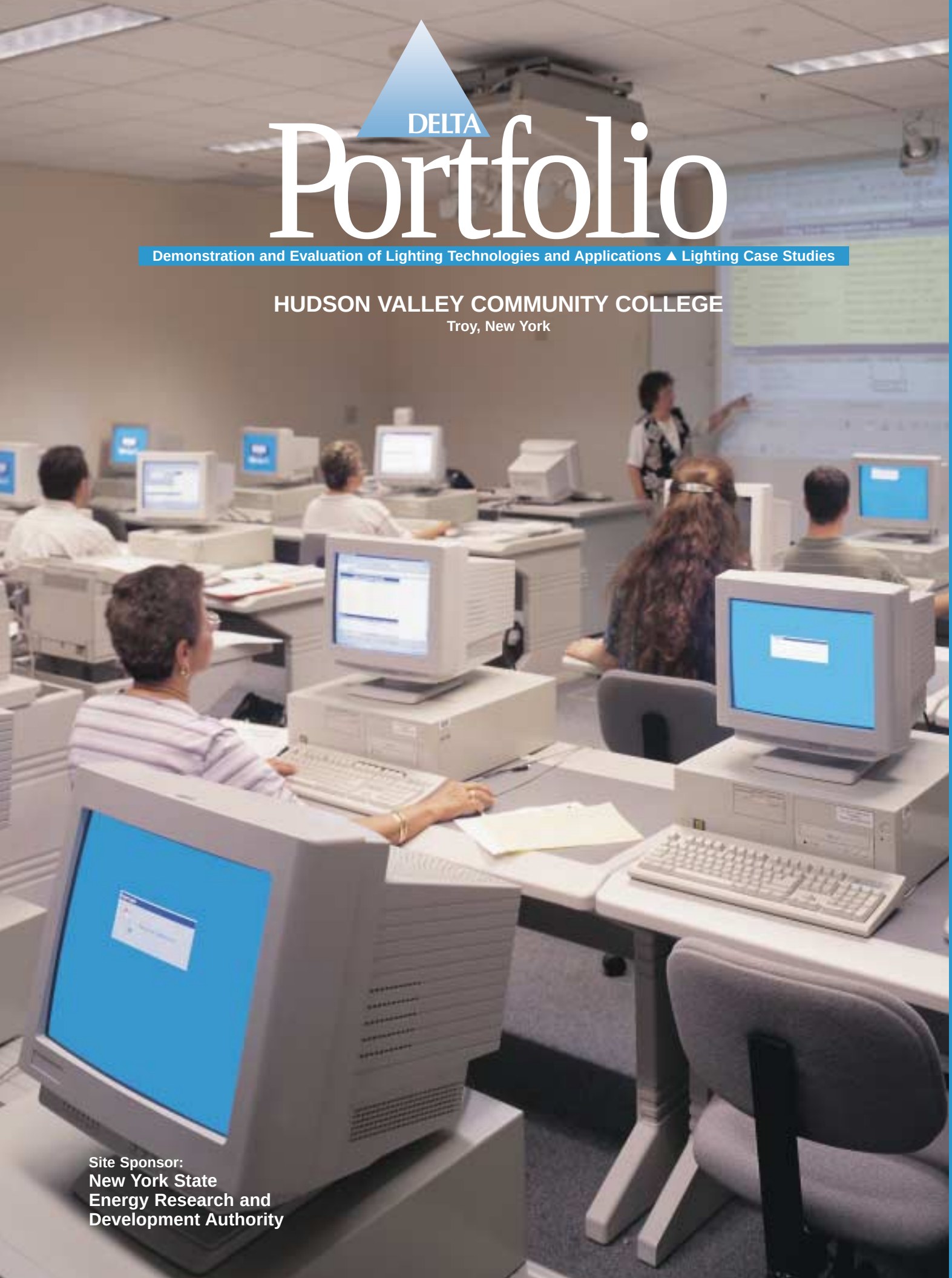


DELTA

Portfolio

Demonstration and Evaluation of Lighting Technologies and Applications ▲ Lighting Case Studies

Volume 3 Issue 1

COMPUTER CLASSROOMS

HUDSON VALLEY COMMUNITY COLLEGE

Troy, New York

Site Sponsor:
New York State
Energy Research and
Development Authority

Contents

Project Profile

Hudson Valley Community College in Troy, New York, opened its Bulmer Telecommunications and Computations (BTC) Center in 1995. The building was designed as a landmark for the college's move towards technologically enhanced learning environments. The 90,000 ft^2 (8,400 m^2) facility houses computer classrooms, distance-learning rooms, traditional classrooms, lecture halls, television studios, photography laboratories, electronic arts equipment, and departmental offices.

