

# Daylighting in Schools, Grades K-12

## Assisting daylight delivery while controlling electric light

Provided by Lutron

By Susan K. Oldroyd, AIA

Benefits for incorporating daylighting principles into schools grades K-12 are twofold: Reduction of energy consumption and costs by greater reliance on natural light, and improved human performance.

Schools typically relied on daylighting as the primary source of illumination before fluorescent lighting became common. The California Department of Education required daylighting standards in school construction, so that all California classrooms built to handle the postwar baby boom in the 1950s and early 1960s were examples of daylight schools. The "Finger Plan" schools with rows of single classrooms with exterior corridors on both sides became a standard for grades K-12. However, in the late 1960s, air

conditioning became common and school design changed. Classrooms were designed with less glass and lower ceilings, and rooms were grouped together in tighter configurations, without solar orientation in mind. The finger plan school design was largely abandoned, and many of the classrooms built since then do not have daylighting, and some rooms have no windows at all.

School districts across the country are experiencing K-12 construction starts in the first half of 2005 averaging four percent higher than the same period in 2004. \$15.6 billion in constructions starts have begun to address overcrowding and inadequate facilities by constructing or renovating school buildings. The need for new facilities will continue to increase, according to Engineering News-Record and McGraw-Hill Construction Research & Analysis, especially in southern regions of the United States experiencing increases in school age populations due to relocation and immigration.

Initial costs are traditionally the most important in school construction budgets, but districts are increasingly focusing on sustainability, as case studies prove incorporating sustainable features into new K-12 schools can be realized within construction budgets, thus providing a more effective learning environment and saving resources. A sustainability measure increasingly integrated into building design is the use of daylight as a primary lighting element in classrooms, common areas, and even gymnasiums. Design features such as light shelves filter and reflect light to control glare and maximize diffuse natural light during K-12 operating hours, which coincide with daylight hours. Lighting controls, such as dimming ballasts, improve the light distribution when daylight is insufficient, and manage energy by turning off lighting by means of occupancy sensors. Clients from K-12 schools are learning the advantages of lighting controls such as energy savings and energy code compliance, while seeking simple, low-cost solutions.



Photographer: Jamie Myers Forsythe

Southwest Community Center Gymnasium, Seattle, WA: This gymnasium uses fabric skylight baffles to diffuse glare and make electric lighting unnecessary during daylight hours. Architect: Weinstein A|U

### CONTINUING EDUCATION

Use the learning objectives below to focus your study as you read **Daylighting in Schools, Grades K-12**. To earn one AIA/CES Learning Unit, including one hour of health safety welfare credit, answer the questions on page 251, then follow the reporting instructions on page 346 or go to the Continuing Education section on [archrecord.construction.com](http://archrecord.construction.com) and follow the reporting instructions.

### LEARNING OBJECTIVES

After reading this article, you should be able to:

- Identify benefits of incorporating daylighting principles into schools grades K-12.
- Describe architectural features used to increase effectiveness of daylighting in interior spaces.
- Determine appropriate building controls for different types of school spaces.

## Increased Student Performance

A 1999 study funded by the Pacific Gas & Electric Company and completed by Hescong-Mahone Group found that students get higher test scores when they learn in classrooms illuminated by daylight. This study of the correlation between daylight availability and test scores showed that natural daylighting in schools resulted in documented increases in student performance regardless of school design and climate. Three elementary school districts (Orange County, California; Seattle, Washington; and Fort Collins, Colorado) were studied. In Orange County, controlling for all other factors, students with the most daylighting in their classrooms progressed 20 percent faster on math tests and 26 percent faster on reading tests in one year than those students in classrooms with the least daylight; students in classrooms with the largest window area progressed 15 percent faster in math and 23 faster in reading than those with the least window area. In Seattle and Fort Collins, students in classrooms with the most daylighting had tests scores seven to eighteen percent higher than students in classrooms with the least daylighting. The authors conclude that there is a valid and predictable effect of daylighting on student performance.

