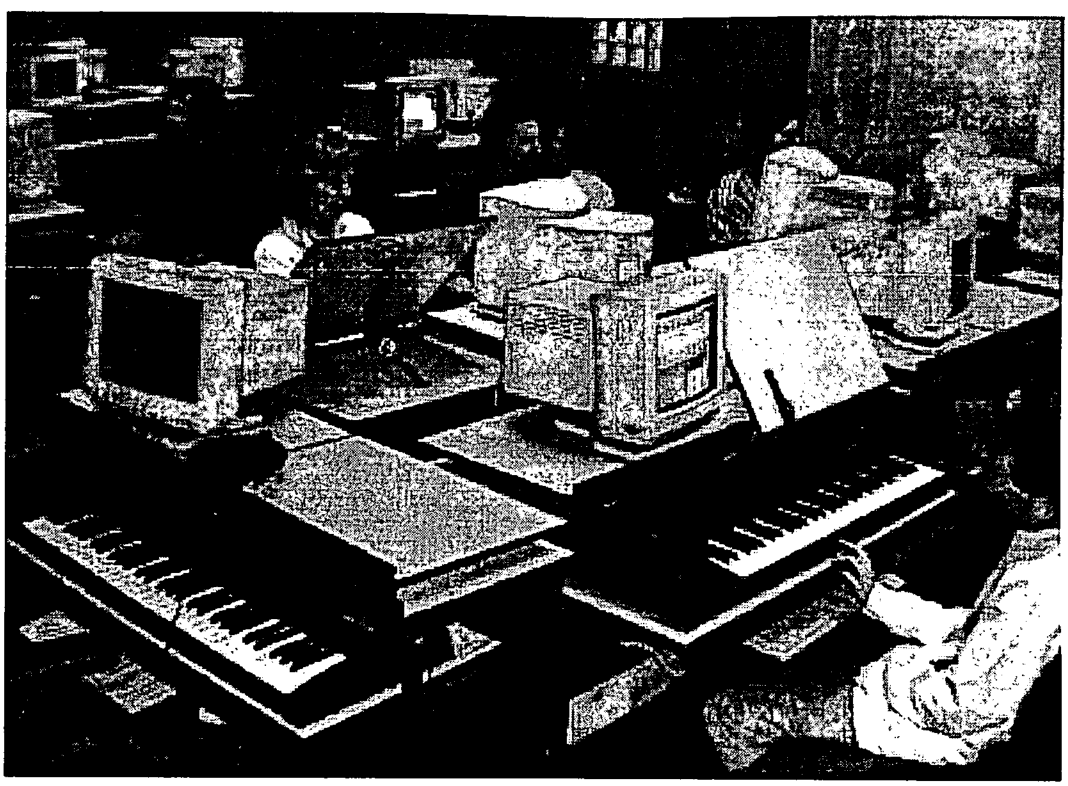

Figure 3-1: The Learning Center is a general access facility, serving the entire college community.

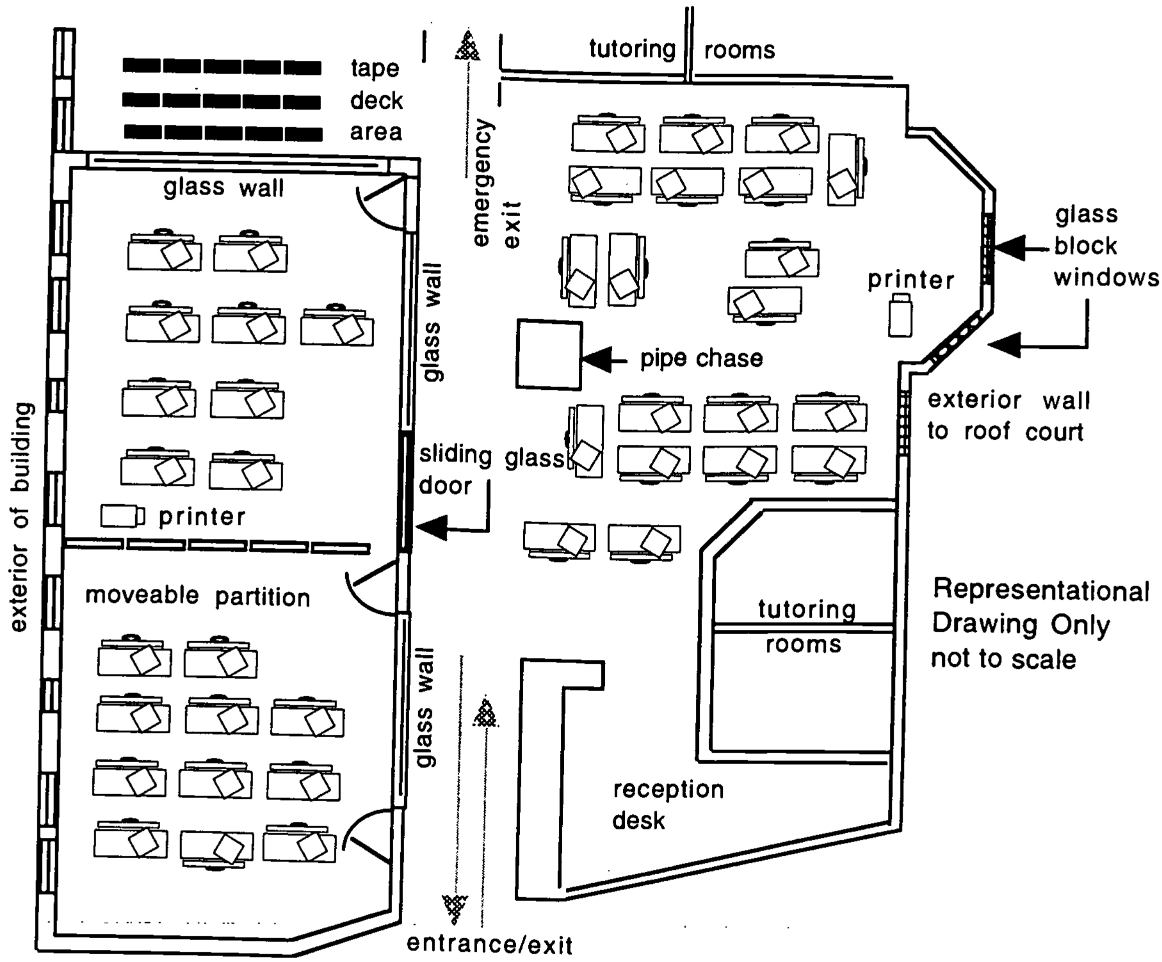

Figure 3-2: Floorplan and layout of the Learning Center. The Center features 40 workstations and other resources.

each equipped with a MIDI-compatible keyboard synthesizer, audiocassette-based mixer/recorder, and computer system with built-in CD ROM capability and adjustable color monitors. Workstation furniture in this lab is custom designed with fully adjustable components, such as keyboard drawers, inclined worksurfaces, and task chairs. Students have access to programs ranging from music sequencing to wordprocessing as well as self-paced interactive instructional aids. Other activities take place in the Center as well, such as listening exercises with cassette decks, individualized peer tutoring, and occasional class sessions. The Center is fully staffed with support personnel, and houses its resources in an area of approximately 2200 square feet.

3-1b. Facility #2: The Center for Technology in Music Instruction (CTMI)

This lab is the first-built among the facilities being studied. It is reserved for faculty use, and typical activities center on the generation of educational software, textbooks, and teaching aids. The CTMI also provides faculty members with opportunities for professional development and personal productivity (Figure 3-3). The facility houses seven workstations, and features a specially configured station for high-end desktop publishing and multimedia development (Figure 3-4). Core equipment and software configuration is similar to the Learning Center with some extras included, such as digital audio tape (DAT) technology, additional synthesizer modules, and high-end publishing programs. The workstation furniture is custom designed and built, but with fewer adjustable features than the furniture in the Learning Center. This facility has 24-hour accessibility, though staff support is available during daytime hours only. Area of the CTMI, including lab staff area, is approximately 540 square feet.

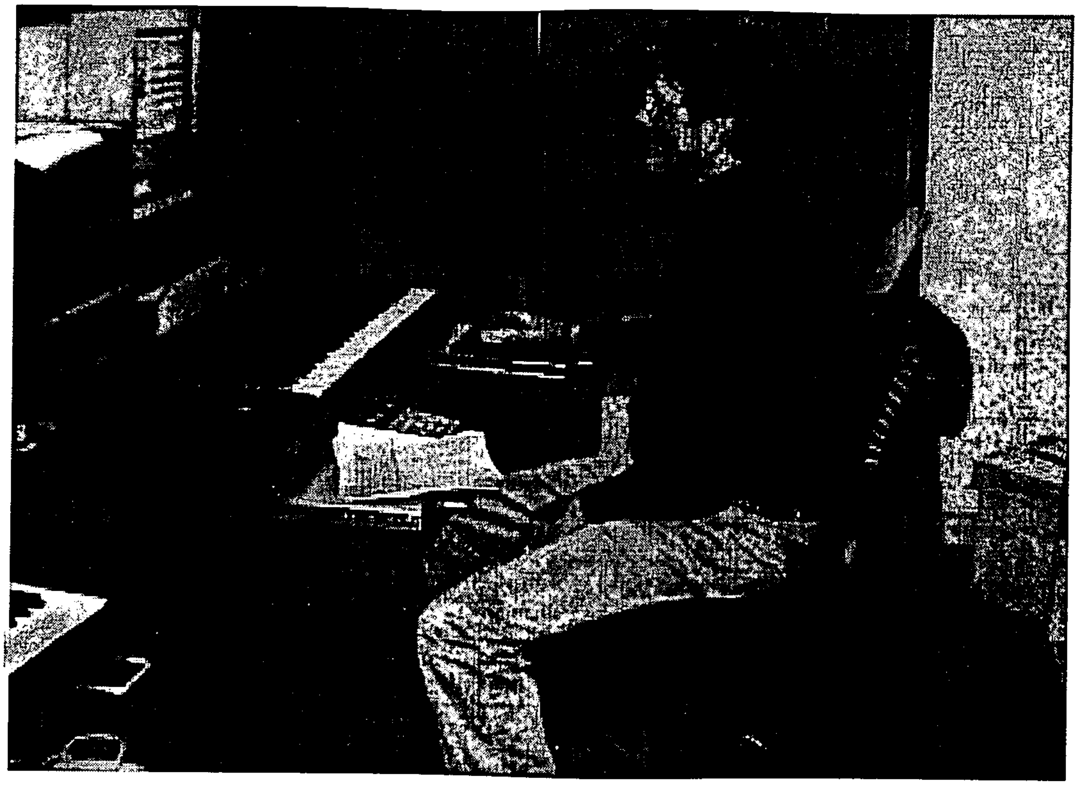

Figure 3-3: The CTMI provides for various faculty development opportunities and serves as a project center.

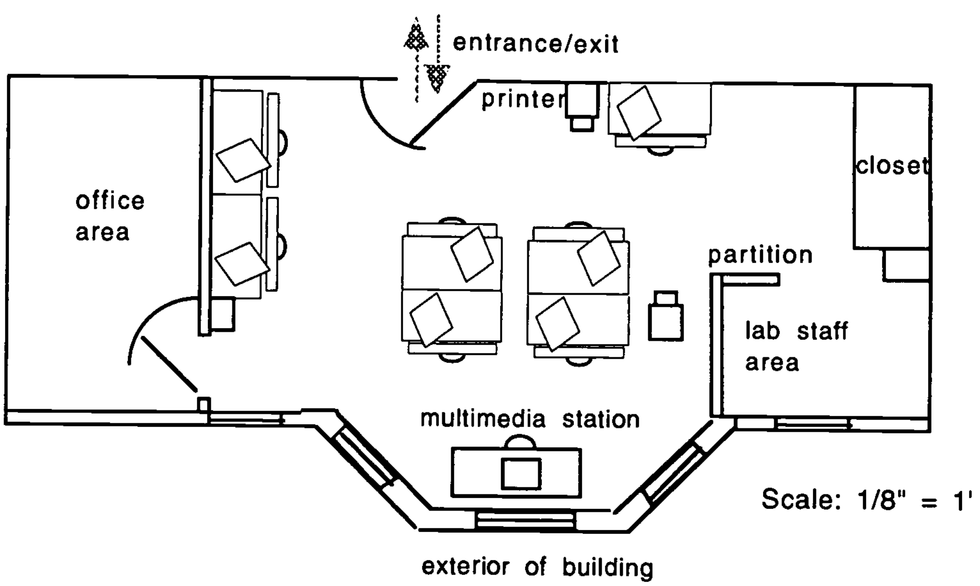

Figure 3-4: Floorplan and layout of the CTMI featuring 7 workstations and multimedia development station.

3-1c. Facility #3: The Professional Writing Lab (PWL)

This lab serves as both a classroom and project lab for students majoring in the various music writing disciplines, such as Composition, Commercial Arranging, Jazz Composition, and Songwriting (Figure 3-5). The design of the 12 workstations is a direct precursor to those in the Learning Center and employs similar features. Computer systems feature full-page black and white computer displays, as the majority of tasks performed here relate to music notation and scoring. As this lab is primarily designed to teach students how to compose music using computer-based tools as well as

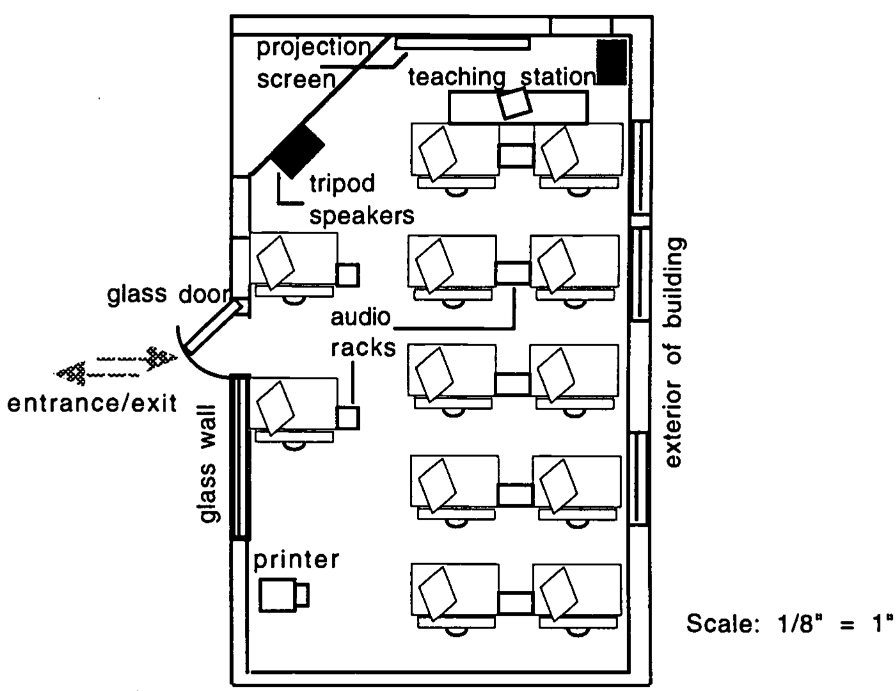

Figure 3-5: Floorplan and layout of the Professional Writing Lab. The 12 workstations provide productivity tools for students majoring in the various music writing disciplines

produce demo quality tapes, the workstations integrate higher-end sound processing and recording equipment than is found in the Learning Center. A particularly interesting aspect of this facility is that the workstation and chair height is increased from the front to the back of the room, producing a tiered effect on a level floor. This results in less interrupted sightlines to the projection display at the front of the room (Figure 3-6). Staff support is provided by a lab manager during regular hours and work-study personnel during off-hours. Laboratory sessions are supervised by a teacher. Approximate area of the PWL is 450 square feet.

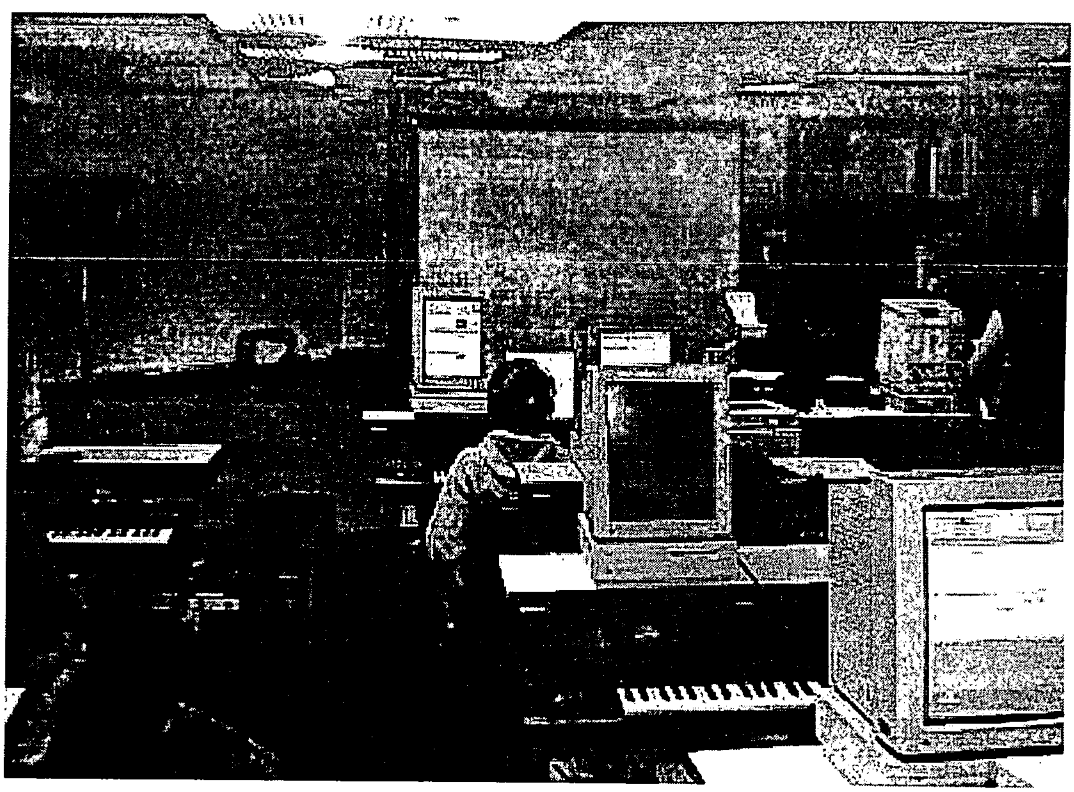

Figure 3-6: Increasing the Professional Writing Lab's workstations by height towards the back of the room results in less interrupted sightlines to the front projection display.

3-1d. Facility #4: The Professional Education Lab (PEL)

This 20 station lab serves as a classroom/project center for students majoring in Music Education and Music Business (Figure 3-7). Completed within the same time frame as the Learning Center, hardware and software offerings are nearly identical with specific applications added to support the educational programs that utilize the facility. While the creation of music in this facility is an essential activity of Music Education coursework, other activities focus on the requirements for such business-related courses as marketing and statistics. Staff support is provided by a lab manager during regular hours and work-study during off-hours. Laboratory sessions are supervised by a teacher. Approximate area of the PEL is 735 square feet.

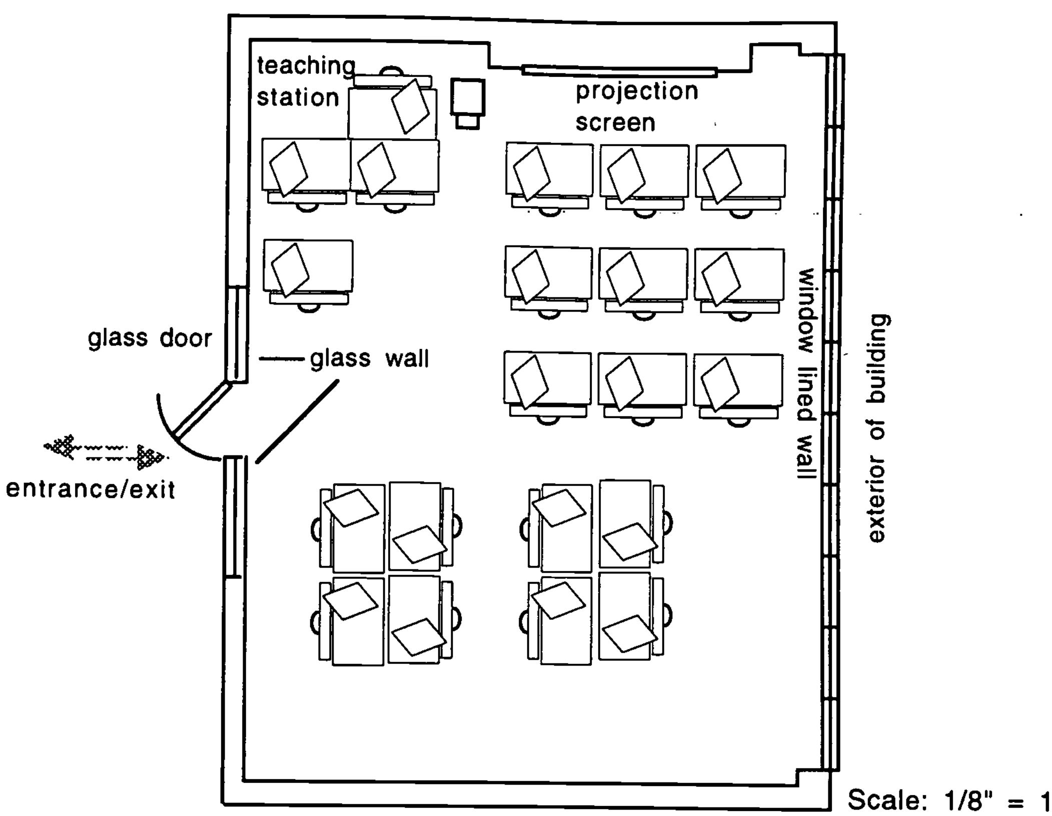

Figure 3-7: Floorplan and layout of the Professional Education Lab. This lab serves the needs of Music Education and Music Business majors.

3-2. Participants

The 120 participants in this study were students and faculty at the site institution who were drawn from the user populations of the four facilities. Users of the Learning Center, Professional Writing Lab, and Professional Education Lab are undergraduate students, while the population of the CTMI, as indicated in Section 3-2b, are faculty members. The age range of the subjects is estimated to be between 18 and 60 years. This span was not seen as problematic, as the ergonomic standards to be used as comparisons address the anthropometry of adults *in general* (see Appendix F). In this era of young teachers and older students, there is even reason to assume a degree of age overlap among the two groups. Also, faculty members who use the CTMI are essentially in a learning and productivity mode not unlike the student users of the other facilities. It was therefore assumed for the purposes of this study that the position of an individual as a student or faculty member would have little bearing on the results.

Of the 120 respondents, 95 were men and 25 were women. While this distribution is seen as a potential limiting factor, the participants were drawn from a student population with a male-female ratio of nearly 5:1. Personal data recorded from the respondents is shown in Table 3-1.

Table 3-1: Personal data of the respondents as recorded from the questionnaire.

Height	**Male**	**Female**
Mean	69.64 in.	64.83 in.
SD	2.94 in.	2.61 in.
Range	60-77 in.	60-69 in.
Weight		
Mean	160.94 lbs.	127.71 lbs.
SD	23.30 lbs.	19.09 lbs.
Range	120-240 lbs.	95-165 lbs.

One of the goals of ergonomics and human factors design is to accommodate 95% of the population (Bennett 1977). A further analysis of individual heights revealed that three of the male respondents exceeded 75 inches, the top value of the 95th percentile male. Another male respondent recorded his height at 60 inches, below the bottom value of the 5th percentile male. All other respondents were within the established ranges for height and weight (see Appendices F and G).

The essential unifying attribute among the participants is that they are all involved in the study of music, and the range of activities across the four facilities in this study are closely related if not identical. Based on the similar characteristics and task orientation of the subjects, as well as the general applicability of anthropometric measures across the adult population, each group was assumed to be comparable to the others for the purposes of this study. Individual subjects were also assumed to be normal, with no unusual physical or mental disabilities.

3-3. Instrumentation

3-3a. User Assessment Instrument

This study employed a modified version of a user assessment questionnaire developed and validated by McVey (1979) in his study of media presentation rooms. McVey's instrument was also modified and used by Bethune (1991) in his study of lecture halls/auditoria - media presentation rooms. It was again necessary to adapt the original questionnaire to address the context of this study in terms of the users, the nature of the tasks, and the standards presented in the literature.

Responses were measured using a five-point Likert-type scale that enabled subjects to numerically rate eleven categories of workstation and interior environmental factors on a scale of 1 (poor) to 5 (excellent). The middle value of "3," assumed to represent a neutral rating, was purposely not labeled "average" in an attempt to provide a continuous choice of answers while not encouraging the respondent to gravitate towards a middle value. Each category consisted of 4 - 7 questions each, with an additional 10-point rating scale to ascertain the importance users placed on that specific category. Questions designed to solicit written subjective comments were also provided. A rating of N/A (not applicable) was also included in the scale for items determined by a respondent to not be represented in a particular facility. The N/A rating was not assigned a numerical value to minimize misinterpretation on the part of the respondent and to streamline the process of data analysis (see Bethune 1991, pp. 91-92). Refer to Appendix C for a copy of this instrument.

3-3b. Environmental Assessment Instruments

The interior environmental factors and workstation configurations of each lab were measured with specific instrumentation. Appendix D provides a complete listing of these instruments.

3-4. Procedures

3-4a. General Procedures

Preceding and during the administration of the survey, documentation was made available to users of each lab that described the adjustable features of the workstations. Depending on the operational conventions of each lab, the documentation was made available either in the form of handouts, on-line help files, or posted bulletin. Periodic observations of users working in each lab indicated that they were aware of and used the adjustable components of the workstations.

Participation in this survey was on a volunteer basis. Subjects were recruited in a manner that was most convenient for each lab. In the Learning Center and the CTMI, subjects were solicited individually either through their response to a posted written request or by asking them directly. Since subjects in the Professional Writing Lab and Professional Education Lab attend regular classes in these facilities, it was most convenient to request their participation during a class session. Lab time outside of class is limited in the PEL and PWL, and student users understandably place a premium on available project time in these facilities. To ensure that all users had adequate time to become familiar with their respective facilities, the survey was administered during the second month of the semester.

3-4b. Instrument Development

A first draft of the questionnaire was given to selected subjects in order to gauge overall readability, comprehension of the questions, appropriateness of the items, and the time frame required for completion. Feedback from this exercise helped to adjust individual items as necessary. Four forms of the final version of the instrument were developed by simply changing the order of the specific environmental sections to control against user responses being influenced by the sequencing of questionnaire items.

3-4c. Pilot Study

A preliminary wave of data collection was conducted during July, 1994. While the smaller summer student population did not yield enough respondents to conduct a reliable analysis or comparison of the four facilities, the situation provided an opportunity to further develop the questionnaire as well as methodology. Upon analysis of the summer data, it was decided to expand and/or clarify the language of some sections in the hope of procuring a more complete and accurate evaluation from the next wave of data.

3-4d. Second Wave

Another wave of user data was collected during a four week period in October, 1994 utilizing the refined questionnaire. Subjects participated in accordance with the general procedures described in Section 3-4a. The number of respondents for each facility appeared to be sufficient for comparison and analyses.

During the same period, an environmental analysis was conducted in each of the four facilities using specific measuring instruments and methods (see Appendix D). Recorded data included workstation furniture measurements, viewing locations, ambient sound levels, luminance and illuminance levels, temperature/humidity readings, and air velocity. These measurements were used to represent the relative acceptability or unacceptability of each workspace factor as compared to current ergonomic and environmental design guidelines, and subsequently compared to the users' relative satisfaction or dissatisfaction with each factor as measured by the questionnaire.

3-5. Research Design

The research approach for this study was derived from McVey (1979), and similarly employed a post-test only comparison of four groups of students who regularly use the facilities under investigation. The real-world interactions between learners and their environment *as they exist* within a particular context was compared to an external model. The model, or the ergonomic standards for computer workspaces presented in the literature, was tested against user perceptions of the facilities as measured by the questionnaire and each facility's unique set of design specifications. The overall approach and desired outcome of this research was based on the *post-occupancy evaluation* (POE) methodologies that have been frequently implemented in the assessment of architecture and interior design. POE is defined by Sommer (1983) as follows: 1) the focus tends to be on a single type of building; 2) the investigator describes rather than manipulates or changes a setting; 3) the work is almost always conducted under natural conditions rather than in a laboratory; and 4) the major goal of the study is application of the results to improve the same or similar settings (p. 136).

Due to the requirements and restrictions inherent in the educational programs supported by the facilities, it was not feasible to randomly assign subjects and treatments (facilities). Kerlinger (1986) addresses the issue of *compromise designs* for such situations:

> It is often difficult or impossible to equate groups by random selection or random assignment, or by matching. Should one then give up doing the research? By no means. Every effort should be made, first, to select and to assign at random. If both of these are not possible, perhaps matching and random assignment can be accomplished. If they are not, an effort should be made at least to use samples from the same population or to use samples as alike as possible. (p. 315)

Accordingly, equivalency of the user groups was assumed under the following criteria: 1) The users perform similar tasks in each of the four facilities selected for this study; 2) core equipment configurations are similar; 3) all subjects had sufficient time to become familiar with their respective learning environments; and 4) subjects were physically and mentally normal adults over the age of 18, and anthropometrically appropriate to the ergonomic guidelines under consideration.

3-6. Treatment of the Data

To facilitate the goals of this study, the data was viewed comparatively across facilities as well as from the direct standpoint of the users. A comparison of the questionnaire results identified those design specifications in each facility that contribute towards the overall group ratings related to each environmental factor. Responses from the questionnaire were then analyzed to determine how the users of each facility rated its specific environmental and ergonomic components. The user ratings were then compared with the results of the environmental analysis to provide a basis from which to affirm, negate, or extend the model implied from the guidelines presented in the literature.

The mean scores from the questionnaire for each workspace factor were used as the primary critieria for the comparison of these factors across the four facilities. Based on the 5-point rating scale, scores of 3.00 and upward were assumed to represent a range of user ratings from neutral to excellent. Ratings below 3.00 were assumed to indicate problems with a specific workspace factor in the opinion of the users. These assumptions are consistent with the McVey (1979) and Bethune (1991) studies.

The Kruskal-Wallis and Friedman statistical tests were used to determine whether significant differences in the user ratings existed between facilities and individual questionnaire items. From the results of these tests, it was possible to ascertain which workspace design specifications were most satisfactory to users. Significance levels for all one-way and two-way comparisons were established at $\alpha = .02$.

A point-biserial correlational analysis was used to determine the strength of the relationship between the user ratings as measured by the questionnaire and the extent to which the workspace factors of each facility were in accordance with ergonomic and environmental design guidelines. The ratings from each facility were compared to the acceptability or unacceptability of individual workspace factors relative to the guidelines, represented as "1" and "0" respectively. An independent correlational analysis was conducted for each facility, with significance level established at $\alpha = .01$.

The Chi-Square statistic was used to test the group rating distributions of individual questionnaire items to determine whether differences existed between three categories of ratings: high (4 or 5), neutral (3), and low (1 or 2) The purpose of this comparison was to determine which workspace factors were the most significant sources of user satisfaction or dissatisfaction. The individual questionnaire items from each facility were examined independently. As there were up to 59 comparisons for each facility, significance level was established at $\alpha = .001$ for overall error control. Items achieving this level were considered to be significant indicators of satisfactory or unsatisfactory ratings, depending on their direction. Items achieving probability levels up to $\alpha = .05$ were treated as a category of marginal data that for comparison purposes imply direction, though were not considered significant indicators of user opinion.

The total analysis employed the above statistical procedures in conjunction with user comments as transcribed from the questionnaire. To obtain a thorough purview of the complex interactions between learners and their environment, the quantitative results, user comments, and environmental analysis are presented with qualitative interpretations to support the findings.

3-7. Limitations

As previously mentioned, random assignment of subjects and/or treatments to groups was not feasible for this study. Two of the facilities, the PWL and PEL, are reserved for and used by students taking specific courses. The Learning Center and the CTMI are free access areas, one being for the general student population and the other for faculty use. Random assignment of subjects would have interfered with normal educational processes, as well as violated established institutional restrictions. Students not enrolled in courses served by the PWL and PEL are not permitted to use those facilities. The CTMI is restricted to faculty use, though this particular constituency is permitted free access. Only the Learning Center is essentially open to *all* constituencies. Therefore, it was necessary to select subjects from each facility's user group. Considering the intent of this study, it was felt that this was a *desirable* arrangement, in that it further ensured that the participants were adequately familiar with their respective facilities, and thus able to more effectively ascertain their assets and shortcomings.

There were likely considerable differences among the subjects with respect to their individual comfort levels and expertise with the technology used in these facilities. This may have affected some individual's perceptions of whether certain environmental factors were facilitating or hindering. Though subjects were not randomly assigned, there are again enough similarities between the groups to assume a comparable distribution of comfort and/or skill level within each.

Again, the overwhelming predominance of male subjects is seen as a limiting factor. As previously indicated, this is a condition of the population from which the sample was drawn. Therefore, while it is possible to examine and discuss the possible effects of gender differences on the user assessment presented in this study, it was not feasible to infer generalizations from the findings.

This study was conducted within the specific context of college-level music education. While the results may indeed have implications for other specialized educational applications, there should be caution in the assumption that any conclusions derived from this study are broadly applicable to other contexts. The purpose of this study *specifically* was to investigate the generalizability of previous standards and research, and its applicability can only be assured within a similar situation.

3-8. Summary of Chapter 3

Employing a user assessment instrument developed by McVey (1979), the environmental specifications of four music education computer labs were evaluated by their respective user groups. The actual specifications were determined through the measurement of the environmental factors in each lab utilizing specific instrumentation. User ratings were cross-referenced to specific environmental factors in order to determine those specifications that achieved satisfactory as well as unsatisfactory ratings. The Kruskal-Wallis and Friedman tests, Chi-square statistic, and correlational procedures were chosen to examine the relationship between the user ratings and the extent that each facility reflects established ergonomic and environmental design guidelines. Chapter 4 describes in detail the process of data collection and analysis.

CHAPTER 4
Analysis of Data

4-1. Workstation Analysis

Individual workstation specifications in each of the labs are detailed in Figures 4-1 - 4-4. This section refers to these figures in the following discussion. For a comparison of these specifications with published standards, refer to Table 2-1 on page 23.

4-1a. Seating

The Learning Center and Professional Education Lab use the same brand and model of seating. The CTMI and the Professional Writing Lab also share seating specifications, and employ taller chairs where needed to accommodate higher desk heights. Overall, the seating specifications for each of the facilities in this study are considered acceptable according to ANSI/HFS (1988) guidelines.

Minimum compressed chair height for the Learning Center and the PEL meets ANSI/HFS (1988) standards, though exceeds other recommendations (see Table 2-1) by as much as three inches (Figures 4-1 and 4-4). Seat pan depth in these facilities also exceeds recommended limits, but the waterfall contour on the front edge of the seat compensates by providing relief for the back of the knee (ANSI/HFS 1988, p.55). Actual measured chair height range for the CTMI and PWL exceeds documented limits, but the inclusion of a foot ring 7.5 inches above the floor permits the user to be seated within the recommended height range (ANSI/HFS 1988, p. 62) (Figures 4-2 and 4-3). In general, the seating in all four of the facilities is appropriate with respect to the height of the workstations.

All chairs are adjustable for a full range of user control and comfort, featuring pneumatic height adjustment as well as mechanisms for backrest height and seatpan tilt. All chair frames are situated on a five-star pedestal with casters for mobility within the workspace. Chairs are padded with about one inch of insulated foam.

Two of the facilities, the Professional Writing and Professional Education labs, have row spacing constricted enough to adversely affect seating comfort and mobility. The Learning Center's row spacing is also under par with respect to the mobility of traffic between rows, but there is adequate room for users to move their chairs within the immediate work area. Considering the range of furniture adjustments, row width was measured as the distance between fully extended worksurfaces (i.e. keyboard and/or synthesizer trays) and the back of the station directly behind (Figures 4-1- 4-3). The reasoning behind this was the notion that workstations should be spaced in a manner that allows the user to maximize all adjustable features, including flexibility of seat movement within the workspace, and have enough additional space remaining for people to pass between rows. By this criteria, row spacing in each of these labs is well below the 36 inch minimum recommended for chairs with casters (McVey 1991). Users are able to fit into the workspace and make room for others moving through the rows by inching their seats and adjusting the workstation components. However, these actions come at considerable inconvenience and at the expense of the workstation's full potential. Spatial considerations are further discussed in Section 4-1f.

4-1b. Desks

At present, the criteria of acceptability for desk dimensions is situational and based on adequacy to a task. All of the workstation desks examined in this study were custom built to support specific tasks and equipment, and feature multiple worksurfaces in contrast to the single-tiered design that characterizes many office workstations. Therefore, some of the design specifications inherent in the workstation desks examined in this study do not have a direct reference point within current published standards pertaining to office environments.

Each workstation appears to support the necessary computing, musical, and audio equipment adequately, and places the equipment within easy reach. The Learning Center, Professional Writing Lab, and Professional Education Lab each provides a surface area for working with paper-based materials, such as books, notes, and music manuscript (Figures 4-1, 4-3 and 4-4). The Learning Center and the PWL incorporate an almost identical angled worksurface design. The Professional Education Lab workstations offer a small, flat worksurface to the user's side, but is insufficient in size for working with a full range of hardcopy. Though the workstations in the CTMI do not provide a dedicated worksurface area for paper-based tasks, bookstands are provided for an acceptable level of reading convenience. However, the overall lack of usable worksurface area renders these stations unacceptable for writing tasks.

Observations of students working in the Learning Center and the Professional Writing Lab indicate that the angled worksurfaces, while spacious and convenient for reading, are not conducive to a comfortable position for writing. The positioning of the worksurface (37.5 inches from the floor in maximum horizontal position) places documents higher than standard desks, and the range of available angles does not appear to compensate for the height. Students can often be seen leaning into the worksurface and positioning their writing arm at an awkward angle (Figure 4-5). Though there is no direct parallel in the literature for this type of worksurface configuration, an assessment based on standard writing surface heights indicates that the design is unacceptable for writing tasks.

Measured clearance envelopes for leg room under the workstation surfaces (height, width, and depth) indicates that all facilities meet or exceed the recommendations for accommodating the 95th percentile male. Leg clearance width was not an issue for any of the stations, as users essentially had the entire width of their workstation desks. Support frames are either located on each side of the station or positioned in such a way so as not to

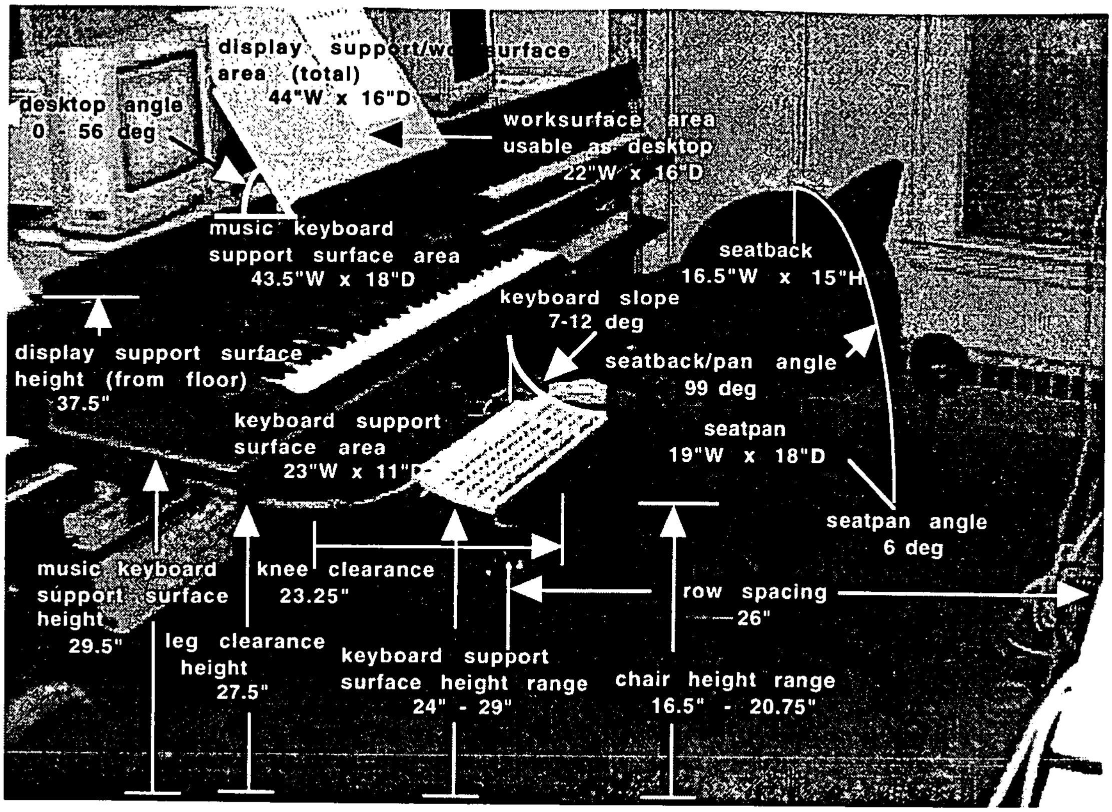

Figure 4-1: Learning Center workstation design specifications.

Additional Notes:
CPU, audio recording equipment, and other peripheral devices are located on shelves in the lower part of the workstation at the user's knees.

