# Learning, Lighting and Color

Lighting Design for Schools and Universities in the 21st Century
By Randall Fielding, AIA

Uniform illumination levels in the classroom and focused brightness on the "teaching wall" made good sense for students in Henry Ford's era. If you were training to take your place on the assembly line, you needed to focus on the work at hand and ahead to your supervisor, but the future no longer belongs to students who look only straight ahead. In a world where advanced degrees in professional disciplines are rapidly becoming a commodity, prosperity belongs to individuals with the ability to react with agility to unpredictable market forces, data, and events.

Fortunately, responding to unexpected events is natural to human beings. We did not evolve as a species to think in a linear path, nor do we learn that way. Effective design is grounded in a firm knowledge of how we do learn, which involves both analysis and synthesis and is alternately sequential and simultaneous. (or as Daniel Pink describes in "A Whole New Mind," the knowledge worker of the 20th century is giving way to the conceptual worker of the 21st century).
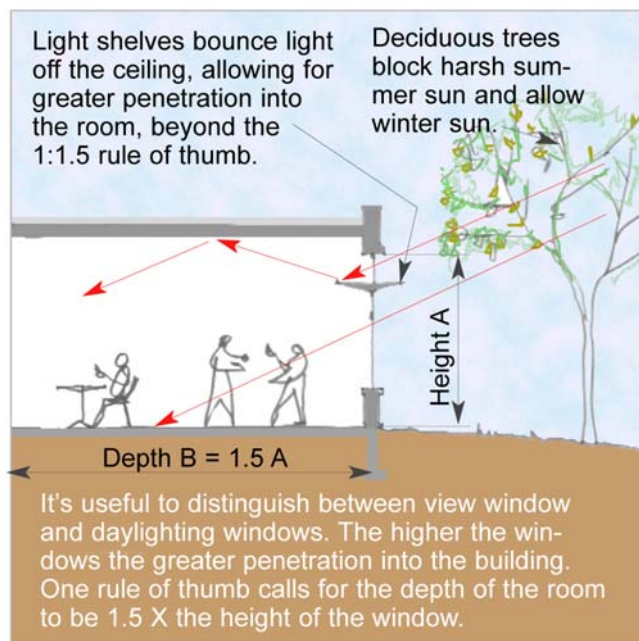
Following the Sun
Paideia Academy, Apple Valley, Minnesota
Fielding Nair International, Design Architect

Light shelves bounce light off the ceiling, allowing for greater penetration into the room, beyond the 1:1.5 rule of thumb.

Deciduous trees block harsh summer sun and allow winter sun.

Height A

Depth B = 1.5 A

It's useful to distinguish between view window and daylighting windows. The higher the windows the greater penetration into the building. One rule of thumb calls for the depth of the room to be 1.5 X the height of the window.

Daylighting
Pattern # 19

How We Learn

We all learn differently, and we learn all of the time. We learn in quiet reflection, in noisy leaps, and in social interactions that arouse our emotions. A wonderful characteristic of learning is that we learn when we feel secure and cozy, and also when we feel challenged. In fact, human beings are wired to learn—to make connections and to recognize patterns in a wide variety of conditions.

Pattern recognition and the ability to extrapolate concepts from information is a key attribute of success in the 21st century. The acceleration of university graduates with advanced degrees worldwide (more than 350,000 per year in India alone) ensures that there is a vastly increasing supply of expertise to process information. The future belongs to individuals who have a firm

grounding in logical and analytical skills, but also have highly developed emotional, kinesthetic, and visual intelligences, and the ability to see the big picture.

Balancing direct/indirect and directional lighting
Hip-hop High, St. Paul, Minnesota
Fielding Nair International, Design Architect

Successful schools and universities are adapting their offerings to learner-centered, rather than teacher or curriculum-centered, modes of delivery. The paradigm is no longer about delivering information, but in nurturing a broad array of learning styles and experiences. Many of the environments for learning have not caught up with these approaches to educational delivery.

The Learning Environment

When working with architects and lighting designers, even visionary educators often ask for the same old classroom, with a few bells and whistles added, such as new carpeting, a ceiling mounted data projector, and extra electrical outlets. However, an effective learning environment in the 21st century has little in common with the rows of classrooms and desks or child factories of the industrial or information age.