## Reduction of Energy Consumption

A white paper by Vivian Loftness, FAIA, titled *Improving Building Energy Efficiency in the U.S.: Technologies and Policies for 2010 to 2050* (2005) lists the combination of daylighting and natural ventilation as one of the five most important directions for energy conservation in the following half century. "More than ten percent of all U.S. energy is used for lighting buildings, much of this during the day when daylight is abundant.... Effective daylighting can yield 30-60 percent reductions in annual lighting energy consumption, with average energy savings for introducing daylight dimming technologies in existing buildings at more than 30 percent.... Research using an advanced electric lighting control system has found that daylight-linked control systems can bring about sustainable reductions of 30-41 percent in electrical energy for an outermost row of lights in a perimeter zone, and 16-22 percent for the second row of lights."

## Code Compliance

Energy efficiency is rapidly becoming the design requirement of the new millennium. Many states and cities have already adopted specific energy-saving guidelines. The following are examples of codes and standards that are being instituted in the United States:

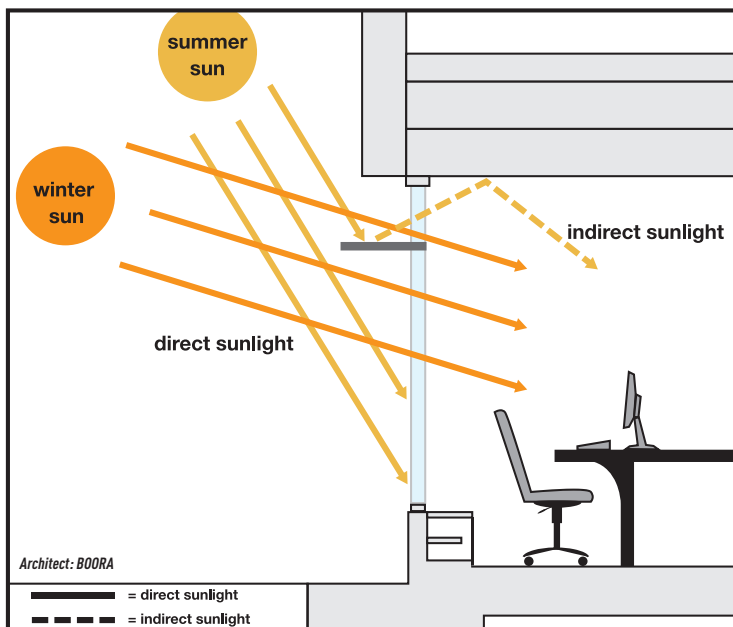
- American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA): This standard encourages the use of energy efficient-lighting controls in design practice for both interior and exterior lighting. Most states have or will adopt energy codes based on the standard.
- Leadership in Energy and Environmental Design (LEED): Efficient lighting controls may contribute to obtaining up to 22 points in five of six LEED credit categories. A minimum of 26 points is required for Leadership in Energy and Environmental Design certification. LEED is a rating system sanctioned by the United States Green Building Council (USGBC) that provides a national standard for what constitutes a green building.
- Title 24: California's building efficiency code (along with those for energy-efficient appliances) has saved more than \$36 billion in electricity and natural gas costs since 1978.

## Architectural Features

Daylighting control principles have two major requirements: directing diffuse daylight delivery into interior spaces and the control of electric lighting output in response to the available daylight. An integrated approach must be conceived from the beginning of the project including building siting and orientation, window and/or skylight design, and

lighting and shading control systems design, as well as ongoing maintenance. Daylight, electric lighting, and shading systems cannot be considered separately because daylighting affects electric lighting use and has the potential of introducing direct sunlight and glare that may be uncomfortable for building occupants. This requires cooperation between architects and lighting engineers. Daylight, electric lighting, controls and building design features must be seen as an integral part of the overall energy optimization program.