All workstation furniture is on wheels for ease of maintenance and reconfiguration of the space when necessary.

Music keyboard drawer slides in and out to adapt to a variety of workstation tasks.

Row spacing is measured as the distance between a fully extended operating edge and the workstation directly behind.

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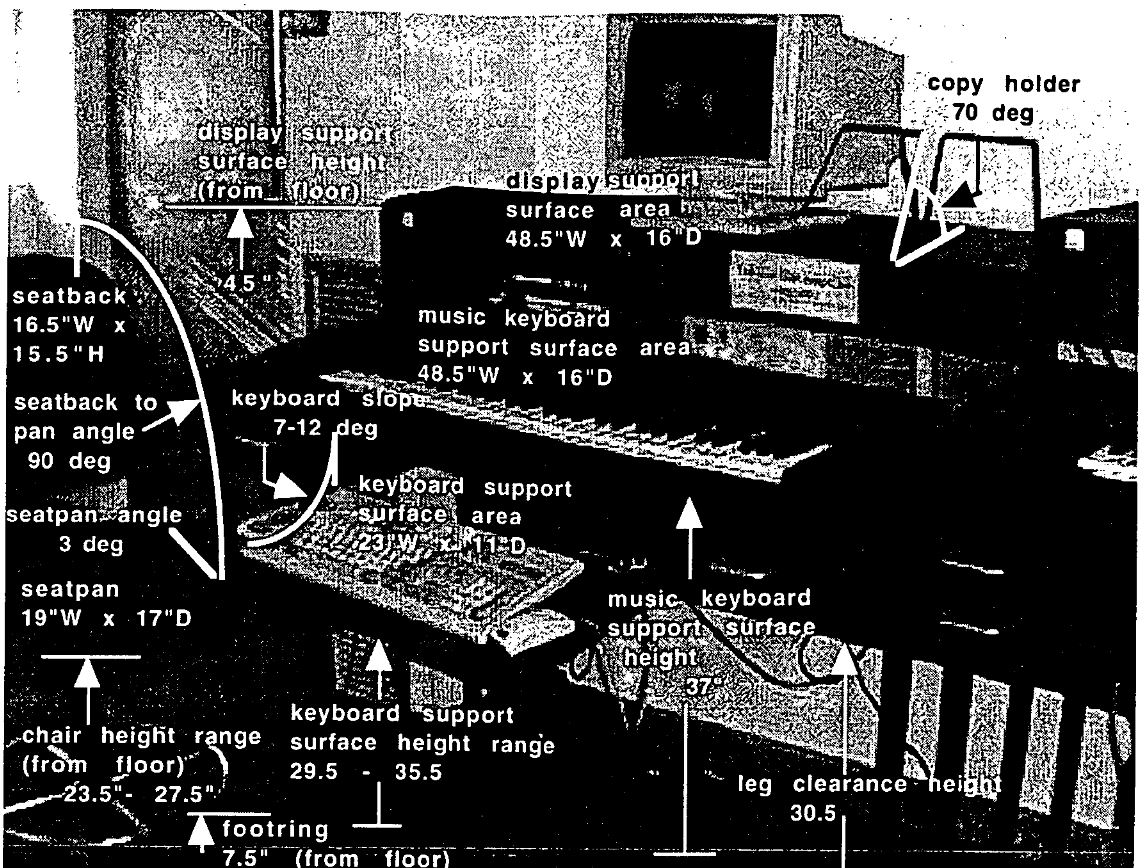

Figure 4-2: CTMI (Faculty Lab) workstation design specifications.

Additional Notes:
These workstations are built higher than some standards may recommend, but the inclusion of higher chairs equipped with footrests accommodate the overall dimensions.

Equipment bays are positioned in front of user.

All workstation furniture is on wheels.

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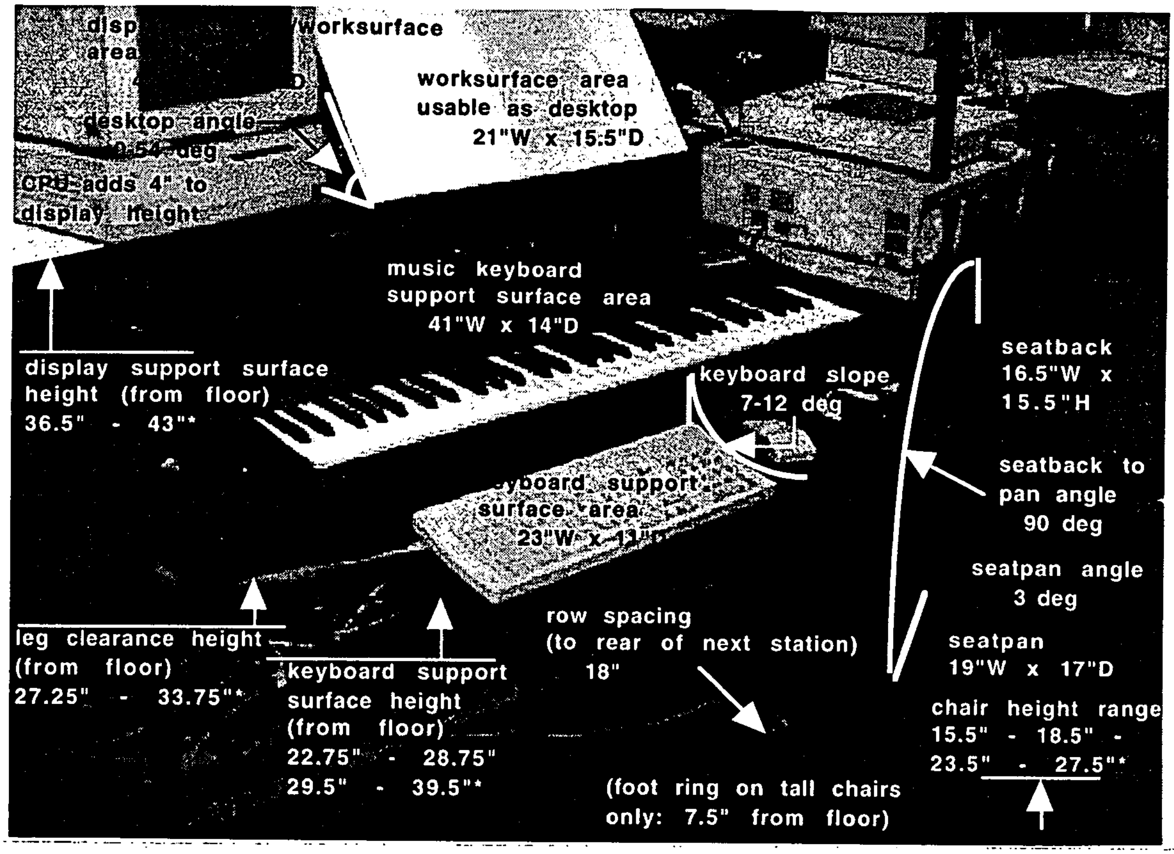

Figure 4-3: Professional Writing Lab (PWL) workstation design specifications.

<u>Additional Notes:</u>

Stations increase in height from the front to the back of the room to simulate a tiered effect for viewing presentations at the front of the room. Dimensions marked with an asterisk (*) indicate the resulting range of measurements. Higher chair heights are equipped with foot rests.

Audio processing and recording equipment is located in a separate cabinet to the side of the user, between each station.

VDTs placed on top of CPUs adds to display support surface height.

Row spacing is measured as the distance between a fully extended operating edge and the station directly behind.

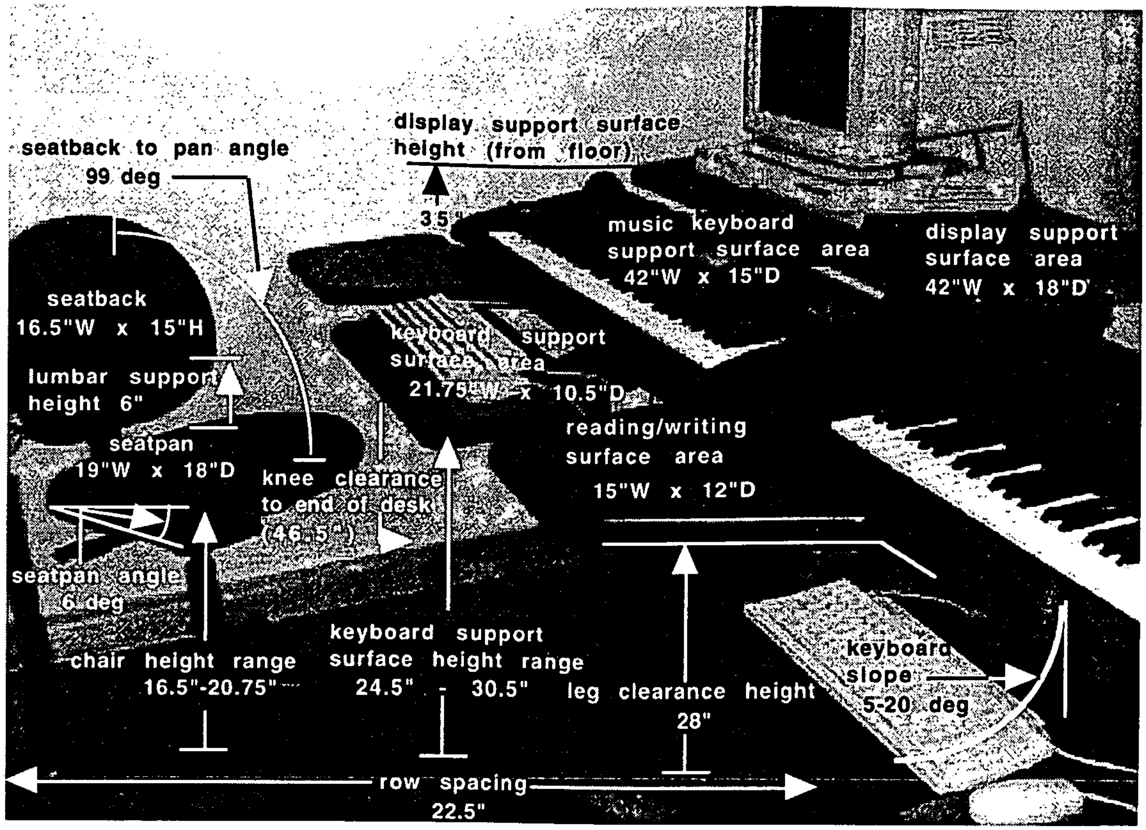

Figure 4-4: Professional Education Lab (PEL) workstation design specifications.

<u>Additional Notes:</u>
There is no dedicated audio recording equipment on these stations, though students can save MIDI sound files to disk for playback through the music synthesizer.

VDTs placed on top of CPUs increase display support surface height.

Row spacing is measured as the distance between a fully extended operating edge and the workstation directly behind.

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Figure 4-5: Writing postures appear awkward when students use the angled worksurfaces in the Learning Center and Professional Writing Lab

interfere with leg room. Hence, all stations feature leg widths greater than 40 inches, well beyond the 20 inch minimum set forth by ANSI/HFS (1988).

The playing height of most acoustic pianos measures 28.5 inches from the floor to the top of the white keys. The playing height of the synthesizers in this study is a function of the height of the music keyboard support surface plus 4 inches from the synthesizer's own casing. Consequently, the playing height of these instruments in each facility is placed higher than a standard piano keyboard. Therefore, for purposes of this study, this aspect of the workstations' design is considered unacceptable.

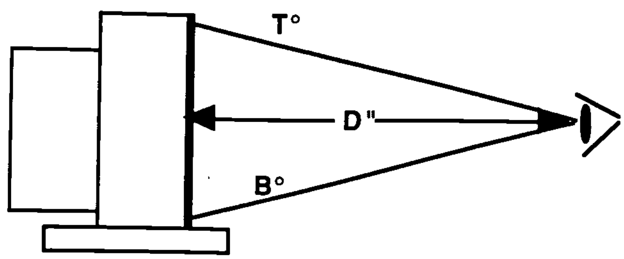
Computer keyboard support surface height ranges in each facility were within the ANSI/HFS (1988) recommendations. The range of adjustments permits users to maintain recommended arm angles and also accommodates the minimum leg clearance envelopes required for the 5th percentile female to the 95th percentile male. Keyboard slope, which is a function of the angle adjustment of the support surface as well as the slant of the keyboard itself, ranged within the ANSI/HFS limit of 0 - 25° in all facilities.

4-1c. Viewing Locations

Viewing distances and sight lines to the computer display were measured in each facility with five subjects, each meeting specific anthropometric criteria for both stature and sitting eye height (see Appendix F). The subjects were seated at each workstation in a position that was individually comfortable and representing each one's typical working posture. Viewing distances were measured with a tape measure and sight lines to the top and bottom of the display were measured with an inclinometer. The results are presented in Table 4-1.

Subjects were able to sit at viewing distances greater than the 12 inch minimum recommended by ANSI/HFS (1988). As the subjects were asked to position themselves as they normally would in an actual working situation, the viewing distances assumed supported previous research on user preferences in viewing locations (Jashinski-Kruza 1990; Grandjean in Salvendy 1987).

Table 4-1: Viewing locations for selected subjects.



	Percentile				
Measure	5th Male	50th Female	50th Male	95th Female	95th Male
Distance from display (D")	LC: 31" CTMI: 30" PWL: 28" PEL: 30"	LC: 33" CTMI: 29.5" PWL: 26.5" PEL: 29"	LC: 27" CTMI: 32" PWL: 24.5" PEL: 28.5"	LC: 25" CTMI: 29" PWL: 27" PEL: 27"	LC: 32.5" CTMI: 31" PWL: 29" PEL: 31"
Sightline to top of display (T^0)	LC: 1^0 CTMI: 5^0 PWL: 10.5^0 PEL: 1.5^0	LC: 9^0 CTMI: 8.5^0 PWL: 12^0 PEL: 7^0	LC: 7^0 CTMI: 7^0 PWL: 12^0 PEL: 7^0	LC: 5^0 CTMI: 4^0 PWL: 9.5^0 PEL: 2^0	LC: 3^0 CTMI: 6^0 PWL: 10^0 PEL: 3^0
Sightline to bottom of display (B^0)	LC: -3^0 CTMI: -5.5^0 PWL: -6^0 PEL: -7.5^0	LC: -1^0 CTMI: -5.5^0 PWL: -7^0 PEL: -5.5^0	LC: -7.5^0 CTMI: -6^0 PWL: -9^0 PEL: -6^0	LC: -7^0 CTMI: -11^0 PWL: -11^0 PEL: -12^0	LC: -9^0 CTMI: -8^0 PWL: -9^0 PEL: -9^0

To measure the sightlines to the top and bottom of the computer display, subjects were asked to site each of these areas in the scope of the inclinometer. It was difficult to determine the extent to which head and/or eye rotations influenced the viewing angles recorded. It was expected that the sight line angles to the top of the screen would decrease as one moves up the percentile ranks, and that sight lines to the bottom would increase in the same direction. However, the table shows that this is not the tendency.

Measurements were based on screens measuring 14 inches diagonally and 8 inches top to bottom for the Learning Center, CTMI, and Professional Education labs. The Professional Writing Lab utilizes *full-page* displays, measuring 13.5 inches diagonally and 11 inches top to bottom.

For each subject in all facilities, the recorded sightlines to the top of the display were above the 0^{0} limit recommended by ANSI/HFS (1988), and most were greater than actual observations of user preferences at VDT stations (Kroemer 1987; Grandjean in Salvendy 1987). These angles are above what would be considered the normal line of sight for most viewers, and would necessitate tilting the head upward to view the top of the display. This tendency is greatest in the Professional Writing Lab, which uses the full-page displays. It should also be noted that these readings were taken with the display in an "average," or straight-on position. With the exception of the Professional Writing Lab, all facilities feature displays on swivel-bases that enable the user to adjust the display angle. Due to space limitations on their workstations, the Professional Writing and Professional Education labs place computer displays on top of the computer's CPU, adding to the existing display support surface height.

As indicated in the literature, there should be sufficient flexibility for user preference in the placement of hard-copy documents, and that VDT and paper-based tasks should be viewable within the same visual plane. In the Learning Center and Professional Writing Lab, paper-based materials such as books, notes, and music manuscript are viewable within the same visual plane as the VDT utilizing the angled worksurfaces on the workstations. The worksurface area and range of angles available to the user for their adjustment appears adequate for a wide range of viewing preferences (Figures 4-1 and 4-3). In the Professional Education Lab, the reading/writing worksurface on the workstations is located within a different visual plane from the VDT, requiring frequent head rotations on the part of the user to alternately view hardcopy and the computer display (Figure 4-6). The CTMI workstations have bookstands placed next to the VDT, which enables the user to adequately view printed documents within the same visual plane as the display. However, the ability to work with documents requiring writing tasks in conjunction with the VDT is hampered by the fact that there is no dedicated writing surface on these workstations.

Figure 4-6: Viewing locations for paper-based tasks and the VDT are located within different visual planes in the Professional Education Lab.

4-1d. Video Display Systems

The Learning Center, CTMI, and Professional Education Lab utilize 14 inch high-resolution color displays. The Professional Writing Lab, supporting mainly music notation activities, features full-page black and white displays.

A subjective evaluation of these displays in each of the facilities indicates that screen size, character legibility, picture quality and color rendition (where applicable) are of good to high quality with respect to their intended use. However, the glossy coating on the screens is unacceptable, as lights, windows, and other bright objects are easily reflected. Potential visual problems resulting from glare can be minimized where the displays are equipped with swivel-bases, which includes all labs except the Professional Writing Lab. Three of workstations in the CTMI are positioned with their screens parallel to the windows, which is especially problematic given the reflective nature of the computer display surface.

White field luminance values were measured in foot-lamberts (fL) from a representative display in each of the facilities. The results are presented in Table 4-3, along with equivalent values in candelas per square meter (cd/m^2). Only the display measured in the CTMI was slightly below ANSI/HFS standards, with all others exceeding the requirements. All VDTs are equipped with brightness and contrast controls for user adjustability. Screen luminance as a visual factor within the total VDT workspace is discussed later in this chapter.

Table 4-2: **Screen luminance values** for each facility.

Facility	Screen Luminance fL (cd/m^2)
Learning Center	34.6 (118.5)
CTMI	9.3 (31.8)
Professional Writing Lab	26.3 (90.1)
Professional Education Lab	39.1 (134)

4-1e. Music and Audio Systems

The choice of electronic music systems and related equipment is largely subjective, and no research-based or other documented standard of comparison exists between comparable models. All facilities feature what would be regarded in the field as industry standard music synthesizers and audio equipment. Except for the Professional Education Lab, equipment is provided at each station for recording projects to cassette tape. The Professional Writing Lab and the CTMI provide high-end recording and sound processing equipment to accommodate their individual educational programs. A subjective evaluation of all music and audio systems indicates that they are of professional quality, sufficient as per each facility's individual requirements, and meet or exceed minimum industry standards. Appendix K provides a complete listing of equipment for each facility.

4-1f. Spatial Considerations

As discussed in Section 4-1a, row spacing is inadequate in the Learning Center, Professional Writing Lab, and the Professional Educational Lab. The arrangement of individual workstations, other equipment external to the workstations, teaching equipment, and staff areas results in a dense room layout that is especially apparent when these facilities are full. While the required hardware and furnishings may fit within the allotted space, it is a tight fit for the users themselves. The CTMI, by virtue of its layout, is the only facility of the four that provides sufficient space between stations. Row spacing in the CTMI was measured at 45 to 52 inches, depending on the location of the workstation.

While there are no specific guidelines for space allotments other than to accommodate the unique situation at hand, it is possible to derive a relationship between each facility's needs and existing conditions. Table 4-4, therefore, presents two values for comparison. The *actual workspace area* for the three facilities in question is derived from a measurement of each lab's existing workstation dimensions with all adjustable components in maximum position, plus the remaining space between rows. The *workspace area needed* is derived from the same workstation dimensions, but incorporates the recommended 42 inches between rows required for maximum user movement as well as the accommodation of a teacher or other person assisting the user. This comparison further illustrates the inadequacies of the workspace areas.

Dedicated space for personal effects is virtually non-existent in all of the facilities. Students generally store their books in and around their workspace area and hang their coats on their chairs. These objects add additional bulk to the workspace areas, and further inhibit traffic between rows.

Table 4-3: Existing and needed workspace areas per person for each facility.

Facility	Existing Workspace Area (Sq. Ft.)	Workspace Area Needed (Sq. Ft.)
Learning Center	21.2	26
Pro Writing Lab	17.2	24
Pro Education Lab	22.7	28.4

4-2. Interior Environmental Analysis

Sections 4-2a and 4-2b refer to Figures 4-7 - 4-10, which show illuminance values as measured in footcandles (FC) and luminance values as measured in footlamberts (fL) for each of the four labs. Engineering texts published by the IES (1989) and other sources express illuminance values in *lux* and luminance values in *candelas per square meter* (cd/m^2). Appendix B provides conversion factors for these values.

4-2a. Lighting

Lighting in each of the four facilities is provided by recessed luminaires fitted with 45° parabolic lenses and cool-white fluorescent bulbs. All facilities feature 11"x 11" luminaires, occupying the same space as a ceiling tile, and spaced 2 tiles apart in the Learning Center and 3 tiles apart in the smaller facilities. General illuminance on essential task areas is acceptable in all of the facilities, and the overall distribution of light on all worksurfaces and keyboards appears to be appropriate as well.

Referring to the IES (1989) *illuminance selection procedure* outlined in Table 2-2, the labs in this study can be determined to meet the following functional criteria: 1) speed and accuracy requirements that are at best important, but not critical; 2) a user population generally under 40 years of age (except CTMI); and 3) reflectance of task background between 30 - 70%. These factors indicate that a general illuminance level of 300 lux (28 FC) from a range of 200-300-500 lux (19-28-46 FC) should be sufficient for these workspaces. As defined by this procedure, the illuminance levels of each of the labs, as measured on tasks areas, are in accordance with recommended guidelines.

Three of the facilities in this study have windows on only one wall. The Learning Center has windows on two walls, with one side composed of glass block which lets in daylight, but hides an unpleasant view of the roof. Room layout in each of the three student labs places workstations perpendicular to the windows, with a few exceptions due to space limitations. As can be seen in Figures 3-4 and 4-7, the CTMI has stations both facing and in front of windows, which can result in reflected as well as direct glare for the user. However, all facilities are equipped with adjustable aluminum blinds or drapes to control for the problems posed by windows in a computing facility.

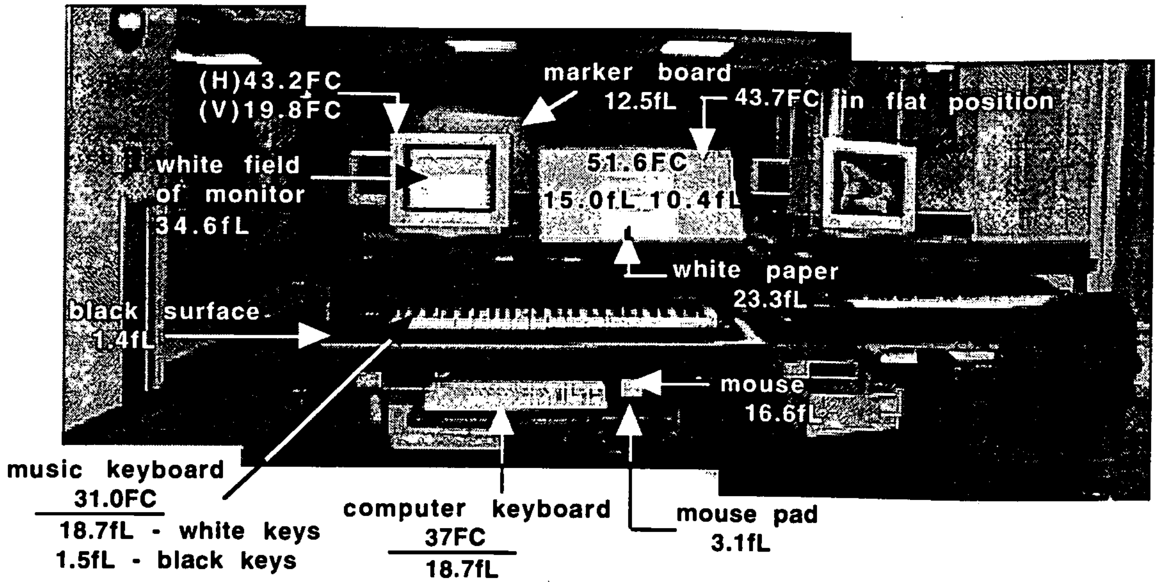


Figure 4-7: Learning Center illuminance (FC) and luminance (fL) values.

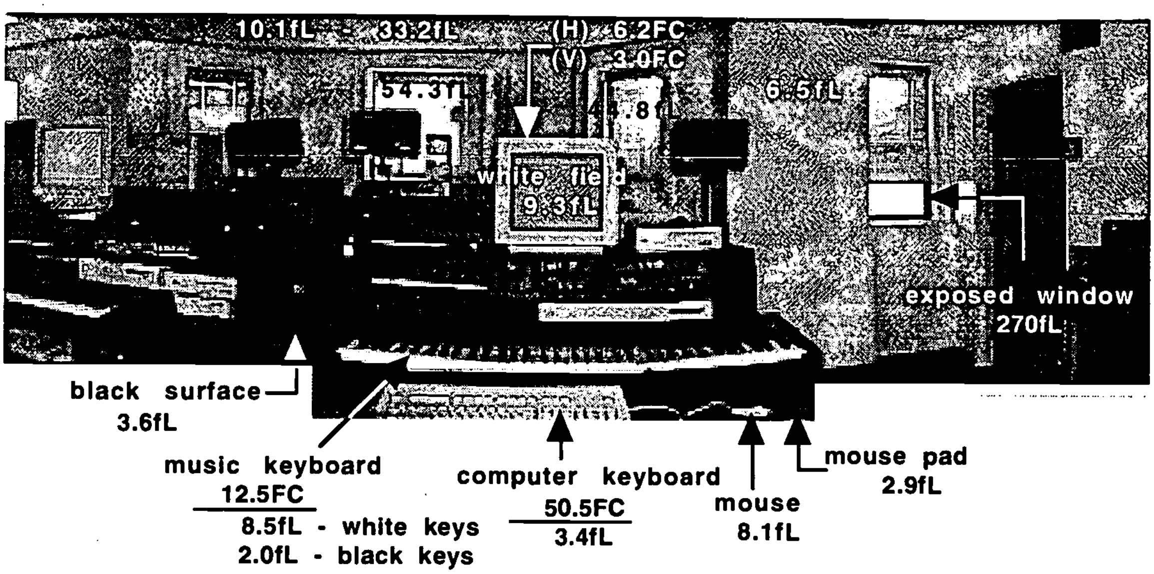


Figure 4-8: CTMI illuminance (FC) and luminance (fL) values.

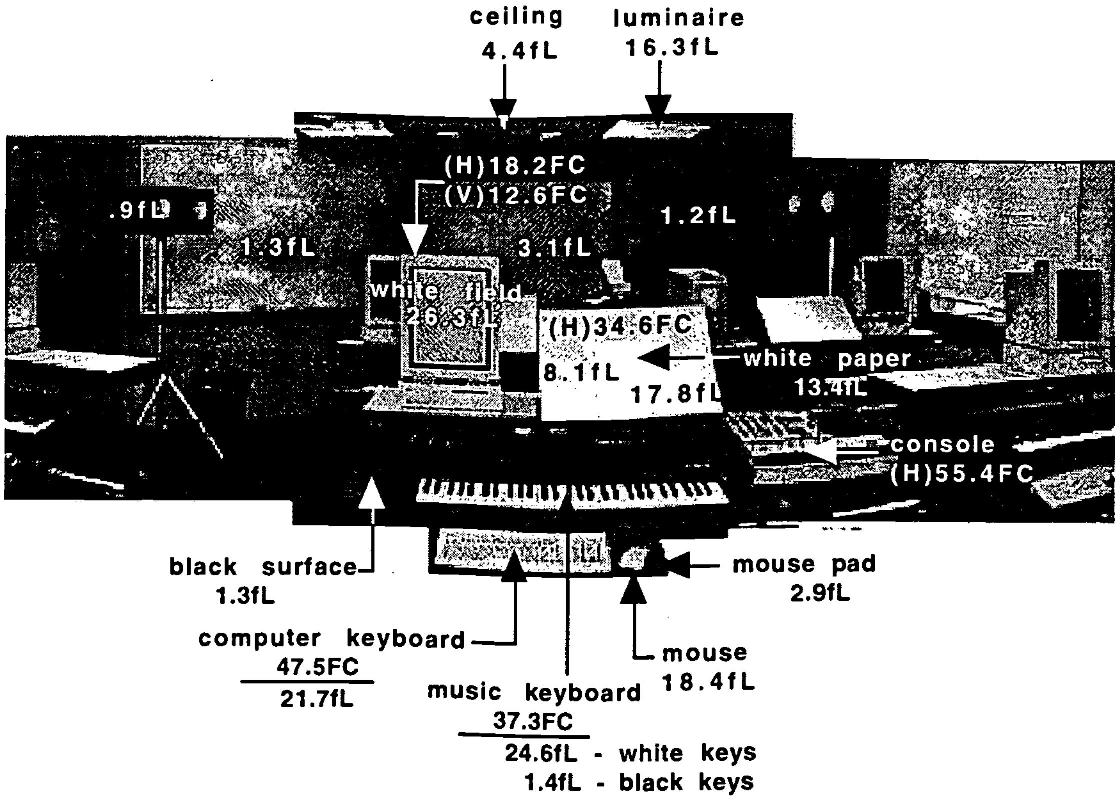


Figure 4-9: Professional Writing Lab illuminance (FC) and luminance (fL) values.

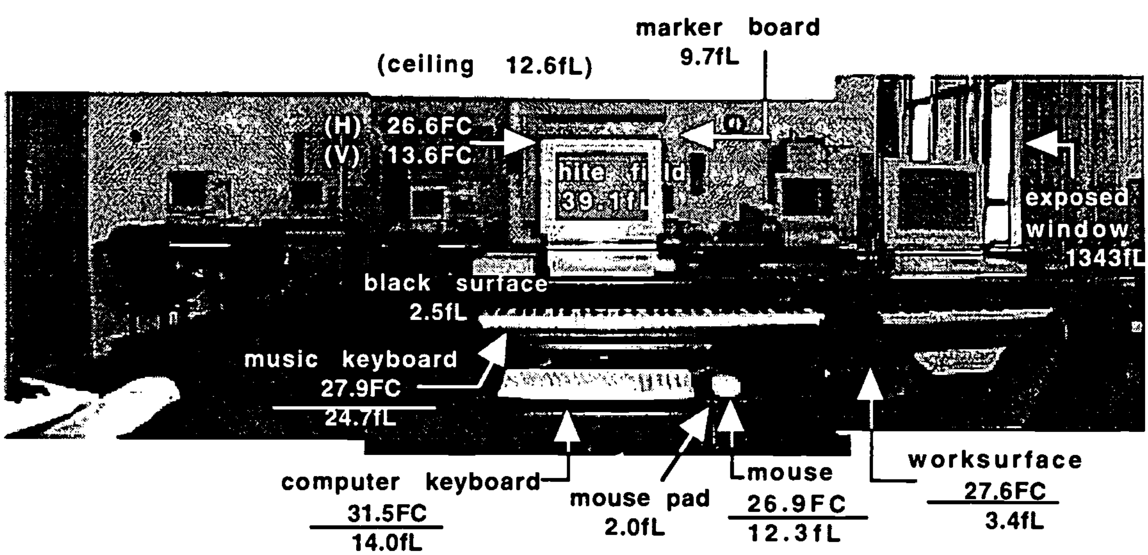


Figure 4-10: Professional Education Lab illuminance (FC) and luminance (fL) values.

4.2b. Color, Reflectance, and Contrast

The luminance values in Figures 4-6 - 4-9, measured in footlamberts (fL), combine to produce the luminance contrasts in the visual field for each workspace. Contrasts between VDT and paper-based visual task areas, as well as their adjacent surfaces, are within the IES (1989) maximum limits in each of the facilities. One potential problem spot exists in the Professional Education Lab (Figure 4-9), where the black worksurface area at the lower right of the workstation is likely to produce luminance contrasts in excess of 3:1 with any paper-based task. This surface is, however, small enough in that an open book or other hardcopy will significantly cover the area.

Other important viewing areas, such as the music and computer keyboards, fall within acceptable contrast limits in relation to other primary viewing surfaces in all of the facilities. Some extreme contrasts, however, can be seen on other adjacent workstation surfaces in each of the figures, such as the black equipment cover versus the white keys of the music keyboard. Since these surfaces are generally out of the primary task viewing area, the potential problems are minimal.

Some potential problems in the *distant* visual surround contrast in three of the facilities are noted. The Professional Writing Lab revealed some extreme contrast differences between distant surfaces and the VDT, which can present visual adaptation problems when a student is using a computer in conjunction with a class lecture or happens to gaze away from the screen

(Figure 4-8). At the time of measurement, both the CTMI and the Professional Education Lab had exposed windows, yielding excessive visual contrasts within the surrounding areas (Figures 4-7 and 4-9). Windows that were effectively shielded in the CTMI were well within the acceptable 1:10 limit (Figure 4-7). Again, all facilities are equipped with adequate window shading which, if properly utilized, should prevent outside light from being problematic.

A subjective evaluation of surface treatments for workstation furniture in each of the facilities indicates that they are in accordance with recommended guidelines. All workstation frames are painted in flat black, and computer equipment is covered in the standard flat platinum hue pervasive among modern brands. Worksurfaces for paper-based tasks, where available, follow IES (1989) recommendations for matte finishes. The Learning Center's worksurfaces are covered with a pale gray matte finish. The Professional Writing Lab's worksurfaces have a matte *white* finish capable of a higher degree of reflectivity, but the potential effects of this are minimized given the room's overall lower lighting levels. A comparison of the two workstations in Figures 4-6 and 4-8 show comparable luminance readings in spite of the differences in illuminance levels falling on the worksurface. However, contrast appears to be less overall in the PWL, with the background luminance slightly exceeding the task in one area of the worksurface. If the white matte surface were to be used in an area with higher ambient lighting levels, it would likely to be too harsh for visual comfort.

The walls in most of the facilities and classrooms at Berklee are painted in various shades of off-white, usually with a semi-gloss finish. The off-whites in the Learning Center, CTMI and Professional Education lab each have a hint of color: the Learning Center in bluegray; the CTMI in gray; and the PEL in green. A subjective evaluation reveals no potential visual discomfort from the finishes in any of these facilities, and the color treatments themselves are appropriate to learning environments requiring quiet concentration. The Professional Writing Lab, painted in a low-luster medium shade of blue, is the only facility where the color scheme may be questionable from an *aesthetic* point of view. While this treatment imparts a closed-in appearance to an already densely configured room, it does not appear to be *visually* distracting or discomforting, and is therefore considered acceptable on that basis. Ceilings in all facilities are fitted with white acoustical tiles with an estimated reflectivity between 85-90%. Carpets are in dark colors, with an estimated reflectivity between 20-25%.

4.2c. Acoustics

Figures 4-11 - 4-14 show the Preferred Noise Criterion (PNC) curves as measured in each of the facilities. Also provided with each figure is an accompanying dBA rating which was also taken at the time of measurement. All facilities were under the 55 dBA limit recommended by ANSI/HFS (1988) for VDT offices. Two of the facilities, the CTMI and Professional Writing Lab, exceeded the recommended 47dBA limit for educational spaces. All of the facilities exceeded the recommended PNC 30-40 range for libraries, self-study areas and classrooms. According to this criteria, each of the labs have steady broadband noise levels high enough to be disturbing to users. From a subjective standpoint, their respective acoustical environments would be considered moderately noisy. The PNC readings also indicate that none of the facilities are within the recommended guidelines for classroom communications.

It was not possible to ascertain the exact noise isolation properties (STC) of the wall construction in most of the facilities. All walls separating each facility from its neighboring spaces appear to be of double construction with Batt insulation, and a subjective evaluation reveals little or no noise intrusion from outside sources. The location of each of the facilities further protects from external noise. None are located directly adjacent to areas of heavy highway traffic, though a minimum amount of traffic and city noise can be heard when the windows are open. The Professional Education Lab and the CTMI are both well isolated in their respective buildings, as each is located away from classroom and student traffic in areas comprised mostly of administrative offices. The Professional Writing Lab is located in an area that sees a significant amount of student traffic, as classrooms and other labs are located within the vicinity. The glass wall separating this facility from the hallway is not acoustically treated, though it appears to provide enough isolation from local noise sources. While the Learning Center is often host to

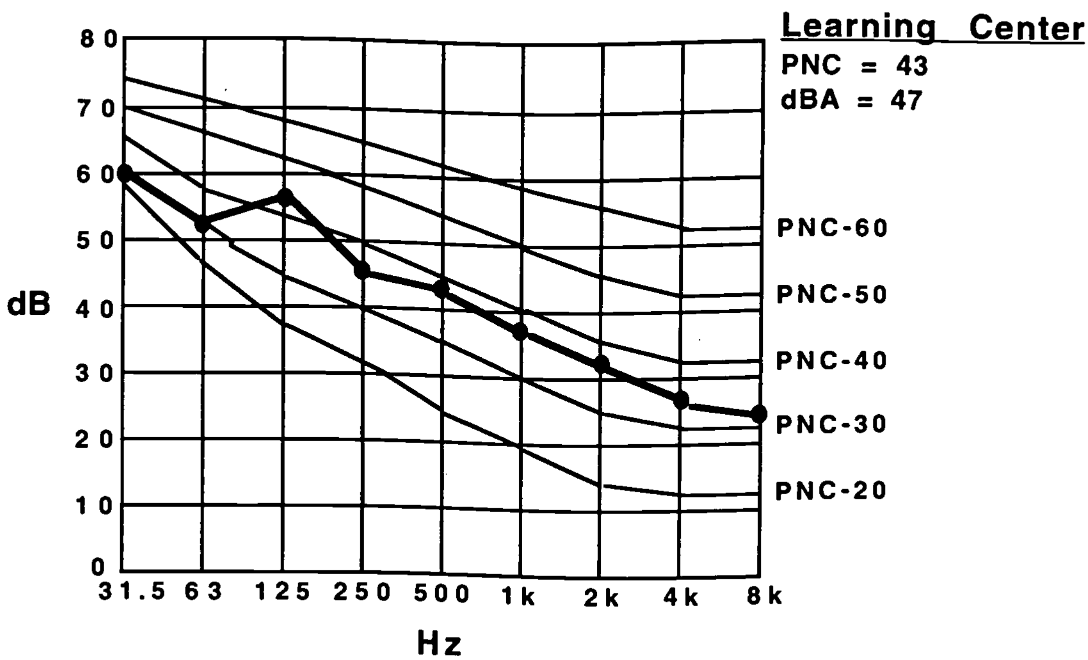


Figure 4-11: Learning Center PNC curve and dBA rating

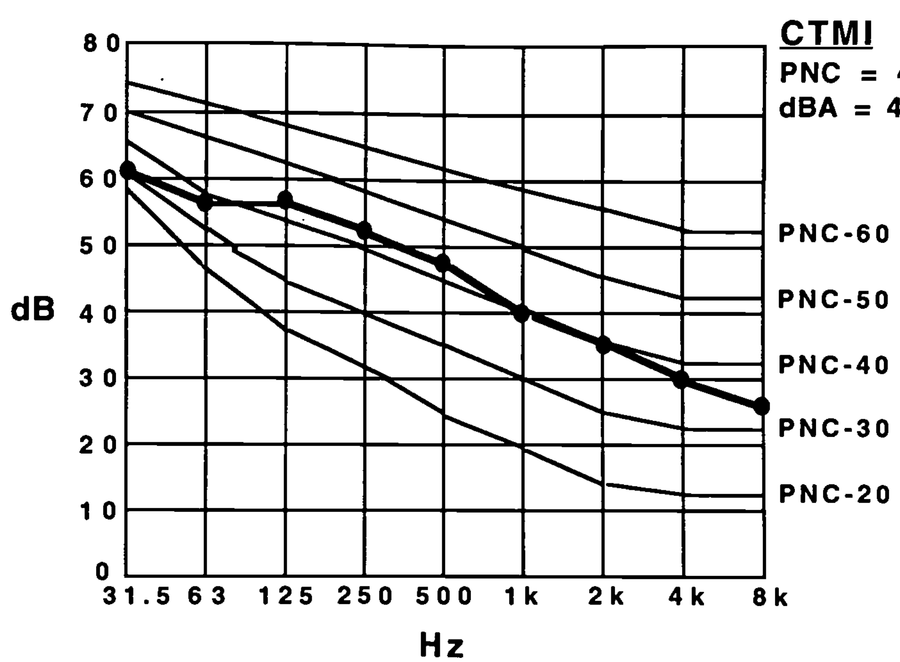


Figure 4-12: CTMI PNC curve and dBA rating

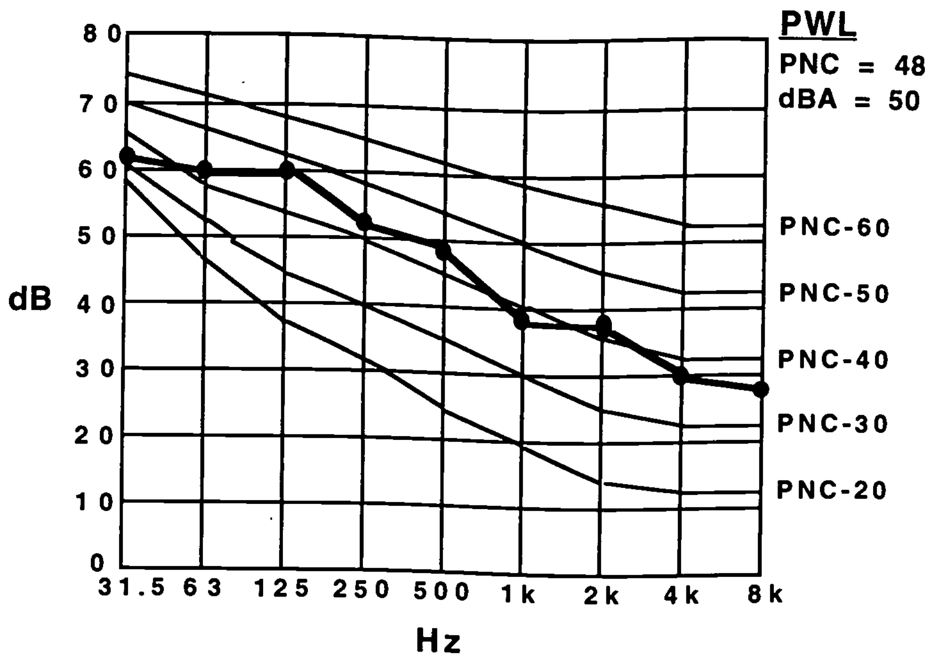


Figure 4-13: Pro Writing Lab PNC curve and dBA rating

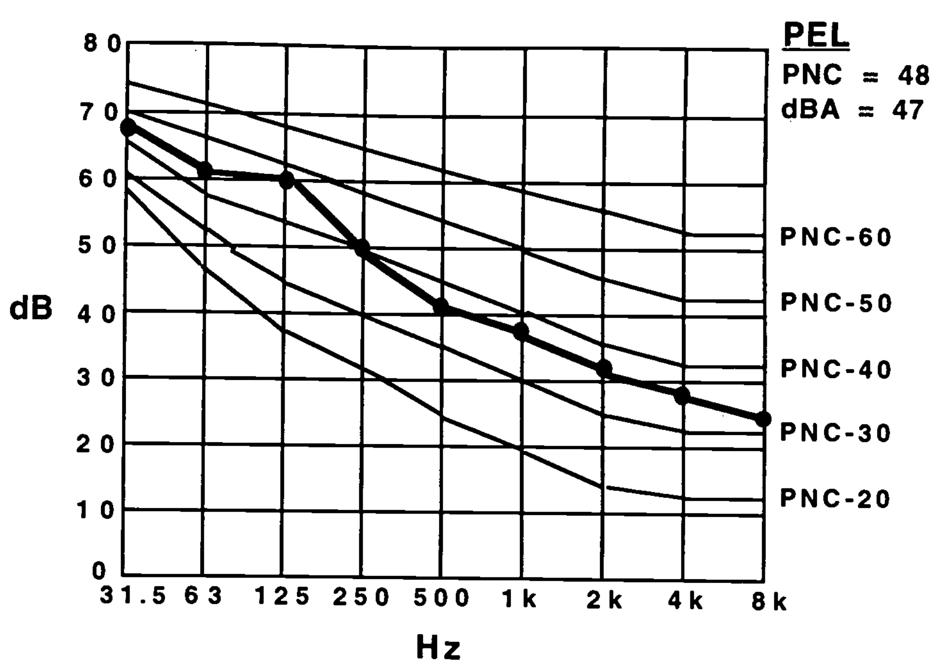


Figure 4-14: Pro Education Lab PNC curve and dBA rating

a wide range of concurrent activity (individual study, occasional class sessions, tutoring, etc.) each activity is acoustically isolated. Tutoring occurs in rooms constructed with double studded Batt insulated walls, yielding an STC rating of 47. The classroom area is separated from the rest of the center with acoustically treated glass rated at STC 37.