Many of the 9,100 students at HVCC are in their early 20's, but the majority (62%) are returning students training for new careers. Classes in the BTC are offered both days and evenings throughout the school year and focus on computer applications. This DELTA publication examines the impact of one lighting scheme for computer classrooms having two different arrangements of computers.

The BTC has 12 computer classrooms, each 850 ft² (79 m²) in size. Ceilings are 9'-5" (2.9 m) in height, with standard 2' x 2' (0.6 m x 0.6 m) acoustic ceiling tiles. Typical surface reflectances were measured as follows: ceiling (94%), walls (58%), desks (27%), and floors (14%).

Windows are located in one wall of BTC classrooms, opposite from the whiteboard and instructor's area. Windows have two types of daylight control. Roll-up translucent shades allow some daylight to enter through the material and around their edges. Additional opaque shades are mounted in sealed tracks to block daylight entirely. DELTA observed that instructors used these opaque shades more frequently than the translucent shades.

A video projector mounted on the ceiling in each computer classroom projects the display from the instructor's monitor onto a screen that is pulled down in front of the whiteboard. When instructors wish to write notes for the students, most choose to use the 12' x 4' whiteboard, which occupies most of the front of the room. Its surface is slightly shiny.

Computer classrooms at BTC have two furniture arrangements, which influence the location and orientation of computers. In one arrangement (see *Front-Facing Computer Classroom*), the computers are aligned in rows across the room. In the other (see *Perimeter Computer Classroom*), the computers are arranged around the perimeter of the room. These two locations and orientations of the computers may affect students' perceptions of the lighting (see *Student and Staff Response*).

Type A parabolic troffers provide ambient lighting in BTC classrooms (see *Specifications* on page 5 or 7). Troffers are arranged in pairs aligned end-to-end (see plans on pages 5 and 7). Each troffer has two linear fluorescent lamps, mounted one above the other. Each troffer is tandem-wired to the adjacent one so one two-lamp ballast can operate one lamp in each troffer. This allows two levels of illumination and minimizes the number of ballasts (and cost) necessary for bi-level switching. Controls are located adjacent to the door.

Type B incandescent trackheads illuminate the whiteboard in the front of each classroom. Instructors have one trackhead pointed downward over their desks, dimmable separately from the other trackheads. On the instructor's desk, the trackhead produces high horizontal illuminances while keeping vertical illuminances on the instructor's computer monitor low. Two wallbox dimmers for these luminaires are adjacent to the instructor's desk.

Lighting Objectives

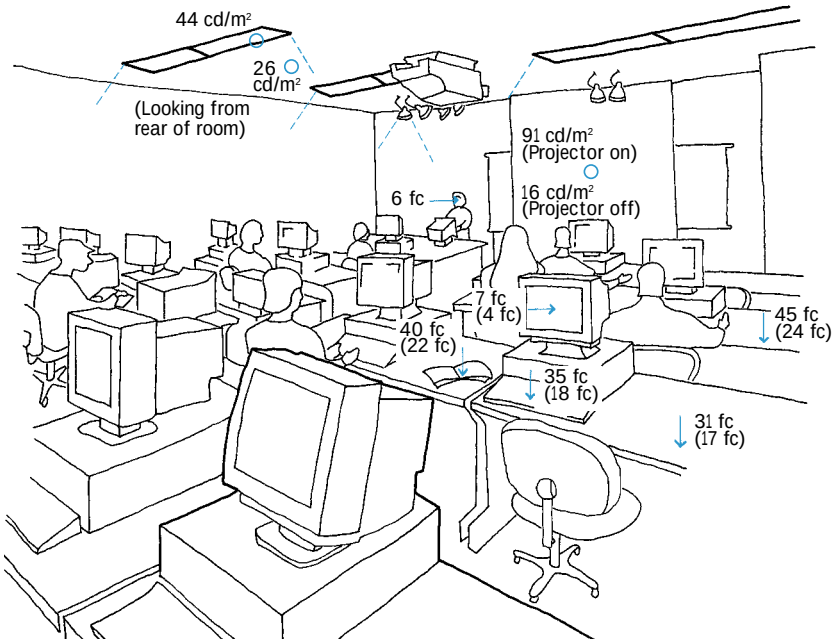
- Provide instructors with the ability to adjust the lighting to meet the visual needs of students in a computer classroom. These needs include seeing projected images, seeing the whiteboard, working on a computer, and taking notes.
- Minimize reflections on computer screens.
- Minimize first cost for luminaires and controls.
- Minimize lighting energy use.