Building form and orientation can be designed to capture more daylight opportunities. The floor plan configuration should maximize the perimeter daylight zone. This may result in a building with a higher skin-to-volume ratio than a typical compact building design. Other examples of design elements used in effective daylighting include light shelves, glazing modulation, and light monitors. A standard window can produce useful illumination to a depth of about one and one-half times the height of the window. As a general rule-of-thumb, the higher the window is placed on the wall, the deeper the daylight penetration. With lightshelves or other reflector systems this can be increased to two times or more. A light shelf is a horizontal light-reflecting overhang placed above eye-level with a



Section through exterior wall showing light shelf, Clackamas High School, Portland, OR: This section indicates daylight bouncing off light shelf onto ceiling, diffusing light throughout the space.

transom window placed above it. This design, which is most effective on southern orientations, improves daylight penetration, creates shading near the window, and helps reduce window glare. Exterior shelves are more effective shading devices than interior shelves. A combination of exterior and interior shading devices will work best in providing an even illumination gradient. Carefully select and detail glazing and location and design of window openings. Glazing specification depends on the exposure; Low E glazing with light transmission of 50 percent should be used on the vision panels with 68 percent or greater transmission on glazing above the light shelf. No light shelves or shading devices, and all 68 percent or greater light transmission glazing should be used on the north side.

Light monitors can follow an east-west axis to maximize exposure to the southern sun. Top-lighting provides interior light that is significantly different from that provided by windows: it can provide relatively uniform light distribution throughout a space, and it is often easy to integrate with electric lighting because light originates from the ceiling in both cases. Roof monitors can be designed to admit daylight and sunlight, although sunlight is difficult to control and best avoided; a roof aperture should be between four to eight percent of the floor area. Shape the roof monitor to admit only daylight from the north. Splaying walls and using matte white reflecting surfaces around the monitor improves light distribution and reduces glare. Using diffusing glass gives better distribution of light if a view of the sky is not critical. Horizontal skylights may result in excessive solar gains in summer. Brighter sky visible through skylights can also cause glare problems. In addition to maximizing the penetration of diffuse light, the building features must diffuse or block direct rays of the sun. Glare and overheating from the sun's direct rays inhibits the performance of visual tasks in classrooms, offices and other similar spaces. In order for spaces to be considered daylit, The USGBC LEED Standard requires that no direct sunlight be admitted to critical task areas.

### Control of Electric Lighting Output

Control of electric lighting output saves energy and improves the overall distribution of light when daylight is insufficient. A building designed for daylighting but without an integrated electric lighting system may even be a net energy loser because of the increased thermal loads. Only when the electric lighting load is reduced will there be more than offsetting savings in electrical and cooling loads. The benefits from daylighting are maximized when both lighting and occupancy sensors are used to control the electric lighting system. Combining lighting control strategies enhances building performance: Using occupancy sensors, daylight sensors, and time clocks with fluorescent dimming can help manage the lighting in an entire building and further reduce electric demand. Energy savings result when sensor and control technologies are employed in each classroom; maintenance is reduced because of less wear and tear on fixtures from using dimmers rather than on/off switches; and student productivity is increased through use of daylight and exact light levels for task needs.

Options for common school lighting control functions in classrooms, common areas, and other types of school areas can provide significant benefits. (Table 1.)

Common School Lighting Control Functions	Benefits
Daylight Sensors and Dimming Ballasts	Reduced energy use Even light level throughout classroom Non-distracting light level changes Increased productivity
Occupant sensing	No wasted energy when classrooms are empty
Dimming wall controls	Saved scenes for various presentation and computer/classwork needs

Table 1



Photographer: Jamie Myers Forsythe

Mt. Angel high performance prototype classroom, Mt. Angel, OR: A rectangular suspended device dubbed "the halo" is made of translucent material that reflects part of the light onto the ceiling and walls, while letting part of the light into the room. Design team: BOORA, SOLARC, Prof. Charlie Brown of the Seattle Daylighting Lab, and SRG Partnership

New installations and retrofits require different approaches. With a new installation, performance targets can be set and a light source and shading device can be chosen based on economic, ergonomic, and technical considerations, e.g., an acceptable payback period. With existing installations, choices will be limited by the building constraints, the availability of daylight, and the lighting controls used.

### Modeling Daylight in Interior Spaces

Joel Loveland, director of the Seattle Daylighting Lab, oversees his group's consultations with architects and lighting designers to shape school designs for maximum daylighting capability. The consultants prioritize daylighting as a building design goal, while working with the budget and programmatic requirements. Some of the design principles of the

Daylighting Lab are:

- Treat the building as a luminaire.
- Separate the vision and daylight glazings.
- Position the daylighting apertures to create mood and visual focus.
- Address the requirements of the visual task.
- Integrate the daylighting system with the architecture.
- Integrate the daylighting system with the other building systems.