All facilities are fitted with carpet and acoustical ceiling tiles, which helps to minimize noise from user traffic and adjacent workspaces. Additionally, the sound levels in each of the labs should adequately mask the typical noises inherent in a computer environment. However, the arrangement of the workstations places users directly adjacent to one another, and closer than the 8 feet generally recommended. This proximity presents other potential acoustical obstacles to users being able to work undisturbed.

4.2d. Thermal Conditions and Air Quality

Thermal Conditions were measured in each lab over the course of a day at 2 hour intervals, starting prior to opening at 9:00 AM and continuing throughout the operating day until 5:00 PM. These readings were taken midway through the same period in October that the user assessment data was collected. Outside temperatures were in the low 70s, which is slightly warmer than is typical for this time of year. HVAC systems were running to compensate for the outside warmth as well as to provide the necessary cooling and ventilation needed for computer labs. Spot readings for both temperature and relative humidity readings were recorded using a digital humidity and temperature meter. Results of these measurements are presented in Figures 4-15 - 4-18.

Most of the readings clustered within the upper region of the winter comfort zone as the operating day progressed, with a couple of readings just entering into the summer comfort zone. Overall, these readings should be appropriate for the fall season in New England, and the medium weight clothing normally worn by students during this time of year. The 3:00 PM reading in the Professional Education Lab, however, was nearly out of the comfort zone entirely. This reading found a fully occupied space with the air conditioning off, windows open, and as a result warm temperatures. When it was commented to the lab staff member on duty that the room felt warm, he replied that he had shut down the air conditioning and opened the windows to bring in some fresh air. Acknowledging that the room had indeed become too warm by this time, the staff member closed the windows and turned the air conditioning back on. By the 5:00 PM reading, the lab had returned to a more comfortable indoor climate. In all of the labs in this study, staff members have access to thermostat controls and windows. Therefore, temperature is regularly monitored and adjusted as needed.

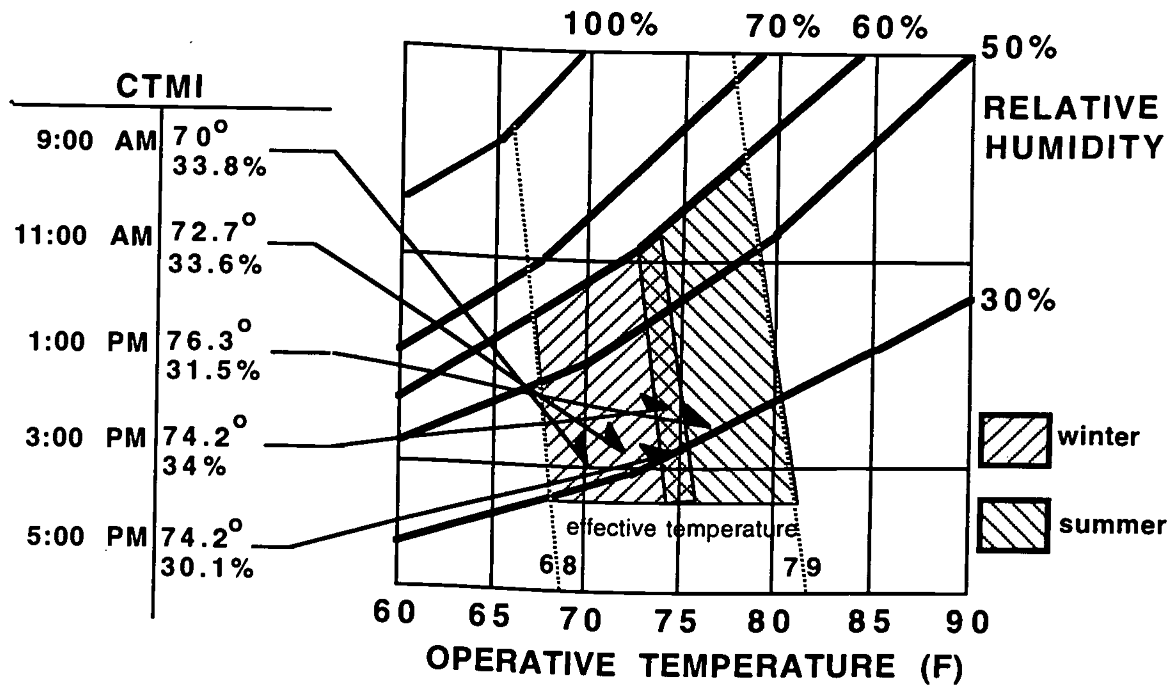


Figure 4-15: Learning Center thermal measures and ASHRAE (1993) comfort zones

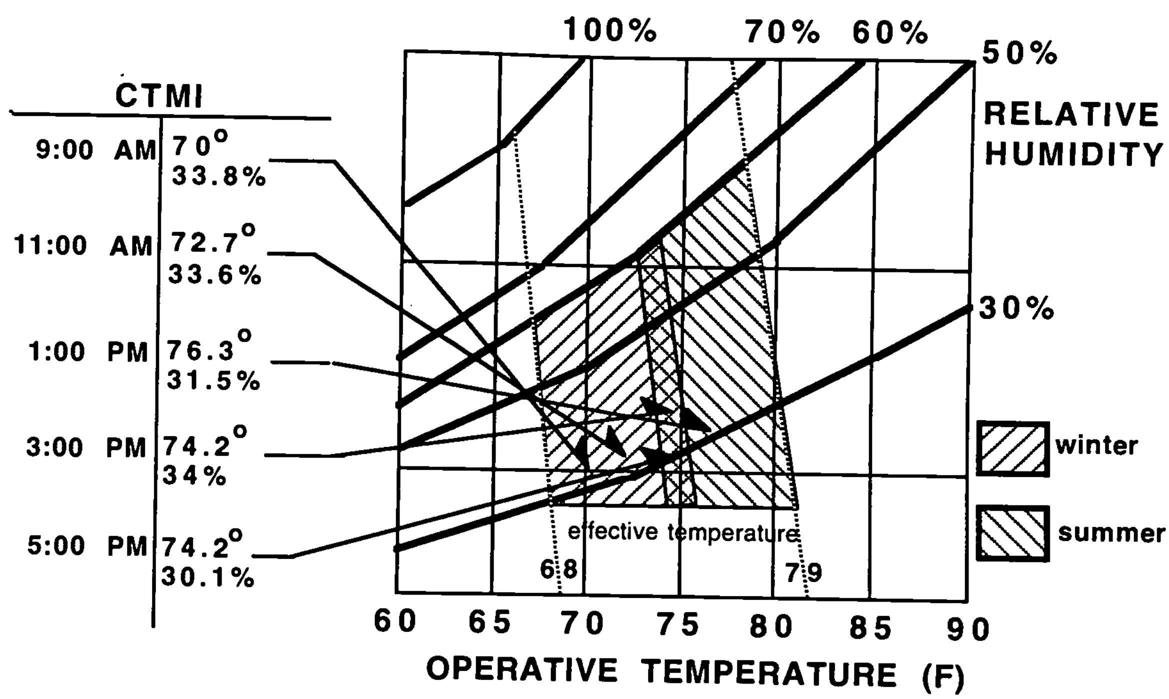


Figure 4-16: CTMI thermal measures and ASHRAE (1993) comfort zones

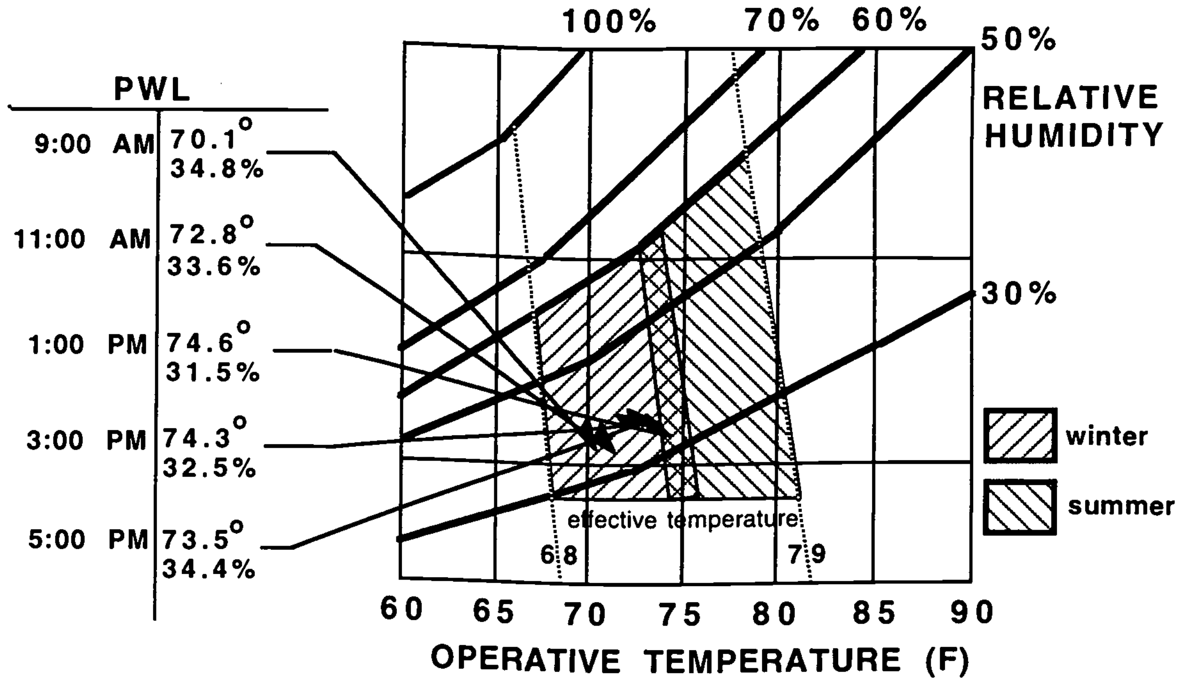


Figure 4-17: Pro Writing Lab thermal measures and ASHRAE (1993) comfort zones

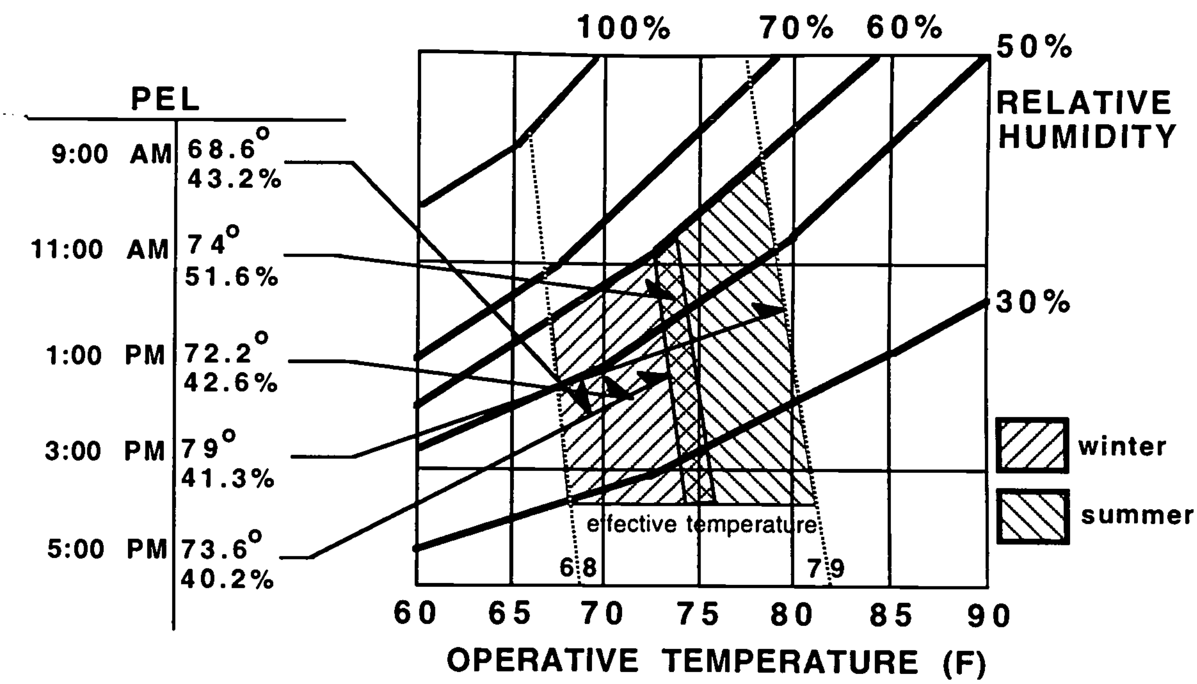


Figure 4-18: Pro Education Lab thermal measures and ASHRAE (1993) comfort zones

It can be determined from the range of readings that thermal conditions for each facility tend to be within established thermal comfort parameters. User needs stemming from the effects of changing temperatures and crowding appear to be adequately compensated through access to thermostat controls. Although general thermal comfort is adequate, humidity levels tend to fall well below established recommendations for an overall 50% level for computer environments. This is more of an issue of potential damage to equipment and data as a result of static. Though most people will feel comfortable at these levels, some occupants may perceive the air as dry.

Figures 4-19 - 4-22 illustrate air movement in feet per minute (fpm) as measured at specific locations in each facility. All of the facilities had readings at the low end of the recommended ranges or below, depending on the proximity to the diffuser. Variability in some of the readings may have been due to the settings of the dampers. While the majority of users are unlikely to perceive these conditions as drafty, others may be uncomfortable with the relatively low velocities.

A subjective evaluation of the overall air quality was conducted in the absence of appropriate instruments for measuring fresh air exchange and content. Again, while the relatively low air movement may be perceived by some users as uncomfortable, the air itself appears to be free of unusual odors and an acceptable level of fresh air exchange appears to be maintained.

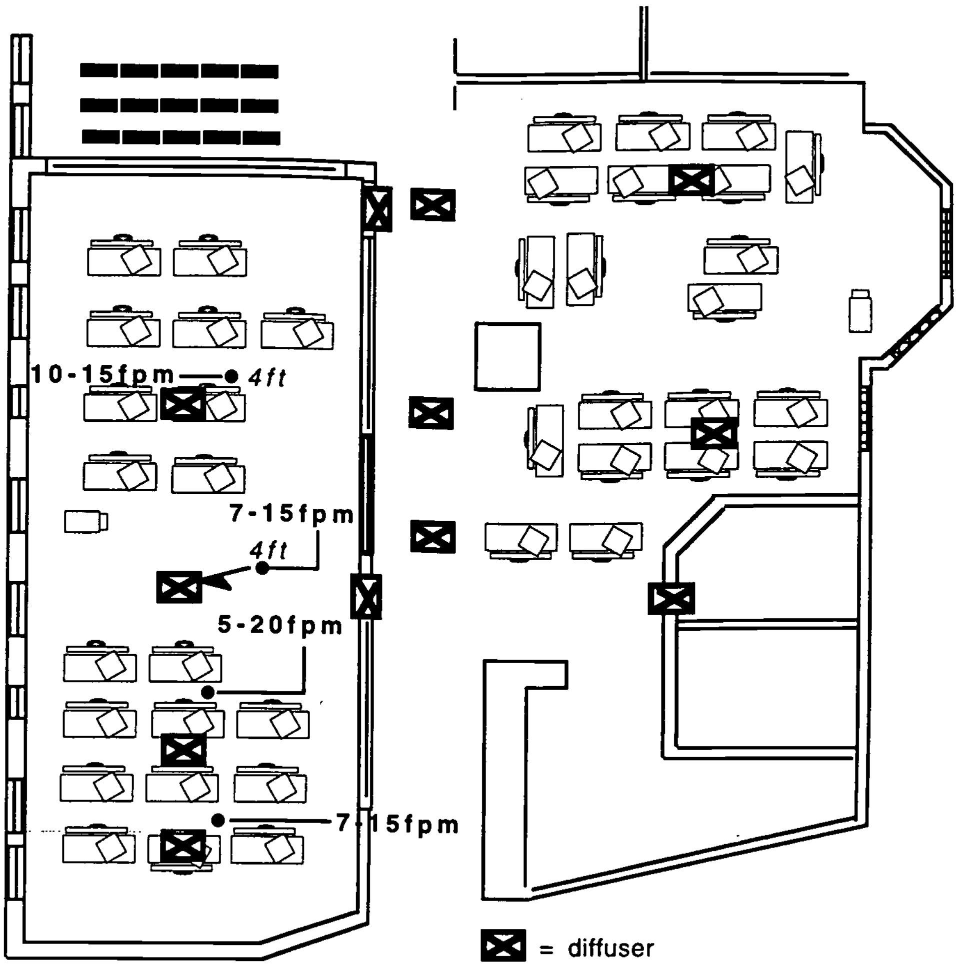


Figure 4-19: Learning Center diffuser locations and air velocity measurements at selected workstations

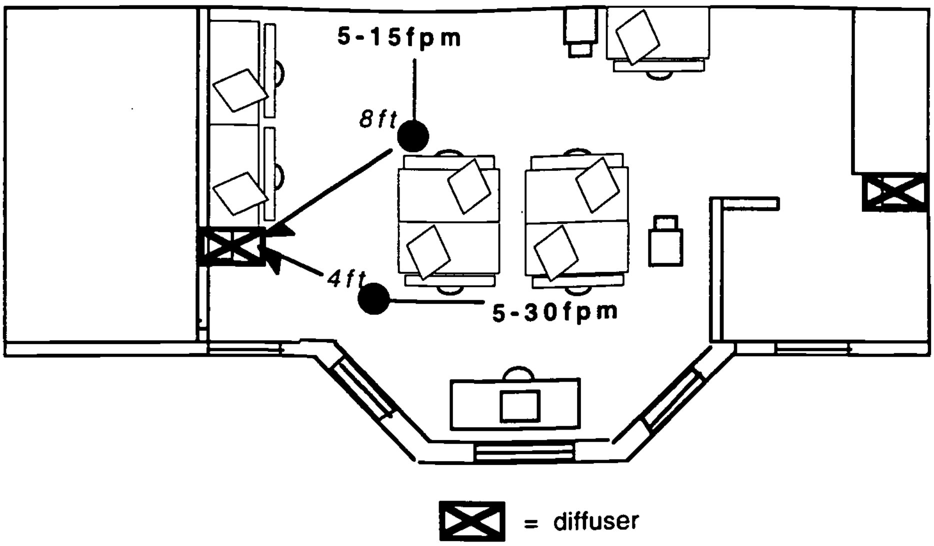


Figure 4-20: CTMI diffuser locations and air velocity measurements at selected workstations

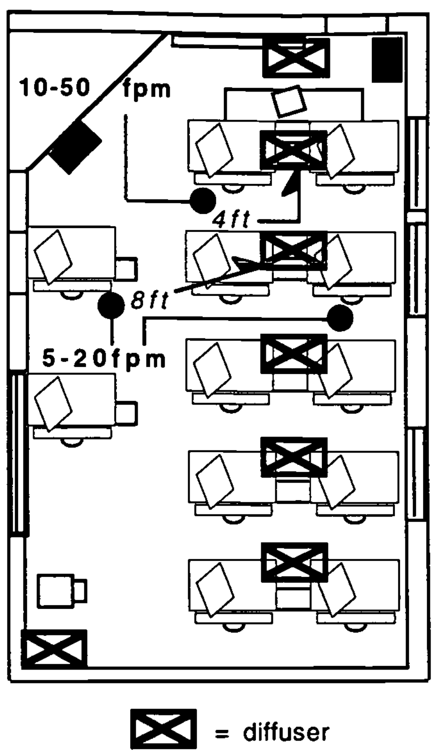


Figure 4-21: Professional Writing Lab vent locations and air velocity measurements at selected workstations

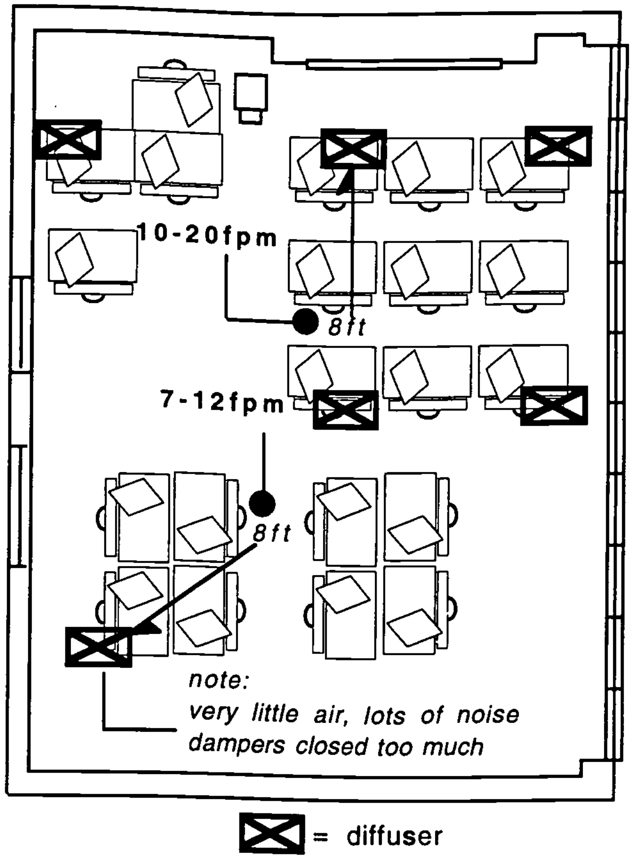


Figure 4-22: Professional Education Lab diffuser locations and air velocity measurements at selected workstations

4.3. Ancillary Elements

4-3a. Technical Support

Technical support is provided in each of the facilities by a combination of regular staff and work-study. Personnel numbers are proportioned according to the size of the lab. The Learning Center, being the largest facility of the four, also has the largest support staff, with three to four people per forty stations on duty during all operating hours. The Professional Writing and Professional Education labs generally have one person on duty at any given time. Given that these two labs are smaller and program centered, the arrangement appears to be adequate. The CTMI requires a different level of support, as faculty members apply the technology to curricular applications as well as personal productivity. For this facility, professional, as well as paraprofessional staff, are available to accommodate specific needs. In all facilities, commercial manuals and customized documentation in the form of handouts or on-line help files are available. In general, resources for technical support in all of the facilities appears to be at acceptable levels.

4-3b. Room Aesthetics

Room aesthetics are generally a matter of subjective interpretation. The Learning Center's well coordinated decor and room configuration is effective enough to take attention from the fact that the ceiling is only 7'6" high. The Professional Writing Lab, as described in the previous section, appears dark for a learning facility, with walls painted in a medium, rather than light shade of blue. The Professional Education Lab has the reputation of having the best view on campus, with windows looking out onto the Fenway. The high ceiling and pale green walls help this room appear more spacious than it actually is.

4-4. Results of the Workstation and Interior Environmental Analyses

Tables 4-4 - 4-7 present an overview of each of the facilities in terms of the data collected from the environmental analyses. These elements are viewed within the context of individual questionnaire items and their relationship to specific guidelines as outlined in Chapter 2. If a given environmental factor is in agreement with the recommendations, its representative questionnaire item is "accepted" by this criteria. Otherwise, it is "rejected" accordingly.

Table 4-4: Learning Center environmental analysis results

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
LEARNING CENTER	Seating	A	A	A	A	A	A	R
	Desks	A	A	A	R	A	R	A
	Viewing Locations	A	A	R	A	A	A	A
A = Accepted by guidelines	Screen Image Qlty	A	A	A	A	R		
R = Rejected by guidelines	Music and Audio Sys	A	A	A	A			
	Lighting	A	A	A	A	A		
	Color/Reflectance	A	A	A	A	A		
	Acoustics	A	R	R	R	R		
	Temperature/Air	A	A	A	A	A	A	
	Tech. Support	A	A	A	A			
	Other	A	A	R	R			

Table 4-5: CTMI environmental analysis results

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
CTMI	Seating	A	A	A	A	A	A	A
	Desks	A	R	A*	R**	A	R	A
	Viewing Locations	A	A	R	A	A	A*	R**
A = Accepted by guidelines	Screen Image Qlty	R	A	A	A	R		
R = Rejected by guidelines	Music and Audio Sys	A	A	A	A			
n/a = not applicable	Lighting	A	A	A	A	A		
**copyholders provided*	Color/Reflectance	A	A	A	*n/a*	*n/a*		
** *no dedicated writing surface*	Acoustics	A	R	R	R	R		
	Temperature/Air	A	A	A	A	A	A	
	Tech. Support	A	A	A	A			
	Other	A	A	R	A			

Table 4-6: Professional Writing Lab environmental analysis results

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
PRO WRITING LAB	Seating	A	A	A	R	A	A	R
	Desks	A	A	A	R	A	R	A
	Viewing Locations	A	A	R	A	R	A	A
A = Accepted by guidelines	Screen Image Qlty	A	A	*n/a*	A	R		
R = Rejected by guidelines	Music and Audio Sys	A	A	A	A			
n/a = not applicable	Lighting	A	A	A	A	A		
	Color/Reflectance	A	A	A	A	A		
	Acoustics	A	R	R	R	R		
	Temperature/Air	A	A	A	A	A	A	
	Tech. Support	A	A	A	A			
	Other	A	A	R	R			

Table 4-7: Professional Education Lab environmental analysis results

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
PRO EDUCATION LAB	Seating	A	A	A	R	A	A	R
	Desks	A	R	A	A	A	R	A
	Viewing Locations	A	A	R	A	A	R	R
A = Accepted by guidelines	Screen Image Qlty	A	A	A	A	R		
R = Rejected by guidelines	Music and Audio Sys	A	A	A	A			
	Lighting	A	A	A	A	A		
	Color/Reflectance	A	A	A	A	A		
	Acoustics	A	R	R	R	R		
	Temperature/Air	A	A	A	A	A	A	
	Tech. Support	A	A	A	A			
	Other	A	A	R	R			

4-5. User Assessment Results

4-5a. Data Overview

The number of respondents to the questionnaire totaled 120 (95 male, 25 female). The questionnaire consisted of 59 items, distributed among 11 sections incorporating 4 - 7 questions each (see Appendix C). Responses to individual items ranging from 1 (poor) to 5 (excellent) were assumed to provide an index of user satisfaction or dissatisfaction with a particular environmental or ergonomic factor. Responses of N/A (not applicable) were not assigned a numerical value and subsequently not included in the analysis. As is typical with questionnaires, some respondents left questions unanswered. Eliminating N/A responses and unanswered questions, a total of 6,748 actual responses were generated out of a possible 7,080, a yield of 95%. Appendix H lists the raw data from each of the facilities.

Results were entered into a database designed with FileMaker Pro©, which calculated the means for individual questionnaire items as well as the frequencies of individual responses. Subsequent statistical analyses were conducted using StatView II© statistical software.

Items 4 and 5 in the Acoustics section of the questionnaire were eliminated from the Learning Center and CTMI results. These questions pertained to a user's ability to listen comfortably within a classroom context. Classes are regularly scheduled in the Professional Writing and Professional Education labs, but only occasionally in the Learning Center and CTMI for special sessions. Therefore, 65% of the respondents in the Learning Center and nearly all of the respondents in the CTMI answered "N/A" or left these items blank. The remaining responses were determined to be unreliable, as they were not based on regular class attendance. The responses to these questions from the PWL and PEL were retained, though restricted to direct comparisons involving these two facilities.

Questionnaire items 4 and 5 in the Color and Reflectance section were considered not applicable (N/A) in the CTMI. It was generally expected that most of the users would have agreed. However, *all* of them responded to these items, most with satisfactory ratings. As indicated in previous sections, there is no desktop area dedicated to reading and writing tasks. Books and other documents are generally placed in bookstands which positions them vertically from the desktop surface, and writing tasks are performed wherever there is room, such as on the user's lap or the music keyboard. Since it was difficult to determine exactly what area of the desk was being rated, these responses were not included in the analysis.

Item 3 from the Computer Screen Image Quality section was considered not applicable (N/A) in the Professional Writing Lab, as the displays in this facility are black and white. It was again expected that this item would have ultimately been dropped from this facility's results due to a large number of N/A or blank ratings, but only 8 of the 34 subjects responded in this way. Though this was not intended to be a "trick question," the results nonetheless demonstrate one of the pitfalls to avoid when conducting a user assessment. As these responses cannot be considered reliable, they are not included in the analysis.

The questionnaire results were analyzed from multiple perspectives. First, responses from the four user groups were compared to validate the data and to determine the extent of the differences in ratings across facilities. Next, the overall results of the user assessment were compared to the results of the environmental analyses to determine the strength of the relationship between the user ratings as measured by the questionnaire and the ergonomic and environmental design guidelines as outlined in the literature. Responses to the individual questionnaire items in each facility were then examined to determine the extent of satisfaction or dissatisfaction expressed by the user groups with specific environmental and ergonomic factors in each facility.

4-5b. Face Validity

As in the McVey (1979) study, a face validity analysis was incorporated into this study to ascertain the respondents' attitudes toward the items in the questionnaire. At the end of each set of questions for a specific environmental factor (i.e. lighting, desks, acoustics), subjects were asked to indicate on a 10-point scale that factor's personal importance to them as users of the facility. The results help to provide an index of the worth of the questionnaire to the subjects, and thus further validate the findings. Table 4-8 presents the mean ratings for each factor. As all of the means are at the upper end of the scale, it can be determined from the results that the items reflected in the questionnaire were considered by the respondents to be relevant to their respective learning environments. It is also possible to derive from the table a design priority that can be applied to similar contexts.

Table 4-8: Face validity analysis for each environmental factor in descending order.

Environmental Factor	Mean	SD
Technical Support	8.41	1.94
Music and Audio Systems	8.28	1.91
Desks	8.14	1.79
Computer Screen Image Quality	8.01	1.92
Seating	7.86	2.05
Temperature and Air Quality (Thermal)	7.86	1.98
Acoustics	7.84	1.98
Lighting	7.84	1.91
Viewing Locations	7.79	1.95
Other	7.62	1.94
Color and Reflectance	7.15	2.37

4-5c. Comparisons Across Facilities

Tables 4-9 - 4-12 provide an overall comparison of the mean group ratings for individual questionnaire items in each facility. The mean response across all facilities was 3.66, with a standard deviation of 1.17. As a general criteria based on the 5-point rating scale employed in the questionnaire, group ratings below 3.00 are assumed to be indicative of problems with a specific workspace factor in the opinion of the users. The statistical methods described in the following paragraphs were used to substantiate the reliability of the data, rank order specific workspace factors for comparison, and determine the extent of the differences in the overall user ratings across the four facilities.

Table 4-9: Learning Center mean scores of questionnaire items.

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
LEARNING CENTER	Seating	4.28	4.28	4.32	4.15	3.87	4.03	2.90
Mean scores of	Desks	4.00	3.50	3.82	2.61	3.95	3.81	3.44
questionnaire items	Viewing Locations	4.35	4.33	4.20	4.45	4.28	3.73	3.74
	Screen Image Qlty	4.68	4.65	4.71	4.38	4.18		
** = dropped from analysis*	Music and Audio Sys	3.49	3.22	3.38	3.26			
	Lighting	4.55	4.35	4.15	3.85	3.95		
	Color/Reflectance	4.25	4.50	4.55	4.33	4.20		
	Acoustics	4.54	2.80	4.00	*	*		
	Temperature/Air	4.30	3.65	3.77	4.05	4.15	4.15	
	Tech. Support	3.80	3.78	4.19	4.00			
	Other	4.15	3.83	2.44	3.18			

Table 4-10: CTMI mean scores of questionnaire items.

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
CTMI	Seating	3.44	3.69	3.25	3.50	3.56	3.44	3.81
Mean scores of	Desks	3.75	2.44	2.94	2.50	3.56	3.43	3.81
questionnaire items	Viewing Locations	3.75	4.00	3.67	3.93	2.62	2.31	2.31
	Screen Image Qlty	4.25	4.31	4.25	3.25	3.31		
n/a = not applicable	Music and Audio Sys	4.00	3.69	3.58	2.93			
** = dropped from analysis*	Lighting	4.00	4.25	4.06	3.31	3.63		
	Color/Reflectance	3.81	4.00	4.06	*n/a*	*n/a*		
	Acoustics	4.00	3.19	3.50	*	*		
	Temperature/Air	3.93	3.73	3.20	3.80	3.80	3.47	
	Tech. Support	4.69	4.75	4.63	4.07			
	Other	3.63	3.75	2.06	2.81			

Table 4-11: Professional Writing Lab mean scores of questionnaire items.

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
PRO WRITING LAB	Seating	2.94	3.00	3.03	2.91	2.94	3.50	2.26
	Desks	3.76	2.94	3.44	2.88	3.34	3.55	3.00
Mean scores of	Viewing Locations	4.06	4.06	3.74	3.91	2.91	2.97	3.27
questionnaire items	Screen Image Qlty	3.94	4.18	*n/a*	4.18	3.79		
	Music and Audio Sys	3.79	3.82	3.82	3.38			
n/a = not applicable	Lighting	4.06	4.12	3.85	3.44	3.64		
	Color/Reflectance	3.58	4.16	4.31	4.03	4.15		
	Acoustics	4.27	3.42	4.00	4.00	3.79		
	Temperature/Air	4.00	3.82	3.24	3.97	3.85	3.62	
	Tech. Support	3.97	4.09	3.61	3.52			
	Other	3.45	3.39	2.71	2.94			

Table 4-12: Professional Education Lab mean scores of questionnaire items.

	Factor	Corresponding Question						
		1	2	3	4	5	6	7
PRO EDUCATION LAB	Seating	3.70	3.87	3.80	3.23	3.00	3.67	1.77
	Desks	3.87	2.20	2.63	2.60	3.07	2.93	3.30
Mean scores of	Viewing Locations	4.03	4.03	3.97	4.07	3.17	2.22	2.29
questionnaire items	Screen Image Qlty	4.07	3.89	3.89	3.75	3.18		
	Music and Audio Sys	3.22	3.18	3.36	2.91			
	Lighting	4.07	3.93	3.79	3.39	3.82		
	Color/Reflectance	3.21	3.70	3.54	3.52	3.79		
	Acoustics	4.10	2.90	3.59	3.52	3.31		
	Temperature/Air	3.86	3.14	2.90	3.93	3.96	3.68	
	Tech. Support	3.12	2.96	3.26	3.23			
	Other	3.15	2.76	1.80	2.04			

The Kruskal-Wallis one-way ANOVA of ranks was used to determine whether the user ratings differed significantly across facilities for each of the 11 subsections of the questionnaire. The intent was to ascertain which facility, for example, was rated highest overall for seating, acoustics, or other environmental category. Except for the results of the acoustics subsection ($p >$ .05), all comparisons were significant ($p <$.02), indicating that the differences in user ratings on each subsection can be attributed to the conditions inherent in each facility. Among the four facilities, the Learning Center ranked highest overall in its user ratings for most of the ergonomic and environmental categories represented in the questionnaire. The Professional Writing Lab ranked highest in music and audio systems and the CTMI ranked highest in technical support. Ratings of the acoustical environment were similar in all facilities, and reflective of their similar conditions. Appendix I includes the results of the Kruskal-Wallis test.

Comparisons of individual questionnaire items were conducted in three steps using the Friedman two-way ANOVA of ranks. The first step compared each item by all subjects (N = 120), and resulted in significant differences in user ratings across facilities for each item (p = .0001). The next step compared items by subjects within each facility, again with significant results across items (p = .0001). The third step compared user ratings of items by facility, also with significant results (p = .0001). The combined results indicate that the differences in user ratings of individual items can be attributed to the conditions inherent in each facility as well as differences among specific workspace factors. The intent of this analysis was to determine which specific workspace factors, both across and within each facility, embodied the highest and/or lowest user ratings.

By way of the Friedman analyses, the workspace factors collectively found to rank highest in all facilities were lighting, computer display image quality, and color and reflectance. Viewing locations for the computer display also ranked high, though items referring to viewing locations for paper-based tasks were ranked comparatively lower. The lowest overall rankings were found in questionnaire items that reflected row space between workstations, personal space, storage for personal effects, and accommodations for working with paper-based tasks. Appendix I includes the results of the Friedman tests.

4-5d. User Ratings vs. Guidelines

A point-biserial correlation was used to determine whether a significant relationship existed between the user ratings as measured on the questionnaire and the relative acceptability or unacceptability of workspace factors as determined by the environmental analysis. The sums of ranks from the Friedman test results from within each facility were used as continuous data representing the overall group ratings on the questionnaire items. The results of the environmental analyses (from Tables 4-4 - 4-7) were dichotomized as "1" representing an item that is acceptable according to ergonomic and environmental design guidelines and "0" representing an unacceptable item. The results, presented in Table 4-13, indicate significant, moderate correlations for all facilities. While it was concluded that the overall direction of the user ratings was attributable in part to the design specifications of the workspace factors, the remaining percentages of variance as implied by the values in the R^2 column for each facility indicate that other factors contributed to the results as well.

Table 4-13: Correlation results from comparisons of user ratings and results of the environmental analyses for each facility.

Facility	Covariance	Correlation (R)	R^2	Significance
Learning Center	52.204	.491	.241	$p < .001$
CTMI	21.276	.410	.168	$p < .01$
Pro Writing	36.453	.377	.142	$p < .01$
Pro Education	55.783	.513	.264	$p < .001$

4-5e. Analysis of User Responses

The Chi-Square (X^2) test and subsequent contingency table analyses were used to examine the frequency of responses within each questionnaire item. For this analysis, the responses from the 5-point scale were categorized into three groups: greater than three (>3), equal to three (=3), or less than three (<3). The rationale for this division was in the assumption that ratings of "4" or "5" represent comparatively high user ratings, and that ratings of "1" or "2" represent comparatively low user ratings. In the context of this analysis, a rating of 3 is regarded as *neutral*. The intent of this analysis was to determine which workspace factors in each facility best reflected an agreement between the users and the ergonomic and environmental design guidelines, as well as which factors appeared to be especially favored or unfavored by the users. A separate Chi-square was calculated for each questionnaire item in each facility. Considering the large number of independent analyses to be conducted, significance for Chi-square was established at $\alpha = .001$ to achieve an overall level of confidence in the results.