Lighting and Control Features

- **Flexibility.** Bi-level switching of the ambient lighting allows adjustments to meet various task requirements. Two dimmable tracklight systems provide separate lighting of the whiteboard and the instructor's desk area.
- **Glare Control.** Parabolic baffles on recessed troffers minimize reflected glare on computer screens. Barn door baffles and cube-cell louvers control glare from the tracklights.
- **First Cost.** The lighting equipment is inexpensive and widely available.
- **Energy use.** T8 fluorescent lamps with electronic ballasts and bi-level switching provide energy-efficient ambient lighting. Dimming of tracklight systems allows additional energy savings. Occupancy sensors in each classroom turn off lights when no one is present.

Front-Facing Computer Classroom

Some instructors prefer to see their students' faces rather than their computer screens. For this reason, they request a front-facing classroom that has 24 desks, each with a computer and some space for taking notes.



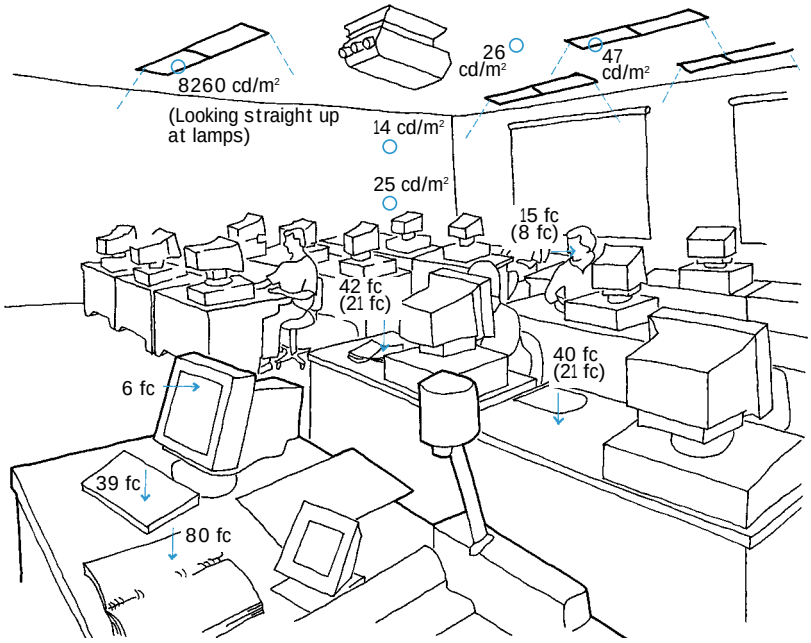
Perspective of front-facing computer classroom, seen from rear. (Measurements for all type A, one type B, and no daylight; 50% switching level for type A shown in parentheses.)

"It would be nice to have [fluorescent] dimming to find just the right light level."

— Instructor

"It's 100% better than our old building!"

— Instructor

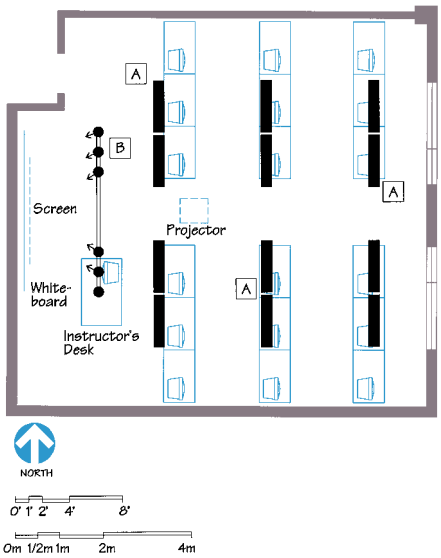


Perspective of front-facing computer classroom, seen from instructor's desk. (Measurements for all type A, one type B, and no daylight; 50% switching level for type A shown in parentheses.)

Room Type	Area	LPD*	ASHRAE/IESNA*	NY State Energy Conservation Construction Code 1991**
7 Front-facing rooms, maximum use	5,980 ft² (556 m²)	1.45 W/ft²	1.60 W/ft²	2.2 W/ft²
7 Front-facing rooms, typical use***	5,980 ft² (556 m²)	0.46 W/ft²	1.60 W/ft²	2.2 W/ft²

*See *Methodology* for definition **Applicable in New York State only, on a whole-buildings basis ***All type A at 50%, one type B at 50%

Front-Facing Computer Classroom Seen From Rear



Front-Facing Computer Classroom Seen From Instructor's Desk

Specifications:

A

Recessed 1' x 4' (0.3 m x 1.2 m) troffer, with two lamps in cross section, stacked vertically; specular parabolic reflector, 9 cells

Lamps: (2) F32T8/735, 78CRI, 3500K CCT

Ballast: Electronic, instant-start, 277 V, two-lamp ballast, tandem-wired to adjoining luminaire to switch upper lamp separately from lower lamp