The Daylighting Lab uses modeling to predict exact natural lighting levels so that electric lighting and controls can be specified to work with and complement the daylight.

### Prototype Classroom

A high performance prototype classroom in Mt. Angel, Oregon, created through the combined efforts of many experts and design firms, including BOORA, SOLARC, Prof. Charlie Brown of the Seattle Daylighting Lab, and SRG Partnership seeks to light a classroom during daylight hours without any electric light, with minimum cost. Electric light was added for the infrequent occasions when the classroom was used at night, but the large skylight opening on the ceiling distributes light to the entire classroom. A rectangular suspended device dubbed "the halo" is made of translucent material that reflects part of the light onto the ceiling and walls, while letting part of the light into the room. The edges of the room receive two sources of light, from the reflection and the direct light. This prototype is designed for single story ground floor buildings in moderate climates but the model could be adapted into two story buildings with light shafts, and other region and climate types.

### Clackamas High School, Portland, OR

BOORA, Portland, OR, has developed successive daylit schools grades K-12 including Ash Creek Intermediate School, Monmouth, OR and Clackamas High School, Portland, OR. Most buildings spend more on cooling than on heating, so daylighting principles in schools typically focus on bringing in light rather than heat. In the case of Clackamas High School (completed in 2002 for \$127.71 /s.f.) control of daylight was accomplished using light shelves and shading devices. Light bounces off the top of the light shelf into the ceiling of the first floor spaces. The overhang shades the window below it. This allows a higher visible transmittance glazing in the daylight aperture if it is out of normal sight lines. Since the ceiling is the most important light-reflecting surface, using this surface to bounce daylight deep into the room can be highly effective. Both of these strategies are utilized in light shelf designs. Rooms in this facility use occupancy sensors, timers and daylight sensors to control output of electric light. Two rows of suspended T-5 fixtures running parallel to exterior windows are used for supplemental lighting, with the inner row on dimming ballasts. Ceilings are shaped to reflect light more evenly throughout rooms. The cafeteria uses virtually no electric light yet offers a variety of light and dark options for students through means of mechanized window shades. (Figure 4.) Heinz Rudolph, FAIA, principal of BOORA, states, "When everything is said and done a building needs a mixture of daylight and electric light, and good control devices."

***"When everything is said and done a building needs a mixture of daylight and electric light, and good control devices"***



Photographer: Michael Mathers

Cafeteria, Clackamas High School, Portland, OR: The cafeteria uses virtually no electric light. Architect: BOORA

CLICK FOR ADDITIONAL REQUIRED READING

The article continues online at <http://archrecord.construction.com/resources/conteduc/archives/0512lutron-1.asp>. To receive AIA/CES credit, you are required to read this additional text. The quiz questions below include information from this online reading. To receive a faxed copy of the material, contact Jeanette Fitzgerald at Lutron, (610) 282-6661 or fax (610) 282-6437.

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LEARNING OBJECTIVES

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- Describe architectural features used to increase effectiveness of daylighting in interior spaces.
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INSTRUCTIONS

Refer to the learning objectives above. Complete the questions below. Go to the self report form on page 346. Follow the reporting instructions, answer the test questions and submit the form. Or use the Continuing Education self report form on *Record's* web site—[archrecord.construction.com](http://archrecord.construction.com)—to receive one AIA/CES Learning Unit including one hour of health safety welfare credit.