Distributions on questionnaire items achieving the specified level of confidence showed the strongest direction in their user ratings, and therefore considered to be clearly indicative of user satisfaction or dissatisfaction. It was further observed, however, that a number of distributions falling short of this confidence level (up to $p = .05$) revealed evidence of varying degrees of group satisfaction or dissatisfaction. Though these distributions were less defined in their direction, it was determined that they represented a category of marginal ratings with implications of their own. Distributions on the remaining items proved to be indeterminate, and are concluded to be largely the result of chance responses, problems with the questionnaire, or at best "mixed reviews." Chi-Square and contingency tables are included in Appendix I.

The following levels of user ratings were derived from the item analysis: *High* - rating distributions that indicate significant satisfaction; *Marginal* - items that appear to be satisfactory to a large percentage of the group, but not considered significant sources of satisfaction due to other factors contributing to the ratings; *Low* - items not considered significant sources of dissatisfaction, but embody ratings low enough to indicate substantial problems with the factor being rated; *Unsatisfactory* - rating distributions that indicate significant dissatisfaction; and *Indeterminate* - rating distributions that reveal no particular direction.

4-5f. Table Comparisons

Tables 4-14 - 4-17 compare the results of the analysis of user ratings for each facility and the results of the environmental analysis. A summary of the tables across facilities is as follows: 1) of the items considered acceptable according to the guidelines, 51% were rated high by the users, 20% were marginal, 27% were indeterminate, and none were rated low or unsatisfactory; 2) of the items considered unacceptable according to the guidelines, 24% were rated high by the users, 6% were marginal, 14% were low, 6% were unsatisfactory, and 51% were indeterminate.

Table 4-14: Learning Center users vs. guidelines.

	Factor	**Corresponding Question**						
LEARNING CENTER		**1**	**2**	**3**	**4**	**5**	**6**	**7**
Users vs. Guidelines	Seating	A/H	A/H	A/H	A/H	A/H	A/H	**R**/I
	Desks	A/H	A/I	A/H	**R**/L	A/H	**R**/H	A/M
A = Accepted by guidelines	Viewing Locations	A/H	A/H	**R**/H	A/H	A/H	A/M	A/H
R = Rejected by guidelines	Screen Image Qlty	A/H	A/H	A/H	A/H	**R**/H		
H = High ratings	Music and Audio Sys	A/M	A/I	A/I	A/I			
M = Marginal ratings	Lighting	A/H	A/H	A/H	A/H	A/H		
L = Low ratings	Color/Reflectance	A/H	A/H	A/H	A/H	A/H		
U= Unsatisfactory ratings	Acoustics	A/H	**R**/I	**R**/H	*	*		
I = Indeterminate results	Temperature/Air	A/H	A/M	A/H	A/H	A/H	A/H	
	Tech. Support	A/H	A/M	A/H	A/H			
* = *dropped from analysis*	Other	A/H	A/H	**R**/L	**R**/I			

Table 4-15: CTMI users vs. guidelines.

	Factor	Corresponding Question						
CTMI		1	2	3	4	5	6	7
Users vs. Guidelines	Seating	A/I	A/M	A/I	A/M	A/I	A/M	A/M
	Desks	A/M	R/I	A/I	R/I	A/M	R/I	A/H
A = Accepted by guidelines	Viewing Locations	A/M	A/M	R/M	A/H	A/I	A/L	R/I
R = Rejected by guidelines	Screen Image Qlty	R/H	A/H	A/M	A/I	R/I		
H = High ratings	Music and Audio Sys	A/M	A/I	A/I	A/I			
M = Marginal ratings	Lighting	A/M	A/H	A/M	A/I	A/M		
L = Low ratings	Color/Reflectance	A/M	A/M	A/H	*n/a*	*n/a*		
U= Unsatisfactory ratings	Acoustics	A/H	R/I	R/I	*	*		
I = Indeterminate results	Temperature/Air	A/H	A/M	A/I	A/M	A/M	A/I	
n/a = not applicable	Tech. Support	A/H	A/H	A/H	A/H			
* *= dropped from analysis*	Other	A/M	A/M	R/L	A/I			

Table 4-16: Professional Writing Lab users vs. guidelines

	Factor	Corresponding Question						
PRO WRITING LAB		1	2	3	4	5	6	7
Users vs. Guidelines	Seating	A/I	A/I	A/I	R/I	A/I	A/I	R/U
	Desks	A/H	A/I	A/M	R/I	A/I	R/I	A/I
A = Accepted by guidelines	Viewing Locations	A/H	A/H	R/H	A/H	R/I	A/I	A/I
R = Rejected by guidelines	Screen Image Qlty	A/H	A/H	*	A/H	R/H		
H = High ratings	Music and Audio Sys	A/H	A/H	A/H	A/I			
M = Marginal ratings	Lighting	A/H	A/H	A/H	A/I	A/M		
L = Low ratings	Color/Reflectance	A/M	A/H	A/H	A/H	A/H		
U= Unsatisfactory ratings	Acoustics	A/H	R/I	R/H	R/H	R/H		
I = Indeterminate results	Temperature/Air	A/H	A/H	A/I	A/H	A/H	A/H	
* *= dropped from analysis*	Tech. Support	A/H	A/H	A/M	A/M			
	Other	A/I	A/I	R/I	R/I			

Table 4-17: Professional Education Lab users vs. guidelines

	Factor	Corresponding Question						
PRO EDUCATION LAB		1	2	3	4	5	6	7
Users vs. Guidelines	Seating	A/M	A/H	A/M	R/I	A/I	A/M	R/U
	Desks	A/H	R/L	R/I	A/I	A/I	R/I	A/I
A = Accepted by guidelines	Viewing Locations	A/H	A/H	R/H	A/H	A/I	R/L	R/L
R = Rejected by guidelines	Screen Image Qlty	A/H	A/H	A/H	A/M	R/I		
H = High ratings	Music and Audio Sys	A/I	A/I	A/I	A/I			
M = Marginal ratings	Lighting	A/H	A/H	A/H	A/I	A/H		
L = Low ratings	Color/Reflectance	A/I	A/M	A/H	A/H	A/I		
U= Unsatisfactory ratings	Acoustics	A/H	R/I	R/M	R/M	R/I		
I = Indeterminate results	Temperature/Air	A/H	A/I	A/I	A/H	A/H	A/M	
	Tech. Support	A/I	A/I	A/I	A/I			
	Other	A/I	A/I	R/U	R/L			

4-6. User Comments

Respondents had numerous opportunities to write comments throughout the questionnaire. Space was provided at the end of each section, and additional items designed to solicit general comments were offered on the last page. Many of the comments reflect the design issues and user ratings discussed so far in this chapter. Others seem to contradict the results while uncovering issues of an individual nature, or provide additional insight into the structure of the questionnaire itself. Some comments appeared to be misplaced by section, as references to one workstation component were written as comments for another. For example, most of the comments in the seating section had more to do with row space and desk issues than the structural characteristics of the chair itself. This is not surprising, considering that many of the environmental components investigated here are essentially interdependent. Appendix J contains the user comments as transcribed from the questionnaires. Table 4-17 provides an overview of the total number of criticisms in relation to the total number of comments per section. Considering the total number of respondents, the yield of comments overall is low. It is also apparent that the users seldom offered comments unless they were criticisms.

Table 4-18: User comments and criticisms. Values represent number of criticisms per total comments.

Item	Learning Center	CTMI	Pro Writing Lab	Pro Education Lab
Seating	11/14	5/5	12/12	9/9
Desks	10/13	5/6	8/8	7/8
Viewing Locations	2/9	1/4	2/6	8/9
Computer Screen Image Quality	0/7	3/6	2/3	2/4
Music/Audio Systems	12/18	1/4	3/7	1/4
Lighting	6/13	4/4	1/3	4/8
Color/Reflectance	1/5	1/4	1/5	2/6
Acoustics	9/13	3/4	3/3	3/8
Temperature/Air Quality	4/14	3/6	3/4	3/6
Tech Support	5/13	2/7	3/5	2/5
Other	4/8	1/2	5/5	3/6

4-7. Additional Data and Observations

Respondents were asked to answer three additional preliminary questions on the first page of the questionnaire: 1) how often the user visited the facility s/he was rating, 2) whether or not the user preferred to work at the same workstation or lab area upon each visit, and 3) what station they were using at the time of evaluation. Where the first two were included as supplementary observations, the third was included to help pinpoint specific environmental and workstation issues for discussion should they arise in the results. Figures 4-22 and 4-23 show the percentages of responses to two of the questions.

As can be seen from the results of the first question, most of the respondents in the three student labs regularly use these facilities twice a week or more. The high percentage of users who frequent the Learning Center more than twice a week is likely an outcome of its extended schedule, which covers seven days a week and operating hours until midnight. The other two student labs are somewhat more restricted in their hours, and have the additional responsibility of holding class sessions that further restrict casual access. CTMI usage appears to be less frequent according to the respondents from this facility, and is possibly the result of the very different schedules and needs of faculty members as compared to students.

The workspace preference patterns appear to differ the most in the Learning Center. As this is a large facility, and often crowded, it is likely that most users will take whatever is available. It is also possible that in a facility of this size, most users may not perceive any real differences among the stations. This facility also had the largest percentage of users who prefer a workspace within the same general area each visit. An examination of the reported locations of these respondents, however, revealed no discernible pattern with regard to what general areas are preferred, or why.

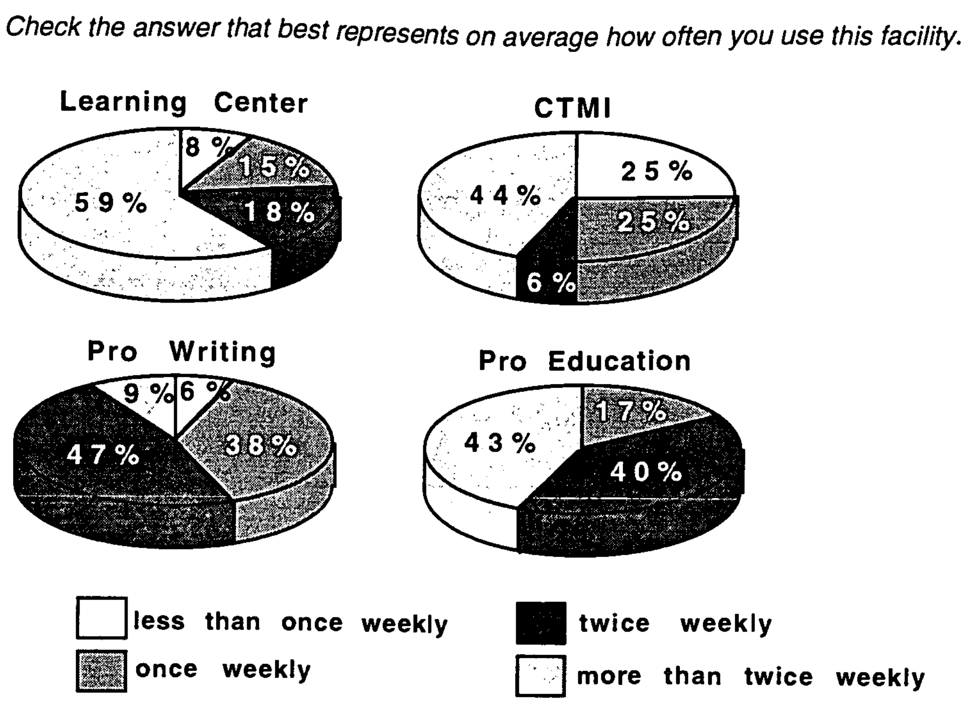


Figure 4-23: Frequency of user visits per facility

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Check the answer that best represents where you prefer to work when you visit this facility.

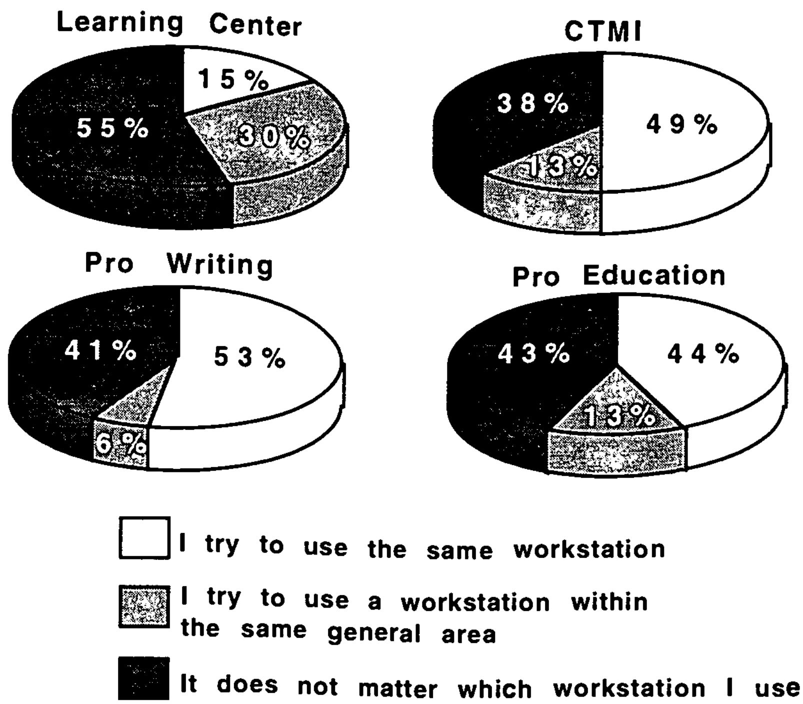

Figure 4-24: User preferences for workspaces per facility

The fact that the Professional Writing and Professional Education labs both hold regular classes may offer some explanation for the larger percentages of users who prefer the same workstation. Though there is no *assigned* seating in these labs, it is a common observance that students in any classroom situation tend to use the same seat. Another possible explanation is the size of the lab where, in contrast to the Learning Center, a choice may be more readily perceived. A closer examination of the respondents' reported locations revealed no discernible pattern for the Professional Writing Lab with regard to this preference, but the users who preferred the same station in the Professional Education Lab were located within the first two rows during the time of this evaluation. The stations in the CTMI do not have ID labels, so most of the users of this facility did not attempt to provide their location. However, the fact that many of the users in this facility prefer the same stations is not surprising, since this lab only has seven stations to choose from.

CHAPTER 5
Discussion of the Results

5-1. Discussion

5-1a. Comparative Overview

From the preceding data analyses conducted in Chapter 4, it was possible to determine which workspace settings and specifications were rated highest and lowest overall. Among the four facilities, the Learning Center appeared to have the highest overall ratings for most of the ergonomic and environmental categories represented in the questionnaire. The individual workspace factors found to embody the highest user ratings in all facilities were lighting, computer display image quality, color and reflectance, and viewing locations to the computer display. The lowest overall ratings were in questionnaire items reflecting row spacing, personal space, storage for personal effects, and accommodations for working with paper-based tasks.

Further comparisons revealed a moderate degree of relationship between the user ratings of workspace factors and the extent to which these factors were in accordance with established ergonomic and environmental design guidelines. A closer examination of rating distributions indicated a general level of agreement between satisfactory user ratings and workspace factors that were in accordance with the guidelines (see Tables 4-14 - 4-17). Among these acceptable factors, however, it was apparent that some specifications were more satisfactory than others, and thereby indicative of user preference. Workspace factors not in accordance with the guidelines appeared to generate more varied responses, with some actually rated satisfactory by the users. This suggests that deviations from the guidelines in some instances were found to be acceptable to users within this specific context.

The following discussion examines which specific workspace factors contributed to the user ratings as well as the apparent differences between the four facilities. Individual specifications and their representative questionnaire items are viewed within the context of the mean user ratings.

5-1b. Seating

Table 5-1 on the following page provides a comparison of the measured seating specifications and their user ratings across the four facilities. These specifications are illustrated in Figures 4-1 - 4-4. User ratings are based on a 5-point scale ranging from 1 (poor) to 5 (excellent).

Though the actual chair specifications in all four facilities were acceptable relative to the ANSI/HFS (1988) guidelines, the user ratings for seating in the Learning Center were rated highest overall with a mean rating of *3.97*. A comparative examination of Table 5-1 shows that most of the specifications in this facility were preferred over the others with the exception of item 7, where a mean group rating of *2.90* indicates problems that are attributable to the Learning Center's row spacing. This workspace factor was also one of the lowest rated in this facility. Measured at 26 inches with

Table 5-1: Comparison of seating specifications and user ratings. All specifications were found to be acceptable relative to ANSI (1988) guidelines unless rejection is indicated with an 'R' following the user rating Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by Item	Learning Center	CTMI	PWL	PEL
1. postural support	seatpan angle seatback to pan angle rating	*6 deg* *99 deg* 4.28	3 deg 90 deg 3.44	3 deg 90 deg 2.94	*6 deg* *99 deg* 3.70
2. support for "shifts" in seating position	seatpan area rating	*19"Wx18"D* 4.28	19"Wx17"D 3.69	19"Wx17"D 3.00	*19"Wx18"D* 3.87
3. chair adjustability	user adjustment controls rating	*yes* 4.32	yes 3.25	yes 3.03	*yes* 3.80
4. chair moveability	casters included rating	*yes* 4.15	yes 3.50	yes 2.91	*yes* 3.23
5. accommodations for resting feet	chair height range footrest if required rating	*16.5"- 20.75"* *yes* 3.87	23.5"-27.5" yes 3.56	15.5" -18.5" 23.5" - 27.5 " yes 2.94	*16.5 "- 20.75 "* yes 3.00
6. back support	lumbar support height [at center] seatback area rating	*6.0" from seat level* *16.5"Wx15"H* 4.03	7.5" from seat level 16.5"Wx15.5"H 3.44	7.5 " from seat level 6.5"Wx15.5"H 3.50	*6 .0" from seat level* *16.5"Wx15"H* 3.67
7. entering and exiting workspace	row spacing rating	26 .0" 2.90 (R)	*45.0" - 52.0"* 3.81	18.0" 2.26 (R)	22.5" 1.77 (R)
overall mean rating		3.97	3.53	2.94	3.29

worksurfaces in maximum extended position, row spacing was determined to be inadequate as compared to the recommended 42 inches. A total of 9 out of 14 written comments complained of tight row spacing, lending further support to this assumption. Two of the comments directly referred to this question: "Stress #7, space too small..." and "#7 would be the only inconvenience."

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The Professional Education Lab features identical chairs to the Learning Center, though the PEL's overall mean rating of *3.29* for seating factors appears to indicate some discrepancy between the two facilities. A comparison of the Learning Center and PEL in Table 5-1 does show comparable ratings for all chair specifications except for chair moveability (*4.15* vs. *3.23*) and accommodations for resting feet (*3.87* vs. *3.00*). The discrepancy appears to have its source in the PEL's row spacing, determined to be inadequate at 22.5 inches. The users expressed significant dissatisfaction with this workspace factor with a rating of *1.77*. This dissatisfaction is supported by user comments, with 8 out of 9 referring to the cramped spacing between stations. While the inadequacies of the Learning Center's row spacing are enough to hamper traffic between rows, there appears to be enough room and flexibility in the space to allow for some chair movement. The spacing in the PEL, however, appears to be restrictive enough to affect chair movement, and it is reasonable to assume that the rating discrepancies in the remaining seating factors can be attributed to inadequate row spacing. Considering the interrelationship of the seating variables, it is likely that the restricted row spacing in the PEL inhibits users from utilizing the maximum potential of the chairs, and contributed to the overall differences in the ratings between the PEL and the Learning Center.

Measured space between stations in the CTMI ranges between 45 and 52 inches, and therefore represents an accommodation that agrees with and even exceeds ergonomic guidelines. The user rating for this factor (*3.81*) indicates further agreement and a preference for this specification. The remaining user ratings for seating in the CTMI appear to represent an overall level of satisfaction as indicated by an average rating of 3.53. In the user comments for this facility, however, 3 of the 5 comments complained about the height of the chairs. While the chairs themselves are proportioned to the height of the workstations, equipped with footrests, and should be comfortable as a result of their basic ergonomic construction, it is reasonable to assume that many users will feel uncomfortable at an elevated working height, even when provided with a footrest. As one user commented: "I feel suspended by the chairs. Prefer feet on the floor."

Users in the Professional Writing Lab rated their seating lowest, with a mean rating of 2.94. The fact that this facility has the least amount of measured space between rows (18 inches) is further reflected in the users expressing dissatisfaction with this condition with a rating of 2.26. This rating was the lowest of all other workspace factors in this facility. Of the 9 comments offered for seating, 8 referred directly to row spacing and/or a feeling of being cramped. It is again felt that inadequate row spacing contributed greatly to the overall results. It should be noted that this facility uses the same chairs as the CTMI, with the taller stations toward the back of the room using higher chairs. There were 4 negative comments in this facility as well concerning chair height.

5-1c. Desks

Table 5-2 on the following page provides a comparison of the measured workstation desk specifications and their user ratings across the four facilities. These specifications are illustrated in Figures 4-1 - 4-4. User ratings are based on a 5-point scale ranging from 1 (poor) to 5 (excellent).

The user ratings for the Learning Center's workstation desks were rated highest overall, with a mean rating of *3.59*. Users in the other facilities appeared to be less satisfied with their workstations desks (CTMI *3.20;* Professional Writing Lab *3.27*) with the lowest overall rating evident from the users in the Professional Education Lab (*2.94*). Equipment locations appeared to be satisfactory in all facilities, though a user rating of *4.00* in the Learning Center indicates a preference for this facility's configuration. Further examination of Table 4-21, however, reveals problems across all facilities with regards to accommodations for paper-based tasks. Ratings of spatial provisions for paper-based tasks in the CTMI (none, *2.44*) and the Professional Education Lab (15"W x 12"D, *2.20*) indicate problems with this workspace factor in the opinion of the users. The specifications in these facilities were rejected in the environmental analysis based on insufficiency to the task (ANSI/HFS 1988), and the user ratings appear to agree. One of the user comments from the CTMI lends further support to these findings: "There is virtually no desk space, especially for large spread-out projects."

Table 5-2: Comparison of desk specifications and user ratings. All specifications were found to be acceptable relative to ANSI (1988) guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. location of equipment and controls	location of equipment and controls	*computer and synthesizer controls within reach.* *CPU and audio equipment located on shelves at lower part of workstation*	all equipment located within reach in front of user.	computer and synthesizer controls within reach audio equipment located in racks to the side of the workstation	computer and synthesizer controls within reach
	rating	4.00	3.75	3.76	3.87
2. space provided for paper-based tasks	worksurface area usable as desktop	*22"Wx16"D*	none	21"Wx15.5"D	15"Wx12"D
	rating	3.50	2.44 (R)	2.94	2.20 (R)
3. desktop angle for reading	desktop angle or range of adjustment	*0 - 56 deg*	copyholder provided at 70 deg.	0 - 54 deg	0 deg
	desktop height	*37.5"*	45.0"	36.5" - 43.0"	28.5"
	rating	3.82	2.94	3.44	2.63
4. desktop angle for writing	desktop angle or range of adjustment	0 - 56 deg	none	0 - 54 deg	0 deg
	desktop height	37.5"	45.0"	36.5 - 43.0"	28.5
	rating	2.61 (R)	2.50 (R)	2.88 (R)	2.60
5. keyboard support surface adjustability	keyboard support surface height range	*24.0"- 29.0"*	29.5"- 35.5"	22.75"- 28.75" 29.5"- 39.5"	24.5"- 30.5"
	keyboard slope	*7 - 12 deg*	7 - 12 deg	7 - 12 deg	5 - 20 deg
	rating	3.95	3.56	3.34	3.07
6. music keyboard playing height	music keyboard support surface height plus keyboard height	*33.5"*	42.0"	31.25"- 37.75"	32.5"
	rating	3.81 (R)	3.43 (R)	3.55 (R)	2.93 (R)
7. knee and leg clearance under the workstation	leg clearance width leg clearance ht . knee depth	44.0" 27.5" 23..25"	*48.5"* *30.5"* *unlimited*	42.0" 27.25 "- 33.75" unlimited	42.0" 28.0" unlimited
	rating	3.44	3.81	3.00	3.30
overall mean rating		3.59	3.20	3.27	2.94

Some discrepancy is noted, however, between the ratings in the Learning Center and the Professional Writing Lab for this item. These two facilities feature similar accommodations and dimensions, though the slightly larger desktop area in the Learning Center (22"W x 16"D vs. 21"Wx 15.5"D) was clearly preferred as indicated by a rating of *3.50* versus the PWL rating of *2.94*.

The reason behind this rating difference is not clear, but it is possible that the requirements of the educational programs utilizing the PWL may reveal more limitations in the accommodations of music manuscript and other related materials.

The Learning Center and the Professional Writing Lab also share a similar desktop design with an adjustable range of inclinations. This design appears to be satisfactory as a reading surface to the users in both facilities, as indicated by ratings of *3.82* in the Learning Center and *3.44* in the Professional Writing Lab. The 0 - 56° inclination range in the Learning Center, however, appears to have a slight advantage over the 0 - 54° range in the PWL. Ratings of this specification as a writing surface, however appear to present problems in both facilities. The combination of desk heights of 36.5 inches or greater and available inclinations was considered unacceptable in that writing tasks are placed at a such a position as to require the user to write almost vertically. Similar ratings were evident from users in both facilities, with ratings averaging *2.61* in the Learning Center and *2.88* in the Professional Writing Lab. A combined total of 8 complaints from both facilities seem to support the awkwardness of this configuration as illustrated in Figure 4-5. One student from the PWL commented " It's easier to take notes on your lap rather than having to reach over the keyboard and everything to write something down on the angled desktop." Another from the Learning Center commented: "Need a side table. Can't write vertically."

The user ratings for both reading and writing angles in the Professional Education Lab appear to indicate problems with this specification. The mean rating was similar for both items at *2.63* and *2.60* respectively. While the height of this surface is comparable to a standard desk and its flat inclination should not be problematic to either reading or writing tasks, it is possible that its location to the side of the user poses inconveniences with respect to the VDT tasks (see Figures 4-4 and 4-6). Though the CTMI stations again offer no dedicated worksurface for paper-based tasks, a bookstand is provided to accommodate reading needs. While apparently adequate to this specific task, the mean rating of *2.94* indicates that users as a group did not find this accommodation sufficient.

Though the playing heights of the music keyboards in each facility are higher than the playing heights of standard acoustic pianos (28.5 inches vs. a minimum height of 31.25 inches), only the *2.93* rating in the Professional Education Lab appeared to express any indication of problems. Users in the other three facilities appeared to be satisfied with this factor (Learning Center *3.81*; CTMI *3.43*; PWL *3.55*). It should be noted, however, that the PEL's music keyboard height of 32.5 inches measures one inch lower than the Learning Center's 33.5 inches, though the Learning Center was the highest rated overall. When interpreting these ratings, it should be noted that the music keyboard as used in this context is generally not played in the traditional pianistic fashion, as it is used more as a sound source and orchestration tool. It should be further noted that many users in the PEL are not frequent users of the music keyboard, as many of the activities in this lab center around courses that are not music related. Two complaints referring to the music keyboard were offered from the PEL: "M.S. keyboard is too high to play on without sitting on top of a book." and "Keyboard up too high with no room to play." Another user from the Learning Center commented: "The keyboard is too high! (even with chair adjustment)."

Specifications for keyboard support surface adjustability, as determined by the height of the support surface and the slope of the keyboard, was preferred in the Learning Center as indicated by a rating of *3.95*. The combined specifications in this facility were a keyboard support surface height range of 24" - 29" and slope range of 7-12^{o}. It should be noted that the conditions in this facility included a shorter chair height range at 16.5 - 20.75 inches. The higher support surface heights in the CTMI and the Professional Writing Lab were compensated by chairs with a range height of 23.5 - 27.5 inches.

Workstations in all facilities meet or exceed the ANSI/HFS (1988) recommendations for leg clearances under the workstation. However, the highest overall level of user satisfaction was evident in the CTMI, as indicated by a mean rating of *3.81*. While it was expected that all of the facilities would demonstrate similar high levels of satisfaction with this desk factor, two user comments illustrated a potential problem. One user in the PWL commented "In order for the keyboard and computer keyboard to be easy to use (comfortable), my legs get squashed at the height I need it." Another from the PEL wrote "My knees tend to bump against the shelf the keyboard sits - that's annoying." These comments appear to reflect the problems with row spacing in each facility. This assumption is loosely supported by the fact that the leg clearance ratings seem to proportionately drop with the measured row spacing in each facility (see Table 5-1). Considering the adequate measured leg clearances and range of keyboard support surface adjustment, it appears that users are not able to get out of the workstation's way enough to assume a position that facilitates comfortable use of the keyboard and adequate knee and leg clearance.

5-1d. Viewing Locations

Table 5-3 on the following page provides a comparison of viewing location specifications and their user ratings across the four facilities. These specifications are presented in Table 4-1, Section 4-1c. User ratings are based on a 5-point scale ranging from 1 (poor) to 5 (excellent).

The ANSI/HFS (1988) guidelines recommend locating viewing angles to the computer display between 0^{o} and 60^{o} below the horizontal line of sight. Users in this context, however, were satisfied with angles of inclination as high as 12^{o} to the top of the display, as evidenced by a rating of 3.74 in the Professional Writing Lab. Preferences for computer display viewing locations appear to be evident in the Learning Center, where the following

Table 5-3: Comparison of viewing location specifications and user ratings. All specifications were found to be acceptable relative to ANSI (1988) guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. viewing distance from the screen being "too far"	viewing distance from user to computer display (measured ranges)	*25.0" - 32.5"*	29.0" - 31.0"	24.5" - 29.0"	27.0" - 31.0"
	rating	4.35	3.75	4.06	4.03
2. viewing distance from the screen being "too close"	viewing distance from user to computer display (measured ranges)	*25.0" - 32.5"*	29.0" - 31.0"	24.5" - 29"	27.0" - 31.0"
	rating	4.33	4.0	4.06	4.03
3. sightline to the top of the screen	angle of sightline inclination to the top of the display (measured ranges)	*1.0 - 7.0 deg*	4.0 - 8.5 deg	9.5 - 12 .0 deg	1.5 - 7 .0 deg
	rating	4.20 (R)	3.67 (R)	3.74 (R)	3.97 (R)
4. sightline to the bottom of the screen	angle of sightline declination to the bottom of the display (measured ranges)	*-1.0 - -9.0deg*	-5.5 - -11.0 deg	-6.0 - -11.0 deg	-5.5 - -12.0 deg
	rating	4.45	3.93	3.91	4.07
5. adjustability of the screen's viewing angle	swivel base provided with the display	*yes*	yes	no	yes
	rating	4.28	2.62	2.91 (R)	3.17
6. viewing comfort for printed materials	accommodations for paper-based tasks in same visual plane as VDT	*yes*	yes (bookstands provided for reading only)	yes	no
	rating	3.73	2.31	2.97	2.22 (R)
7. convenience of working with printed materials and the computer screen simultaneously	worksurface area usable as desktop for writing tasks	*22"Wx16"D*	none	21"Wx15.5"D	15"Wx12"D
	accommodations for paper-based tasks in same visual plane as VDT	*yes*	yes (bookstands provided for reading only)	yes	no
	rating	3.74	2.31 (R)	3.27	2.29 (R)
overall mean rating		4.15	3.22	3.56	3.40

specifications were rated accordingly: distance to the display between 25 and 32.5 inches, *4.33*; angle of sightline inclination to the top of the screen between 1^{o} and 7^{o}, *4.20*; angle of sightline declination to the bottom of the screen between -1^{o} and -9^{o}, *4.45*.

Viewing locations for paper-based tasks, as represented in questionnaire items 6 and 7, were among the lower rated workspace factors within the CTMI and the Professional Education, and consistent with the findings outlined in the previous section on desks. Users in the CTMI rated both of these factors 2.31, again evident of the lack of usable space for printed materials. Two out of the four users comments offered in this section reiterated this issue: "Because we use so many things it's hard to place everything where it's most convenient;" and "Working with external objects like papers, books is a small irritation because location of a spot for them is not adjacent to screen." A third comment offered a suggestion: "It would help to have adjustable trays for positioning documents."

The Professional Education Lab ratings for items 6 and 7 were 2.22 and 2.29 respectively. It is reasonable to assume that these low ratings were attributable to a combination of insufficient desk space and an inability to view documents within the same visual plane as the VDT. Two user comments from the PEL reiterated the issue of insufficient document space discussed in the previous section on desks: "Not enough room for writing materials;" and "The desk at the workstation is OK for 1 page writing - but no for holding any other materials." Two others directly referred to viewing positions: "No way to position books or notes;" and "If typing something, it's hard to keep turning your head to the right, small desk portion."

The Learning Center's specifications appear to be preferred by users, in that there is sufficient space to place documents, and within the same visual plane as the VDT. Items 6 and 7 in this facility were rated *3.73* and *3.74* respectively. Though the Professional Writing Lab has similar accommodations, they seem to rank a distant second to the Learning Center with ratings of *2.97* for item 6 and *3.27* for item 7. While there is no clear reason for this discrepancy, it is possible that the users in the PWL may have been more critical of the accommodations by virtue of the fact that they use the facility for in-class work as well.

5-1e. Computer Screen Image Quality

Table 5-4 on the following page provides a comparison of computer display specifications and their user ratings across the four facilities. User ratings are based on a 5-point scale ranging from 1 (poor) to 5 (excellent).

Users appeared to be largely satisfied with the computer display image quality in their respective facilities, as indicated in the overall mean ratings for all display system factors: Learning Center, *4.52;* CTMI, *3.87;* PWL, *4.02;* and PEL, *3.76.* Where the overall user ratings in the Learning Center were highest, discrepancies between the ratings in the Learning Center and those from the PEL are noted in that these two facilities use the same display. The 9.3 fL luminance level of the displays in the CTMI was found to be slightly below the ANSI/HFS 10 fL minimum recommendation, though users in this facility appeared to be satisfied with this factor as evidenced by a rating of *4.25.* Though there were no complaints expressed regarding image or color rendition, some users expressed a desire for larger displays: "It would be nice to have 22" screens but I realize that's not possible."

Table 5-4: Comparison of computer display specifications and user ratings. All specifications were found to be acceptable relative to ANSI (1988) guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. brightness of the display	white field luminance of the display	*34.6 fL*	9.3 fL	26.3 fL	39.1 fL
	rating	4.68	4.25 (R)	3.94	4.07
2. legibility of the display	clarity of characters and graphics based on subjective evaluation	*acceptable*	acceptable	acceptable	acceptable
	rating	4.65	4.31	4.18	3.89
3. correctness of color	color rendition based on subjective evaluation	*acceptable*	acceptable	N/A	acceptable
	rating	4.71	4.25	N/A	3.89
4. size of the screen	diagonal measurement	*14"*	14"	14" "portrait"	14"
	rating	4.38	3.25	4.18	3.75
5. ability to resist reflected glare	anti-glare coating or accessory	*no*	no	no	no
	swivel base provided with the display	*yes*	yes	no	yes
	rating	4.18 (R)	3.31 (R)	3.79 (R)	3.18 (R)
overall mean rating		4.52	3.87	4.02	3.76

The uncoated and non-diffuse surface treatments of the computer displays, while not in accordance with ANSI/HFS (1988) guidelines, did not appear to present significant problems, as indicated by the user ratings from each of the facilities for this display factor: Learning Center, *4.18;* CTMI, *3.31;* PWL, *3.79;* and PEL, *3.18.* In the CTMI, where three of the workstations are positioned so as to place the computer displays parallel to the windows, two of the user comments specifically referred to reflected glare on the VDT: "CTMI can be a little disturbing because it reflects light through the windows;" and "Glare from windows can be a problem." Referring back to the discrepancies between the ratings in the Learning Center and the PEL, it appears that the PEL's *3.18* rating on item 5, while not unsatisfactory, still appears to indicate display reflectance problems according to some of the users in this facility. While there were no complaints from the Learning Center, two complaints were offered from the PEL. One user writes "Need glare filters" while the other states that "Larger screens with less reflective surfaces would be great." One possible explanation centers on the layout of the PEL, which has one wall lined with windows facing due west (see Figure 3-7). If the drapes are open, the mid-day sun can be strong enough to wash out images on the computer screen, regardless of the workstations placement relative to the windows.

5-1f. Music and Audio Systems

Table 5-5 on the following page provides a comparison of music and audio system specifications and their user ratings across the four facilities. A listing of equipment for each facility is available in Appendix K. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent)

The Professional Writing Lab's music and audio systems were rated highest overall among the four facilities, with a mean user rating of *3.70*. The CTMI was the next highest rated with an overall mean of *3.55*. Both offer a greater variety of audio and recording equipment, which is closely tied to the educational activities supported by these facilities. It should also be noted that the PWL, by virtue of the educational programs it supports, probably has the best trained users among the four facilities. As classroom activities directly center around the use of the equipment and its application to the art of music composition, it can be reasonably assumed that the users have a level of comfort that would have facilitated assessment of the equipment. Users in the CTMI, however, appeared to express somewhat greater satisfaction with the sound quality of their equipment, as indicated by a rating of *4.00*.

The Professional Education Lab's ratings appear to be the lowest of the four facilities, with an overall mean of *3.17*. While this rating is not indicative of dissatisfaction, it should be noted that 25% of the responses from the PEL on this section were "N/A" or blank. Many users of this facility do not use these systems since a large percentage of this facility's educational

Table 5-5: Comparison of music and audio systems specifications and user ratings. All specifications were found to be acceptable relative to industry standards unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. clarity of synthesizer sounds, recordings, and other audio playback	quality of sound based on subjective evaluation	good-excellent	*good-excellent*	good-excellent	good to excellent
	rating	3.49	4.00	3.79	3.22
2. layout of audio system controls (clear and logical?)	clarity of control layout based on subjective evaluation	acceptable, though slightly confusing	acceptable	*acceptable*	acceptable
	rating	3.22	3.69	3.82	3.18
3. layout of synthesizer controls (clear and logical?)	clarity and logic of control layout based on subjective evaluation	acceptable	acceptable	acceptable	acceptable
	rating	3.38	3.58	3.82	3.36
4. headphone comfort	size of speakers	3.5"	3.5"	*3.5"*	3.5"
	foam padding	.25"	.25"	*.25"*	.25"
	rating	3.26	2.93	3.38	2.91
overall mean rating		3.34	3.55	3.70	3.17

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activity centers on courses that are not music related. Considering the activities for which this lab was built, the music systems in this facility are appropriately minimal, in that there is a comparable music synthesizer at each workstation, but no dedicated audio recording equipment. It is therefore possible that some unsatisfactory user ratings were based on a perceived *lack* of equipment, rather than quality.

The only apparent evidence of problems with music and audio systems in the four facilities comes from the user comments. Two users from the Learning Center felt that the combination tape deck/mixer unit was difficult to figure out, as expressed in these comments: "The tape deck is complicated, unlabled as to which tracks are dedicated to which components of the workstation, and usually produces a poor recording;" and "Mixer is difficult to figure out and not always in the same configuration." One user complaint expressed issues that might be solved with better documentation and support: "I answered 1-3 low because these stations have many options (which is great), but almost too many. I sometimes wish there were easy access to answers like keyboard set-up, mixer set-up, etc."

While headphone comfort appears to have mixed reviews across the four facilities, it should be noted that all labs use the same headphones. While some dissatisfaction appears to be evident in the ratings from the CTMI (*2.93*) and the PEL (*2.91*), the only actual complaints about the headphones, 10 in all, came from the Learning Center and Professional Writing Lab. Only three of the complaints expressed physical discomfort while wearing the headphones, while 8 referred to noises (hissing, buzzing) in the speakers. The constant use of the headphones in these facilities leads to frequent wire breakage, as indicated by a PWL user comment: "New headphones are a little delicate." Noise emanating from other electrical sources, such as the lights or other workstation equipment, appears to contribute as well to the perceived hissing and buzzing in the headphones.

5-1g. Lighting

Table 5-6 on the following page provides a comparison of lighting specifications and their user ratings across the four facilities. These specifications are illustrated in Figures 4-7 - 4-8. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent).

Collectively, lighting systems were among the highest rated workspace factors across all of the facilities, and reflective of the overall acceptable levels relative to IES (1989) guidelines. The overall mean ratings from each facility are as follows: Learning Center, *4.17;* CTMI, *3.85;* PWL, *3.82;* and PEL, *3.80.* The Learning Center's specifications were rated highest overall, indicating user preferred conditions with reference to this facility's range of general illuminance as measured on primary task areas (31-51.6 FC, *4.55*), maximum luminance contrast between primary task areas within the workspace (1.8 : 1, *3.95)*, and maximum luminance contrasts between the VDT and distant surround *(*2.8:1, *3.95).* Though exposed window conditions were noted in the CTMI and the Professional Education Lab at the time of measurement, there do not appear to be any significant problems indicated in the ratings or user comments. Either the window shields were drawn, or the users were not affected. As one user in the PEL commented: "Window is currently open. I prefer natural sunlight."