Wattage: 58 W per 2-lamp ballast

B

Two-circuit track lighting, 12' (3.6 m) long, with PAR38 track-heads, white finish, barn door baffles, and $^{1}/_{2}$" (13 mm) black cube-cell louver

Lamp: 90PAR38/FL/Halogen

Wattage: 90 W per lamp

Perimeter Computer Classroom

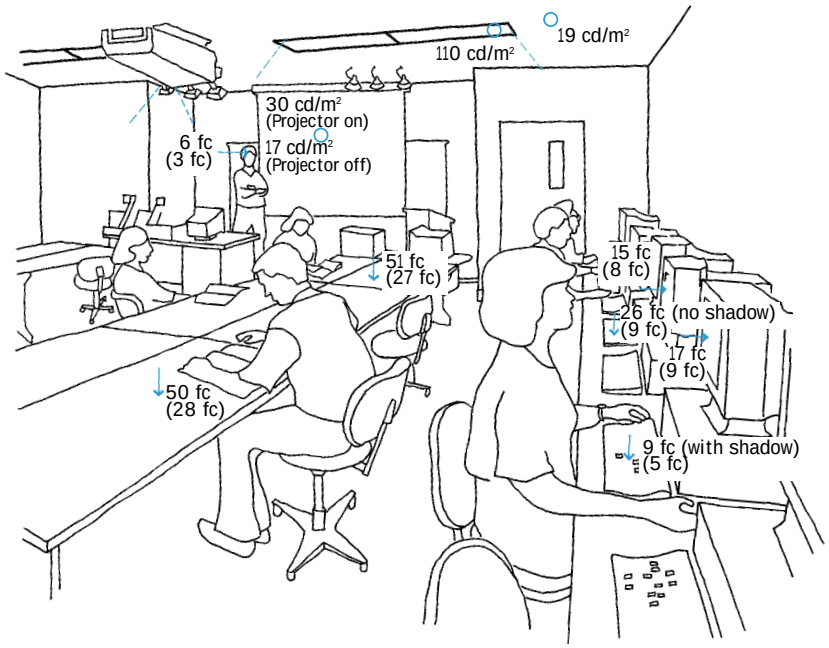
Some instructors prefer to be able to see the computer monitors throughout the room. In this case, instructors request a perimeter-style classroom, in which 24 computers line the walls. Other desks in the center of the room provide space to spread out papers and facilitate group projects.

Lighting systems in perimeter rooms are the same as in front-facing rooms. Because luminaires are not located above the computers, illuminances on keyboards are lower than in the front-facing rooms.

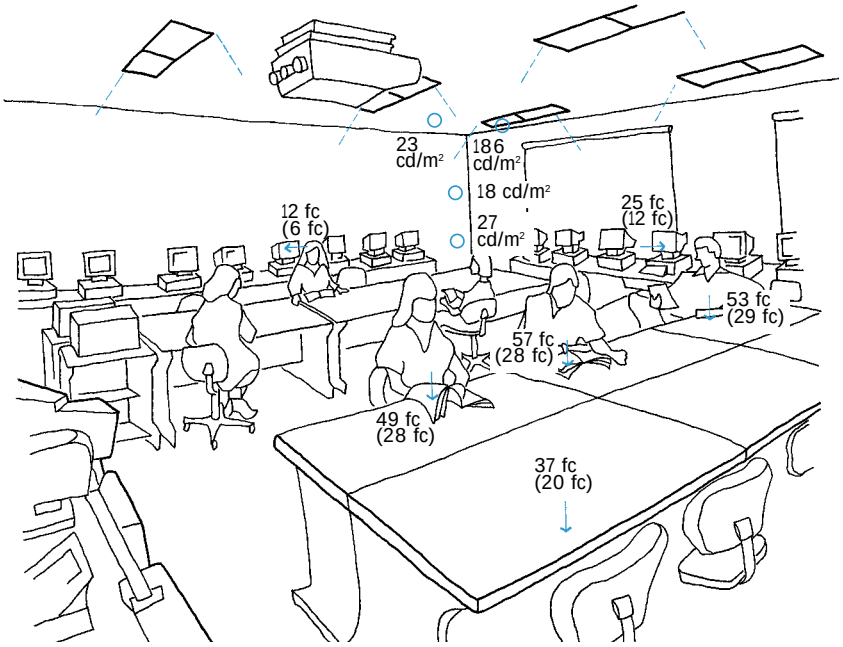
In some seating positions, students cast shadows on their keyboards. Indeed, surveys from students in perimeter-style rooms are slightly less positive than those from students in the front-facing rooms (see *Student and Staff Response*).

"It's difficult to find a 'happy medium' when the students need to take notes."