Great learning environments exhibit similar characteristics as great cities and great landscapes. Some of the characteristics of great educational spaces are timeless, like a mature forest, and others change rapidly, like Times Square in New York City.

Patterns of Learning Activity and Design

Identifying patterns of learning activity and design prior to laying out a building is a good way to ensure an effective solution—one that takes advantage of the full range of human capabilities. In the book *The Language of School Design* (DesignShare, 2005), Prakash Nair and I identify 18 learning modalities and 25 design patterns. The patterns are not a complete list of all the possible scenarios, but describe a well-rounded mix of indoor and outdoor spaces, including, quiet, reflective areas; messy, lab-like spaces; and social watering-hole spaces. This article features a few of these patterns herewith comments on the role of lighting in each.

Vistas of 50 feet (15 meters) or more allow us to change our focal length, important to both eye health and comfort.

Interior and exterior vistas
Design Pattern # 10
(patterns by Fielding Nair International)

Vistas, Movement, and Lighting Design Principles

It's a natural reflex to look up from a task frequently, and refocus on an element in the distance. People often do this unconsciously. For example, among a group of people in a library or office, individuals look up and out often, with little apparent goal. In fact, they are resting their eyes, by changing the focal length—a form of stretching.
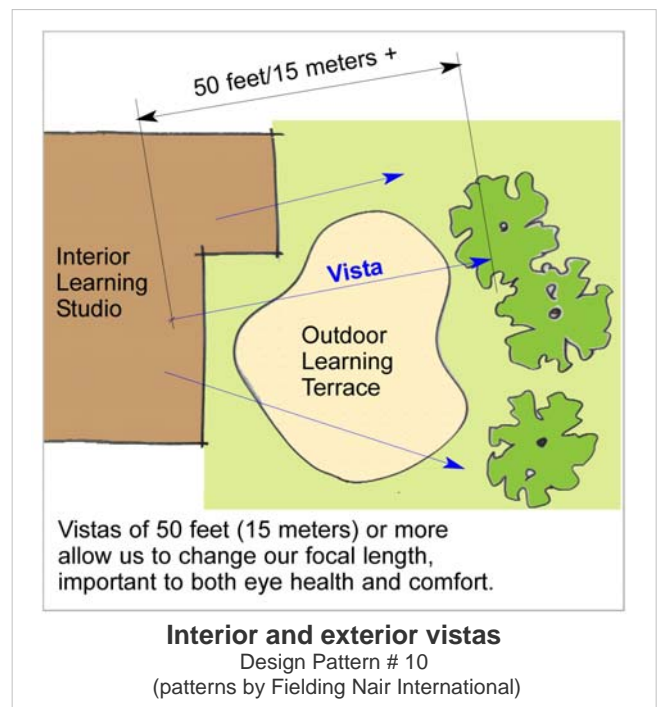
Instinctively, we tend to move towards light and color (unless we are frightened, and in a flight state). Designers can take advantage of the reflex to look up and out. Vistas can be designed to define and order movement, by leading first the eye and then the body through space.

Spruce Street Nursery School
Bargmann Hendrie + Archetype, Inc.
DesignShare.com 2005 Honor Award
Photo © Lucy Chen

Movement is a stimulus to learning, but paths that are confusing or counter-intuitive don't make us feel secure enough to learn at our best. Designers can use movement as a positive design generator by choreographing scenarios in advance. (Imagine that you are entering a campus or school building. What do you see? Where is your eye drawn to?) If a visual element at the far corner from a visitor's starting point is highlighted, a person will be attracted to move towards it. The visual destination element may be a sculptural form, taller than the elements around it, or it could be a wall with a brighter color, and a higher level of illumination.
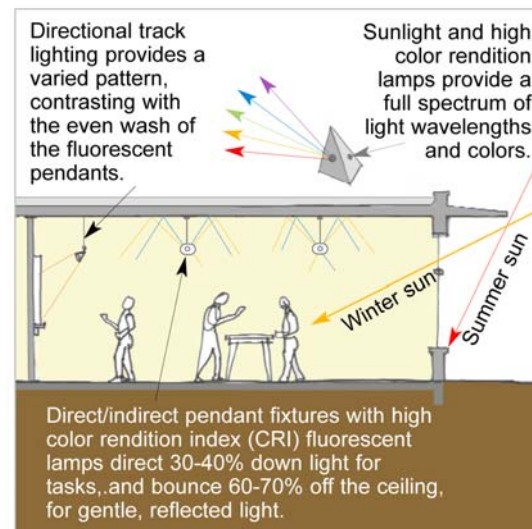
Full-Spectrum Lighting
Lighting designers often wrinkle their noses when someone mentions full-spectrum lighting—thinking of the hyped commercial claims for "miracle lights." There is not a good consensus on the definition of a full-spectrum lamp, or on its clinical benefits.