Table 5-6: Comparison of lighting specifications and user ratings. All specifications were found to be acceptable relative to IES (1989) guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. sufficiency of light for reading printed materials	illuminance range as measured on primary task areas	*31 - 51.6 FC*	12 .5 - 50.5 FC	34.6 - 47.5 FC	27.6 - 31.5 FC
	rating	4.55	4.00	4.06	4.07
2. provision of light control so as not to wash out images on the computer display	luminaires fitted with 45 degree diffusers	*yes*	yes	yes	yes
	rating	4.35	4.25	4.12	3.93
3. provision of evenly distributed and shadow free light	minimum - maximum illuminance ranges within the work area	*19.8-51.6 FC*	3.0 - 50.5 FC	12.6 - 47.5 FC	13.6 - 31.5 FC
	quality of illuminance distribution across the work area based on subjective evaluation	*acceptable*	acceptable	acceptable	acceptable
	rating	4.15	4.06	3.85	3.79
4. pleasantness of the "color" of the light	type of lamps	*cool white fluorescent*	cool white fluorescent	cool white fluorescent	cool white fluorescent
	rating	3.85	3.31	3.44	3.39
5. the absence of discomforting glare	luminaires fitted with 45 degree diffusers	*yes*	yes	yes	yes
	windows shielded with louvers or drapes	*louvers*	louvers	louvers	drapes
	luminance range and maximum luminance contrast of primary task and viewing areas within workspace (keyboards, worksurfaces, VDT)	*18.7fL-34.6fL* *1.8 : 1*	3.4 fL - 9.3 fL 2 .7 : 1	8.1 fL - 26.3 fL 3 .2 : 1	14.0 fL - 39.1 fL 2 .8 : 1
	other luminance values measured in the distant surround	marker board: 12 .5 fl	exposed window: 270 fL shielded windows: 54.3 fL; 44.8 fL	luminaire: 16.3 fL distant surfaces: 1.2 fL - 3.1 fL	marker board: 9.7 fL exposed window: 1343 fL
	maximum luminance contrast ratio (VDT and distant surround)	*2 .8 : 1*	1 : 5 .8 with windows shielded	20 .2 : 1	4 :1 with windows shielded
	rating	3.95	3.63	3.64	3.82
overall mean rating		4.17	3.85	3.82	3.80

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There were a total of 9 negative comments across all facilities expressing some displeasure with fluorescent lighting. None of the mean ratings, however, were indicative of group dissatisfaction with regard to the appearance of the cool white fluorescent luminaires used in all of the facilities: Learning Center, *3.85*; CTMI, *3.31*; PWL, *3.44*; PEL, *3.39*. The Learning Center was the only facility that received a few brief compliments on its lighting, such as "Comfortable reading light, glare free." Another comment from the Learning Center, however, is probably a typical sentiment found among users in educational as well as commercial workspace settings: "No matter what you do, you're not going to get perfect lighting. So just work with what you have got." One user, however, provided an interesting suggestion for the Learning Center: "It is difficult to see and control the tape/recorder mixer - could be relocated or lighted."

5-1h. Color and Reflectance

Table 5-7 on the following page provides a comparison of color and reflectance specifications and their user ratings across the four facilities. Specifications for luminance contrasts are illustrated in Figures 4-7 - 4-8. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent).

Color and reflectance was also among the more highly rated workspace factors in all four of the facilities in this study, as indicated by the overall mean ratings from each facility: Learning Center, *4.37*; CTMI, *3.96*; PWL, *4.05*; PEL, *3.55*. The pale blue-gray color scheme in the Learning Center received the

Table 5-7: Comparison of color and reflectance specifications and user ratings. All specifications were found to be acceptable relative to IES (1989) and other ergonomic guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. pleasant and comfortable color scheme	interior color scheme	*walls: pale blue/gray*	walls: pale gray	walls: medium blue	walls: pale green
		carpet: charcoal blue	carpet:: charcoal gray	carpet: dark brown	carpet: dark brown
	rating	4.25	3.81	3.58	3.21
2. non-distracting color scheme	appropriateness of color scheme to the requirements of the space	*appropriate*	appropriate	appropriate, though dark for this size room	appropriate
	rating	4.50	4.00	4.16	3.70
3. absence of discomforting glare from the walls	wall paint treatment	*semi-gloss*	semi-gloss	low-luster	semi-gloss
	specular reflectance based on subjective evaluation	*within acceptable limits*	within acceptable limits	within acceptable limits	within acceptable limits
	rating	4.55	4.06	4.31	3.54
4. desktop surface as glare-free background for reading	maximum task-surround luminance contrast ratio (paper : desktop)	*2.2:1*	N/A	1.6:1	hardcopy covers surface when used; uncovered surface measured at 3.4 fL
			N/A		
	desktop surface treatment	*matte finish*		matte finish	matte finish
	rating	4.33	N/A	4.03	3.52
5. color of desktop surface as visually comfortable background for reading	desktop color treatment	*light gray*	N/A	white	black
	rating	4.20	N/A	4.15	3.79
overall mean rating		4.37	3.96	4.05	3.55

highest overall ratings for its perceived pleasantness (*4.25*) and non-distracting presence (*4.50*). The Learning Center's desktop task-surround luminance contrasts (2.2 : 1) were also the highest rated (*4.33*), as was the color treatment of the desktop (light gray, *4.20*).

It should be noted, however, that color and reflectance as a workspace factor ranked lowest on the face validity analysis in terms of its importance to users. Also, it appears that this section was probably the most difficult to communicate to the user. Though the overall ratings are high, and appear to be in agreement with the acceptable color schemes, surface treatments, and task-surround contrasts as measured in each individual facility, the user comments seem to indicate detachment from the issue at hand. As the majority of working tasks in these facilities are focused locally and away from the more distant aspects of the surrounding environment, it is likely that users within this context will not be conscious of these issues unless the problem is serious enough so as not to escape notice. Among the user comments supporting this assumption: "The walls make no difference;" "To tell you the truth, I never noticed;" and "I never pay attention to the color and reflectance." Another user, obviously prompted by the questionnaire items referring to the color and reflectance of the desktop surface, writes "I wish there was a place for writing on a manuscript or other forms of paper."

Other user comments indicate that many of ratings on this section may have been the result of aesthetic judgments rather than reactions to the task-surround contrast. For many people, it is likely that "color" is an aesthetic, rather than visual term. As one user commented: "The room does not create a reflecting problem nor do the stations. The color could be richer in my opinion."

5-1i. Acoustics

Table 5-8 on the following page provides a comparison of acoustical specifications and their user ratings across the four facilities. PNC and dBA ratings are illustrated in Figures 4-11 - 4-14. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent).

Each of the four facilities were similar in their acoustical conditions. All would be considered "moderately noisy" in terms of recommended Preferred Noise Criterion (PNC) ratings, and thereby unacceptable relative to current acoustical guidelines (Beranek et al 1971). Each facility had ambient noise levels from room equipment above the recommended PNC-40: Learning Center, PNC-43; CTMI, PNC-45; PWL, PNC-48; PEL, PNC-48. These conditions, however, were not unsatisfactory to the users of each facility, as indicated by their respective ratings of *4.00*, *3.50*, *4.00*, and *3.59* on item 3. These factors also did not appear to result in significant user dissatisfaction with respect to classroom communications as expressed in items 4 and 5 in the PWL (*3.79*) and the PEL (*3.32*). Though the PWL appears to be preferred over the PEL for classroom communications, the relatively high level of ambient noise is similar in both facilities.

Table 5-8: Comparison of acoustical specifications and user ratings. All specifications were found to be acceptable relative to acoustical guidelines (Beranek et al 1971; Ramsey and Sleeper 1989) unless rejection is indicated with an 'R' following the user rating. All others were found to be acceptable. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. isolation from noise from areas outside of the room	surrounding interior location of room	*offices*	offices	hallway, classrooms	offices
	surrounding exterior location of room	*side street*	side street	side street	side street
	wall construction	*Batt insulated double walls*	Batt insulated double walls	Batt insulated double walls	Batt insulated double walls
	rating	4.54	4.00	4.27	4.10
2. isolation from noise from adjacent workspaces or other areas within the room	acoustical surface treatments	acoustical ceiling tile, wall-to-wall carpet	acoustical ceiling tile, wall-to-wall carpet	*acoustical ceiling tile, wall-to-wall carpet*	acoustical ceiling tile, wall-to-wall carpet
	proximity of workspaces to each other	directly adjacent	directly adjacent	*directly adjacent*	directly adjacent
	rating	2.80 (R)	3.19 (R)	3.42 (R)	2.90 (R)
3. excessive noise from room equipment (i.e. computers, printers, HVAC)	ambient noise (PNC)	PNC-43	PNC-45	PNC-48	PNC-48
	ambient noise (dBA)	47 dBA	49 dBA	50 dBA	47 dBA
	rating	4.00 (R)	3.50 (R)	4.00 (R)	3.59 (R)
4. ability to hear teacher during classroom presentations	ambient noise (PNC)	*dropped from analysis*	*dropped from analysis*	*PNC-48*	PNC-48
	ambient noise (dBA)			*50 dBA*	47 dBA
	rating			4.00 (R)	3.52 (R)
5. ability to hear other students during class presentations	ambient noise (PNC)	*dropped from analysis*	*dropped from analysis*	*PNC-48*	PNC-48
	ambient noise (dBA)			*50 dBA*	47 dBA
	rating			3.79 (R)	3.31 (R)
overall mean rating		3.78	3.56	3.90	3.48

An important consideration regarding the acoustical issues discussed here should be noted: *headphones are worn for most activities occurring in these workspaces.* This may provide some explanation as to why users are not bothered by the level of ambient noise in the room. Therefore, users have an additional buffer against possible noise intrusions, and many potential annoyances in the acoustical environment will likely go unnoticed. As one user in the CTMI commented "When I stop and listen it is actually rather noisy in this room but luckily it does not bother me."

Some problems appear to be evident for item 2, which refers to isolation from noise from neighboring workspaces. Users in the Learning Center and the PEL rated this item *2.80* and *2.90* respectively. This workspace factor also generated the largest number of user comments for this section. A total of 11 comments, mostly from the Learning Center, referred to noise from neighboring workstations, complaining about other users "banging," "slamming," or "plunking" the keyboard synthesizers. The Learning Center was rated lowest for this condition, and likely attributable to the fact that this facility is the most populated. Also, compared to the other student labs, the Learning Center is less used for formal class sessions, and it is likely that the more controlled conditions of a classroom combined with the lower number of users will yield less noise.

Though all facilities feature adequate acoustical surface treatments for minimizing this type of noise, there are no intervening partitions to serve as acoustical barriers and the arrangement of the workstations places them directly adjacent to one another; closer than the 8 feet recommended for office environments (Ramsey and Sleeper 1989). Therefore, it is apparent that the close arrangement of the workstations does not allow enough distance for noise levels to drop off. The problem described above is especially evident when a user is creating a drum track using the sampled drum and percussion sounds available in the synthesizer. The user often assumes that these drum sounds must be played aggressively to get the "right effect," in spite of the fact that volume and velocity are controllable within the equipment and software. For these and similar facilities, this is a difficult problem to control, and symptomatic of the emerging interactions between art and technology. It is also impractical in terms of instructional needs and spatial resources for educational institutions to space their workstations 8 feet apart. Perhaps the addition of acoustical barriers, or a supplementary acoustical treatment of the music keyboard support surface, would help to alleviate the problem

5-1j. Thermal Conditions and Air Quality

Table 5-9 on the following page provides a comparison of thermal specifications and their user ratings across the four facilities. Effective temperatures readings are illustrated in Figures 4-15 - 4-18. Air velocity readings are illustrated in Figures 4-19 - 4-22. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent).

In general, thermal conditions were rated satisfactorily by users across all four facilities, and the ratings appeared to be in agreement with the acceptable overall comfort levels as measured by ambient temperature and relative humidity readings. Overall user ratings for thermal factors are as follows: Learning Center, *4.01*; CTMI, *3.65*; PWL *3.75*, PEL, *3.58*. Conditions in the Learning Center were rated highest for most factors, though the ratings on item 2 (room temperature not being too warm for comfort) appear to favor the Professional Writing Lab (*3.82* vs. *3.65*). Though thermal conditions are subject to a number of external conditions. such as personal comfort, seasonal clothing, and access to HVAC controls, it is possible to derive from Table 5-9 that users preferred an ambient temperature range between 69.2° and 74.6° F, at a relative humidity range between 33.1 and 36.0%.

Table 5-9: Comparison of thermal and air quality specifications and user ratings. All specifications were found to be acceptable relative to ASHRAE (1993) guidelines unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. room temperature not being too cool for comfort	air temperature range as measured over the course of a day	*69.2 - 76.6 deg F*	70.0 - 76.3 deg F	70.1 - 74.6 deg F	68.6 - 79.0 deg F
	rating	4.30	3.93	4.00	3.86
2. room temperature not being too warm for comfort	air temperature range as measured over the course of a day	69.2 - 76.6 deg F	70.0 - 76.3 deg F	*70.1 - 74.6 deg F*	68.6 - 79.0 deg F
	rating	3.65	3.73	3.82	3.14
3. freshness of air quality	quality of air based on subjective evaluation	*acceptable*	acceptable	acceptable	acceptable
	rating	3.77	3.20	3.24	2.90
4. absence of excessive draft from vents or windows	air velocities form a range of measurements throughout the facility	*5 - 20 fpm*	5 - 30 fpm	5 - 50 fpm	7 - 20 fpm
	rating	4.05	3.80	3.97	3.93
5. humidity level not being to moist for comfort	range of relative humidity readings as measured over the course of a day	*33.1 - 36.0%*	30.1 - 34.0%	31.5 - 34.8%	40.2 - 51.6%
	rating	4.15	3.80	3.85	3.96
6. humidity level not being to dry for comfort	range of relative humidity readings as measured over the course of a day	*33.1 - 36.0%*	30.1 - 34.0%	31.5 - 34.8%	40.2 - 51.6%
	rating	4.15	3.47	3.62	3.68
overall mean rating		4.01	3.65	3.75	3.58

Though air velocity ranges were under par throughout each of the facilities, drafty conditions appear to be nonexistent, and are reflected in the ratings on item 4 for each facility: Learning Center *4.05;* CTMI *3.80;* PWL, *3.97;* PEL *3.93*. It is possible, however, that greater air movement may enhance comfort for some users, and enhance the perceived quality of the air. Though there were no detectable odors at the time of measurement in any of the facilities, a number of comments referred to stale air, with two comments in the Learning Center specifically referring to odor coming from equipment. Air quality in the Professional Education Lab appears to present some problems, as indicated by a user rating of *2.90*. Five of the six comments offered in the PEL refer to stale and stuffy air, though a source for this problem could not be determined. Other comments throughout the four facilities ranged from "Dry and dusty" and "stuffy" to "the air is good" and "...this room is quite OK compared to others."

Thermal conditions are one of the most difficult environmental factors to measure and assess, with the range of comments and ratings often contradicting one another. For example, two of the comments made references of summer and winter conditions, even though this assessment was conducted in the fall. This indicates that some caution is warranted when interpreting user assessments of thermal conditions, as it is possible that many users rated the environment based on cumulative experience. Thermal conditions are especially prone to this, given their dynamic nature and personal significance to the user.

5-1k. Technical Support

Table 5-10 on the following page provides a comparison of technical support specifications and their user ratings across the four facilities. User ratings are based on a 5-point scale ranging from 1(poor) to 5 (excellent).

Technical support was the highest ranked factor in terms of importance to the user, as indicated by the results of the face validity analysis. Users appeared to be largely satisfied with the level of technical support in their respective facilities, as indicated by the following overall ratings: Learning Center, *3.94;* CTMI *4.53;* PWL *3.79;* PEL *3.14.* The CTMI was rated highest among the four facilities, and appeared to show an advantage in the number of support staff per station (*4.69*) as well as level of expertise (*4.75*). As a resource for faculty members, it should be noted that the level of support here differs from the other labs in that individual training can be provided on request in a more intimate and supportive atmosphere than is often possible in the larger student labs. Where the Professional Education Lab was rated lowest overall in technical support, the issues appear to be more reflective of understaffing. Two of the five user comments indicated a need for more staff support in the PEL.

Table 5-10: Comparison of technical support specifications and user ratings. All specifications were found to be acceptable unless rejection is indicated with an 'R' following the user rating. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. availability of technical support staff	ratio of on-duty staff to number of workstations	1:4	*2 :7*	1:12	1 : 20
	rating	3.80	4.69	3.97	3.12
2. expertise of technical support staff	level of support staff	combination of professional staff and work-study	*professional staff*	combination of professional staff and work-study	combination of professional staff and work-study
	rating	3.78	4.75	4.09	2.96
3. availability of, manuals or other documentation	types of documentation available	factory manuals, on-line help	*factory manuals, on-line help*	factory manuals, on-line help	factory manuals, on-line help
	rating	4.19	4.63	3.61	3.26
4. clarity of manuals or other documentation	overall level of difficulty	average to easy	*average to easy*	average to easy	average to easy
	rating	4.00	4.07	3.52	3.23
overall mean rating		3.94	4.53	3.79	3.14

5-1I. Other Considerations

Table 5-11 on the following page provides a comparison of additional factors and their user ratings across the four facilities. Floorplan layouts are available in Chapter 3, Figures 3-2 - 3-5. User ratings are based on a scale of 1 (poor) to 5 (excellent)

Users appeared to favor the aesthetics and layout of the Learning Center overall, rating these factors *4.15* and *3.83* respectively. Users in the PEL appeared to express some dissatisfaction with the layout of that facility, as expressed in a rating of *2.76*. The reason behind this is not clear, though the

Table 5-11: Comparison of "other" specifications and user ratings. All factors were found to be acceptable unless rejection is indicated with an 'R' following the user rating. All others were found to be acceptable. Specifications in italics indicate user preferred conditions as determined by the overall group ratings.

Item	Specifications represented by item	Learning Center	CTMI	PWL	PEL
1. overall attractiveness of the room	room aesthetics	*color coordinated* *low ceiling* *interior glass walls for "open" feeling* *impressive size*	small room good spatial arrangement	color scheme is somewhat dark in appearance dense arrangement	bright room nice view high ceiling dense arrangement
	rating	4.15	3.63	3.45	3.15
2. access to essential equipment, materials, and support staff	room layout	*see Chapter 3, Figure 3-2*	see Chapter 3, Figure 3-3	see Chapter 3, Figure 3-4	see Chapter 3, Figure 3-5
	rating	3.83	3.75	3.39	2.76
3. storage capabilities for personal effects (i.e. coats, hats, books, etc.)	accommodations for personal effects	virtually none, except for floor space and backs of chairs	virtually none, except for floor space and backs of chairs	virtually none, except for floor space and backs of chairs	virtually none, except for floor space and backs of chairs
	rating	2.44 (R)	2.06 (R)	2.71 (R)	1.80 (R)
4. personal space	space per person	*21.2 sq. ft.*	29.61-31.95 sq. ft.	17.2 sq. ft.	22.7 sq. ft.
	rating	3.18 (R)	2.81	2.94 (R)	2.04 (R)
overall mean rating		3.40	3.06	3.12	2.43

fact that users in this facility were the least satisfied with their row spacing may indicate a sense of inconvenience. Nearly all facilities were rated low in terms of their accommodations for personal effects: Learning Center, *2.44;* CTMI, *2.06;* PWL, *2.71;* PEL, *1.80.* One user in the Learning Center commented: "You do have enough space to lay your books around you. But then no one can pass." Another from the PWL reiterated this complaint: "There is no room to put a jacket or book bag without it possibly getting in the way of foot room.

Item 4, which refers to personal space and perceived crowding, appeared to be problematic in the CTMI (*2.81*), PWL (*2.94*) and PEL (*2.04*). A relationship between this item and row spacing as represented in seating item #7 is possible. However, this did not appear to be evident in the CTMI, where row spacing was highly rated (*3.81*). This indicates that row spacing was likely not a factor in perceived crowding. One of the two comments offered from this facility offers a possible explanation: "It was OK at the beginning, but more people use it more frequently."

5-1m. Additional Comments

Four open ended questions were placed at the end of the questionnaire to solicit user comments. It was hoped that these comments would provide information useful to the improvement of these and similar learning environments as well as the ongoing development of the user assessment methodology employed in this study. The following paragraphs present an overview of the responses to each, as well as potential implications where applicable. These comments, as transcribed from the questionnaire, are available in Appendix J.

In your opinion, are there any other factors that should have been considered in this evaluation? If so, what are they?

The responses to this question were a potpourri of user speculations, contemplations, and requests that were largely unrelated. A number of recurring references to operating hours came from Professional Education Lab, though they were presented as complaints rather than suggestions. A related suggestion from the CTMI referred to the location of a facility, in terms of its accessibility. Both availability and accessibility are important to the satisfactory functioning of facilities such as these, and should be considered when evaluating workspaces and other educational resources. Therefore, future versions of the questionnaire should include a section on access.

Other comments referred to the appropriateness and capabilities of workstation equipment, namely the computer and software. It is likely that the ergonomics and human factors engineering of software would constitute a separate study in itself, though a similar methodology to the one in this study could be successfully employed.

As a place to learn and work, what do you like best *about the design and layout of this facility?*

In all facilities, most of the responses to this question focused on the availability of equipment and the immediate workstation area. There were few compliments on the surrounding built environment, and this is to be expected since it is not the focal point of the workspace. When the environment is supportive, it is generally unnoticed. If the air conditioning is functioning well, the lights are sufficient, and the color scheme subtle, it is a rare instance when a user will offer compliments on these items. Hence, the majority of comments throughout the questionnaire were complaints prompted by negative conditions. What appears to be most important to the users are the tools directly at their disposal. The environmental surround plays a supportive and covert role in the functionality of a workspace. One user's comment, naive as it may appear, lends support to this assumption:

"Design and layout - I don't know. The workstations seem to be where learning takes place, so I feel neither of these contribute too much to the environment.

It should be noted that the CTMI was the only facility that mentioned technical support staff in this section. It is apparent throughout this study that technical support is important to users of these facilities, and appears to be especially so with faculty members who depend on this resource for their professional development.

What do you like least?

Many of the complaints offered in the individual questionnaire sections were reiterated here. Recurring themes, such as noise from neighboring workstations, crowding, and inadequate row spacing predominated the comments. Additional comments were made concerning the workstation heights in the CTMI. A couple of comments referred to the lack of Internet availability, which will have new implications for user assessments in the very near future.

If you were in a position to recommend design changes to this facility, what would they be?

The most salient theme in this section, for all four facilities, was space, whether referring to the immediate workspace area or the room in general. Other recommendations offered in this section were space for writing tasks, requests for additional equipment, and extended operating hours.

5-2. Ancillary Performance Test

A supplementary study was conducted to examine the possible effects of each facility's ergonomic and environmental conditions on the performance of typical workstation tasks. A perceptual test developed by this researcher and his advisor was administered through a wordprocessing program, and required subjects to perform the manual and visual tasks typical of workstation use. The task was to find and mark the letter "C" among multiple lines of Cs, Ds, and Os. Subjects had to view the display, use the mouse to place the cursor and scroll the window, and use the keyboard to mark their answer. A correct answer was simply a slash (/) in front of the letter "C " (Figure 4-23). Appendix E is a hardcopy sample of this test.

OOC/OOOODOOOC/ODDOOODDOC/OOODDD

Figure 5-1: The performance test required subjects to find and mark the letter "C"

Four male subjects were each exposed to two conditions. First, a baseline measure was obtained from each subject by administering the test in a neutral environment (a workstation in a private office). After a period of three days, each subject was assigned to one of the facilities and retested with a different form of the test. All testing sessions were timed with a stopwatch and limited to 5 minutes. The resulting score was determined by the number of C's correctly marked. Table 4-19 shows each subject's baseline score, score achieved in the subject's respective facility, and relative increment or decrement in performance. The Wilcoxin signed ranks test was performed on the scores to determine whether there were differences between the baseline and the treatment scores as a group. The result of this comparison was insignificant ($p = .19$).

Table 5-12: Performance test results

Subject/Assigned Facility	Baseline	Treatment	% Difference
Subject #1/Learning Center	110	142	29%
Subject #2/CTMI	139	142	2%
Subject #3/Pro Writing Lab	166	163	-2%
Subject #4/Pro Education Lab	137	160	17%

Upon completion of the performance test, each subject was asked to comment on the workspace in general. The subject assigned to the Professional Education Lab remarked about the "sluggish" computer keyboard. The CTMI subject remarked that the station was "awful," and that the mouse tray kept sliding. He also noted that he was distracted by people talking in the room. The Professional Writing Lab subject thought the exercise was fun, but stressful, and offered no further comments. The subject assigned to the Learning Center remarked that he "felt closer to the monitor in this facility than in the first test," and thus perceived the monitor position as being somewhat higher. He also remarked about having trouble with his midvision at this position, as he wears bifocals.

This supplementary study was intended to add an additional perspective to the overall research, though it was not expected to be conclusive. Also, it was ultimately determined that exercises such as this are generally not typical of the types of activities that occur in music education computer labs, or any educational situation where sustained thinking and reflection are part of the task. It is feasible, however, that a similar instrument and methodology could be employed in workspace contexts where performance is critical, or that instruments and methods appropriate to a specific context could be developed and implemented.

CHAPTER 6
Summary and Conclusions

6-1. Summary of the Study

This study was an investigation of the applicability of current ergonomic and environmental design guidelines developed for computerized offices and other non-educational settings to the needs of users of educational computing workspaces. The specific setting chosen was college-level music education, which provided both a perspective on a unique application of technology in education as well as the needs of a unique user population. A total of 120 subjects, selected from the users of four music education computer laboratories at the Berklee College of Music participated in the study.

In addition to investigating the applicability of the guidelines to an actual education setting, this study also intended to reaffirm the notion that users were reliable evaluators of their learning environment, and therefore important sources of information for the development, evaluation, and improvement of educational facilities. The study also intended to show that the ergonomic and environmental features of the learning environment are relevant to the users, and that user needs should be seriously considered by the designers and administrators of similar educational facilities. Further investigation into each facility's individual workspace factors was conducted to determine which design specifications were preferred by the users.

The facilities themselves were selected for their similar equipment, task orientation, and user populations, but differing workspace configurations and interior environmental factors. The Learning Center, a general access computing and learning resource facility, serves the entire college community and is the largest of the four with 40 stations. The CTMI, an 8 station lab oriented toward faculty development and productivity, serves the computing needs of the college's teachers. The Professional Writing Lab, a 12 station facility, supports specific educational programs within the college's various music composition disciplines. The Professional Education Lab, a 20 station facility, supports specific educational programs in the fields of music education and music business.

Each facility was measured with appropriate instrumentation and methods to determine if their respective workspace factors were within the standards outlined in the literature. Eleven categories of these components and their specific attributes were measured: seating, desks, viewing locations, display image, music and audio systems, lighting, color and reflectance, acoustics, thermal conditions, technical support, and other ancillary elements. Ergonomic and environmental components were represented in specific questionnaire items. Volunteer participants who were users of the facilities were given the questionnaire and asked to rate the attributes of their workspace on a scale ranging from 1 (poor) to 5 (excellent).

Statistical analyses revealed significant differences overall in the user ratings between facilities and across individual questionnaire items. The design specifications of the Learning Center ranked highest among the four facilities for most of the workspace factors investigated in this study. Exceptions were technical support, where the CTMI ranked highest, and music and audio systems, ranking highest in the Professional Writing Lab. The interior environmental factors of lighting, color and reflectance, and display image quality ranked highest overall across all facilities. Viewing locations to the computer display were also among the highest ranking items, including the higher than recommended sightlines to the top of the display. The lowest ranking items across all facilities were related to row spacing, storage for personal effects, accommodations for working with paper-based tasks, and personal space.

Employing correlational methods, a moderate relationship was determined to exist between the questionnaire results and the findings of the environmental analysis, indicating that the overall direction of the user ratings was attributable to the relative acceptability or unacceptability of specific workspace factors. The group ratings on individual questionnaire items were then examined for their frequency distributions to determine which workspace factors reflected the highest and lowest group ratings. While this combined analysis indicated that there was a general trend toward user satisfaction with workspace factors designed in accordance with ergonomic and environmental design guidelines, some specifications found not to be in accordance with the guidelines were rated satisfactory by the users. Among factors that were in accordance with the guidelines, some specifications appeared to be clearly preferred over others.

6-2. Conclusions and Recommendations

6-2a. Conclusions of the Study

The results of this study imply that current ergonomic and environmental design guidelines are applicable to the design of workspaces in music education computer laboratories. This contention finds support in the overall relationship found to exist between the user ratings as measured by the questionnaire and the relative acceptability or unacceptability of specific workspace factors as determined by these guidelines. Further support was evident in findings indicating that workspace components designed in accordance with the guidelines tended to be rated more satisfactorily by users than those that were not.

While these guidelines are and were expected to be appropriate overall, it was necessary to ask the users of these facilities to understand their unique interactions with the learning environment. While it is evident that the guidelines contribute substantially to a satisfactory workspace, it is also apparent that their efficacy is reduced if other elements of the workspace are not designed within the context of an integrated system. Accordingly, an ergonomically acceptable chair is reduced in quality if there is not enough space to use it effectively.

This study also concludes that users perceive the ergonomic and environmental components of their workspace as important and relevant, and further concludes that users are able to reliably identify acceptable and unacceptable ergonomic and environmental factors in their learning environment. The results of the questionnaire, supported by user comments and criticisms, indicated that the users evaluated their learning environments thoughtfully and critically, and that the outcome was an accurate assessment in terms of the specific interactions, needs and requirements of these workspaces.

6-2b. Applications of the Findings

The findings from this study can be used as a reference point for the continued development and improvement of new and existing facilities supporting similar technology and tasks. Accommodating unique needs such as the ones examined in this study is a difficult process, as tasks must be prioritized within the overall design of the workspace and educational goals and objectives must be reached in an atmosphere of practicality. The recommendations outlined below are based on the findings of this study, and are offered as flexible guidelines for the most optimal learning and working conditions possible within this and similar contexts.

Seating: Chairs with a height range which allow users to rest their feet on the floor (16.5 - 20.75 inches), are preferable over taller chairs with footrests. Users will find these seat dimensions, within a range of adjustability, to be satisfactory as well: seatpan angle 6°; seatback to pan angle 99°; lumbar support height; 6 inches from seat level; seatback area 16.5"W x 15"H; seatpan area 19"Wx18"D. Row spacing between workstations should meet or exceed the recommended 42 inches to allow for user comfort, passage between rows, and optimal chair flexibility

Desks: As much dedicated space as possible should be provided for working with books and paper-based tasks. The height of the surface should be as close to standard desk height as the overall design goals will allow. Users in this context appeared to be satisfied with music keyboard playing heights that were higher than standard acoustic pianos. However, it may be advantageous (as well as appreciated by piano majors) to design the music keyboard support surface to where it allows a playing height as close as possible to standard pianos. Again adequate row spacing should be provided for optimal use of adjustable equipment support surfaces while meeting ANSI/HFS (1988) guidelines for clearances under the workspace.

Viewing Locations: Though users in this study appeared to be satisfied with sightline inclinations to the top of the computer display as high as +12°, users appeared to express greater satisfaction with an upper limit of 7°. This suggests that the lower inclinations were preferable, and that the ANSI/HFS (1988) recommendations for a 0° maximum sightline inclination should continue to be a design goal. Viewing distances to the screen should range between 25-32.5 inches. Display adjustability (i.e. swivel bases) should also be provided, especially in the case of non-diffusive computer display surfaces.

Accommodations for viewing hard copy documents should be within the same visual plane as the computer display.

Lighting: An illuminance range between 30 and 50 FC (300 - 500 lux) should be provided for reading tasks. Task-surround luminances in the primary viewing areas should not exceed 3:1, though values under 2:1 may be perceived as more visually comfortable. It should be noted that all of the facilities in this study employ cool-white fluorescent lamps. Though users appeared to be largely satisfied with this solution, a comparative investigation of different phosphor combinations, color temperatures and color renditions may find alternative solutions to be more acceptable. Standard precautions against glare (i.e. shielded luminaires, window louvers) should be consistently and properly used.

Color and Reflectance: Users in this study appeared to prefer a pale blue-gray color scheme, though other colors schemes in this study proved essentially satisfactory as well. Semi-gloss wall surface treatments should keep specular reflectance at acceptable levels. Any color treatment that is within the guidelines for educational facilities is appropriate. Consistent with IES (1989) recommendations, desktop and equipment surfaces should be treated with a matte finish.

Acoustics: Users in this context appeared to be satisfied with ambient noise levels as high as PNC-48; higher than the PNC-40 recommended for areas designed for quiet concentration (Beranek et al 1971). This includes not only individual learning tasks, but classroom communications as well. However, this is seen as an adaptation on the part of the students to the relatively noisy environments to which they are exposed daily. Further, the frequent use of headphones in these spaces further minimizes the effects of these sound levels. Therefore, these findings do not invalidate PNC-40 as a valid criteria for noise control. Intermittent noise from neighboring workspaces was found to be particularly disruptive to users. While locating workstations 8 feet apart with acoustic partitions is not a practical solution for most educational institutions, supplementary acoustical treatment for "high impact" peripherals (such as music and computer keyboards) might be designed or retrofitted to the workstation itself.

Thermal Conditions: The ASHRAE (1993) guidelines will provide adequate thermal comfort for most users in this context. Users in this study appeared to prefer room temperatures between 69° and 77° F, and relative humidity levels between 33 and 36%.

Technical Support: These services should not be overlooked in these facilities, and should be an integral part of their design specifications. The results of the face validity analysis indicates that it should be a top priority in the planning of learning facilities incorporating computer-based technologies. Though there are few standards or studies on this topic, this aspect of the workspace is likely to be a growing, ever important component of computer workspaces in higher education. It would also be advantageous if technical support personnel were conversant with ergonomic concepts in addition to expertise with hardware and software.

Other Considerations: While aesthetics are a matter of personal taste and subject to the style of an individual educational institution, attention should always be paid to creating as attractive of an environment as possible. While spatial factors again are limited for many educational institutions, accommodations for personal space and storage should be considered wherever possible. The provision of adequate space between workspaces (42 inches or more between rows) will probably be sufficient.

6-2c. Implications and Additional Recommendations

Guidelines such as the 1988 ANSI/HFS workstation standards and others investigated in this study are developed to improve the interface between the user and the technology as well as the overall working environment. Derived from valid research in various disciplines, the intent of these guidelines is to enhance user productivity, performance, and comfort while eliminating potential sources of stress and stress-related injuries. However, the guidelines investigated in this study are largely based on research pertaining to offices and other non-educational settings. There have been few studies that have investigated the application of these guidelines to educational settings, and none that have previously addressed their application to independent learning environments for music education.

In addressing the applicability of current ergonomic and environmental design guidelines, this study found that workspace design specifications that were in accordance with these guidelines were rated comparatively higher by users than those that were not. Exceptions were noted, though they were few and only modest deviations from these standards. Therefore, these exceptions should not be taken as evidence that the guidelines are too strict for these specific factors, or this specific context.

For example, while users appeared to be satisfied overall with sightline inclinations to the top of the computer display as high as $+12^{\circ}$, users preferred a maximum of $+7^{\circ}$, which is only slightly higher than the 0° recommended by ANSI/HFS (1988). Accordingly, where users appeared to be satisfied with ambient noise levels higher than the PNC-40 limit established by Beranek (1971), the results were confounded by the fact that headphones are worn for most of the activities occurring in these workspaces. It is also reasonable to assume that users will adapt to conditions over time, even if these conditions are not conducive to their health and productivity.

It is also apparent from the results of this study that users will accept conditions that differ modestly from ergonomic and environmental design guidelines. Therefore, the information gathered in a user assessment should not only be viewed within the context of what is acceptable to the user, but also with the knowledge of what the user will tolerate. As in the sightline example, user preference was evident in the specification that was closest to the recommended guidelines.

In light of the findings, this study concludes that current ergonomic and environmental design guidelines are applicable to the design of workspaces in music education computer laboratories, and should be used in the planning and design of similar educational facilities.

6-2d. Recommendations for Further Study

This study should be replicated at a different musical institution with similar workspaces. Investigators should consider querying different populations (i.e. faculty, students, freshman, seniors, women) using the *same* facility to determine if other attributes beyond design specifications influence user ratings.

The methods and findings presented in this study appear applicable to any specialized workspace or other learning environment. Workspaces for graphic arts, CAD, or biomedical environments can benefit from a customized study such as this to validate or extend established guidelines for these specific contexts

The McVey (1979) and Bethune (1991) studies investigated learning environments that were largely *fixed*, in that users had little or no control over the immediate configuration of the workspace. In the learning environments investigated in this study, users were able to adjust workstation components such as chairs and equipment support surfaces. This fact adds to the dynamics of the user's interaction with the workspace that may be difficult to ascertain with a "snapshot" methodology. Further investigations can greatly benefit with combinations of open ended interviews and video taping that would dynamically extend the analysis into the subtleties of the interactions. It is likely that investigations such as the one presented here would lend themselves well to hybrid research designs incorporating both quantitative and qualitative methods, or perhaps methods that are entirely qualitative.

Two of the facilities in this study are used as classrooms. While the focus of this study was on individual workspaces, future researchers may want to investigate classroom applications of similar environments. This should combine approaches and findings from this study, as well as the classroom and lecture hall emphases of McVey (1979) and Bethune (1991). The incorporation of computers into traditional classroom formats presents a virtually unexplored set of environmental variables.

The performance test outlined in Section 4-8 should be further developed in one of two directions: 1) use in workspace environments where performance is critical and/or 2) symbols appropriate to the intended task of the facility, such as musical notes and symbols in the case of this study.

Research and standards in the area of technical support for facilities such as these are scarce. As technology becomes pervasive in higher education, this topic becomes increasingly critical. An investigation into technical support should be conducted as a separate study in order to ascertain the inherent variables, such as expertise, attitude, versatility, and communication skills. As the evidence from this study indicates that technical support is regarded as an important environmental attribute to users of facilities such as these, planners and administrators will require guidelines derived from thoughtful research.

Judging from some the comments offered by users on the questionnaire, this exercise appeared to be a valuable learning experience for the participants. It appears to have provided an opportunity for them to articulate what is not often describable. It is also likely that this process enabled those who participated to be somewhat more aware of the factors in their learning environment, and to seek out ways in which to improve their daily interactions. Upon completion of a study such as this one, a follow up study should be conducted to see if the work habits of users change as a result of participation in a user assessment.

APPENDIX A: Glossary of Terms

Ambient Lighting - The overall spread of illuminance, or background light.

Decibel (dB) - A unit of measure representing the intensity of a sound source. The *dBA* scale is often used for noise control applications because of its approximation of the human hearing curve.

Illuminance - A measure of the amount of light falling on a surface. Illuminance values are expressed in lumens per square meter (lux) or footcandles (FC), both of which represent the intensity of light per unit area. See Appendix B for conversions.

Luminaire - A complete lighting fixture unit consisting of a lamp and the parts designed to distribute the light and position or protect the lamps.

Luminance - A measure of the amount of light coming from a surface. The light may be reflected on an object or opaque surface from a source of illumination, or transmitted through a transparent or translucent surface such as a window or VDT screen. Luminance values are expressed in candelas per square meter (cd/m2) or footlamberts (fL). See Appendix B for conversions.

Masking - The application of steady broadband sound to cover up other sounds and noises in the environment to the extent that they are less noticeable to the occupants of a space. Masking is often a function of the HVAC or lighting systems of a room, or can be generated artificially.

MIDI - Acronym for *Musical Instrument Digital Interface.* A communication protocol for exchanging data between electronic musical instruments and associated devices (i.e. computers, effects, other MIDI instruments)

MIDI interface - a device that adds MIDI ports to a computer system.

Noise Criteria Curves (NC) - A family of curves relating the spectrum of noise to the acoustical requirements of a space as a criteria for noise control. The allowable ambient background noise levels of a given space can be expressed as a single number representing a specific set of curves. The curves permit higher noise levels at lower frequencies.

Operative Temperature - Air temperature, as expressed in degrees Fahrenheit (^{0}F) or Celsius (^{0}C).

Parabolic lenses - Plastic lenses designed to shield luminaires and reflect light downward and away from VDTs, worksurfaces, and an occupant's line of sight. The area directly under the fixture is illuminated.

Post-Occupancy Evaluation (POE) - A survey of the users of a built environment to evaluate the appropriateness of its design. The information acquired is subsequently applied to future designs and improvements of similar environments.

Preferred Noise Criteria Curves (PNC) - Essentially the same as NC curves, but lower the allowable sound pressure levels of the upper and lower octave bands for each curve.

Reflectance - The proportion of light falling on a surface which is reflected from the surface. If a surface reflects half of the light falling on it, its reflectance value would be 0.50, or 50%.

Relative Humidity (RH) - The percentage of the amount of moisture in the air in relation to the maximum amount that can be contained at a given temperature.

Sitting Eye Height - The vertical distance from the sitting surface to the inner corner of the right eye, with the subject sitting erect.

Sound Transmission Class (STC) - A measure of the effectiveness of a partition construction in reducing airborne sound transmissions. These ratings are limited to evaluating speech privacy potential, and not the isolation of low frequency or impact noise sources.

Synthesizer - An electronic musical instrument capable of making music and sounds by creating and modifying its own waveforms and sending them out as an audio signal. Many modern synthesizers utilize digital sound samples that are capable of simulating acoustic instruments.

Task Lighting - Lighting located near a task area.

Worksurface - The surfaces supporting the keyboard and the display, as well as surface area for tasks such as reading and writing.