— Instructor



Perspective of perimeter computer classroom, seen from rear. (Measurements for all type A, one type B, and no daylight; 50% switching level for type A shown in parentheses.)

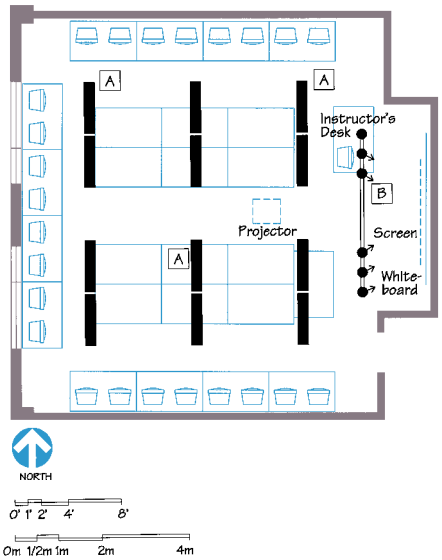


Perspective of perimeter computer classroom, seen from instructor's desk. (Measurements for all type A, one type B, and no daylight; 50% switching level for type A shown in parentheses.)

Room Type	Area	LPD*	ASHRAE/IESNA*	NY State Energy Conservation Construction Code 1991**
5 Perimeter rooms, maximum use	4,260 ft² (396 m²)	1.45 W/ft²	1.60 W/ft²	2.2 W/ft²
5 Perimeter rooms, typical use***	4,260 ft² (396 m²)	0.46 W/ft²	1.60 W/ft²	2.2 W/ft²

*See *Methodology* for definition **Applicable in New York State only, on a whole-buildings basis ***All type A at 50%, one type B at 50%

Perimeter Computer Classroom Seen From Rear



Perimeter Computer Classroom Seen From Instructor's Desk

Specifications:

A

Recessed 1' x 4' (0.3 m x 1.2 m) troffer, with two lamps in cross section, stacked vertically; specular parabolic reflector, 9 cells

Lamps: (2) F32T8/735, 78CRI, 3500K CCT

Ballast: Electronic, instant-start, 277 V, two-lamp ballast, tandem-wired to adjoining luminaire to switch upper lamp separately from lower lamp

Wattage: 58 W per 2-lamp ballast

B

Two-circuit track lighting, 12' (3.6 m) long, with PAR38 track-heads, white finish, barn door baffles, and $^{1}/_{2}$" (13 mm) black cube-cell louver

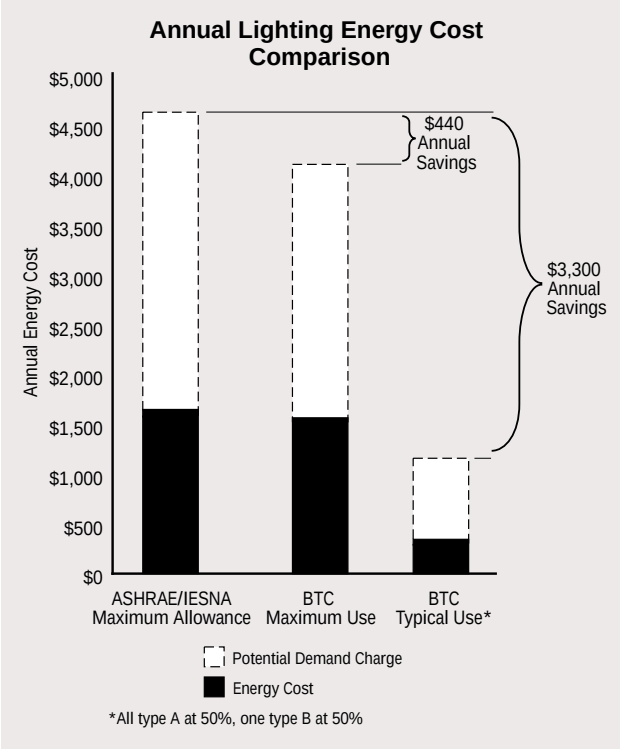
Lamp: 90PAR38/FL/Halogen

Wattage: 90 W per lamp

Project Evaluation

Controls

Bi-level switching for type A luminaires and wallbox dimmers for type B trackheads allow occupants to adjust light levels. Instructors use these systems but expressed a desire to adjust light levels to an even greater extent (see *Student and Staff Response*). DELTA observed that infrared occupancy sensors in each classroom turn off the lights within 30 to 50 minutes when no movement is detected.



Installation Cost

The lighting designer for the BTC considered several different systems. The final decision was based primarily on the projected initial cost of the overall system, together with the mounting restrictions of a low ceiling height. The installed cost of this lighting system is estimated to be approximately $2/ft² ($21/m²).