QUESTIONS

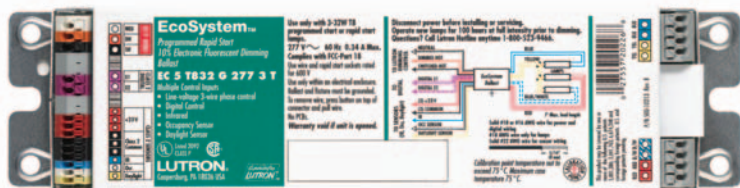
1. Which of the following is not a benefit of integration of daylighting principles?
  - a. Reduction of energy consumption and costs.
  - b. Improved mechanical systems lifespan.
  - c. Improved human performance.
  - d. Energy code compliance.
2. The 1999 study by Heschong-Mahone Group made what correlation?
  - a. Students got lower test scores when affected by glare.
  - b. Students got higher test scores in classrooms illuminated with daylight.
  - c. Students' test scores were affected by type of subject matter.
  - d. Students' test scores depend on climate.
3. Average energy savings for introducing daylight dimming technologies in the perimeter daylight zone of existing buildings are more than \_\_\_ percent:
  - a. 10 percent
  - b. 25 percent
  - c. 30 percent
  - d. 20 percent
4. Energy codes based on this standard have been adopted by most states:
  - a. National Electrical Code (NEC)
  - b. Universal Building Code (UBC)
  - c. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA)
  - d. International Energy Agency Solar Heating and Cooling (IEA SHC)
5. Two major requirements of daylighting control principles are directing diffuse daylight delivery into interior spaces and the control of electric lighting output in response to the available daylight.
  - a. True
  - b. False
6. Which of the following architectural features is not useful for maximizing building daylighting potential?
  - a. Light shelves
  - b. Building form and orientation
  - c. Light monitors
  - d. Dark finish materials
7. The USGBC LEED Standard requires what in order for spaces to be considered daylight?
  - a. That a roof aperture not exceed eight percent of the floor area.
  - b. That roof monitors admit only daylight from the north.
  - c. That no direct sunlight be admitted to critical task areas.
  - d. That occupant sensors be used in classrooms.
8. What percent of dimming is recommended for classrooms?
  - a. One percent architectural dimming
  - b. Five percent high performance dimming
  - c. Ten percent lighting management dimming
  - d. Twenty percent lighting controls
9. Which of the following is NOT an example of lighting controls suitable for schoolroom use?
  - a. Dimming ballasts
  - b. Photoelectric light sensors
  - c. Motion detectors
  - d. Occupancy Sensors
10. What is the most common daylight control lamp source?
  - a. Fluorescent
  - b. HID
  - c. Incandescent
  - d. High pressure sodium



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Lutron Electronics Co., Inc., ([www.lutron.com](http://www.lutron.com)) headquartered in Coopersburg, Pennsylvania, is the world's leading designer and manufacturer of lighting controls, lighting control systems, and shading solutions for residential and commercial applications.

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Dimming ballasts replace non-dim ballasts in fluorescent fixtures, improving the energy performance and flexibility of any space.

## Dimming Ballasts

Dimming fluorescent lighting instead of repeated switching helps to maintain lamp life. Dimming also saves electricity and reduces the demand on HVAC systems. A proper dimming ballast smoothly varies the light output of electric lights by altering the amount of power flowing to the lamps. When coordinating electric light levels with available daylight, the dimming ballast monitors the amount of daylight present and raises or lowers electric light levels to maintain the target illuminance on the work surface. Dimming controls in some situations save more energy than switching if they are linked to daylight and if lamps are dimmed at the start of their lifetimes to compensate for their increased output. Dimming controls are less obtrusive to occupants than switching, but a manual override is recommended in areas where occupants expect to have control. Switches can also be used instead of dimmers, but this is not recommended except for limited applications because they are more obtrusive and may use more energy than dimming switches. High frequency dimming produces the greatest savings in all but the most well daylighted rooms. A problem with photoelectric switches is rapid switching on and off when daylight fluctuates around the switching illuminance. This can annoy occupants and reduce life. Various techniques have been developed to reduce the amount of switching. Multi-level switching control uses two switching illuminances, one at which the lights are switched off and another, lower illuminance level at which the lights are switched on. Photoelectric switching with a time delay can also introduce a delay in the switching process.