APPENDIX B: Conversions

Illuminance conversion factors:

1 lux = 0.09 footcandle
1 footcandle = 10.76 lux.
1 footcandle = 1 lumen per square foot

To obtain a certain number of footcandles, multiply lux by 0.0929.
To obtain a certain number of lux, multiply footcandles by 10.76

Luminance conversion factors:

1 candela per square inch = 1,550 candelas per square meter

To obtain a certain number of candelas per square inch, multiply candelas per square meter by 0.000645

Although the footlambert is a deprecated unit of luminance, it is equal to 0.00221 candelas per square inch, or 3.4 candelas per square meter.

To obtain a certain number of candelas per square meter, multiply number of footlamberts by 3.426

To obtain a certain number of footlamberts, multiply number of candelas per square meter by 0.2919

(IES 1989, p.24)

APPENDIX C: User Assessment Instrument

TECHNOLOGY LAB EVALUATION

Purpose and Overview

This survey is part of an independent research project designed to evaluate music education technology labs. Its purpose is to determine what you and other users of facilities such as this one find acceptable or unacceptable in your work areas. Therefore, you will be asked to rate specific elements of this facility, such as workstation equipment and furnishings, lighting, sound levels, room temperature, and technical support.

Please do not write your name anywhere on this questionnaire. It is intended that you remain anonymous. Only your responses to the questions are necessary for this evaluation.

When filling out this questionnaire, please be seated at one of our workstations with equipment on as in a normal working situation.

Please answer each question. Mark your answers using the 5-point rating scale provided for each item. If the item does not seem to apply, mark *N/A* for "Not Applicable." You will also be asked to provide additional comments throughout this questionnaire. The entire process should take about 10 - 15 minutes.

When finished, please return this questionnaire to the lab monitor on duty, your teacher, or designated drop-off area.

Thank you for your participation in this survey.

Preliminary Questions

1. What is your approximate height? _______

2. What is your approximate weight? _______

3. Please indicate your gender (male = M, female = F) _________

4. From the choices below, check the answer that best represents on average how often you use this facility.

___ less than once weekly ___ once weekly ___ twice weekly ___ more than twice weekly

5. From the statements below, check the answer that best represents where you prefer to work when you visit this facility.

____ I try to use the same workstation.

____ I try to use a workstation within the same general room location.

____ It does not matter which workstation station I use.

6. What is the ID number of the workstation where you are presently sitting? ________

SEATING

RATE YOUR WORKSTATION SEAT IN TERMS OF:

1) how well you are able to maintain a comfortable posture while working;

N/A	1 Poor	2	3	4	5 Excellent

2) how easily you are able to shift your position while working;

N/A	1 Poor	2	3	4	5 Excellent

3) the extent to which you are able to adjust the chair for performing various tasks comfortably (i.e. playing the keyboard, typing, viewing the computer screen);

N/A	1 Poor	2	3	4	5 Excellent

4) how easily you are able to move the chair within your immediate work area while seated;

N/A	1 Poor	2	3	4	5 Excellent

5) the accommodations (i.e. floor or footrest) for resting your feet;

N/A	1 Poor	2	3	4	5 Excellent

6) how well the chair supports your back;

N/A	1 Poor	2	3	4	5 Excellent

7) how easily you are able to enter and exit your workspace without disturbing others at adjacent workstations.

N/A	1 Poor	2	3	4	5

Excellent____

In the space below, note any additional observations you may have regarding the workstation seating.

Please rate on the ten point scale below the workstation seating in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

DESKS

RATE YOUR WORKSTATION DESK IN TERMS OF:

1) how conveniently you are able to reach equipment and operate controls;

N/A	1 Poor	2	3	4	5 Excellent

2) the amount of space provided to you for working with printed materials such as books and notes;

N/A	1 Poor	2	3	4	5 Excellent

3) the desktop angle provided (or the extent of its adjustability) as it relates to your reading comfort;

N/A	1 Poor	2	3	4	5 Excellent

4) the desktop angle provided (or the extent of its adjustability) as it relates to your writing comfort;

N/A	1 Poor	2	3	4	5 Excellent

5) the extent to which you are able to adjust the computer keyboard to a position that is comfortable to use;

N/A	1 Poor	2	3	4	5 Excellent

6) the positioning of the music synthesizer keyboard as it relates to your playing comfort;

N/A	1 Poor	2	3	4	5 Excellent

7) the adequacy of room provided for your knees and legs.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the workstation desk.

Please rate on the ten point scale below the workstation desk in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

VIEWING LOCATIONS

RATE THE VIEWING LOCATIONS OF YOUR COMPUTER SCREEN AND PRINTED MATERIALS IN TERMS OF:

1) your viewing distance from the screen being not too far;

N/A	1 Poor	2	3	4	5 Excellent

2) your viewing distance from the screen being not too close;

N/A	1 Poor	2	3	4	5 Excellent

3) your line of sight to the top of the screen being not too high;

N/A	1 Poor	2	3	4	5 Excellent

4) your line of sight to the bottom of the screen being not too low;

N/A	1 Poor	2	3	4	5 Excellent

5) the extent to which you are able to adjust the computer screen's viewing angle to where it is comfortable to you;

N/A	1 Poor	2	3	4	5 Excellent

6) how well you are able to place at a comfortable viewing position books, notes, and other printed materials you are likely to use during operation;

N/A	1 Poor	2	3	4	5 Excellent

7) how conveniently you are able to work with printed materials and the computer screen simultaneously.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations on the workstation's viewing locations.

Please rate on the ten point scale below the workstation's viewing locations in terms of their personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

COMPUTER SCREEN IMAGE QUALITY

RATE THE IMAGE QUALITY OF THE COMPUTER SCREEN IN TERMS OF:

1) its ability to display images of appropriate brightness;

N/A	1 Poor	2	3	4	5 Excellent

2) its ability to display images that are legible;

N/A	1 Poor	2	3	4	5 Excellent

3) its ability to display images that have correct color;

N/A	1 Poor	2	3	4	5 Excellent

4) the *size* of the screen, in that it is sufficient for your work;

N/A	1 Poor	2	3	4	5 Excellent

5) its ability to resist reflections from lights, windows, and other bright objects to the extent that these reflections are not disturbing to you while you work.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the computer screen's image quality.

Please rate on the ten point scale below the computer screen's image quality in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

MUSIC AND AUDIO SYSTEMS

RATE YOUR WORKSTATION'S MUSIC AND AUDIO SYSTEMS IN TERMS OF:

1) the clarity of the synthesizer sounds, recorded music, and/or other audio playback;

N/A	1 Poor	2	3	4	5 Excellent

2) the layout of the audio system controls, in that their individual functions are clear and logical to you;

N/A	1 Poor	2	3	4	5 Excellent

3) the layout of the music synthesizer controls, in that their individual functions are clear and logical to you;

N/A	1 Poor	2	3	4	5 Excellent

4) how comfortable the headphones are after you have worn them for an extended period of time.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the workstation's music and audio systems.

Please rate on the ten point scale below the workstation's music and audio system in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

LIGHTING

RATE THE ROOM'S LIGHTING IN TERMS OF:

1) its ability to provide you with enough light for reading printed materials such as books and notes;

N/A	1	2	3	4	5
	Poor				Excellent

2) its ability to provide enough light without washing out the images on your computer screen;

N/A	1	2	3	4	5
	Poor				Excellent

3) its ability to provide light for your work area that is evenly distributed and shadow free;

N/A	1	2	3	4	5
	Poor				Excellent

4) how pleasing the color of the light is to you;

N/A	1	2	3	4	5
	Poor				Excellent

5) the absence of discomforting glare.

N/A	1	2	3	4	5
	Poor				Excellent

In the space below, note any additional observations you may have regarding the room's lighting.

Please rate on the ten point scale below the facility's lighting in terms of its personal importance to you as a user.

1	2	3	4	5	6	7	8	9	10
Low									High

COLOR AND REFLECTANCE

RATE THE ROOM'S COLOR AND REFLECTANCE IN TERMS OF:

1) how well the room's color scheme produces an environment that is pleasant and comfortable;

N/A	1 Poor	2	3	4	5 Excellent

2) how well the room's color scheme allows you to concentrate on work without distraction;

N/A	1 Poor	2	3	4	5 Excellent

3) the absence of discomforting glare from the walls;

N/A	1 Poor	2	3	4	5 Excellent

4) how well the desktop surface provides you with a comfortable, glare free background for reading printed materials;

N/A	1 Poor	2	3	4	5 Excellent

5) the *color* of the desktop surface as a visually comfortable background for reading and writing.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the room's color and reflectance.

Please rate on the ten point scale below the room's color and reflectance in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

ACOUSTICS

RATE THE ROOM'S ACOUSTICAL ENVIRONMENT IN TERMS OF:

1) your ability to work without being disturbed by noise from areas *outside* of the room, such as adjacent rooms, hallways, or areas outside of the building;

N/A	1	2	3	4	5
	Poor				Excellent

2) your ability to work without being disturbed by noise from activities at neighboring workstations or other areas *within* the room;

N/A	1	2	3	4	5
	Poor				Excellent

3) your ability to work without being disturbed by noise from room equipment (i.e. computers, printers, air conditioning units);

N/A	1	2	3	4	5
	Poor				Excellent

4) your ability to hear a teacher when the room is used for class presentations;

N/A	1	2	3	4	5
	Poor				Excellent

5) your ability to hear other students asking questions when the room is used for class presentations.

N/A	1	2	3	4	5
	Poor				Excellent

In the space below, note any additional observations you may have regarding the room's acoustics.

Please rate on the ten point scale below the room's acoustics in terms of its personal importance to you as a user.

1	2	3	4	5	6	7	8	9	10
Low									High

TEMPERATURE AND AIR QUALITY

RATE THE ROOM'S TEMPERATURE AND AIR QUALITY IN TERMS OF:

1) the overall room temperature, as to its not being too cool for your comfort;

N/A	1 Poor	2	3	4	5 Excellent

2) the overall room temperature as, to its not being too warm for your comfort;

N/A	1 Poor	2	3	4	5 Excellent

3) the *quality* of the air, as to its being fresh or stale;

N/A	1 Poor	2	3	4	5 Excellent

4) the absence of excessive draft from air conditioning vents or windows;

N/A	1 Poor	2	3	4	5 Excellent

5) the room's humidity level, as to its not being too moist for your comfort;

N/A	1 Poor	2	3	4	5 Excellent

6) the room's humidity level, as to its not being too dry for your comfort.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the room's temperature and air quality.

Please rate on the ten point scale below the room's temperature and air quality in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

TECHNICAL SUPPORT

RATE THIS FACILITY'S TECHNICAL SUPPORT IN TERMS OF:

1) the availability of technical support staff;

N/A	1 Poor	2	3	4	5 Excellent

2) the ability of technical support staff to provide expert assistance on how to effectively use the workstations in this facility;

N/A	1 Poor	2	3	4	5 Excellent

3) the availability of manuals or other information that provides advice on how to effectively use the workstations in this facility;

N/A	1 Poor	2	3	4	5 Excellent

4) the ability of available manuals or other information to clearly explain how to effectively use the workstations in this facility.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding the technical support in this facility.

Please rate on the ten point scale below the technical support in this facility in terms of its personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

OTHER CONSIDERATIONS

RATE THE FOLLOWING "OTHER CONSIDERATIONS" REGARDING:

1) the room's overall attractiveness;

N/A	1 Poor	2	3	4	5 Excellent

2) how easily the room's layout allows you access to essential equipment, materials, and support staff;

N/A	1 Poor	2	3	4	5 Excellent

3) the room's storage capabilities for coats, hats, books, and other personal effects;

N/A	1 Poor	2	3	4	5 Excellent

4) the room's ability to provide enough space so as not to feel crowded.

N/A	1 Poor	2	3	4	5 Excellent

In the space below, note any additional observations you may have regarding these "other considerations."

Please rate on the ten point scale below the factors considered in this section in terms of their personal importance to you as a user.

1 Low	2	3	4	5	6	7	8	9	10 High

ADDITIONAL INFORMATION

PLEASE ANSWER THE FOLLOWING QUESTIONS: IF YOU NEED ADDITIONAL SPACE, FEEL FREE TO USE THE BACK OF THIS PAGE.

1. In your opinion, are there any other factors that should have been considered in this evaluation? If so, what are they?

2. As a place to learn and work, what do you like *best* about the design and layout of this facility?

3. What do you like *least*?

4. If you were in a position to recommend design changes to this facility, what would they be?

APPENDIX D: Instrumentation for Environmental Measurements

The following instruments were used to measure the interior environmental factors in each lab:

Empire Protractor, Model #36

Extech Instruments Digital Thermometer/Hygrometer, Model #4465CF

General Radio Model 1933 Sound Analysis System

Keuffel & Esser Co. Inclinometer

Kurz Air Velocity Meter, Model #441S

Spectra Footcandle/Footlambert Meter, Model #FC 200

Stanley Tape Measure, 16' Leverlock Model #30-516

APPENDIX E: Performance Test

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APPENDIX F: Anthropometric Table

The table below, adapted from ANSI/HFS (1988) and Kroemer (1989), lists anthropometric values pertinent to VDT workstation design. These values are derived from U.S. civilian body dimensions.

Values are expressed in inches (centimeters). F = Female; M = Male

	5th percentile	50th percentile	95th percentile	Standard Deviation
Stature (height)	F: 58.8 (149.5) M: 63.7 (161.8)	F: 63 (160.5) M: 68.3 (173.6)	F: 67.4 (171.3) M: 72.6 (184.4)	F: 2.6 (6.6) M: 2.7 (6.9)
Buttock - Knee Length (sitting)	F: 20.4 (51.8) M: 21.3 (54.0)	F: 22.4 (56.9) M: 23.4 (59.4)	F: 24.6 (62.5) M: 25.3 (64.2)	F: 1.2 (3.1) M:1.2 (3.0)
Buttock-Popliteal Distance (sitting)	F: 16.9 (43.0) M: 17.4 (44.2)	F: 18.9 (48.1) M: 19.4 (49.5)	F: 21.0 (53.5) M: 21.6 (54.8)	F: 1.2 (3.1) M: 1.2 (3.0)
Elbow-Fingertip Length	F: 15.2 (38.5) M: 17.4 (44.1)	F: 16.5 (42.1) M: 18.8 (47.9)	F: 18.1 (46.0) M: 20.2 (51.4)	F: 0.8 (2.2) M: 0.8 (2.2)
Elbow Rest Ht. (sitting)	F: 7.1 (18.1) M: 7.5 (19.0)	F: 9.2 (23.3) M: 9.5 (24.3)	F: 11.0 (28.1) M: 11.6 (29.4)	F: 1.1 (2.9) M: 1.2 (3.0)
Eye Height (sitting)	F: 26.6 (67.5) M: 28.6 (72.6)	F: 28.8 (73.3) M: 31.0 (78.6)	F: 30.9 (78.5) M: 33.2 (84.4)	F: 1.3 (3.3) M: 1.4 (3.6)
Foot Length	F: 8.8 (22.3) M: 9.8 (24.8)	F: 9.4 (24.1) M: 10.6 (26.9)	F: 10.3 (26.2) M: 11.4 (29.0)	F: 0.4 (1.2) M: 0.5 (1.3)
Hip Breadth (sitting)	F: 12.3 (31.2) M: 12.1 (30.8)	F: 14.3 (36.4) M: 13.9 (35.4)	F: 17.2 (43.7) M: 16.0 (40.6)	F: 1.4 (3.7) M: 1.1(2.8)
Knee Height (sitting)	F: 17.8 (45.2) M: 19.4 (49.3)	F: 19.6 (49.8) M: 21.3(54.3)	F: 21.5 (54.5) M: 23.3 (59.3)	F: 1.0 (2.7) M: 1.1 (2.9)
Popliteal Height (sitting)	F: 14.0 (35.5) M: 15.4 (39.2)	F: 15.6 (39.8) M: 17.4(44.2)	F: 17.4 (44.3) M: 19.2 (48.8)	F: 1.0 (2.6) M: 1.1 (2.8)
Thigh Height (above seat)	F: 4.2 (10.6) M: 4.5 (11.4)	F: 5.4 (13.7) M: 5.6 (14.4)	F: 6.9 (17.5) M: 7.0 (17.7)	F: 1.0 (1.8) M: 0.6 (1.7)
Weight in lbs (kg)	F: 101.8 (46.2) M: 123.9 (56.2)	F: 134.7 (61.1) M: 163.1 (74.0)	F: 198.2 (89.9) M: 214.0 (97.1)	F: 30.4 (13.8) M: 27.7(12.6)

APPENDIX G: Personal Data and Other Information

The lists below are data from the first page of the questionnaire. Includes personal data (height in inches, weight in lbs, gender); frequency of use: l = less than once a week, o = once a week, t = twice a week, m = more than twice a week; station preference: s = same; g = general area; n = does not matter.

Learning Center ($N = 40$)

	Height	Weight	Gender	Frequency	Station pref
1.	70	150	m	m	n
3.	67	139	m	m	n
3.	67	121	m	m	n
4.	67	150	f	m	s
5.	70	180	m	l	n
6.	72	180	m	m	n
7.	65	154	m	o	n
8.	72	180	m	t	s
9.	66	145	m	m	g
10.	71	185	m	t	n
11.	72	160	m	m	n
12.	70	180	m	m	s
13.	76	195	m	o	s
14.	75	170	m	t	n
15.	67	154	m	m	n
16.	74	175	m	t	g
17.	70	140	m	m	g
18.	71	135	m	o	n
19.	68	132	m	m	g
20.	64	160	m	m	s
21.	69	147	m	m	n
22.	63	165	f	m	n
23.	65	125	m	m	n
24.	67	146	m	m	g
25.	63	140	f	o	g
26.	70	175	m	t	g
27.	68	165	m	l	n
28.	70	175	m	m	n
29.	73	240	m	m	g
30.	67	135	f	l	n
31.	68	150	m	t	n
32.	68	160	m	t	n
33.	72	135	m	m	n
34.	67	130	m	o	s
35.	64	160	f	m	g
36.	69	170	m	o	n
37.	71	159	m	m	g
38.	73	159	m	m	g
39.	67	140	m	m	n
40.	69	180	m	m	g

CTMI ($N = 16$)

	Height	Weight	Gender	Frequency	Station pref
1.	68	155	m	o	n
2.	63	105	f	t	s
3.	70	160	m	m	s
4.	74	195	m	m	s
5.	71	155	m	m	s
6.	70	155	m	o	n
7.	62	110	f	m	g
8.	72	180	m	l	g
9.	72	200	m	m	s
10.	72	180	m	l	n
11.	71.5	175	m	m	n
12.	66	145	m	o	s
13.	70	175	m	l	s
14.	70	220	m	m	s
15.	68	115	f	l	n
16.	67.5	130	m	o	n

Professional Writing Lab ($N = 34$)

	Height	Weight	Gender	Frequency	Station pref
1.	65	162	m	m	n
2.	70.5	148	m	o	s
3.	65	125	m	m	n
4.	67	130	f	o	s
5.	69	130	m	t	n
6.	68	145	f	t	n
7.	71	143	m	t	s
8.	67	160	m	o	n
9.	60	100	f	o	n
10.	70	160	m	t	n
11.	72	120	m	o	n
12.	74	200	m	t	s
13.	68	146	m	t	n
14.	68	145	m	o	s
15.	73	170	m	o	s
16.	67.5	150	m	t	g
17.	68	120	f	l	s
18.	70	168	m	m	s
19.	72	160	m	t	s
20.	68.5	145	m	l	s
21.	68	160	m	t	s
22.	72	175	m	t	s
23.	60	95	f	o	n
24.	63	110	f	t	s
25.	70	160	m	t	s
26.	72	175	m	o	s
27.	60	145	m	o	n
28.	63	150	f	t	g
29.	69	139	m	t	s
30.	66	135	m	o	n

Professional Writing Lab (*continued*)

	Height	Weight	Gender	Frequency	Station pref
31.	74	180	m	o	n
32.	72	155	m	t	s
33.	67	135	f	o	n
34.	68	140	m	t	s

Professional Education Lab (*N* = 30)

	Height	Weight	Gender	Frequency	Station pref
1.	70	155	m	m	n
2.	66	115	f	t	g
3.	73	175	m	m	n
4.	77	230	m	m	s
5.	67	140	m	o	s
6.	70	200	m	t	n
7.	70	165	m	t	s
8.	72	157	m	t	n
9.	62	120	f	t	n
10.	72	180	m	t	n
11.	71	155	m	m	n
12.	70	150	m	t	n
13.	67	180	m	o	n
14.	68	130	f	o	n
15.	67	160	m	m	n
16.	64	105	f	m	n
17.	74	180	m	m	n
18.	66	130	f	m	s
19.	67	150	m	o	g
20.	* *	* * *	f	m	s
21.	63	120	f	t	s
22.	68	170	m	m	s
23.	70	220	m	o	s
24.	76	135	m	t	s
25.	64	140	m	m	g
26.	65	125	f	t	s
27.	68	135	m	t	s
28.	69	155	f	m	g
29.	65	135	m	t	s
30.	69	165	m	m	s

APPENDIX H: Raw Data

Learning Center ($N = 40$)

Seating
1. 5 5 5 3 3 4 5 4 5 5 3 5 5 5 4 4 4 5 5 3 4 5 4 3 5 5 4 3 4 4 5 5 3 5 3 4 4 4 5 5
2. 5 5 5 33 4 5 4 5 5 4 5 5 5 4 5 4 5 5 3 4 5 5 5 4 5 4 4 4 4 4 5 1 5 3 4 4 4 3 5
3. 5 4 5 * 4 4 5 5 5 5 4 5 5 5 4 4 4 5 5 3 4 5 4 3 4 5 4 3 4 5 4 * 3 5 3 5 4 4 4 5
4. 5 5 5 3 3 4 5 4 5 4 3 5 4 5 5 4 4 5 5 4 4 5 5 3 4 2 4 4 4 5 4 4 5 5 3 4 4 4 3 3
5. 4 5 5 4 4 * 4 3 3 5 2 5 4 4 5 4 4 4 4 4 3 4 5 2 4 3 4 3 4 5 4 5 2 5 1 5 3 2 5 5
6. 5 5 5 4 3 4 3 3 5 5 2 5 4 4 5 3 4 5 5 1 5 5 4 4 5 4 4 4 4 5 4 5 2 5 2 4 4 2 4 5
7. 3 5 5 1 3 4 2 2 2 5 1 3 1 4 1 4 3 3 4 5 3 5 3 3 3 1 4 3 1 5 4 5 1 5 2 3 1 1 1 1

Desks
1. 4 3 5 4 5 3 3 4 4 5 4 5 5 3 4 5 4 4 4 3 4 5 3 4 3 4 4 4 3 5 5 5 4 4 3 4 3 4 3 5
2. 3 3 5 2 * 3 3 4 5 4 3 5 4 4 3 5 2 3 4 5 4 3 * 2 4 2 4 5 2 5 5 3 2 3 2 3 4 3 2 5
3. 5 5 5 1 * 5 5 4 3 5 3 5 4 5 4 5 3 4 4 4 4 3 3 2 1 3 4 5 4 5 5 4 4 4 2 2 3 5 2 5
4. 2 1 5 1 * 4 1 1 1 4 2 5 * 3 4 2 2 3 4 1 3 2 2 2 1 3 4 5 1 5 5 4 2 2 2 1 2 1 1 5
5. 3 1 5 3 * 1 5 5 5 5 4 5 5 3 4 4 2 4 5 4 4 5 4 4 2 3 4 5 4 5 5 * 4 4 2 5 4 5 3 5
6. 3 5 4 4 * 3 4 3 1 5 3 5 3 2 4 3 4 5 4 4 4 4 3 * 3 5 4 3 5 * 5 5 4 4 3 5 3 * 4 4
7. 4 1 5 4 * 1 5 2 2 5 2 5 4 2 4 2 3 4 2 4 3 5 4 3 3 5 4 3 3 4 5 5 2 4 2 4 1 3 5 5

Viewing Locations
1. 5 5 5 4 4 5 5 4 4 5 3 5 5 5 4 5 5 5 4 4 4 5 5 3 4 4 3 4 4 5 5 3 5 5 2 5 5 4 3 5
2. 5 5 5 4 3 5 5 1 4 5 5 5 5 4 5 5 5 4 4 5 5 5 3 4 5 3 4 4 5 5 2 5 4 3 5 5 4 3 5
3. 5 5 5 4 4 5 5 4 4 5 2 5 5 3 4 5 4 5 5 4 3 4 5 5 4 4 3 3 4 5 5 2 3 5 2 5 4 5 4 5
4. 5 5 5 4 3 5 5 1 4 5 5 5 5 5 4 5 4 5 5 4 3 5 5 5 4 4 3 5 4 5 5 3 5 5 3 5 5 5 5 5
5. 5 5 5 4 4 5 5 3 2 5 2 5 5 4 5 5 5 5 5 5 4 4 3 5 4 4 3 3 4 5 5 4 4 5 1 5 5 5 4 5
6. 4 4 5 5 3 5 5 2 2 5 3 4 5 5 4 5 3 3 3 3 3 4 2 2 2 4 5 4 5 5 4 4 5 1 3 4 4 2 5
7. 5 5 5 4 4 4 * 2 3 5 3 4 5 4 3 5 3 4 4 4 4 4 3 * 2 3 4 5 4 4 5 5 3 5 1 3 3 3 2 3

Computer Screen Image Quality
1. 5 5 5 5 4 5 5 5 5 5 5 5 5 5 4 4 5 4 5 5 5 5 4 4 3 5 4 5 5 5 5 5 4 4 4 4 5 5
2. 5 5 5 5 4 5 3 5 5 5 5 5 5 5 5 4 5 4 5 5 5 5 4 5 4 4 5 4 5 5 5 5 5 3 5 4 4 5 4
3. 5 5 5 5 4 5 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 4 5 5 4 5 4 5 5 5 5 5 3 4 3 5 * *
4. 5 5 5 5 4 5 4 3 5 5 4 3 5 4 5 4 4 5 4 5 4 5 4 4 4 5 4 4 5 5 5 5 5 5 4 5 2 4 4 3
5. 5 5 5 5 * 4 5 3 5 5 3 4 5 4 4 4 4 4 4 5 4 5 5 2 4 5 4 4 4 5 5 5 4 5 1 5 1 3 4 5

Music and Audio Systems
1. 4 2 4 5 4 2 5 2 3 5 4 2 3 5 1 3 3 5 4 3 4 * 4 4 3 5 3 4 4 * 4 5 2 4 3 3 1 * 4 3
2. 4 1 5 5 4 3 4 3 3 4 4 2 1 3 4 2 5 4 5 4 3 * 3 4 3 4 3 3 3 * 4 4 2 4 2 3 1 * 2 1
3. 5 1 5 5 5 4 5 2 3 5 1 2 2 3 3 2 4 4 4 4 3 * 3 4 3 2 3 5 3 * 4 5 2 4 2 4 1 * 3 5
4. 3 5 5 4 4 3 5 4 1 3 2 4 1 * 4 1 3 5 2 5 4 4 3 3 2 4 3 4 2 * 2 5 2 5 4 5 1 2 4 1

Lighting

1. 5 5 5 5 4 5 4 3 4 5 4 5 5 4 5 5 5 5 5 5 5 4 5 4 5 3 4 5 4 5 4 4 4 5 5 4 4 5 5
2. 4 5 5 5 4 5 5 3 4 4 4 5 3 5 5 4 5 5 5 5 3 5 4 3 3 4 4 4 5 5 5 5 4 5 3 5 3 4 5 5
3. 4 5 5 5 5 5 4 3 4 5 2 5 3 3 5 5 4 5 5 4 5 5 4 3 3 3 4 3 4 5 5 3 5 4 2 4 5 3 5 5
4. 5 5 5 5 4 5 5 3 4 5 1 5 1 4 5 4 4 5 5 4 2 5 5 * 2 4 4 3 4 4 5 3 3 2 2 3 4 2 4 5
5. 4 5 5 5 5 5 * 3 4 5 1 5 1 5 5 4 4 3 5 * 3 5 5 1 2 5 3 4 3 5 4 5 3 5 1 5 * 3 5 5

Color and Reflectance

1. 5 5 5 5 5 1 5 3 4 5 4 5 5 4 5 4 4 5 5 4 4 4 4 5 4 5 3 4 4 5 5 2 4 5 3 5 3 4 4 5
2. 5 5 5 5 4 5 5 3 4 5 4 5 5 5 5 4 4 5 5 5 5 4 5 4 4 3 4 5 5 5 3 4 5 3 5 4 5 4 5
3. 5 5 5 5 5 5 5 5 4 5 4 5 5 5 5 4 4 5 5 5 5 4 2 3 5 3 5 5 5 5 2 5 5 5 5 3 4 5 5
4. 5 5 5 5 5 5 2 4 4 5 3 5 5 4 5 4 4 5 5 5 5 5 4 4 3 5 3 4 4 5 5 4 4 3 2 5 3 4 4 5
5. 5 5 5 5 3 1 5 4 4 5 3 5 4 4 3 5 5 5 4 5 5 5 4 5 4 5 4 4 4 5 5 1 4 4 3 5 4 3 4 5

Acoustics

1. 4 5 5 5 4 5 5 5 5 5 4 5 5 5 2 * 4 5 4 5 4 5 4 5 4 3 5 4 4 5 5 5 5 5 5 2 5 5 5 5
2. 3 1 3 5 3 4 5 1 3 3 1 4 3 3 1 3 3 5 2 5 2 4 2 1 3 4 5 3 1 3 5 5 1 2 1 2 2 1 1 3
3. 4 4 3 5 5 3 5 5 5 5 4 5 5 4 3 4 4 5 5 5 4 4 4 1 4 2 5 4 3 2 5 4 4 4 4 4 4 3 3 4
4. 5 * * 3 * * * 5 * * * * * 4 4 * 4 5 3 * 3 * 3 3 * * 5 * 3 * * 5 * * * * * * * *
5. * * * 5 * * * 5 * * * * * 4 4 * 4 4 3 * 3 * 4 3 * * 5 * * * 4 3 * * * * * * * 5

Temperature and Air Quality

1. 4 5 5 5 4 5 4 4 2 5 4 5 4 5 5 3 3 5 5 5 4 5 4 5 3 5 3 4 4 5 4 4 4 5 4 3 5 5 4 5
2. 2 5 5 5 4 3 5 1 4 5 4 5 3 4 5 3 4 4 5 5 3 5 3 2 3 4 3 3 4 5 4 2 4 4 1 4 2 5 3 1
3. 4 5 5 5 5 4 4 3 4 5 4 5 4 4 4 3 4 3 5 5 4 5 3 3 3 4 3 3 4 5 3 * 3 2 2 5 2 1 5 2
4. 4 5 5 5 4 4 * 3 1 5 4 5 4 5 4 4 4 5 4 5 5 5 4 2 4 5 3 4 4 5 3 3 4 4 4 4 5 2 5 3
5. 4 5 5 5 4 2 5 3 4 5 4 5 4 4 4 4 3 5 4 5 5 5 5 4 4 4 3 4 4 5 3 4 3 4 4 4 4 5 3 5
6. 4 5 5 5 5 4 5 3 4 5 4 5 4 5 4 4 3 5 5 5 5 5 4 2 3 3 4 4 5 3 4 4 4 3 5 2 5 2 5

Technical Support

1. 5 5 5 4 5 4 2 2 4 4 3 2 3 4 1 5 3 5 5 3 4 5 5 2 3 4 4 5 4 5 5 1 4 5 4 5 2 4 5 2
2. 5 5 4 4 5 3 4 3 3 4 3 2 3 3 1 4 3 5 5 2 3 5 5 4 3 5 4 5 4 5 5 2 4 5 3 5 2 4 5 2
3. 5 5 5 * 5 4 3 5 3 5 3 4 5 3 2 5 4 5 5 4 4 4 5 3 4 5 4 4 3 * 5 2 4 5 3 5 * 5 5 5
4. 5 5 5 * 5 4 5 3 4 5 3 3 3 5 3 4 4 5 4 * 4 4 5 3 4 1 4 4 4 * 5 2 3 5 4 5 * 3 5 5

Other

1. 5 5 5 5 5 1 5 4 2 5 4 5 5 4 5 4 5 * 4 4 5 4 5 5 4 5 3 5 4 5 4 4 4 5 3 4 2 1 3 5
2. 5 5 5 5 3 3 5 3 3 4 2 5 4 3 5 4 4 5 4 4 4 5 5 2 3 5 4 4 2 5 4 3 3 4 2 4 3 4 3 3
3. 2 2 5 2 3 * 1 3 2 * 2 4 * * 2 1 2 3 2 * 3 1 3 2 3 3 4 2 * 5 3 3 2 4 1 3 1 2 1 1
4. 3 5 4 2 3 2 5 3 2 5 1 4 3 4 5 4 2 4 2 4 3 4 3 2 3 5 4 3 3 5 4 2 3 4 1 3 2 4 1 1

CTMI ($N = 16$)

Seating
1. 3 3 2 4 4 4 4 2 4 3 5 3 5 4 1 4
2. 3 3 3 4 4 4 3 3 5 4 5 4 5 5 1 3
3. 2 1 3 4 4 2 3 2 5 4 3 5 4 5 1 4
4. 3 1 3 4 3 4 2 4 5 4 4 4 5 5 1 4
5. 3 3 3 4 3 4 2 2 5 4 4 5 5 4 2 4
6. 3 3 4 5 4 4 3 2 4 4 4 1 5 4 1 4
7. 4 3 2 3 5 5 4 1 4 4 5 5 5 4 4 3

Desks
1. 3 2 4 4 4 4 3 4 4 5 4 5 4 3 3 4
2. 5 3 3 2 3 1 2 1 4 2 1 2 2 3 2 3
3. 1 3 3 4 3 4 1 1 4 2 3 5 4 4 2 3
4. 1 2 2 4 3 1 1 1 4 2 4 2 4 4 2 3
5. 1 3 4 4 5 3 4 2 5 4 4 4 4 4 2 4
6. 1 4 2 * 4 3 3 4 4 4 4 5 4 4 2 *
7. 4 4 2 4 4 5 4 2 5 4 5 4 5 4 1 4

Viewing Locations
1. 3 4 5 4 1 4 3 4 3 3 4 5 5 5 4 3
2. 3 4 5 4 * 4 3 4 5 3 4 5 5 4 4 3
3. 4 4 2 4 3 3 3 4 4 3 4 5 5 4 * 3
4. 4 4 5 4 * 4 3 4 5 4 4 5 5 4 1 3
5. 2 * 1 4 1 5 * 1 4 1 3 5 * 3 1 3
6. 3 2 2 4 3 4 2 1 1 4 1 2 2 4 1 3
7. 3 2 2 4 4 3 1 1 1 2 1 3 2 4 1 3

Computer Screen Image Quality
1. 3 4 5 4 4 5 4 4 4 4 4 5 5 5 5 3
2. 4 4 5 4 3 5 4 4 4 4 5 5 5 5 5 3
3. 4 * 5 4 * 4 3 4 * 4 * 5 5 5 5 3
4. 3 2 3 2 5 2 4 2 3 3 4 5 5 4 4 3
5. 2 2 3 4 2 4 2 2 1 5 4 4 5 4 5 4

Music and Audio Systems
1. 2 4 4 * 5 4 * 4 2 5 * 5 5 5 3 4
2. 3 3 4 * 4 4 * 1 4 5 * 5 5 4 3 3
3. 4 3 3 * 4 4 * 1 2 4 * 5 5 4 4 *
4. 3 1 2 5 4 4 * 1 1 4 * 2 5 3 4 2

Lighting
1. 3 4 3 4 3 5 3 4 5 5 4 5 5 5 3 3
2. 4 4 4 5 3 5 3 4 4 5 4 5 5 5 5 3
3. 4 3 4 4 3 5 3 2 4 5 5 5 5 5 5 3
4. 2 3 1 5 3 5 3 3 3 4 4 4 5 4 1 3
5. 3 3 4 4 2 4 3 3 3 4 4 4 5 4 5 3

Color and Reflectance
1. 3 4 5 4 3 5 4 1 3 4 5 5 5 4 3 3
2. 4 4 5 4 4 5 4 2 3 4 5 5 5 4 3 3
3. 4 4 5 4 3 5 3 4 3 4 5 5 5 4 4 3
4. 3 4 5 4 3 5 2 3 5 4 5 5 5 4 4 4
5. 3 4 5 4 4 5 3 1 5 3 4 5 5 4 5 5

Acoustics
1. 2 5 2 5 5 4 4 2 4 5 4 4 5 4 4 5
2. 2 4 1 5 3 2 3 2 4 4 2 4 4 4 4 3
3. 2 3 2 4 4 3 4 2 5 4 3 5 4 4 3 4
4. 4 * * * * * * 3 * * * * * * * *
5. * * * * * * * 3 * * * * * * * *

Temperature and Air Quality
1. 4 3 4 4 4 4 * 4 4 5 4 2 4 4 4 5
2. 5 4 2 4 4 3 * 4 4 5 4 2 3 4 3 5
3. 5 3 3 4 3 3 * 2 4 4 4 1 3 4 1 4
4. 5 3 3 4 4 5 * 2 4 4 4 2 5 4 3 5
5. 5 4 3 4 5 4 * 4 3 4 4 3 3 4 3 4
6. 5 4 3 4 2 2 * 4 3 4 4 3 4 4 2 4

Technical Support
1. 4 4 5 5 5 5 4 4 5 5 5 5 5 5 5 4
2. 4 4 5 5 5 5 5 4 5 5 5 5 5 5 5 4
3. 5 4 4 5 5 5 4 5 4 5 4 5 5 5 5 4
4. 4 3 3 5 5 5 1 5 4 * 4 4 4 5 5 4

Other
1. 3 4 5 4 4 4 3 1 3 5 4 4 5 4 2 3
2. 3 4 3 4 5 4 3 3 3 5 4 4 5 3 4 3
3. 1 2 1 1 4 4 1 1 2 2 1 4 3 3 1 2
4. 1 3 1 2 4 4 3 1 4 4 3 4 5 2 2 2

Professional Writing Lab ($N = 34$)

Seating
1. 3 4 3 2 4 2 4 3 1 2 1 1 3 1 4 5 2 5 4 2 4 4 3 4 3 3 5 3 3 5 2 3 1 1
2. 3 5 4 2 3 2 3 3 2 2 2 2 3 1 3 3 3 2 5 1 4 4 3 5 4 3 5 3 3 5 4 3 1 1
3. 3 5 4 * 5 1 3 4 4 2 1 3 2 1 3 1 3 3 4 2 4 3 4 4 4 4 5 2 4 5 2 3 1 1
4. 3 5 3 3 2 1 3 2 1 2 1 2 2 2 3 4 3 3 5 2 4 4 4 4 4 3 5 2 2 5 4 3 1 2
5. 3 4 3 1 4 3 3 1 1 5 1 4 3 4 3 5 3 4 4 1 4 4 4 4 2 3 * 4 1 5 3 1 1 1
6. 3 4 3 2 5 1 4 4 2 5 2 5 3 3 4 5 3 4 5 2 4 4 4 4 3 4 5 4 4 5 2 3 2 2
7. 3 5 1 3 1 2 2 1 5 1 1 2 2 3 2 1 2 2 1 2 2 3 2 3 1 3 5 2 2 1 4 1 3 3

Desks
1. 4 4 3 5 4 4 2 4 5 5 4 4 4 2 4 5 4 5 5 3 4 4 3 3 3 4 4 * 3 5 4 2 2 3
2. 3 5 3 1 5 4 3 3 5 1 3 1 4 1 4 5 2 4 3 3 4 1 3 1 1 3 3 1 3 5 4 1 3 2
3. 4 5 4 1 5 4 4 4 4 2 4 * 3 4 4 5 3 4 4 3 4 3 3 2 4 3 4 * 3 4 3 1 3 2
4. 4 3 2 1 4 4 4 1 4 3 3 2 3 2 4 2 3 2 4 4 4 2 3 4 1 4 4 * 1 * 3 1 3 1
5. 4 5 4 2 4 3 3 * 5 2 4 2 2 4 4 2 3 4 4 3 4 4 4 4 3 4 5 * 3 4 2 2 2 2
6. 4 5 3 3 3 4 3 4 4 3 4 4 3 3 4 4 2 3 3 3 4 4 2 4 4 4 5 * 3 4 4 4 2 4
7. 4 5 4 1 4 2 4 3 5 2 3 1 3 1 3 2 3 5 4 3 4 3 4 4 4 4 4 * 2 4 1 1 1 1

Viewing Locations
1. 3 5 3 5 5 4 4 4 5 5 5 5 4 5 4 5 4 3 4 4 4 5 2 3 4 3 4 3 3 5 4 4 3 5
2. 3 5 3 5 5 3 4 4 5 5 5 5 4 5 4 5 4 3 4 4 4 5 2 4 4 3 4 3 3 5 4 4 3 5
3. 3 5 3 1 3 3 4 4 4 5 5 5 4 5 4 3 3 3 5 4 4 5 1 4 3 4 4 3 2 5 4 4 3 5
4. 3 5 3 5 4 3 4 4 3 5 5 5 4 5 3 5 4 3 5 3 4 5 1 4 3 4 4 3 3 5 4 4 3 5
5. 3 4 1 1 2 2 2 * 3 5 5 4 3 4 4 1 3 1 5 4 4 * 1 4 3 4 4 3 2 2 3 1 3 2
6. 3 5 4 1 4 3 3 4 5 5 1 2 3 2 3 5 2 2 3 4 4 3 1 1 3 4 3 2 3 * 3 1 3 3
7. 3 5 4 1 4 4 4 4 5 5 5 3 3 3 4 5 3 1 3 3 4 3 1 4 3 4 4 1 3 * 3 1 3 2