Energy Impact

At maximum light output (1.45 W/ft²) during all scheduled class times, the lighting system in all 12 of the computer classrooms combined saves $440 annually because of reduced energy costs and power demand compared to classrooms lighted to standards delineated in the energy standard, ASHRAE/IESNA 90.1 (1999). When ambient light levels are reduced to half of full output and only one trackhead is on (0.46 W/ft²), savings increase to over $3300 annually. This condition was considered “typical” because DELTA observed this condition in use most frequently (see figure at left and *Methodology*). Even greater energy savings could be achieved by using lower wattage halogen/IR lamps in the trackheads to achieve a similar illuminance.

Environmental Impact

Reduced energy use from all 12 of the computer classrooms at BTC will result in lower annual power plant emissions (see table below).

Reduced Pollution Compared to System Operating at ASHRAE/IESNA Maximum Lighting Power Density

	U.S. Environmental Protection Agency Pollution Estimates					
	SO_2		NO_X		CO_2	
	lbs	kg	lbs	kg	lbs	kg
Annual savings, maximum use	**19**	**9**	**7**	**3**	**2,799**	**1,271**
Annual savings, typical use*	**144**	**65**	**55**	**25**	**21,094**	**9,577**

Sulfur dioxide (SO_2) is associated with visible pollution (haze) and acid rain.
Nitrogen oxides (NO_X) are one of the main causes of ground level ozone (smog) and acid rain.
Carbon dioxide (CO_2) is a possible contributor to global warming.

* All type A at 50%, one type B at 50%

Student and Staff Response

Students in each type of classroom were surveyed. Four instructors, three of whom taught in both types of classrooms, were interviewed (see *Methodology*).

Questions on the student survey focused on two concerns: visibility under the lighting and comfort of the lighting.

The responses to the survey questions relating to visibility showed that the use of bi-level switching changed the ability to see the various tasks in the classroom. Specifically, reducing ambient light levels increased the percentage of students who found it easy to see the video projection but decreased the percentage of students who had enough light to take notes and see the whiteboard. These changes occurred in both types of classroom, by day and by night (see table below).

As for the survey questions concerning comfort, more students found the lighting comfortable in the front-facing room than in the perimeter room. This difference may have been caused by the placement of luminaires relative to the computers, as the periphery was darker and prone to shadows (see plans on pages 5 and 7). This response occurred for both day and night conditions.

When the fluorescent lighting was on during the day, fewer students agreed that reflections were noticeable on the computer screens in the perimeter room than in the front-facing room. DELTA noted that in the perimeter rooms some computer screens faced the short ends of the luminaires so the reflected images in these screens were smaller; whereas in the front-facing rooms all computer screens faced the long side of the luminaires, so all reflections were large.

Overall, the students found the lighting to be comparable to other computer classrooms they had used.

All the instructors interviewed by DELTA commented that they needed a better balance between the lighting needs of the video projector and the needs of the students taking notes. One instructor wished that the lighting in the front half of the class could be turned off, leaving only the rear illuminated. This system would prevent the projector image from becoming washed

Percentage of students who agreed:

	Day						Night			
	Front-facing Room (n = 24)			Perimeter Room (n = 22)			Front-facing Room (n = 24)		Perimeter Room (n = 22)	
	fluor. 100% on	fluor. 50% on	all off	fluor. 100% on	fluor. 50% on	all off	fluor. 100% on	fluor. 50% on	fluor. 100% on	fluor. 50% on
Visibility										
There is enough light in this classroom for taking notes.	96%	83%	50%	86%	76%	57%	96%	90%	86%	52%
It is easy to see the video projection.	59%	68%	89%	38%	48%	57%	42%	81%	36%	52%
It is not easy to see the whiteboard without tracklights.	57%	50%	72%	48%	50%	60%	50%	76%	57%	60%
Comfort										
The lighting in this classroom is comfortable.	92%	91%	67%	73%	70%	75%	79%	100%	62%	67%
Reflections in the computer screens are noticeable.	54%	52%	11%	38%	33%	62%*	39%	40%	48%	38%

Note = Students were asked to omit responses regarding conditions they had not encountered. Percentages were calculated based on the number of respondents for each question.