Dimming is important because the human eye responds to low light levels by enlarging the pupil, allowing more light to enter the eye. This response results in a difference between measured and perceived light levels. A lamp that is dimmed to ten percent of its maximum measured light output is perceived as being dimmed to only 32 percent. Likewise, a lamp dimmed to one percent is perceived to be at ten percent. Descriptions of different levels of dimming follow:

- One percent architectural dimming provides very fine light level control to users for aesthetic effect or for very stringent lighting or audiovisual design criteria. Architectural spaces often have a strong focus on aesthetics and comfort, creating an environment that portrays class and distinction. Architects and designers create these spaces for maximum versatility and require subtle control of the lighting. Room types: theater, auditorium, lobby
- Five percent high performance dimming offers energy savings, aesthetic appeal, and space flexibility, allowing users to operate their lights at 100%, 5%, and anywhere in-between. Room types: meeting rooms, classrooms.
- Ten percent lighting management dimming works well for a classroom, cafeteria, or office lighting application. To maximize the benefits of a lighting management system, use dimming ballasts. Ten percent dimming is ideal for use in any space where saving energy is a primary goal. Room types: most spaces including classroom, library, cafeteria, meeting room, graphic art workstation, office, corridor/stairwell, utility room, restroom

Manual dimmers are available for incandescent, fluorescent, and certain high-intensity discharge (HID) sources. Both step and continuous dimming are available for incandescent fixtures. Multiple dimming methods are available for both fluorescents and HIDs, though HID dimming is limited by color rendition and flicker problems. Experience has shown that manual controls are not used effectively. Many occupants leave electric

lighting on once it is switched on even if the illumination from daylight is at a level that would be considered adequate if the occupant were entering the space. Today, there are a number of light control systems that can cap the maximum light level provided by a manual dimmer, reducing the electricity used when lights are left on. Energy savings cannot be realized in daylight buildings unless the electric lights are dimmed or switched in response to the amount of available daylight. The energy savings achieved with daylight-responsive lighting controls will depend on the daylight climate, the sophistication of the controls, and the size of the control zones. An evaluation of currently available responsive control systems is presented in the International Energy Agency Solar Heating and Cooling (IEA SHC) Application Guide. This evaluation has shown that daylight-responsive systems used up to 40 percent less than non-controlled systems. Cooling load reductions have also been noted, which can save an additional two to three percent of electrical energy consumption. Savings can be larger than 40 percent especially in toplit spaces. In hot climates, the cooling savings can also be larger.

## Photoelectric Light Sensors

A key element of all types of photoelectric control is the sensor, which detects the presence or absence of daylight and sends a signal to a controller that will adjust the lighting accordingly. Threshold on and off values can be set to respond to specific lighting conditions. These sensors can operate on/off switching of various luminaires or lamps within luminaires and they can also operate a continuous dimming system. Continuous dimming system may cost more than switching systems but they have greater user satisfaction because the change in lighting levels is not as noticeable. Added labor costs for additional wiring and circuits necessary for switching may increase the initial cost of a switching system.



Photosensors, also known as daylight sensors, monitor the amount of daylight present in a space. Daylight sensor shown above in actual size.

The location of the sensor is important because it influences the type of control algorithm used. The photoelectric cell or sensor is often located on the ceiling and is calibrated on site to maintain a constant illuminance level. A single sensor that dims large areas can cause problems if buildings or trees overshadow some parts of the interior space. It has been found that with innovative daylighting systems such as light shelves, a partially shielded sensor (shielded from the window only) is not susceptible to sky conditions and direct light from the window. A controller is located at the beginning of a circuit (normally the distribution board or the ceiling space) and incorporates an algorithm to process the signal from the photosensor and convert it into a command signal that is received by the dimming or switching unit. Photosensor-activated dimmers may be the most important dimming technique. It matches the available natural daylight and lighting system output to produce consistent illuminance. Electronic or other dimming ballasts allow for control of the light level. These systems require careful integration of control systems and sensors.

## Occupancy Sensors

Occupancy sensors detect when a space is occupied by using passive infrared, ultrasonic, or a combination of the two technologies. Once the heat or movement of the occupant is no longer detected, and after a preset delay time, the sensor will emit a signal to extinguish the lights. Occupancy sensors used alone are good for low or intermittent use areas such as storage rooms, restrooms, private offices, and corridors. Sensors can be installed at a wall switch, wall mounted, ceiling mounted, or recessed in a pendant fixture depending upon preference and room layout.