The desire for a broad spectrum of light and color is consistent with a more holistic curriculum—one that takes into account a variety of learning styles and modalities. We all learn differently and at different times. We need a variety of lighting levels and qualities and colors of light. It's natural to want lighting that most closely matches the full spectrum of daylight. The pattern for full spectrum lighting is one example of how this is applied in a learning studio. The following examples of 21st century school design patterns illustrate how these lighting design principles apply.
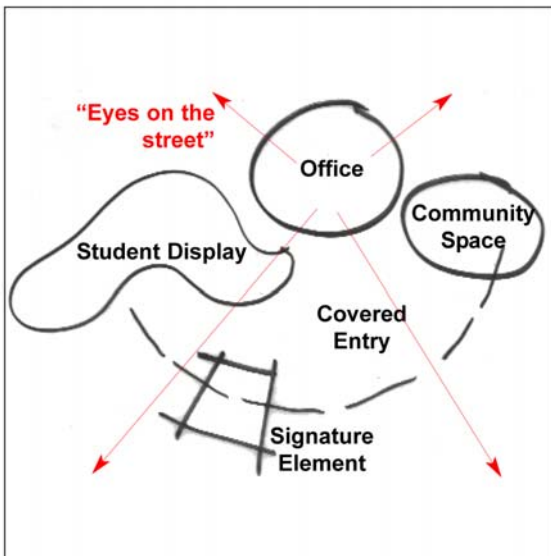
Welcoming Entry
It's important for a school or university to have a signature—a unique presence in the landscape or cityscape and community. Learners that feel a sense of connection and personal identification with a small learning community (SLC) attain higher test scores and have a significantly greater graduation rate. Research demonstrates that "small' is defined as 150 students or less. (A recent study by Albuquerque Pubic schools demonstrates conclusively that the positive effects of 120 student academies are completely lost when the academies grow to 180).

Full Spectrum Lighting
Pattern # 21

Since most schools and universities accommodate more than 150 students, one way to leverage the positive effects of small learning communities is to break down the scale of the environment into smaller buildings or clusters of spaces. The entry to each SLC can be individualized, reinforcing its unique identity. Lighting plays an important role in creating this identity.


Welcoming Entry
Pattern # 2

The entry area includes a series of inter-connected spaces, each warranting a different approach to lighting. The signature element and student display area should be highlighted. For display areas, track fixtures are all good options, with wall wash, linear directional and low voltage lights.. In the office and community space, a mix of direct/indirect pendants with directional fixtures in selected areas usually makes sense.

The principles of movement and lighting apply to all of the spaces connected to the entry way itself. For example, the wall opposite the entry door to the community space might have a deeper color and a large mural reflecting unique qualities of the community. Directional lighting on the mural would highlight it with a high illumination level. The rest of the room might utilize direct/indirect pendants, with a distribution of 60% uplight and 40% downlight.

Science Lab Areas

Science education at its best takes advantage of all of our senses—it's at once analytical, mathematical, collaborative and kinesthetic. The pattern for science and life skills, such as student interaction and collaboration, supports all of these modalities. One learning community in Bridgehampton, NY, used this pattern as a basis for all of their learning spaces, including arts and humanities. The traditional departmental separation between "soft" humanities subjects and "hard" sciences reinforces, in a negative sense, the 19th and 20th century schism between analytical and synthetic thinking. Conversely the pattern shown here brings analytical, intuitive, and kinesthetic strengths together to foster innovation and conceptual thinking.