Computer Screen Image Quality
1. 4 5 5 5 4 2 4 4 3 4 5 3 4 4 4 5 3 4 5 4 4 5 3 3 5 4 5 3 2 5 4 4 3 3
2. 3 5 5 5 4 4 4 5 3 4 5 3 4 4 5 5 3 5 5 4 4 5 3 4 5 4 5 3 4 5 4 4 4 3
3. 4 5 * * * 3 1 * 2 1 5 1 * 3 5 5 3 * 4 3 4 5 3 4 5 3 5 3 1 * 4 1 3 *
4. 4 5 5 5 5 4 5 4 4 4 5 5 4 5 5 4 3 5 5 3 4 5 1 5 5 4 5 3 4 5 4 1 3 4
5. 3 5 4 2 3 3 4 4 5 3 5 5 4 4 4 5 2 5 5 3 4 3 1 4 4 4 4 3 3 5 4 4 3 5

Music and Audio Systems
1. 4 5 4 5 4 4 3 4 5 5 4 3 4 5 3 3 2 4 4 3 4 4 3 4 4 3 3 3 4 5 4 4 4 2
2. 4 5 4 4 4 4 2 4 5 5 5 4 3 5 3 4 3 3 5 3 4 4 2 4 4 4 4 3 3 5 4 2 3 5
3. 4 5 4 3 3 4 4 4 5 3 5 5 3 4 3 4 3 3 5 4 4 4 2 4 4 4 4 2 3 5 4 4 3 5
4. 4 5 2 4 4 1 3 4 5 5 4 5 3 2 2 4 3 3 4 3 4 4 1 1 4 4 4 3 3 5 4 3 3 2

Lighting

1. 3 4 4 5 4 3 5 4 5 4 4 5 4 5 4 4 4 5 3 3 4 5 2 4 5 4 5 4 4 5 4 4 3 3
2. 4 5 4 4 3 3 5 4 5 4 4 5 4 4 4 5 4 5 4 3 4 4 3 4 4 4 5 4 4 5 4 4 3 5
3. 4 4 4 3 3 3 5 4 4 4 3 5 4 5 4 5 3 5 2 2 4 5 2 4 4 4 5 4 4 5 4 4 3 3
4. 3 4 2 4 2 2 5 3 5 3 4 5 4 4 4 3 2 5 3 3 4 4 3 3 2 4 4 4 3 5 4 3 3 1
5. 3 5 3 2 3 2 4 4 5 2 5 5 4 4 4 5 2 5 4 3 4 4 * 3 3 4 5 4 3 5 4 3 2 2

Color and Reflectance

1. 3 4 2 3 4 3 4 4 4 5 5 1 3 1 4 4 2 5 3 3 4 5 3 4 3 4 5 4 4 * 4 4 2 5
2. 4 5 3 3 4 4 4 4 4 5 5 5 3 5 4 5 4 5 4 3 4 5 * 4 4 4 5 4 4 * 4 4 3 5
3. 4 5 4 4 4 3 4 5 5 5 5 5 3 5 4 5 4 5 5 4 4 5 * 4 4 4 5 4 4 * 4 4 3 5
4. 4 4 4 5 5 3 5 4 5 3 5 5 3 4 4 * 2 5 5 3 4 4 2 4 4 4 5 4 3 * 4 4 4 5
5. 4 4 4 5 5 2 5 4 5 4 5 5 4 4 4 5 3 5 4 3 4 4 3 4 4 4 5 4 4 * 4 4 4 5

Acoustics

1. 4 5 2 5 4 4 3 5 4 5 5 4 4 5 4 4 5 5 5 3 * 3 4 5 4 4 5 5 4 5 4 4 4 4
2. 2 3 2 4 4 4 4 5 5 3 5 5 3 1 3 3 4 4 4 4 * 3 4 5 2 1 5 4 1 5 4 2 3 2
3. 3 4 3 4 5 4 4 5 5 3 5 5 4 4 3 5 5 4 4 3 * 5 4 5 3 4 5 4 2 5 4 2 3 4
4. 4 4 3 4 4 5 4 5 5 4 5 5 4 5 3 5 3 4 4 2 2 4 3 5 3 4 4 4 3 5 4 4 3 4
5. 4 4 3 4 4 5 4 4 5 3 5 5 2 4 3 5 3 4 3 3 * 4 2 5 3 3 4 4 3 5 4 4 3 4

Temperature and Air Quality

1. 3 5 3 3 4 4 5 4 5 4 5 4 4 5 3 4 4 5 4 3 4 4 2 4 4 4 5 3 4 5 4 4 3 5
2. 4 4 4 5 4 4 5 4 5 4 5 2 4 4 4 4 4 5 4 2 4 4 2 2 4 4 4 3 4 5 4 3 3 3
3. 3 5 2 4 4 2 4 4 5 2 5 4 3 3 3 4 4 5 3 3 4 4 1 2 4 2 4 3 3 * 4 1 2 1
4. 3 5 3 5 4 4 5 4 5 3 5 5 4 5 3 5 4 5 4 3 4 4 2 3 3 4 5 4 4 5 4 1 3 5
5. 2 5 3 4 4 1 4 4 5 2 5 5 4 5 3 4 4 5 5 2 4 4 2 4 4 4 5 4 4 5 4 5 3 3
6. 2 4 3 3 4 1 4 4 4 2 5 5 4 5 3 4 4 5 5 2 4 4 2 4 4 3 5 4 4 5 4 1 3 3

Technical Support

1. 4 4 4 5 4 5 4 4 4 3 3 4 4 5 4 5 4 4 5 3 4 5 4 4 4 4 3 * 3 5 4 1 3 5
2. 4 5 5 5 4 5 5 4 4 3 3 4 4 5 4 5 4 4 5 3 4 5 4 5 4 4 3 * 3 5 4 1 3 5
3. 4 3 5 3 4 4 5 2 5 5 3 4 4 5 3 5 3 2 5 4 4 * 3 4 4 4 3 * 2 * 4 1 3 2
4. 4 4 4 2 3 * 5 2 5 5 3 4 4 4 3 5 2 * 5 3 4 4 3 4 4 4 3 * 2 * 4 1 2 *

Other

1. 3 4 2 3 4 2 3 3 5 3 5 2 3 4 3 5 2 5 4 3 4 4 2 4 4 4 5 4 3 * 3 3 1 5
2. 4 5 2 4 3 3 3 2 4 3 5 2 4 4 4 5 3 4 5 3 4 2 3 4 4 3 4 2 3 * 4 1 1 5
3. 2 4 1 3 1 3 4 4 3 2 5 2 2 3 2 2 3 1 5 3 4 5 1 4 3 3 3 2 1 4 3 1 1 2
4. 1 5 1 3 2 2 3 3 5 3 5 2 2 3 2 3 3 2 4 3 4 4 3 4 3 4 3 3 3 * 3 1 1 4

Professional Education Lab ($N = 30$)

Seating
1. 2 3 2 5 3 4 5 4 3 3 4 4 3 5 5 4 3 4 3 3 4 4 2 5 4 4 4 4 4 5
2. 5 3 2 5 4 4 5 4 3 4 3 4 4 5 5 4 4 3 3 3 3 4 2 5 4 3 5 4 4 5
3. 1 3 2 5 4 4 5 4 4 2 5 5 4 5 5 3 3 3 3 3 3 4 2 5 4 5 5 4 4 5
4. 1 3 1 5 4 4 3 3 3 5 3 5 4 5 1 3 2 1 3 3 3 4 1 3 3 4 5 3 4 5
5. 2 3 3 1 3 4 5 2 4 2 4 * 4 * 2 5 1 2 2 4 1 3 2 4 3 * 4 4 2 5
6. 1 3 2 4 3 4 4 4 5 3 4 4 4 4 5 5 2 4 3 3 5 3 2 4 4 4 3 4 5 5
7. 1 1 1 1 4 1 3 3 3 1 1 1 4 1 1 1 1 1 2 2 1 2 1 1 1 4 1 2 1 5

Desks
1. 5 4 4 2 3 4 3 3 5 2 4 4 5 5 4 4 4 3 4 3 4 4 3 4 4 4 5 4 4 5
2. 2 1 3 1 1 4 3 3 3 1 3 2 3 1 1 3 1 1 2 4 2 4 1 3 2 2 3 3 2 1
3. 2 1 4 1 2 4 4 3 5 1 2 5 2 3 1 1 2 1 2 4 3 4 1 4 3 4 4 3 2 1
4. 2 1 3 3 1 4 3 2 5 1 1 1 4 2 1 3 3 2 1 4 4 4 1 4 3 4 2 4 3 2
5. 2 4 1 2 4 4 3 3 3 4 1 4 4 2 1 4 3 2 2 4 5 4 2 4 2 3 2 4 4 5
6. 2 4 1 4 3 4 3 3 5 1 * * 3 1 1 2 3 2 3 3 3 4 3 4 3 3 3 4 4 3
7. 2 3 1 5 4 5 4 3 4 2 3 4 4 5 5 2 3 3 3 4 3 3 2 4 1 2 5 3 3 4

Viewing Locations
1. 4 2 4 5 4 4 3 4 5 2 4 4 4 4 * 5 4 4 4 4 5 5 3 3 4 5 5 4 4 5
2. 4 4 4 5 4 4 3 4 4 3 4 5 4 5 * 5 2 4 4 4 2 5 3 3 4 5 5 4 4 5
3. 4 4 2 5 4 3 3 4 5 4 5 5 4 3 * 5 3 4 4 4 5 4 3 3 4 5 3 4 4 5
4. 4 4 2 5 4 3 3 5 5 3 5 5 3 5 * 5 5 4 4 4 5 4 3 3 4 5 3 4 4 5
5. 4 4 4 4 3 2 3 2 3 1 1 5 3 * 1 5 1 2 3 4 4 4 3 3 5 5 4 3 3 3
6. 3 1 1 1 3 3 * 3 2 1 1 2 4 1 1 2 3 2 2 3 * 4 2 3 * 4 2 3 2 1
7. 2 1 1 1 4 3 * 3 1 1 1 2 3 1 1 3 4 2 2 4 * 4 2 3 3 4 2 3 2 1

Computer Screen Image Quality
1. 4 4 4 4 4 4 5 4 4 3 4 5 4 5 5 5 4 4 3 4 * * 4 3 5 3 4 4 4 4
2. 3 4 3 5 4 4 5 4 3 3 4 5 4 5 5 4 2 4 3 4 1 1 4 3 3 5 4 4 4 4
3. 3 4 4 3 4 4 5 3 3 3 4 5 4 5 5 5 3 4 3 4 * * 4 3 5 * 4 4 3 4
4. 3 4 2 4 4 4 5 3 2 2 3 4 4 5 5 4 3 4 3 4 * * 4 3 5 5 5 4 3 4
5. 3 3 1 5 4 3 3 3 2 1 3 4 3 5 1 5 1 4 3 3 * * 3 3 5 3 5 3 4 3

Music and Audio Systems
1. 3 4 1 3 3 2 * 3 3 3 * * 4 4 5 * 4 1 2 3 * * * 4 5 4 4 4 2 3
2. 3 2 1 4 4 3 * 3 * 3 * * 4 4 5 * 2 1 2 3 * * * 4 4 4 4 3 3 3
3. 3 3 * 3 4 2 * 4 5 3 * * 4 5 3 * 2 1 2 3 * * * 4 4 4 4 4 3 4
4. 2 3 * 1 3 4 * 3 3 2 * * 4 2 3 * 2 1 3 3 * * * 5 2 5 4 4 3 2

Lighting

1. 4 5 1 5 4 5 5 5 3 5 1 5 5 5 2 5 2 4 3 4 * 5 4 4 5 5 5 4 4 4
2. 3 4 1 5 4 4 5 4 3 3 4 5 5 5 2 5 3 4 3 4 * 4 4 4 5 5 4 4 4 4
3. 4 2 1 5 4 5 5 4 4 3 4 5 5 4 1 5 3 4 3 3 * 4 4 4 5 5 4 3 3 4
4. 5 3 1 3 3 3 5 4 4 2 1 5 5 3 * 5 2 4 2 3 * 3 3 4 5 5 2 4 2 4
5. 5 2 1 4 4 4 5 4 5 4 4 4 5 4 * 5 2 4 3 3 * 3 3 4 5 5 4 4 3 4

Color and Reflectance

1. 5 4 2 3 3 3 3 3 5 1 1 2 4 4 3 5 1 4 3 2 1 3 * 4 5 4 4 3 4 4
2. 5 4 * 4 4 3 4 3 5 2 3 3 4 5 * 5 1 4 3 3 1 4 * 4 5 5 4 4 4 4
3. 1 4 4 4 3 3 4 4 5 2 4 4 4 5 * 5 1 1 3 3 1 4 * 4 5 5 4 4 4 4
4. 5 3 1 4 4 4 4 4 1 2 4 4 4 4 1 5 1 4 3 4 3 4 * 4 5 5 4 4 3 4
5. 5 4 1 4 4 4 5 3 5 2 4 5 4 5 5 5 1 4 3 3 3 4 * 4 4 5 3 4 4 3

Acoustics

1. 5 3 3 4 4 5 5 4 5 4 5 4 3 5 4 5 1 4 3 4 5 5 2 4 5 5 5 4 4 4
2. 3 3 4 2 4 2 4 2 3 1 3 3 3 5 2 2 * 4 3 3 1 4 2 4 5 5 1 2 1 3
3. 3 3 4 4 4 3 4 3 4 2 4 4 3 4 2 5 * 4 3 3 3 4 2 4 5 5 5 3 3 4
4. 2 3 2 2 5 4 4 4 * 2 4 4 3 4 2 5 1 4 2 3 4 5 4 4 5 5 4 3 4 4
5. 2 3 1 3 4 4 4 4 3 2 4 4 3 2 2 5 * 4 2 3 2 4 3 4 5 5 3 3 4 4

Temperature and Air Quality

1. 4 3 5 4 4 3 3 4 5 4 5 4 4 5 1 5 * 4 3 4 5 4 3 3 * 4 4 3 4 4
2. 3 4 1 4 4 3 3 2 5 2 5 4 3 1 3 5 1 4 3 4 5 2 1 3 * 4 2 3 3 4
3. 1 2 1 2 4 2 4 3 5 2 2 4 4 1 1 3 2 4 3 3 5 2 3 4 3 4 4 4 2 3
4. 4 4 4 4 4 4 5 4 5 4 3 4 3 5 2 3 3 4 3 3 5 3 3 4 5 5 5 3 5 5
5. 4 4 4 5 4 3 5 4 5 3 3 4 4 3 * 5 4 4 3 3 4 4 3 4 * 5 4 4 4 5
6. 3 2 2 3 4 3 4 4 5 3 3 4 3 5 * 5 5 4 3 3 3 4 2 4 * 5 4 4 4 5

Technical Support

1. 2 1 1 4 4 2 3 4 4 4 2 3 2 4 2 4 * 2 2 3 * 3 2 5 * * 5 4 5 4
2. 2 2 4 4 3 1 3 3 4 3 3 2 3 2 2 5 1 1 3 3 * 3 2 5 * * 4 3 5 4
3. 2 3 4 5 3 2 1 4 3 2 4 4 3 4 3 4 1 1 4 4 * 3 1 5 * * 5 4 5 4
4. 3 3 4 5 4 3 1 4 4 1 4 3 2 3 4 3 * 1 3 4 * 3 1 5 * * 5 4 4 4

Other

1. 3 3 1 3 2 3 4 3 4 1 3 3 4 * 3 5 1 3 4 3 * * 2 4 5 * 4 3 3 5
2. 2 3 1 3 4 1 4 3 3 1 2 2 4 * 1 3 * 1 4 3 * * 2 4 3 * 4 3 3 5
3. 1 1 1 1 2 1 4 2 4 1 1 1 2 * 1 1 1 1 1 2 * * * 3 4 * 2 1 2 4
4. 1 1 1 1 3 1 4 2 3 1 1 3 2 * 1 3 2 1 1 2 * * 2 4 * * 2 2 3 4

APPENDIX I: Data Tables

Kruskal-Wallis Test Results: Comparisons of Questionnaire Sections

Seating				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	277	142690.5	515.13
# cases = 832	CTMI	112	47653	425.47
H = 86.48 p = .0001	PWL	236	75927	321.72
H corrected for ties = 91.8 p = .0001	PEL	207	80257.5	387.72
# tied groups = 5				

Desks				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	268	12494	466.25
# cases = 814	CTMI	110	43303	393.66
H = 32.48 p = .0001	PWL	228	91952	403.3
H corrected for ties = 34.68 p = .0001	PEL	208	71496	343.73
# tied groups = 5				

Viewing Locations				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	278	139654.5	502.35
# cases = 818	CTMI	106	34489	325.37
H = 69.25 p = .0001	PWL	234	89286	381.56
H corrected for ties = 74.57 p = .0001	PEL	200	71541.5	357.71
# tied groups = 5				

Computer Screen Image Quality				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	197	67904.5	344.69
# cases = 548	CTMI	76	17972	236.47
H = 66.38 p = .0001	PWL	136	35119	258.23
H corrected for ties = 75.6 p = .0001	PEL	139	29430.5	211.73
# tied groups = 5				

Music and Audio Systems				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	149	30381.5	203.9
# cases = 426	CTMI	52	11867.5	228.22
H = 13.42 p = .0036	PWL	136	32532	239.21
H corrected for ties = 14.6 p = .0022	PEL	89	16170	181.69
# tied groups = 5				

Lighting				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	196	66235	337.93
# cases = 588	CTMI	80	22013.5	275.17
H = 19.52 p = .0002	PWL	169	45200.5	267.46
H corrected for ties = 21.61 p = .0001	PEL	143	39717	277.74
# tied groups = 5				

Color and Reflectance				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	200	66666.5	333.33
# cases = 552	CTMI	48	12338.5	257.05
H = 50.13 p = .0001	PWL	162	43608	269.19
H corrected for ties = 56.92 p = .0001	PEL	142	30015	211.37
# tied groups = 5				

Acoustics				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	119	22244.5	186.93
# cases = 354	CTMI	48	7712.5	160.68
H = 6.89 p = .0755 (NS)	PWL	99	18893	190.84
H corrected for ties = 7.46 p = .0587 (NS)	PEL	88	13985	158.92
# tied groups = 5				

Temperature and Air Quality				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	238	94880	398.66
# cases = 704	CTMI	90	28877.5	320.66
H = 21.64 p = .0001	PWL	203	70539	347.48
H corrected for ties = 24.01 p = .0001	PEL	173	53863.5	311.35
# tied groups = 5				

Technical Support				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	153	36699	239.86
# cases = 448	CTMI	63	19668	312.19
H = 61.67 p = .0001	PWL	126	27772.5	220.42
H corrected for ties = 67.14 p = .0001	PEL	106	16436.5	155.06
# tied groups = 5				

Other				
df = 3	Facility	# Cases	Σ Ranks	Mean Rank
# groups = 4	LC	153	40043	261.72
# cases = 451	CTMI	64	14531.5	227.05
H = 33.01 p = .0001	PWL	133	30584	229.95
H corrected for ties = 34.68 p = .0001	PEL	101	167.5	166.01
# tied groups = 5				

Friedman Test Results: Questionnaire Items x Subjects (All Facilities)

df = 56
# samples = 57
#cases = 120
χ_r^2 = 1066.88 p = .0001
χ corrected for ties = 1250.72 p = .0001
tied groups = 527

Item	Σ Ranks	Mean Rank	Item	Σ Ranks	Mean Rank
Seating 1	3437	28.64	MusAud 4	2706.5	22.55
Seating 2	3617	30.14	Lighting 1	4524	37.7
Seating 3	3539.5	29.5	Lighting 2	4440	37
Seating 4	3163	26.36	Lighting 3	4018	33.48
Seating 5	2892.5	24.1	Lighting 4	3245	27.04
Seating 6	3580.5	29.84	Lighting 5	3595.5	29.96
Seating 7	1898	15.82	ColorRef 1	3594	29.95
Desks 1	3739	31.16	ColorRef 2	4379	36.49
Desks 2	2174.5	18.12	ColorRef 3	4460	37.17
Desks 3	2828.5	23.57	ColorRef 4	4032.5	33.6
Desks 4	2013.5	15.78	ColoRef 5	4301	35.84
Desks 5	3226	26.88	Acoustics 1	4654	38.78
Desks 6	2947	24.56	Acoustics 2	2526	21.05
Desks 7	2946	24.55	Acoustics 3	3679	30.66
ViewLoc 1	4254.5	35.45	TempAir 1	4122.5	34.35
ViewLoc 2	4315.5	35.96	TempAir 2	3317.5	27.65
ViewLoc 3	3910.5	32.59	TempAir 3	2870.5	23.92
ViewLoc 4	4302.5	35.85	TempAir 4	3992.5	33.27
ViewLoc5	3060	25.5	TempAir 5	3980.5	33.17
ViewLoc 6	2275.5	18.96	TempAir 6	3656.5	30.47
View Loc 7	2460	20.5	Tech 1	3821.5	31.85
Image 1	4575	38.12	Tech 2	3777.5	31.48
Image 2	4669	38.91	Tech 3	3838	31.98
Image 3	4881.5	40.68	Tech 4	3440	28.67
Image 4	4182	34.85	Other 1	3345.5	27.88
Image 5	3499.5	29.16	Other 2	3000	25
MusAud 1	3248.5	27.07	Other 3	1351	11.26
MusAud 2	2992.5	24.94	Other 4	1902	15.85
MusAud 3	3161.5	26.35			

Friedman Test Results: Questionnaire Items x Subjects (Learning Center)

df = 56
# samples = 57
#cases = 40
χ_r^2 = 424.03 p = .0001
χ corrected for ties = 520.49 p = .0001
tied groups = 168

Item	Σ Ranks	Mean Rank	Item	Σ Ranks	Mean Rank
Seating 1	1328.5	33.21	MusAud 4	791	19.77
Seating 2	1351	33.78	Lighting 1	1506.5	37.66
Seating 3	1354	33.85	Lighting 2	1396.5	34.91
Seating 4	1262.5	31.56	Lighting 3	1249	31.23
Seating 5	1040.5	26.01	Lighting 4	1108.5	27.71
Seating 6	1198	29.95	Lighting 5	1130	28.25
Seating 7	651.5	16.29	ColorRef 1	1351.5	33.79
Desks 1	1129	28.23	ColorRef 2	1505.5	37.64
Desks 2	871	21.77	ColorRef 3	1544	38.6
Desks 3	1072	26.8	ColorRef 4	1395.5	34.89
Desks 4	526.5	13.16	ColoRef 5	1331	33.28
Desks 5	1151.5	28.79	Acoustics 1	1523.5	38.09
Desks 6	974	24.35	Acoustics 2	570.5	14.26
Desks 7	832.5	20.81	Acoustics 3	1166	29.15
ViewLoc 1	1387	34.67	TempAir 1	1334.5	33.36
ViewLoc 2	1380	34.5	TempAir 2	967.5	24.19
ViewLoc 3	1280.5	32.01	TempAir 3	1026.5	25.66
ViewLoc 4	1457	36.42	TempAir 4	1200.5	30.01
ViewLoc5	1339.5	33.49	TempAir 5	1234	30.85
ViewLoc 6	986	24.65	TempAir 6	1261	31.52
View Loc 7	950.5	23.76	Tech 1	1126	28.15
Image 1	1500.5	40.01	Tech 2	1075	26.88
Image 2	1606	40.15	Tech 3	1300	32.5
Image 3	1643.5	41.09	Tech 4	1180.5	29.51
Image 4	1432	35.8	Other 1	1300	32.5
Image 5	1295	32.38	Other 2	1028	25.7
MusAud 1	859	21.48	Other 3	378.5	9.46
MusAud 2	704	17.6	Other 4	674.5	15.86
MusAud 3	801.5	20.04			

Friedman Test Results: Questionnaire Items x Subjects (CTMI)

df = 54
# samples = 55
#cases = 16
χ_r^2 = 233.22 p = .0001
χ corrected for ties = 270.1 p = .0001
tied groups = 71

Item	Σ Ranks	Mean Rank	Item	Σ Ranks	Mean Rank
Seating 1	425.5	26.59	MusAud 4	290.5	18.16
Seating 2	467	29.19	Lighting 1	543.5	33.97
Seating 3	385.5	24.09	Lighting 2	600.5	37.53
Seating 4	429.5	26.84	Lighting 3	556	34.75
Seating 5	435	27.19	Lighting 4	374	23.38
Seating 6	435.5	27.22	Lighting 5	412	25.75
Seating 7	497	31.06	ColorRef 1	495.5	30.97
Desks 1	459.5	28.72	ColorRef 2	546.5	34.16
Desks 2	217.5	13.59	ColorRef 3	535	33.44
Desks 3	287	17.94	Acoustics 1	555	34.69
Desks 4	218.5	13.66	Acoustics 2	346	21.62
Desks 5	443.5	27.72	Acoustics 3	417.5	26.09
Desks 6	387.5	24.22	TempAir 1	514.5	32.16
Desks 7	528.5	13.03	TempAir 2	481	30.06
ViewLoc 1	471.5	29.47	TempAir 3	371	28.19
ViewLoc 2	515.5	32.22	TempAir 4	500	31.25
ViewLoc 3	434	27.12	TempAir 5	484.5	30.28
ViewLoc 4	505.5	31.59	TempAir 6	411	25.69
ViewLoc5	233.5	14.59	Tech 1	738.5	46.16
ViewLoc 6	190.5	11.91	Tech 2	746	46.62
View Loc 7	194.5	12.16	Tech 3	709	44.31
Image 1	593.5	37.09	Tech 4	567.5	35.47
Image 2	612.5	38.28	Other 1	439	27.44
Image 3	615.5	38.47	Other 2	457.5	28.59
Image 4	364	22.75	Other 3	138	8.62
Image 5	384	24	Other 4	264.5	16.53
MusAud 1	565	35.31			
MusAud 2	434	27.12			
MusAud 3	415.5	25.97			

Friedman Test Results: Questionnaire Items x Subjects (Professional Writing Lab)

df = 57
# samples = 58
#cases = 34
χ_r^2 = 329.58 p = .0001
χ corrected for ties = 404.21 p = .0001
tied groups = 137

Item	Σ Ranks	Mean Rank	Item	Σ Ranks	Mean Rank
Seating 1	690.5	20.31	MusAud 4	883	25.97
Seating 2	728.5	21.43	Lighting 1	1249	36.74
Seating 3	762	22.41	Lighting 2	1288	37.88
Seating 4	676	19.88	Lighting 3	1151.5	33.87
Seating 5	674.5	19.84	Lighting 4	890.5	26.19
Seating 6	963	28.32	Lighting 5	1008	29.65
Seating 7	425	12.5	ColorRef 1	972	28.59
Desks 1	1073	31.56	ColorRef 2	1303	38.32
Desks 2	732	21.53	ColorRef 3	1411.5	41.51
Desks 3	898.5	26.43	ColorRef 4	1224.5	36.01
Desks 4	692	20.35	ColoRef 5	1301	38.26
Desks 5	862.5	25.37	Acoustics 1	1393	40.97
Desks 6	914.5	26.9	Acoustics 2	931.5	27.4
Desks 7	741.5	21.81	Acoustics 3	1207	35.5
ViewLoc 1	1224	36	Acoustics 4	1183.5	34.81
ViewLoc 2	1227.5	36.1	Acoustics 5	1024.5	30.13
ViewLoc 3	1058	31.12	TempAir 1	1197	35.21
ViewLoc 4	1138.5	33.49	TempAir 2	1121	32.97
ViewLoc5	657.5	19.34	TempAir 3	786	23.12
ViewLoc 6	701.5	20.63	TempAir 4	1198	35.24
View Loc 7	842	24.76	TempAir 5	1144	33.65
Image 1	1196	35.18	TempAir 6	1003	29.5
Image 2	1340	39.41	Tech 1	1196	35.18
Image 4	1343	39.5	Tech 2	1300	38.24
Image 5	1086.5	31.96	Tech 3	1020.5	30.01
MusAud 1	1081.5	31.81	Tech 4	935	27.5
MusAud 2	1096.5	32.25	Other 1	867	25.5
MusAud 3	1095	32.21	Other 2	875.5	25.75
			Other 3	549	16.15
			Other 4	639.5	18.81

Friedman Test Results: Questionnaire Items x Subjects (Professional Education Lab)

df = 58
# samples = 59
#cases = 30
χ_r^2 = 442.77 p = .0001
χ corrected for ties = 499.82 p = .0001
tied groups = 139

Item	Σ Ranks	Mean Rank	Item	Σ Ranks	Mean Rank
Seating 1	1047.5	34.92	MusAud 4	660.5	22.02
Seating 2	1126.5	37.55	Lighting 1	1281	42.7
Seating 3	1126	37.53	Lighting 2	1219.5	40.65
Seating 4	829	27.63	Lighting 3	1116.5	37.22
Seating 5	748.5	24.95	Lighting 4	910.5	30.35
Seating 6	1026.5	34.22	Lighting 5	1099.5	36.65
Seating 7	315.5	10.52	ColorRef 1	809	26.97
Desks 1	1131.5	37.72	ColorRef 2	1048	34.93
Desks 2	422	14.07	ColorRef 3	1002.5	33.42
Desks 3	618	20.6	ColorRef 4	1009.5	33.65
Desks 4	624	20.8	ColoRef 5	1095	36.5
Desks 5	816	27.2	Acoustics 1	1245	41.5
Desks 6	694.5	23.15	Acoustics 2	701.5	23.38
Desks 7	870.5	29.02	Acoustics 3	975	32.5
ViewLoc 1	1229.5	40.98	Acoustics 4	991	33.03
ViewLoc 2	1243	41.43	Acoustics 5	883	29.43
ViewLoc 3	1198	39.93	TempAir 1	1094	36.47
ViewLoc 4	1230.5	41.02	TempAir 2	783.5	26.12
ViewLoc5	802	26.73	TempAir 3	710.5	23.68
ViewLoc 6	427	14.23	TempAir 4	1157.5	38.58
View Loc 7	469.5	15.65	TempAir 5	1182.5	39.42
Image 1	1256	41.87	TempAir 6	1029	34.3
Image 2	1145	48.17	Tech 1	790	26.33
Image 3	1121	37.37	Tech 2	680.5	22.68
Image 4	1074.5	35.82	Tech 3	873	29.1
Image 5	782	26.07	Tech 4	868	28.93
MusAud 1	821	27.37	Other 1	776	25.87
MusAud 2	794	26.47	Other 2	613	20.43
MusAud 3	901	30.03	Other 3	266	8.87
			Other 4	339.5	11.32

Chi-Square Results (Learning Center)

All results for 2df

Item	Chi-Square	Probability	Item	Chi-Square	Probability
Seating 1	41.61	.0001	Lighting 1	68.617	.0001
Seating 2	48.662	.0001	Lighting 2	45.361	.0001
Seating 3	47.561	.0001	Lighting 3	29.457	.0001
Seating 4	40.56	.0001	Lighting 4	22.23	.0001
Seating 5	25.381	.0001	Lighting 5	18.428	.0001
Seating 6	35.159	.0001	ColorRef 1	48.212	.0001
Seating 7	.65	.7225	ColorRef 2	58.415	.0001
Desks 1	32.158	.0001	ColorRef 3	52.863	.0001
Desks 2	3.9	.1423	ColorRef 4	48.212	.0001
Desks 3	19.079	.0001	ColorRef 5	43.861	.0001
Desks 4	12.302	.0021	Acoustics 1	59.589	.0001
Desks 5	26.556	.0001	Acoustics 2	.95	.6218
Desks 6	17.052	.0002	Acoustics 3	35.459	.0001
Desks 7	7.826	.02	TempAir 1	48.662	.0001
ViewLoc 1	48.662	.0001	TempAir 2	12.953	.0015
ViewLoc 2	43.861	.0001	TempAir 3	14.578	.0007
ViewLoc 3	39.36	.0001	TempAir 4	36.634	.0001
ViewLoc 4	48.662	.0001	TempAir 5	44.461	.0001
ViewLoc 5	43.561	.0001	TempAir 6	35.459	.0001
ViewLoc 6	12.953	.0015	Tech 1	21.355	.0001
ViewLoc 7	13.952	.0009	Tech 2	13.403	.0012
Image 1	74.169	.0001	Tech 3	28.781	.0001
Image 2	68.617	.0001	Tech 4	21.253	.0001
Image 3	56.563	.0001	Other 1	40.685	.0001
Image 4	57.964	.0001	Other 2	17.154	.0002
Image 5	45.036	.0001	Other 3	8.449	.0146
MusAud 1	7.175	.0277	Other 4	1.55	.4606
MusAud 2	2.824	.2436			
MusAud 3	3.874	.1441			
MusAud 4	5.55	.0623			

Observed Frequency Tables (Learning Center)

	Seat 1	Seat 2	Seat 3	Seat 4	Seat 5	Seat 6	Seat 7	Desks1
< 3	0	1	0	1	5	5	15	0
= 3	8	5	5	7	6	4	11	11
> 3	32	34	33	32	28	31	14	29

	Desks2	Desks3	Desks4	Desks5	Desks6	Desks7	View1	View2
< 3	8	6	22	5	2	11	1	2
= 3	12	7	4	5	11	7	5	5
> 3	18	26	12	28	23	21	34	33

	View3	View4	View5	View6	View7	Image1	Image2	Image3
< 3	3	1	3	7	4	0	0	0
= 3	5	5	4	9	11	1	2	3
> 3	32	34	33	24	23	39	38	35

	Image4	Image5	MuAd1	MuAd2	MuAd3	MuAd4	Light1	Light2
< 3	1	3	7	9	10	12	0	2
= 3	3	3	10	11	9	7	2	7
> 3	36	33	20	17	18	19	38	33

	Light3	Light4	Light5	ColRf1	ColRf2	ColRf3	ColRf4	ColRf5
> 3	2	7	5	2	0	2	2	2
= 3	9	5	7	4	4	2	4	5
< 3	29	27	25	34	36	35	34	33

	Acou1	Acou2	Acou3	Temp1	Temp2	Temp3	Temp4	Temp5
< 3	2	16	3	1	7	5	3	1
= 3	1	13	6	5	9	10	5	6
> 3	36	11	31	34	24	24	31	33

	Temp6	Tech1	Tech2	Tech3	Tech4	Other1	Other2	Other3
< 3	3	8	6	2	2	4	4	19
= 3	6	5	10	7	9	3	11	10
> 3	31	27	24	28	25	32	25	8

	Other4
< 3	12
= 3	11
> 3	17

Chi-Square Results (CTMI)

All results for 2df

Item	Chi-Square	Probability	Item	Chi-Square	Probability
Seating 1	3.877	.1439	Lighting 1	9.506	.0086
Seating 2	6.129	.0467	Lighting 2	17.386	.0002
Seating 3	2.376	.3048	Lighting 3	9.881	.0072
Seating 4	6.129	.0467	Lighting 4	1.626	.4435
Seating 5	3.877	.1439	Lighting 5	6.129	.0467
Seating 6	6.129	.0467	ColorRef 1	7.63	.022
Seating 7	9.131	.0104	ColorRef 2	12.883	.0016
Desks 1	9.881	.0072	ColorRef 3	14.009	.0009
Desks 2	4.628	.0989	Acoustics 1	17.386	.0002
Desks 3	.125	.9394	Acoustics 2	2.376	.3048
Desks 4	4.628	.0989	Acoustics 3	3.877	.1439
Desks 5	9.131	.0104	TempAir 1	18.073	.0001
Desks 6	5.626	.06	TempAir 2	7.191	.0275
Desks 7	17.386	.0002	TempAir 3	1.562	.4579
ViewLoc 1	7.63	.022	TempAir 4	7.191	.0275
ViewLoc 2	11.694	.0029	TempAir 5	9.442	.0089
ViewLoc 3	6.065	.0482	TempAir 6	4.564	.1021
ViewLoc 4	13.945	.0009	Tech 1	32.02	.0001
ViewLoc 5	1.435	.4881	Tech 2	32.02	.0001
ViewLoc 6	6.129	.0467	Tech 3	32.02	.0001
ViewLoc 7	3.877	.1439	Tech 4	13.945	.0009
Image 1	21.513	.0001	Other 1	6.504	.0387
Image 2	21.513	.0001	Other 2	8.38	.0151
Image 3	11.502	.0032	Other 3	9.131	.0104
Image 4	.5	.7787	Other 4	1.626	.4435
Image 5	6.129	.0467			
MusAud 1	9.69	.0079			
MusAud 2	5.187	.0748			
MusAud 3	5.498	.064			
MusAud 4	2.249	.3248			

Observed Frequency Tables (CTMI)

	Seat 1	Seat 2	Seat 3	Seat 4	Seat 5	Seat 6	Seat 7	Desks1
< 3	3	1	5	3	3	3	2	1
= 3	4	6	3	3	4	3	3	4
> 3	9	9	8	10	9	10	11	11

	Desks2	Desks3	Desks4	Desks5	Desks6	Desks7	View1	View2
< 3	9	5	9	3	3	3	1	0
= 3	5	5	2	2	2	0	5	4
> 3	2	6	5	11	9	13	10	11

	View3	View4	View5	View6	View7	Image1	Image2	Image3
< 3	1	1	6	10	9	0	0	0
= 3	5	2	3	3	4	2	2	2
> 3	9	12	4	3	3	14	14	10

	Image4	Image5	MuAd1	MuAd2	MuAd3	MuAd4	Light1	Light2
< 3	4	6	2	1	2	6	0	0
= 3	6	1	1	4	2	2	6	3
> 3	6	9	10	8	8	6	10	13

	Light3	Light4	Light5	ColRf1	ColRf2	ColRf3	Acou1	Acou2
< 3	1	3	1	1	1	0	3	5
= 3	4	6	6	5	3	4	0	3
> 3	11	7	9	10	12	12	13	8

	Acou3	Temp1	Temp2	Temp3	Temp4	Temp5	Temp6	Tech1
< 3	3	1	2	3	2	0	3	0
= 3	4	1	3	5	3	5	3	0
> 3	9	13	10	7	10	10	9	16

	Tech2	Tech3	Tech4	Other1	Other2	Other3	Other4
< 3	0	0	1	2	0	11	7
= 3	0	0	2	4	7	2	3
> 3	16	16	12	10	9	3	6

Chi-Square Results (Professional Writing Lab)

All results for 2df

Item	Chi-Square	Probability	Item	Chi-Square	Probability
Seating 1	.235	.889	Lighting 1	33.598	.0001
Seating 2	.412	.8139	Lighting 2	42.424	.0001
Seating 3	1.618	.4454	Lighting 3	21.948	.0001
Seating 4	1.118	.5718	Lighting 4	5.355	.0688
Seating 5	1.264	.5314	Lighting 5	8.678	.013
Seating 6	7.826	.02	ColorRef 1	11.15	.0038
Seating 7	15.769	.0004	ColorRef 2	36.539	.0001
Desks 1	16.445	.0003	ColorRef 3	45.012	.0001
Desks 2	.205	.9024	ColorRef 4	27.713	.0001
Desks 3	7.942	.0189	ColorRef 5	43.1	.0001
Desks 4	1.941	.379	Acoustics 1	43.1	.0001
Desks 5	5.824	.0544	Acoustics 2	6.56	.0376
Desks 6	11.326	.0035	Acoustics 3	23.506	.0001
Desks 7	2.853	.2401	Acoustics 4	27.566	.0001
ViewLoc 1	26.89	.0001	Acoustics 5	16.092	.0003
ViewLoc 2	26.89	.0001	TempAir 1	30.068	.0001
ViewLoc 3	14.534	.0007	TempAir 2	28.479	.0001
ViewLoc 4	19.476	.0001	TempAir 3	3.383	.1843
ViewLoc 5	1.058	.5892	TempAir 4	22.83	.0001
ViewLoc 6	.558	.7564	TempAir 5	24.772	.0001
ViewLoc 7	3.736	.1544	TempAir 6	15.063	.0005
Image 1	22.83	.0001	Tech 1	30.92	.0001
Image 2	34.657	.0001	Tech 2	30.92	.0001
Image 4	36.952	.0001	Tech 3	8.442	.0147
Image 5	16.652	.0002	Tech 4	7.852	.0197
MusAud 1	20.182	.0001	Other 1	4.442	.1085
MusAud 2	19.123	.0001	Other 2	4.971	.0833
MusAud 3	20.182	.0001	Other 3	1.824	.4017
MusAud 4	6.061	.0483	Other 4	1.264	.5314

Observed Frequency Tables (Professional Writing Lab)

	Seat 1	Seat 2	Seat 3	Seat 4	Seat 5	Seat 6	Seat 7	Desks1
< 3	12	11	11	14	10	8	22	4
= 3	10	13	8	9	9	7	8	7
> 3	12	10	14	11	14	19	4	22

	Desks2	Desks3	Desks4	Desks5	Desks6	Desks7	View1	View2
< 3	10	5	12	9	3	11	1	1
= 3	12	9	7	6	11	7	8	8
> 3	11	18	13	17	19	15	25	25

	View3	View4	View5	View6	View7	Image1	Image2	Image4
< 3	3	1	12	10	6	2	0	2
= 3	10	11	8	13	12	8	7	4
> 3	21	22	12	10	15	24	27	28

	Image5	MuAd1	MuAd2	MuAd3	MuAd4	Light1	Light2	Light3
< 3	3	2	3	2	7	1	0	3
= 3	9	9	8	9	9	6	5	7
> 3	22	23	23	23	18	27	29	24

	Light4	Light5	ColRf1	ColRf2	ColRf3	ColRf4	ColRf5	Acou1
< 3	6	6	5	0	0	2	1	1
= 3	11	8	8	5	3	5	3	3
> 3	17	19	20	27	29	25	29	29

	Acou2	Acou3	Acou4	Acou5	Temp1	Temp2	Temp3	Temp4
< 3	8	2	1	2	1	4	9	2
= 3	7	7	7	10	7	4	8	8
> 3	18	24	25	21	26	26	16	24

	Temp5	Temp6	Tech1	Tech1 2	Tech3	Tech4	Other1	Other2
< 3	5	6	1	1	5	6	6	7
= 3	4	6	6	6	8	6	11	9
> 3	25	22	26	26	28	17	16	17

	Other3	Other4
< 3	15	10
= 3	10	14
> 3	9	9

Chi-Square Results (Professional Education Lab)

All results for 2df

Item	Chi-Square	Probability	Item	Chi-Square	Probability
Seating 1	1104	.0033	Lighting 1	26.9	.0001
Seating 2	16.8	.0002	Lighting 2	23.3	.0001
Seating 3	12.6	.0018	Lighting 3	16.5	.0003
Seating 4	2.4	.3012	Lighting 4	2.2	.3329
Seating 5	2.7	.2592	Lighting 5	17.4	.0002
Seating 6	12.6	.0018	ColorRef 1	1.9	.3867
Seating 7	25.4	.0001	ColorRef 2	12.9	.0016
Desks 1	22.4	.0001	ColorRef 3	14.2	.0008
Desks 2	9.8	.0074	ColorRef 4	16.1	.0003
Desks 3	5	.0821	ColorRef 5	16.5	.0003
Desks 4	2.6	.2725	Acoustics 1	29.6	.0001
Desks 5	4.2	.1225	Acoustics 2	.3	.8607
Desks 6	2.2	.3329	Acoustics 3	8.5	.0143
Desks 7	1.8	.4066	Acoustics 4	10.9	.0043
ViewLoc 1	30.9	.0001	Acoustics 5	2.9	.2346
ViewLoc 2	26.9	.0001	TempAir 1	19	.0001
ViewLoc 3	21.1	.0001	TempAir 2	.9	.6376
ViewLoc 4	21.1	.0001	TempAir 3	1.4	.4966
ViewLoc 5	1.3	.522	TempAir 4	18.2	.0001
ViewLoc 6	8.9	.0117	TempAir 5	23	.0001
ViewLoc 7	7	.0302	TempAir 6	8.6	.0136
Image 1	33.2	.0001	Tech 1	4	.1353
Image 2	19	.0001	Tech 2	.5	.7788
Image 3	16.5	.0003	Tech 3	4.1	.1287
Image 4	12.2	.0022	Tech 4	3	.2231
Image 5	4.2	.1225	Other 1	3	.2231
MusAud 1	2.9	.2346	Other 2	1.1	.5769
MusAud 2	3	.2231	Other 3	21.7	.0001
MusAud 3	4.6	.1003	Other 4	12.3	.0021
MusAud 4	2.4	.3012			

Observed Frequency Tables (Professional Education Lab)

	Seat 1	Seat 2	Seat 3	Seat 4	Seat 5	Seat 6	Seat 7	Desks1
< 3	3	2	4	6	11	4	23	2
= 3	9	8	7	12	5	7	3	6
> 3	18	20	19	12	11	19	4	22

	Desks2	Desks3	Desks4	Desks5	Desks6	Desks7	View1	View2
< 3	17	15	14	11	7	7	2	2
= 3	10	5	7	5	13	10	3	4
> 3	3	10	9	14	8	13	24	23

	View3	View4	View5	View6	View7	Image1	Image2	Image3
< 3	1	1	7	16	16	0	1	0
= 3	7	7	10	8	7	4	7	9
> 3	21	21	12	3	5	24	20	18

	Image4	Image5	MuAd1	MuAd2	MuAd3	MuAd4	Light1	Light2
< 3	3	5	5	5	4	8	4	2
= 3	7	14	8	8	7	8	2	5
> 3	18	9	10	9	11	6	23	22

	Light3	Light4	Light5	ColRf1	ColRf2	ColRf3	ColRf4	ColRf5
< 3	3	7	3	7	3	5	5	3
= 3	6	8	5	9	6	4	4	6
> 3	20	13	20	13	18	19	20	20

	Acou1	Acou2	Acou3	Acou4	Acou5	Temp1	Temp2	Temp3
< 3	2	11	3	7	7	1	8	12
= 3	4	9	10	4	8	7	9	7
> 3	24	9	16	18	14	20	12	11

	Temp4	Temp5	Temp6	Tech1	Tech2	Tech3	Tech4	Other1
< 3	1	0	3	10	9	7	5	5
= 3	9	7	9	4	10	6	9	12
> 3	20	21	16	12	8	14	12	9

	Other2	Other3	Other4
< 3	9	20	17
= 3	9	1	5
> 3	7	4	3

APPENDIX J: Student Comments

SEATING

Learning Center

It is crowded and it is easy to be disturbed by someone next to you.