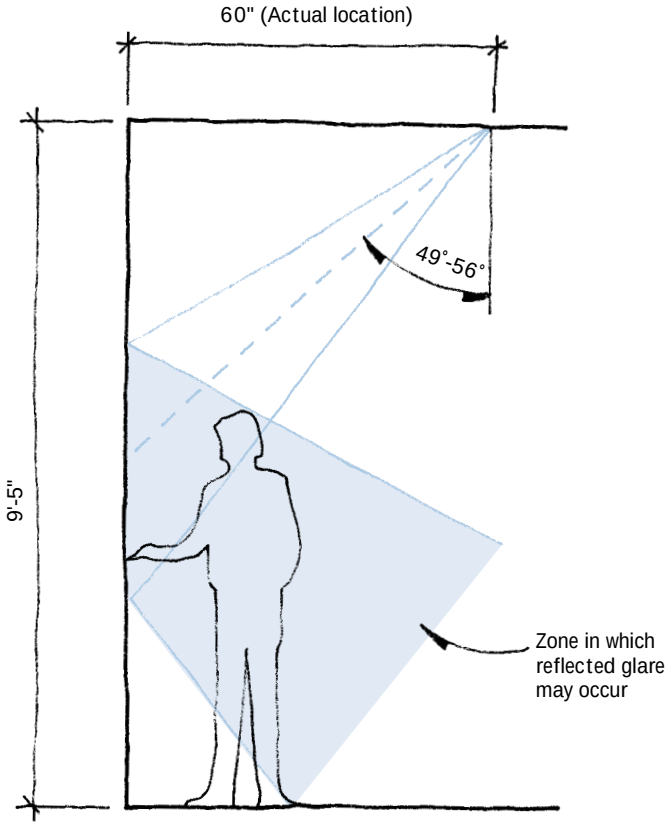
* DELTA assumes this response was due to the western exposure of this classroom, with surveys filled out late in the afternoon when sunlight was penetrating deep into the room.

Project Evaluation *(continued)*

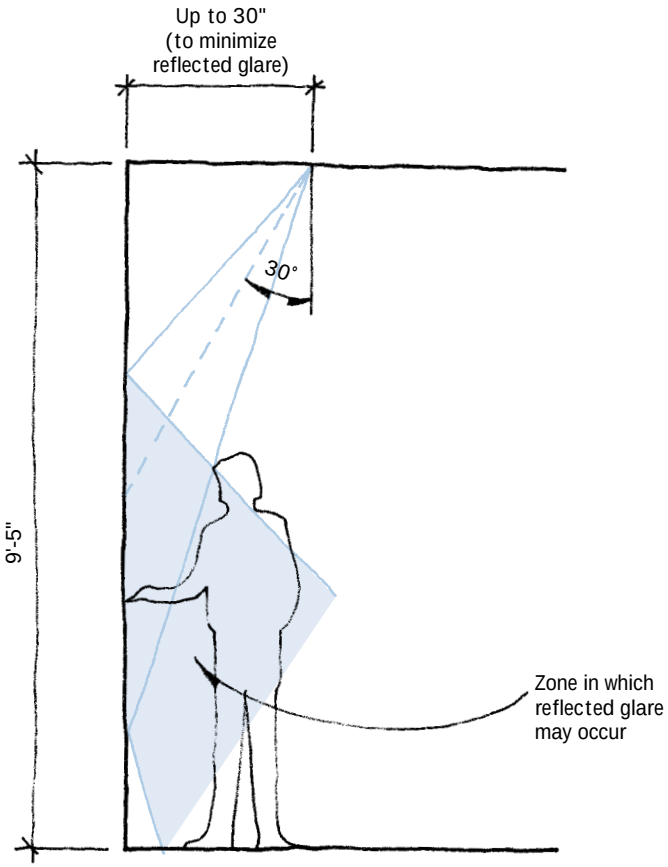
out, yet students would be able to take notes. Another instructor wished he could dim the fluorescent lamps in the whole room down to a point below the 50% level achieved with bi-level switching. Another possibility also requiring new equipment would include a separate lighting system for note-taking, or the use of more powerful video projectors.

Most instructors enjoyed having a dimmable trackhead above their desks. Impressions about the lighting for the whiteboard were less favorable, however. One instructor complained that light from the rest of the trackheads caused reflected glare on the whiteboard. The glossy surface characteristics of whiteboards were partly responsible for this problem. The location of reflected glare was also caused by the geometry between the luminaire, the whiteboard, and the instructor using the board. Type B trackheads were mounted on the ceiling at 60" (1.5 m) from the whiteboard, forming an angle ranging from 49˚ to 56˚ from vertical, depending on where the trackhead was aimed (see drawings below). Complaints about reflected glare by the instructors could be minimized by mounting the trackheads closer to the board, forming an angle of less than 30˚ from vertical.

Maintenance staff had no major complaints about ballast, lamp, or controls technology. DELTA noted that maintenance staff tended not to aim the trackheads at the center of the whiteboard. As a result, the illuminance distribution on the whiteboard was non-uniform. These problems of reflected glare and mis-aiming may explain why many instructors choose not to use the trackheads to illuminate the whiteboard. The students, however, found it difficult to see the whiteboard without light from this system (see table on page 9).