The lighting should vary to reflect the character of each space. The soft seating in the research and development (R&D) think tank might include low voltage pendants for soft, ambient light. The walls of the same space would benefit from directional track or linear fluorescents to highlight "tech art" and student work on the

Grainger Center for the Imagination and Inquiry at the Illinois Mathematics and Science Academy, Aurora, Illinois. Architect: OWP&P Architects, Inc.
(photo Courtesy of Scott McDonald @ Hedrich blessing).

walls. Direct/indirect pendant fixtures in the active lab space might reverse the percentage of up and downlight used in humanities spaces, with 60% or 70% downlight versus 40%.
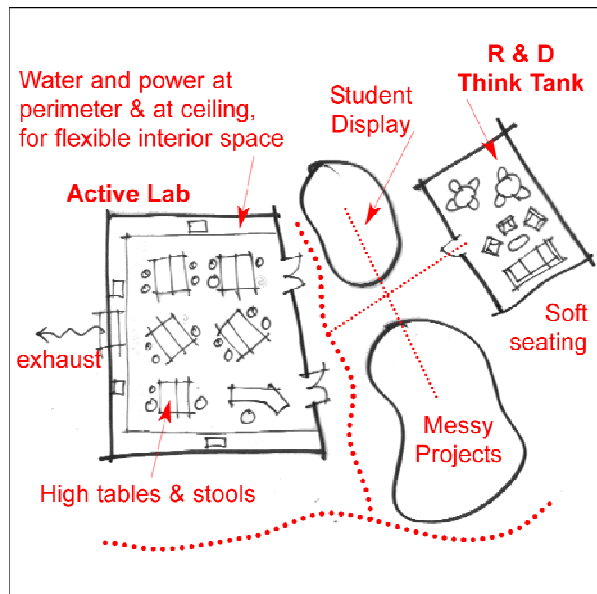
Science Suite & R&D lab
Pattern # 5

Learning from the Past

Before developing new patterns for learning and design in the future, it's useful to look back and avoid the mistakes of the past. Many myths about lighting and color need to be dispelled.

Seven Myths about Lighting and Color in Educational Architecture

Myth # 1: Uniform brightness Level

Many educational "specs" and building codes call for a uniform brightness of 55 foot candles in academic spaces. However, in 20 years of educational architecture, I have never been "written up" for varying the lighting levels. As discussed in the introduction, uniform illumination makes more sense for assembly line training. For the holistic thinkers of the 21st century, however, it's a concept that has passed its time. Alternatively, 55 foot candles can light the center of the room, with lower illumination in a niche or bay that serves as a breakout space and higher illumination on display walls.

Myth # 2: Primary colors for children

Often the strategy is expressed that brightly lit, primary colors are the best environments for young children. This is not born out by any reputable research. In fact, experience has shown that children are wonderfully sensitive and responsive to nuances in both lighting ad color. For example, children are particularly attuned to the colors of nature and human skin tones, and yet these are completely out of the primary range. Primaries can be harsh—use them sparingly.

Myth # 3: Red incites aggression, green is calming

The research indicating that the color red incites aggression, green is calming and yellow stimulates the intellect is simplistic and outdated. Hundreds, if not thousands, of schools, hospitals and prisons were painted light green (thought to induce calm) in the middle of the 20th century, with the result that this perfectly good color family was tainted as an "institutional kiss of death" by the 1980s and 90s. All colors have a place for learners of all ages, when used thoughtfully. A good application depends on the cultural and climatic context, available resources and lighting.

Millennium High School, New York City
Planner: Fielding Nair International;
Architect: HLW International
(Photo Courtesy of Richard Cadan.)

It's a good idea to use a larger percentage of ceiling and wall surfaces with a higher Light Reflectance Value (LRV), in order to boost lighting efficiency. (Lighting designers can reduce the

number of fixtures by as much as 25% by taking the LRV of adjacent surfaces into account.) Efficiency, however, is not a good reason to use exclusively light colors. Utilizing more saturated accent colors in selected areas is more important for providing a varied, stimulating learning environment.