Stress #7, space too small to work behind others to get somewhere. Specially carrying instruments.

see last section.

it's pretty good.

I have to scoot up when someone needs to get past and they usually end up bumping into me, anyway.

Getting the music keyboard and the computer keyboard to a comfortable and productive arrangement is sometimes difficult.

The chairs are a lot more comfortable than the wooden classroom chairs.

Some chairs are broken, and due to limited space the workstations are sometimes cramped together during busy hours.

#7 would be the only inconvenience.

Chair adjustability for tall people is great!

Keyboard table is too low. It rests on my legs and I uh... never mind.

People have to be cautious when walking by to not bump the computer.

I need more space between the knees and the keys of the computer.

In most of he stations, it's very cramped. I usually have at best one bag with me & it's hard trying to get in & out without bumping anyone. Also I don't like other people being able to look at what I'm working on. We need more space and privacy.

We sometimes get so comfortable at our stations that we block each other in.

Professional Writing Lab

There are no foot rests. It's also hard to squeeze by someone, w/o disturbing them, to get in and out this station (#10).

Too many wires that could be pulled out accidentally (no room)

These chairs baffle me & are all too high.

These chairs are terrible. You need a chair with a reclining back. Also, it is hard to lower the chairs to a comfortable level for typing. My legs are usually jammed under the keyboard.

L19 is way to cramped to work comfortable in. You must get up if someone wants to get by.

Too close as far as one behind the other.

The stations are packed in a little tight so you end up banging the stations in back of you all the time.

Seats are too high.

It is very hard to work because the chair is too high and hard to keep on siting.

I wack my knees on keyboard

Too many stations in the room. Reducing the number by 2 would increase the amount of space.

Just a little too cramped

Professional Education Lab

Keyboards are situated so that I cannot fit my legs under it (they're very long) unless I lower the chair all the way. This hurts my back after a while.

#7 is very poor here

Kinda closed in.

Too crammed. Were like sardines!

Students who are seated at IBMs behind me have problems entering & exiting.

Spaces are crowded, have to squeeze by.

It is too crammed, not enough space to move around & you always have to ask persons to excuse you to get out from your station.

#7 The stations by the door allow enough space. The stations in groups of 3s are too close and you end up definitely disturbing people or being disturbed by them on their way out.

The major problem is mobility to & from the workstations. They are spaced too close together.

Faculty Lab (CTMI)

The chairs are overdesigned.

Somewhat difficult to move - wheels "stick" to carpet.

Chairs are too high (so is the equipment...)

I feel suspended by the chairs. Prefer feet on the floor.

I don't like having the whole station, including the chair, so high. I would prefer a normal size chair, and appropriately proportioned workstation.

DESKS

Learning Center

I find it very difficult to write on an angled platform.

It would be nice to adjust the height and angle of the monitor and the writing space. I have corrective lenses and at times, the glare is unbearable. The distance from the computer keyboard (typing) and the monitor is too much.

Need a side table. Can't write vertically.

Due to the positioning of the stations, when its crowded it is difficult to walk to the printer without bumping into a neighboring student.

it's good.

The computer keyboard sometimes won't go high enough. I have long legs.

Very or extremely difficult to do very much writing (neat writing that is).

Raising the seat height to compensate for lack of keyboard (synth) adjustment will bring upper legs & knees into keyboard (computer) shelf.

It can be a bit difficult to write by hand, obviously try to read my writing. Sometimes I have to turn my neck in many directions to accomplish tasks.

It is very flexible. I like it.

See page 1.

The keyboard is too high! (Even w/chair adjustment)

I don't like that you have to reach down & underneath to get at the disk drive & mixer.

Professional Writing Lab

It's easier to take notes on your lap rather than having to reach over the keyboard and everything to write something down on the angled desktop.

I cannot sit at any of the workstations comfortably

It is impossible to write on anything except your lap.

In order for the keyboard & computer keyboard to be easy to use (comfortable) my legs get squashed at the height I need it.

There is no place to write comfortably.

No where to write

If your too tall - there's not enough space for my legs but, everything is in arms length

The chairs have no height adjustment, or maybe I just stoopid

Professional Education Lab

Computer keyboard not as accessible as I would like - mouse too far away.

Not very manageable

M.S. keyboard is too high to play on without sitting on top of a book. Computer keyboard makes it hard to cross your legs.

keyboard up too high w/ no room to play

I do feel that the book rest should be on the left-hand side instead of the right, because it makes it hard to see the instructor.

Too cramped

Not bad, but sometimes writing or reading manual is hard. Overall workspace is small.

My knees tend to bump against the shelf the computer keyboard sits - that's annoying.

Faculty Lab (CTMI)

There is virtually no desk space, esp. for large, spread out projects.

Insufficient room for working from books, bad angle.

Since I am short I have to leave my seat to reach some of the equipment.

Computer screen is too far away for me.

I wish it were lower so I could use a shorter chair.

Would help to have rollers i.e. the keyboard tray to tuck out of the way if needed- to rigid a set up, but considering the equipment, understandable.

VIEWING LOCATIONS

Learning Center

It's hard to write anything by hand. Need a small table. The keyboard gets in the way for this.

it's really good.

Again. Very difficult. But, the adjustable easel is so-so or better than nothing.

Too far away.

Its hard having a notebook writing stuff and a regular look all at once. Maybe one of the screen clips would help.

What is this?

It seems a little high.

It would be nice to have more shelf space (maybe a shelf as a retracting arm, or something). I tend to use some heavier/thicker books than most people, but a wide edge on the raise-up panel would be nice, too.

Professional Writing Lab

I think it would be better to have the screen lower (i.e. closer to the synth keyboard).

There are practically no desks in this school to write on. As I'm writing I'm leaning forward.

I would have an adjustment on the back of computer screen to lift it up. Also I would like a pull out board to my right to write on.

Moveable monitors are much nicer to work with.

I like the set up - I really like the large screens.

There is no place that you can write & take notes.

Professional Education Lab

Not enough room for writing materials

The printing facilities are poor

Get the keyboards out!

There should be a sliding device, similar to the computer keyboards, for the musical keyboard.

I like to put books on my lap to read; the computer keyboard is too low to comfortable do this.

No way to position books or notes

No enough room behind me!

If typing something it's hard to keep turning your head to the right, small desk portion.

The desk at workstation is OK for 1 page writing - but not for holding any other materials.

Faculty Lab (CTMI)

The midi station is more important than easy comparison of screen and other.

Because we use so many things it's so hard to place everything where it's most convenient.

It would help to have adjustable trays for positioning documents.

- screen placement is not adjustable
-working with external objects like papers, books is small irritation because location of spot for them is not adjacent to screen.

COMPUTER SCREEN IMAGE QUALITY

Learning Center

Disturbs my head. I would prefer less "radiation" - type feeling. (I know you can't feel radiation, but try to understand what I mean)

-Pretty Good-

it's really good.

It's getting worse. (the survey)

No problems, save for small score sizes.

It would be nice to have 22" screens but I realize that's not possible.

Imaging is fine. And easy enough to change.

Professional Writing Lab

No color, too small, too complicated looking. Everything's square.

The lights really reflect on the top part of my screen.

Fluorescent glare is a little tricky, but that's nothing horrible.

Professional Education Lab

The images projected on the overhead are terrible. Classes should not use this as an instructional tool.

Need glare filters

Larger screens with less reflective surfaces would be great.

Screen is fine.

Faculty Lab (CTMI)

All monitors should be the same size and style.

How about full page in color?

Re 4) If they can be bigger, even better.
Re 5) CTMI can be a little disturbing because it reflects light through the windows.

Glare from windows can be a problem. Distance from screen too far.

Lighting is incorrect for this type monitor.

Larger screens are better...

MUSIC AND AUDIO SYSTEMS

Learning Center

Great headphones; terrible buzzing.

The recorder (cassette) on the audio system is of poor quality, which is unfortunate since I use it a lot. Also its location is inconvenient.

Many buzzes on some stations. Some headphones lost stereo. Only one side works.

The tape deck is complicated, unlabled as to which tracks are dedicated to which components of the workstation, and usually produces a poor recording.

headphones not too comfortable.

Recently, a student told me how dissatisfied he was w/ the X3. I have no problems w/ it. It is a little complex, not easy to figure.

Properly adjusted mix channels helps with audio signal dramatically.

When people "pound" on the keyboard its extremely annoying, and distracting.

Mixer is difficult to figure out and not always is the same configuration.

I don't have much experience with it.

The broken earphones, where only one speaker works (certain workstations have this problem). The hiss of the Fostex and of the synth sometimes.

Sometimes you can hear a buzz in the headphones, very loud noise, and the tape recorders do not record very well.

Lots of static and L/R dropouts on headphones.

Please put near keyboard information on how to get different sounds etc.... from it.

Some of the headphones "hiss" or only work out of one ear.

The headphones suck. I know they were generous donations, but they're poor quality, uncomfortable after awhile, and usually chock-full of ear fudge & ear stink!

I just tinker with some of the synth stuff, I can almost never get anything to work. You would think it would be set up so it would easy to come in & play or whatever. I can't get any sound out of the programs. It should be easier to come in & use without having to ask for hours of help from someone who doesn't have time. The headphones hurt with glasses

I answered 1 - 3 low because these stations have many options (which is great) but almost too many. I some times wish there were easy access to answers like keyboard set-up, mixer set-up, etc. Also, the audio output itself is often rather noisy (buzzes, ground loops, etc.).

Professional Writing Lab

I would put audio systems higher off the ground

Most of the rhythm section sounds aren't very good. Piano, guitar worst, bass & drums.

New headphones are a little delicate. Samples are a little outdated.

Distortion in headphones

Using the M1 would increase the number of different types of drum sounds.

After a while, the headphones start to hurt & they don't produce the best sound - (somewhat distorted)

I can't see so good

Professional Education Lab

Music software in this lab is lacking.

Love the X3.

Audio is updated, and enjoyable to use.

Volume not loud enough through headphones.

Faculty Lab (CTMI)

Some of my responses are the result of lack of familiarity with the controls.

Need more synths with more realistic horn sounds. The Kurzweils were much better.

don't use

It would be great to have isolated cubicles where you could play music through quality speakers.

LIGHTING

Learning Center

Comfortable reading light; glare free.

Still, the learning C is better lighting than the library, classrooms, practice rooms, etc.

its good.

Shadows in the corner workstations are bad.

Fine.

I hate fluorescent lights.

No matter what you do you're not going to get perfect lighting. So just work with what you have got.

It is difficult to see and control the tape recorder/mixer - could be relocated or lighted.

Overhead fluorescent lights are horrible!! I always try to find a chair w/out an overhead light. Especially with all the computer and looking at the screen - we need natural (bulb) lighting in a mellow pleasing color.

Ooh! Fluorescent lights get me hot!

The light is great ...butters fly in the moon light.......

It does not seem brighter or darker in any one particular location. This my answer to question #5.

I don't like fluorescent lights. They give headaches & eye fatigue. Regular lights would be much better.

Professional Writing Lab

It would be nice if it were a little darker in here.

Fluorescent lights are really gross.

Overhead lights are a little too office like. Soft lighting would be preferred - but go with the masses.

Professional Education Lab

It is more dim towards the front of the room. More often than not, I work from the middle -> back.

Fluorescent lighting sucks. Curtains should be open.

The lighting, when exposed to for an extended time, causes headaches.

Color sucks.

I sometimes feel like I'm in a greenhouse for plants. The light, although "yellowy-warm" definitely feels unnatural.

It is sometimes hard for the transparency projection to be clear because of brightness or angle of the screen.

Most fluorescent lighting is very noticeable, and sometimes my eyes start to lose focus.

Window is currently open. I prefer natural sunlight.

Faculty Lab (CTMI)

The machines that face the window suffer from washout due to light leakage from the windows.

I like the windows but it also creates a distracting glare.

The sunlight thru the windows and the fluorescent lights cause inconsistent glare on screens.

Fluorescent lights a problem for me - photosensitivity issue

COLOR AND REFLECTANCE

Learning Center

it's very good.

Good. Almost too good.

Is white on white justifiable as a color scheme?

the colors are great.

The glare is from the lights themselves & the grates.

Professional Writing Lab

I hate blue

Color seems to be OK. Reflections are all right. Perhaps color could be changed for it to be more feasible for our eyes.

Very soothing room.

I never pay attention to the color and reflectance

I wish there was a place for writing on a manuscript or other forms of paper

Professional Education Lab

In terms of reflection, seeing the board is difficult @ times!

Light could perhaps be a little less neon & abrasive

This room is very dull: gray and brown and cream. The blinds are always closed. Definitely a "lab" -

As classrooms go, the color scheme is all-right - the paint isn't peeling or chipped - so it's good enough to provide a comfortable environment.

White walls and fluorescent lights combined with computer screens is too much.

It's up to date, and not old furniture, carpet, etc.

Faculty Lab (CTMI)

Reflectance is not a problem, color scheme is terrible.

The walls make no difference.

* to tell you the truth, I never noticed

The room does not create a reflecting problem nor do the stations. The color could be richer in my opinion.

ACOUSTICS

Learning Center

People, students mainly, listen to their music with too loud volume. The tendency is clear: Rock players, with worse hearing, keep it louder.

Something has to be done about people banging the keyboards. If you are not sequencing, its impossible to stand. I've left due to this many times.

it's good.

I can hear everything everyone does within a two work-station radius. It gets very annoying sometimes.

Students playing so loud on the keyboard is very distracting. I like sitting away from the front desk also. 1) Because I don't want to socialize w/someone walking in, who may recognize me. 2) There is a lot of talking going on.

You can always hear your neighbor's work.

Plunking of keyboards bothered me (people doing music). Can hear music from headphones

Neighboring workstation noise is distracting. (mentioned previously)

They are o.k.

Everyone slams the keys! No instruments allowed!

The acoustic is great. I hear a rhapsody.... except when there is an asshole banging the keyboard next to me...

I find it highly irritating when some idiot has to hit the keyboard with 30 lbs. of force for his drum track.

It's terribly annoying when someone's stomping out a sequence on the keyboard. KLICK KLICK KLACK!!! etc. It's really disturbing. We like quiet.

Professional Writing Lab

I can always hear what someone else is working on (even if they are across the room). I don't know if its because of the headphones or because the students have their volume turned up too damn high. Also I can always hear other people pressing the keys on the synth while working on a project.

The acoustics are terrible in this room.

Headphones tend to bleed greatly.

Professional Education Lab

I rarely use the co keyboard in conjunction w/ the computer. I liked it last year when C played CD's quietly during lab time.

Its hard to see the teacher & the board.

Background music might be nice.

Seem fine to me.

There's always a hum in the room. (from printer?) It gives me a headache - it's aggravating. The room is otherwise quite quiet.

It's generally difficult to hear because all the computers generate a hum sound. But there's nothing that can be done about that?

#2 is poor, but usually doesn't bother me. When people are asking questions or even laughing I seem to like to listen and join in. It's also easy to block it out when necessary.

Speakers in front of room "buzz" when used for class presentations,

Faculty Lab (CTMI)

It is too close quartered overall.

when I stop & listen it is actually rather noisy in this room but luckily it does not bother me.

I hear other people talking which distracts me.

Vibrations and hums.

TEMPERATURE AND AIR QUALITY

Learning Center

The air is often too warm and stale causing me to feel tired and sometimes ill.

The air quality is horrible. The computers/synths smell! The answer is: more space or less workstations.

Some spots are too warm. (Close to the heating vents)

When the L.C. is busy, the room is often very hot and stuffy. When I sit next to the printer, I notice that it gives off an ozone odor. I try not to sit next to the printer, but sometimes that's the only station open.

not too bad.

it is a little dry in here.

This is one of the only rooms at the school which is comfortable year around.

I prefer it when it is colder, much colder.

after the lights get me aroused, it's hard for it not to be too humid.

Thanks for not being too cold!

The air is great. I feel like singing "Do you really love me?..."

I often find the "classroom section" of the Learning Center quite warm.

There were times this past summer into the first few weeks this fall when somehow the AC and/or vent cranked. Very uncomfortable, and rectified at my request.

Everything's good.

Professional Writing Lab

Dry and dusty.

This room is stuffy/stale

The room temperature seems to be screwed-up all over Berklee. In fact this room is quite OK compared to others.

dusty

Professional Education Lab

It does get stuffy at times

Too hot in here. No fresh air makes me very tired.

The air is good

Gets stuffy and smelly. Makes me suffocate, specially in the wintertime ... too hot, no ventilation.

Sometimes heat is cranked too high.

I do not believe the windows open (fresh air).

Faculty Lab (CTMI)

The air in this part of the building is inconsistent at best.

Humidity to prevent static elec is preferable

Re questions 1) & 4) - it seems to depend on where you sit. Over the summer there were times when I felt it was too cold after sitting here for a few hours.

Static shocks are annoying. I like to open windows when possible.

Poor air quality to the point of headache.

Sometimes too humid (but rarely). Never too dry...

TECHNICAL SUPPORT

Learning Center

Great staff!

Computer knowledge is great, music knowledge is terrible.

it's very good.

I feel that often the staff will fix something, but never explain what was wrong or how to fix it if that problem occurs again. More explanation would be helpful.

The manuals are too exhausting. Something more clear and concise to get you going would be better.

The staff is helpful, especially BH! He knows the material well, and is great & willing to help.

need more staff.

When there are problems of any kind sometimes it's difficult to find someone to get help from.

It would help to be able to check manuals out of the learning center for thorough reading - perhaps it would be necessary to order extra manuals from the manufacturer.

Is there a manual on how to become an artist?

JL, R, &R stand out as exemplary, helpful people. In general, the rest of the staff here are non-committal, hurried, insensitive, and sometimes even rude. If a question is answered in these ways and is furthermore demonstrated hastily, it only fosters ill-will towards said staff member, and doesn't help if the problem is encountered again in the future.

I need someone to ask questions to for about 2 hours & get some understanding.

Few of the staff know enough about the equipment to effectively solve problems, though most are friendly.

Professional Writing Lab

No laymen outline on basics of use

I wish we could print out manuals

Only problem with non-teaching staff - sometimes, they don't really help and don't make the effort.

During lab hours much attention is needed during that time. For little things and sometimes one person is not enough. Attitude is generally excellent.

What's up guy

Professional Education Lab

It's fair... it assumes a lot of computer knowledge.

need more technical support

Need more help

The computer lab should be open during the day either Saturday or Sunday <u>or</u> open till 9 on Monday & Friday.

The workstudy people are nice & very helpful.

Faculty Lab (CTMI)

Tech support is very good here!

The manuals are locked in another room after hours.

Manuals are now in office which is locked evenings & weekends - ick

Re 4) depends...

Tech support is excellent and available

Manuals vary - some better than others. I've never used manuals in this facility.

Computer manuals are rarely clear. T & staff are fantastic.

OTHER CONSIDERATIONS

Learning Center

The layout is too crowded!! There is absolutely no place for books, bags, and coats. people are constantly tripping over other people's stuff. And its annoying when you have to move your chair in so somebody can get by. Its very distracting!

The software, the speed of the computer, the amount of sounds, the screen size and the types of tape decks are not important at all! The important thing is - PLEASE NOTICE, you all computer freaks, - the work environment (chairs, air quality, light, etc.)!

Hard to move around with instruments.

it's pretty good.

You do have enough space to lay your books around you. But then no one can pass.

Coat racks would make life easier, but not worth raising tuition.

It can get very crowded in here, especially accessing the printer on the side of the desk - when a document is printed its very difficult to get in there & out again to retrieve it.

I've said it already.

Professional Writing Lab

There is no room to put a jacket or book bag w/out it possibly getting in the way of foot room.

We are in a tomb. The room is always empty & locked between 4 -6. That's very dumb.

The room is too small. Not nearly enough room to move and work freely.

Nowhere to place wet damp winter clothes or no place to put your instrument.

Bigger rooms and more space!!

Professional Education Lab

- WEEKEND HOURS _ PLEASE!! (@ least Sat's.)

need more space between workstation aisles to walk and not climb over people.

A little crowded - but we have a lot of computers

needs to be less crowded

Sometimes our classes have too many people in them to possibly be comfortable.

Room is generally fine.

Faculty Lab (CTMI)

It was OK at the beginning, but more people use it more frequently.

No place to hang my coat. It would be nice to have two-tone color combinations like at Museum of Fine Arts.

ADDITIONAL INFORMATION

In your opinion, are there any other factors that should have been considered in this evaluation? If so, what are they?

Learning Center

The computers themselves, which I find to my liking, as the availability of software.

Sell disks here!

I feel this was a very complete evaluation, however, you failed to ask about the tutoring rooms and tutors.

Waiting lists. Why don't you manage to get more stations, maybe an additional lab?

Pretty good survey. I hope you direct your concentration, with this evaluation, to improve the human aspect of working at a computer, and not the computer itself.

Access for more advanced users to other programs or tools they might want to bring.

Ease of checking in and checking out. Availability of workstations.

There should be a drumset with MIDI pickups.

No.

I would like to have seen discussed other software programs.

Outside noise (ex. other musicians being too loud). Stereo going on while I'm trying to concentrate.

Workstation availability times.

Technical support on all programs not only the easy ones, at all times. Why closing on holidays?

I don't think so.

No everything's been covered.

Maintenance of work stations

Importance of pictures on walls (high).

NONE. PLEASE, NO MORE!

Just people being loud. Slamming keys, playing guitars and basses.

No.

No.

Pretty comprehensive survey.

Professional Writing Lab

People with allergies.

The teacher's screen is sometimes hard to see at other stations.

I would like to have a wider selection of sounds to choose from and work with!!!

I think it is well covered except since this sounds like a possible re-vamp in the works - sampling modules and tape decks could be upgraded. The teachers even say they think this is outdated.

No

None

The ability to remove gaseous emanations when obnoxious/noxious students emit these strange odors should be considered.

More lab time

Professional Education Lab

The hours that this lab are open are inconvenient.

1. Background music (ambiance) 2. Rules and Regulations

Ask questions that have something to do with the students complaints. OPEN THE LAB ON WEEKENDS.

Time available to use the lab. A few hours on a sat. would be nice.

I think the actual computers could be faster and have more RAM and hardware space.

Seems like you covered them all

No.

Students availability to complete their homework successfully in allotted amount of lab time

Computer capability?

More hours maybe on weekends? Learning Center in 150 Mass. Ave. building needs to synch up with this center in 1140.

Sight lines for teaching - overheads, etc.

Very well thought out evaluation

No.

Faculty Lab (CTMI)

NO

None

Does available equipment/software enable you to adequately address your needs/desired use of workstation?

Kind of equipment and other technical enhancements

The software available (it's great) & the computers we have. (they're great)

Location of the facility in regards to how easily accessible it is could be a factor.

no.

Ergonomic considerations of all equipment (more attention to)

The nature of available technology (equipment) and software.

Everything was covered well.

As a place to learn and work, what do you like *best* about the design and layout of this facility?

Learning Center

The Mac IIvx, the screens, the convenience.

The keyboard & keypad stand.

It's always clean and the colors, walls, rugs, and glass are attractive. The seats are also more comfortable than most.

To learn? I learn at home or in class, but this is a great place to professionalize the basic ideas I have. Print tunes, cover letters etc. I don't think you should learn from a computer. It's stupid.

Everything is "hear" to learn to hear and play.

The efficient layout design of the workstations. The applications available.

The rug.

I like blue.

The equipment available.

Very uniformed and clean. Yea!! A+ on that one.

Overall good but the back section is hard to move around.

Superior software technology.

Depending on what station you're using and what are you working with, sometimes it can become a nightmare. (crashing computers, losing work)

Late hours, convenience, friendly staff.

The floor.

It's a private and creative learning environment. I like the workstations in general.

I like the convenience of all the equipment at hand.

It is great! I love being here.

The many programs available and the quality of equipment.

Versatility of workstations so as to have good posture.

Fluorescence.

A lot of neat things.

The workstation's set up.

"The shadow of your smile"

The software, facilities, and opportunities to learn about new technology is unsurpassed.

design and layout - I don't know. The workstations seem to be where learning takes place, so I feel neither of these contribute too much to the environment.

Computer, color screen, tape decks.

Individual workstations - everything in one spot.

I like working here, its very comfortable.

Professional Writing Lab

The compact set up

The padding on the chair

It is not as large and crowded as the Learning Center. It is also quieter.

The space to my sides.

The equipment is excellent to begin a working knowledge of M101

I like the hands-on experience a lot! The teachers & lab monitors know their stuff & are very patient.

Calmness, the ability to work for several hours at a time.

It does allow you to get work done because when you sit down at the stations you are not bothered by other people.

The beautiful closet

The equipment and staff

Everything you need is already laid out. This is more equipment than I have at home so I think this evaluation is stupid. Why complain if everything is here for us.

The big computer screen in front

The individual sections

it's an overall comfortable atmosphere

Close to instructor - good layout!

Warm atmosphere and number of seats.

It gives you competitive equipment to give you a good understanding of some of the products available on the market.

Professional Education Lab

The stations are close enough to talk to another student if we need help, but if we have any personal effects w/us, it gets tight in a hurry.

The lighting is good.

The view when it's not blocked by curtains.

The workstations, except for a lack of a good writing desktop

It has sufficient light.

Bigger; faster computers.

Clean.

It's very clean.

comfortable & quiet

The fact we're able to learn and use this equipment I can't afford and get a basic starting knowledge.

Comfortable chairs. Nice "desk" layout

The chairs are comfortable and position of the screens.

Faculty Lab (CTMI)

It is very accessible (no barriers)

Geometrical possibilities for interesting things to do.

Not too crowded.

Wide variety of appropriate and up to date hardware and software.

Its accessibility.

Everything in one place. (gear, software, support)

The air quality and comfort at the stations.

Excellent equipment.

Tech Support

Technical support and (its) proximity.

accessibility

Accessible, comfortable, & great support staff.

Each station has similar equipment.

What do you like *least*?

Learning Center

The lighting, the tape decks.

The smell.

Too crowded!! It is very easy to be disturbed by people talking, playing music so you can hear what's coming from their headphones, and/or you are disturbed by the aggressive rhythmic playing on the keyboard. And I always get disturbed by people walking by and having trouble fitting.

As I said, waiting lists, and people that work here and don't know enough about the software as to help you.

Air quality, and the vibe that is created by those who say that the computers aren't good or contemporary enough. They lack the sense of balance. See the practice rooms or the ensemble rooms as a comparison.

Noise from the keyboards.

Workstations not being available. The temperature is oftimes too hot. Sometimes the tech support staff is either unable or reluctant to help. The check in/out procedure is inefficient.

The constant beating on keys.

No internet.

Not open late enough.

Perhaps, (and this is being picky) workstations are not very accessible w/out disturbing others.

Outside noise.

Neighboring workstation noise.

I am a business major. A program should be developed enabling us to solve and think out business situations. For those of us who can't do an internship yet, we have no way of applying & practicing our knowledge. Will it happen?

The sound of haphazardly clicking keyboards all around.

<u>At Ease</u>

Book manuals ability to instruct new users of music software

The walls.

The lack of staff and sometimes inability to help due to unfamiliarity with certain programs. Also, the workstations need a little table or something for books, etc.

The outrageous price of tuition. I don't pay 20,000 a year for this.

When there is nobody to answer questions I may have, and sometimes noisy headphones and bad-working tape recorders. Otherwise congratulations, it is GREAT.

Fluorescent lighting.

Not enough facilities.

Other people being loud.

Waiting in line for a computer.

If I should lose you......

I am often irritated by "noisy drum players" on the keyboard or people who are just plain uncourteous to those who desire quiet working environments.

rude support staff, no free cookies (joke) - 98% of everyone at their stations banging the life out of there keyboards in the quest for cool vision drum tracks.

-- Nothing

Noise from others, lack of space.

That I can't move in. Or take one of the stations home. I'd bring it back. Honest.

Professional Writing Lab

The lack of leg space under the computer key pad & reaching so far to write.

Not being able to write on paper easily and the dust and no ventilation or sunshine.

It isn't always open

It's like a vacuum in here. So easy to loose track of time.

I don't have enough room between my legs & the typing keyboard.

Crampness (is that a word?) of workstations. It is very annoying & disrupting when people have to move in and out.

There is not enough room to move between computers.

Space!

I would like to use other sequence programs, not just vision (Performer, Cubase...)

Noise from other people at other workstations

A lot of times I come in to work & the lab is full.

The inability to get off a station on the right side when someone is sitting on the left.

lighting

Not enough good sounds on the synths.

Feels a little crowded.

Workstation

Computers are blocking lecturer.

There are not many lab assistants available.

Professional Education Lab

It is too small

The air and temperature

The hours that the lab is open

Crowded, very crowded

It's small, cramped, poorly laid out, and horribly decorated.

No writing space. Too crowded. Not open enough hours, weekends. Not enough stations.

There's not enough space

A little too crowded, not enough access hours, no storage place for coats and other books.

Not enough room to walk past a person sitting at a workstation. Ventilation.

The desk, and a student's ability to write on it.

Faculty Lab (CTMI)

The cramped, close quarters; the cluttered tight workarea.

It takes too much time.

No desk space. Not enough sound modules/sound processing gear.

workstation setup being too high

Lack of privacy and concentration

The fact that network reliability is not always assured, as well as the lack of pro tools at each station for serious MIDI/digital audio projects and lack of dial-up PPP.

I don't like being up high and would prefer a more spread out placement of equipment from left, middle to right and some up above certain things (cockpit).

The size of room and location.

workstation height.

lack of space.

Central cluster of stations - crowding. And air quality.

Sometimes too crowded

If I use a computer in the lab 3 times in one day, it means I must boot up the computer 3 times. It would save me a lot of time if computers were turned on in the morning & off at night.

A chair! Hard to adjust, not comfortable. Back support very often in awkward position.

Each station should have separate lighting functions, with no overhead lights.

If you were in a position to recommend design changes to this facility, what would they be?

Learning Center

Lighting and audio systems.

Free beer & playboys in the men's room.

The stations, some perhaps should be located against the walls and less dual rows. There is a need for space behind a person as they sit and face their station. It would be nice if each station was more separate from another station. However, here at Berklee with the lack of space I don't know if this is possible. Swinging and adjustable arms to place material to read etc.... on would be great. If it was possible to put the monitor on an adjustable arm I would suggest it. That way, no matter what your height or vision problem, or physical problem you'd be able to adjust the monitor to exactly a position that is most comfortable. It is necessary to be comfortable and not distracted to do any amount of good work/learning. Some of us spend more than an hour a day in here.

Less stations or more space. 40 stations is too much in a space of appr. $100m^2$.! Not because it's crowded with people, but because the computers smell so bad.

Individual cubicles like the one's for tutoring for those wanting to play. (Stations thinned down, just for eartraining)

Find some way to merge the services of the library and the L.C. so a student can use the services of both at the same time. For example, a student who is writing a paper could do his research and write the paper in one place. An arranger could get a lead sheet, borrow a version of the tune & listen to it, then arrange it in the same room.

More Jimi Hendrix posters.

get on the internet.

More room for the workstations to keep from crowding and not as much noise.

With new Boylston bldg. / Kick some people (offices) out of this immediate area and get more workstations.

Some headphones are mono. Yech!

Stop the clicking of synthesizers!

Dedicate more space between stations for users privacy.

I'm not in a position. Sorry.

Some graffiti on the walls!

The layout's nice, except if I could only create more room and more stations that would be it.

it's pretty good.

I like it like this.

Add sustain pedals.

All bulb lighting - with warm toned light. Put mixer above monitor (somehow) (high up anyhow).

Color.

I would improve the staff organization for more orientation to the user. There is a lot of equipment and all of them "cutting edge," but I am somewhat confused about what equipment is in here and how can I reach them. For example, if I wasn't too curious I wouldn't have known that there were digital audio capabilities. And I still don't know how to get working with them.

Get more workstations - with extra space.

Add swimming-pool, more pianos (like K1000) than synthesizers.

More space between stations and a place to wait when you're on the waiting list.

1) expansion 2) different arrangement options 3)a less vibration-prone floor 4) one person checking people in & one person checking people out.

Maybe install a waterfountain.

More space between all stations, maybe some dividing panels, cubicles, etc.

I recommend that you don't ask me; I am a musician, not an architect!

Professional Writing Lab

It would be good to have a little more space for books, and just general space w/o being too cramped. It's okay now but not the greatest. A footrest, to stretch out your legs, would be nice. Right now I'm just using the crossed wires on the back of the keyboard synth stand.

Adjust computer keypad so there's more leg space & put a writing facility right next to the chair.

Please read before mentioned.

New chairs and eventually new keyboards/synths.

More room between stations front to back

Larger room. Bigger space per individual.

Get a new, larger room, that would be adequate to work in.

More sounds!

BIGGER!

Just to allow a little more room between computers.

Writing desk next to computer keyboard. Score corrections are difficult.

Bigger room, more leg room.

Just make it a little bigger but its not really a big deal.

Nuke Berklee and start over

Better sounds

Nothing

To get a bigger room for the lab

Professional Education Lab

More stations, more open lab time, weekend hours.

Increase the space in aisles so people can walk about easily. Increase moisture in the air - its a little dry.

Better ventilation. Alternative lighting. Design workstations for taller people (maybe stools w/high desks?)

more space.

Larger, better floor plan for workstations

First - Decorate to promote learning and atmosphere
2nd - redesign the workstations for comfort
3rd - Obtain a larger facility

Has to be bigger.

Spread us out into two rooms! decoration!

Amount of time it's open

Enlarge the space, closet space, better sight lines

More room, better ventilation.

The desks could be adjusted so a person could write or place materials more closely to oneself.

Faculty Lab (CTMI)

A bigger room - more writing and spread-out space, More storage for personal belongings.

Better sound modules. Sampling capability.

Some sort of reasonable writing area. More stuff!

correct the above

Make it larger, give more room to each user, separate media developer's desk from faculty lab, bring workstations down to sitting height, allow for RH and LH writing.

More spread out, separate cubicles that are isolated and a reorganization of gear to a more easily accessible "cockpit" situation.

expand and have more private spaces to work.

larger stations, or stands of some sort for books & manuscripts

Breaking up central cluster. Change the type of lighting (tungsten). Less rigid structure of individual station - change of air quality.

larger facility.

To add a space for books, for writing (Presently, there's no room for these)

Same, plus a larger room.

APPENDIX K: Equipment Lists

Each of the facilities in this study features custom designed workstations configured to support the range of tasks performed by their respective users. The lists below show the general workstation configuration of each lab. All equipment is housed in custom designed workstation furniture as described in Chapter 4.

Learning Center
Macintosh IIvx computer, 8mb RAM, 80 mb hard disk, CD ROM
14" Apple color display
Korg X3 keyboard synthesizer
Fostex MC102 stereo mixer/tape deck
Opcode MIDI translator
AKG model #K141 headphones

CTMI
Macintosh Quadra 650 computer, 8mb RAM 80 mb hard disk, CD ROM
14" Apple high resolution color display
Korg T2 or T3 keyboard synthesizer
Korg 05R/W sound module
Kawaii 16 channel audio mixer
Sony DAT recorder, model 75ES
Sony cassette recorder, model TCRX370
SoundTools (digital audio recording)
AKG model #K141 headphones

Professional Writing Lab
Macintosh IIsi computer, 8mb RAM, 80mb hard disk
Macintosh Portrait Display
Korg T3 music synthesizer
Roland U220 sound module
Kawaii MSR 8 channel mixer
Nakamichi cassette deck
Opcode Studio 3 MIDI interface
Omni rack
AKG model #K141 headphones

Professional Education Lab
Macintosh LCIII computer, 8mb RAM, 80mb hard disk
14" Apple high resolution color display
Korg X3 keyboard synthesizer
Opcode MIDI translator
AKG model #K141 headphones

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B.A., Glassboro State College, Glassboro, NJ, 1976. Communications Major.

Professional Experience

April 1989 - Present: Director of Learning Support Services, Berklee College of Music. Responsible for the administration of the Berklee College Learning Center. Served as the Center's primary designer and project manager.

September 1987- February 1989 - Consultant and Trainer, Academic Computing Services, UMass, Boston. Trained and advised users in general software applications. Worked in the university's Adaptive Computer Lab training disabled students and faculty in the use of adaptive peripherals and software.

June 1986 - August 1987 - Computer systems consultant and sales associate, Radio Shack, Pennsville, NJ.

December 1985 - May 1986 - Substitute teacher, Penns Grove-Carney's Point NJ school systems.

January 1981 - September 1987 - Professional musician, drum instrumentalist. Numerous performances in the jazz and rock idioms throughout the United States.

January 1977 - January 1981 - Drum and percussion instrumentalist, U.S. Navy Band, 6th Naval District, Charleston, South Carolina. Performance in the jazz, rock, and orchestral idioms. Studied at Armed Forces School of Music, Little Creek, VA.

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