Reflected glare on a glossy whiteboard can occur when a luminaire is mounted at a distance greater than 30 inches from the board.



Reflected glare can be minimized by mounting the luminaire up to 30 inches from the board to form an angle of less than 30˚ from vertical.

Methodology

This section gives details about methods and assumptions used in this publication.

Photometric Measurements

DELTA selected one example of each of the two types of rooms to perform illuminance and luminance measurements, after dark, with the blinds closed. The lighting system, ceiling heights, window size and location, and surface reflectances were all the same in both rooms. Lighting conditions for these measurements included all type A luminaires, one type B over the instructor's desk.

Surveys

During the summer of 2000, DELTA distributed surveys to classes being held in the two types of computer rooms. Two classes (with 6 and 18 students, respectively) were surveyed in a front-facing room, and one class (with 22 students) was surveyed in a perimeter room. All students in these classes answered the survey.

Installation Cost

To estimate installation costs of this lighting system, DELTA consulted the estimating resource *R.S. Means Electrical Cost Data 2000*, and quotes from local lighting representatives.

Energy Analysis

To analyze annual electrical cost savings, DELTA consulted class schedules for spring, summer, and fall semesters in the seven front-facing rooms and the five perimeter rooms. The seven front-facing classrooms together were scheduled for a total of 11,000 hours per year, while the five perimeter classrooms were scheduled for a total of 8,600 hours per year. These hours of use were multiplied by the maximum lighting wattage to determine the maximum energy use.

DELTA observed that a second condition was more typically used, with the fluorescent lighting operating at 50% and the instructor's trackhead at 50% light output.

DELTA compared these energy use estimates with the ASHRAE-IESNA 90.1 (1999) standard power densities for lighting in classrooms, multiplied by the total area of the rooms and the hours listed above. Subsequent electrical cost savings were calculated using actual rates charged to Hudson Valley Community College, of 6.3¢ per kWh and a monthly demand charge of $15 per kW (assuming the lighting is on at the point of peak monthly building demand).

Environmental Impact

DELTA based the environmental impact figures in the table on page 8 on the U.S. Environmental Protection Agency's September 1996 publication, "Conservation News Online." This document is available online at http://www.epa.gov

Abbreviations

Abbreviations mentioned in this report include:

LPD = Lighting Power Density

ASHRAE = American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

IESNA = Illuminating Engineering Society of North America

Lessons Learned

Classrooms with video projectors may require low light levels.

Computer classes sometimes use video projectors to display images, but for some video projectors, bright ambient light may wash out images. Low ambient light levels increase visibility of projector images, but may interfere with student note taking.

Instructors like to have their own task lighting.

In each computer classroom at the Bulmer Telecommunications and Computations Center, a separate dimmable tracklight is mounted above the instructor's desk. Instructors appreciate this amenity, since all other lights tend to be off to accommodate projected images.

Instructors would prefer not to walk away from their desks to change light levels.

In a video projector environment, the light levels may need to change several times during class. Providing switches at the instructor's desk location would minimize the hassle of getting up and walking over to switches by the door.

Instructors wish to control daylight in computer classrooms.

To reduce ambient light levels and to minimize reflected glare on student screens, instructors at the Bulmer Telecommunications and Computations Center can control daylight through a choice of window shade types and positions. These options are widely used.

Illumination for whiteboards must be considered carefully.

Whiteboards have glossy surfaces that may lead to reflected glare for the instructors who write on them. This problem could be minimized by mounting luminaires closer to the whiteboard (see diagram on page 10).

Location of video projectors and below-ceiling luminaires must be carefully coordinated.

A computer classroom's video projector is often mounted on the ceiling in front of a projection screen. Below-ceiling luminaires may block the path of video projected images.

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Program Director: Sandra Vasconez
Project Manager: Jennifer Brons
Evaluation Leader: Peter Boyce
Reviewers: Russ Leslie, Conan O'Rourke, Mark Rea
Editors: Marilyn R. P. Morgan, Keith Toomey
Technical Assistance: Jean Paul Freyssinier, Carlos Inclán, Milena Simeonova, Swapna Sundaram, John Tokarczyk, Zengwei Fu
Illustrations: Feng Zhao

CREDITS
BTC: Ronald Payson, Director of Center for Effective Teaching
NYSERDA: Marsha Walton
Architect: Einhorn Yaffee Prescott
Engineer: Einhorn Yaffee Prescott
Lighting Designer: Einhorn Yaffee Prescott
Electrical Contractor: Lacorte Companies
Luminaire Manufacturers: A: Columbia, B: Indy
DELTA Portfolio Graphic Design and Production: The Type & Design Center, Inc.
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e-mail: lrc@rpi.edu • www.lrc.rpi.edu

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