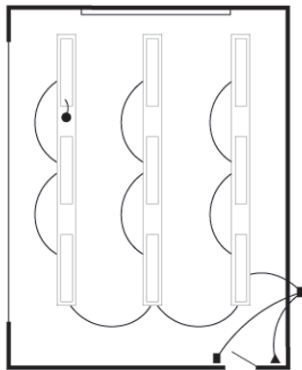
Occupancy sensors turn lights off when rooms are empty. Dual technology ceiling mount occupancy sensor shown.

## Integrated Systems Software

Integrated systems software integrates environment sensors, such as daylight and occupant sensors, with personal controls, such as wall controls and infrared remotes. With 60 percent of energy use in schools going to lighting, the combined effect of multiple environment sensors and personal controls operating together brings energy savings to spaces that previously had none. Ballasts can be flexibly programmed, instead of wired, to work individually or as a group. This eliminates the need for an area to be rewired when changes take place, creating flexibility in a space that adjusts to shifting needs. Control software reduces lighting system maintenance. All of the environment sensors and personal controls connect directly to a ballast, removing interfaces, power packs, and control devices that on other systems require more parts, programming and maintenance.

### K-12 Schools

Typical Layout:



Typical layout of control devices in a classroom.

Researchers have found that physical and perceived performance of a daylight control system can differ. If the user finds the environment created by the system to be uncomfortable or disturbing in any way (abrupt on-off switching), the system is likely to be rejected or an attempt will be made to compromise it. Energy savings are therefore directly related to a system's acceptance and proper operation by the user. Hard-to-operate systems are likely to be compromised. In addition, inappropriate ambience can result in rejection of the system. View aesthetics are also an important consideration. Users often do not accept daylight without view. In addition, the quality of light is important as is the avoidance of high contrasts and absolutely uniform lighting.

An important but often overlooked aspect of control installations is the training of

maintenance personnel and building occupants in the operation and purpose of a daylight responsive control system. Although most manufacturers provide technical support during and for a period following installation of their systems, it is easier and more economical if those managing and occupying the building can address most problems. Building and facility managers need to be aware of how to operate the system and adjust it. They need to understand the system's performance. Building occupants should receive information about the purpose of the system.

Fluorescent lighting systems are the most common daylight control lamp source because of the availability of step switching and dimming systems. HID sources are typically not a good choice for daylight switching or occupancy sensors because of the extended strike and re-strike times. There are now two-step HID sources available that may be useful in some step switching applications where the "off" mode is not desired during a typical day. A daylighting design will use both occupancy and light sensors. With these two control strategies the lights will come on only when the room is occupied and only if there is insufficient daylight. In most designs, a manual override is provided for user convenience.

## Modeling Daylighting

Physical models are a very effective way to analyze daylighting performance. Even simple models can begin to inform the designer of how daylight will behave in the building. It is important that the daylight apertures be accurately modeled and that the materials used to construct the model have the designed reflectance values. The model can then be tested on the actual site or under artificial sky conditions in a daylighting laboratory. A sundial with the appropriate latitude attached to the model base allows the designer to simulate various dates and times of the year. Computer analysis is another method of testing a daylighting solution. Typically a three-dimensional digital model is constructed using computer-aided design software that is then imported into the lighting software. The programs then require the operator to define all surface characteristics, sky conditions, location, and date and time. Many of these programs can produce photorealistic renderings of the proposed design.

To make informed decisions about the technology most appropriate for a space, designers must understand the daylight characteristics of that space. The physical daylight model is one of the most fundamental and useful tools for assessing and predicting daylight levels and qualities. One method of measuring and reporting a design's performance is in terms of daylight factors. A daylight factor is the amount daylight inside a space expressed as a percent of available exterior daylight. Photocells (light sensors) and a data acquisition system are used to measure daylight factors. Up to seven photocells are placed at strategic locations within the model measure interior light levels while a reference photocell placed on the model's roof measures available daylight. The value measured at each interior photocell is divided by that at the exterior reference value to determine daylight factors. The same equipment can also be used to measure absolute illuminance levels in lux and footcandles. Daylight distribution and absolute illuminance are not solely dependent upon building properties such as geometry, glazing selection, and the finish of interior surfaces. Exterior conditions including ground reflectance and horizon obstructions such as buildings and vegetation also influence interior lighting characteristics.