Myth # 4: Neutral colors are best

A common myth is that the best palette for learning environments is comprised of neutral colors, because it allows the students and teacher to become the focus, rather than the architecture. This is the same reasoning that was used in the 1960s and 70s to justify the proliferation of sterile glass, steel and aluminum boxes in cities around the world. The thought was that flexible, rationally engineered buildings could house anything with equal efficiency, downplaying monumental architecture and reinforcing "humanity" instead. This strategy of neutral design backfired and resulted in a period of architectural history often considered soulless.


Colegio Altamira
Penalolen, Chile. Architect: Mathias Klotz.
Photo: R. Fielding

Architects may proclaim proudly that they have specified six different shades of white in a school building, only to find that the architects are the only ones who notice any distinction between the shades of white! Research shows that learning benefits from a stimulus-rich environment, which is not supported by a palette that is dominated by gray, beige, white or off white; this applies to both building interiors and exteriors. There is rarely a good reason to take a neutral approach with educational architecture.
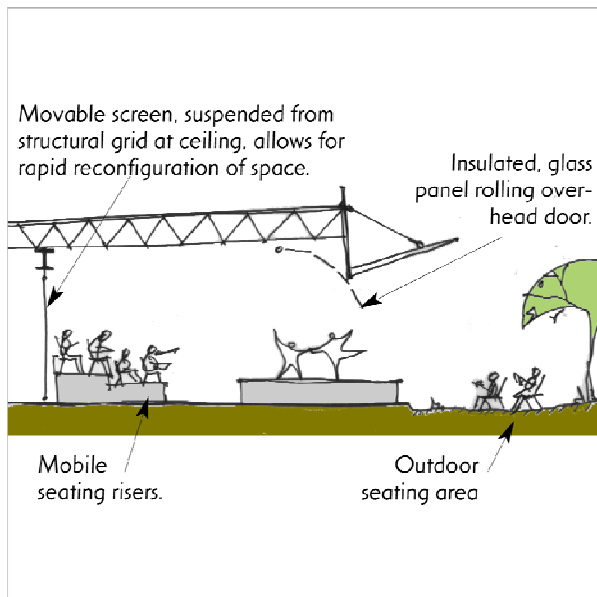
Art, Music & Performance
Design Pattern # 6

Myth # 5: It's best to use all the same lamps

Such uniformity has nothing to do with how we learn, but rather what's easiest to manage. This myth only eases the burden on maintenance people who will want to stock a single lamp type. This is like forcing all students to sit still on hard plastic chairs and stare straight ahead, listening to the same thing at the same time. Businesses can't compete using this kind of approach—if businesses don't respond to what consumers want, competitors will win the business. Learning organizations are becoming more like businesses; the successful ones are focusing on the educational consumer, not on their own convenience. Stock a variety of lamp types, and prioritize the needs of the learner.

Myth # 6: It's best not to use natural light in gymnasiums

It is often assumed that natural light is difficult to control, but natural light is perhaps the single-most important element in the learning environment. Research shows that in daylighted classrooms math scores improve by 20% and verbal scores by 22%. Eliminating natural light in gymnasiums because it's difficult to control glare is a lazy approach to design. Using north light, filtered light, and adjustable lighting control devices are just a few ways to utilize natural light in a competitive athletic environment.

While it's impossible to predict all of the ways that spaces will be used in a vibrant school or university over time, insure that a majority of those spaces are daylighted.

Myth # 7: Performance spaces should not have any windows
This myth is based on the assumption that it's important to control the lighting. There are many expensive, windowless black boxes with proud facility owners. After hundreds of hours with drama, dance and music performers, my experience is that performers would prefer spaces that more closely resemble artists' lofts with lots of light and views of the city, landscape, or campus green. The big picture idea with a black box theater is about a space that is adaptable, and less structured than a traditionally rigged theater, with a fly space, heavy curtain, and proscenium stage. At a high school in New York, the board--mostly comprised of professional theater people--asked for a black box approach, because they felt that it challenged students to think more creatively than a fully rigged theater. A better term for black box might be a white box—a kind of "Tabla Rasa"—a blank canvas for students to design, rather than have the structure of the theater itself dictate the creative approach. In a similar manner, designers do not need to rigidly dictate in advance how theater students will light the "house." It is better to provide them with choices, including an option for natural light and transparent surfaces that allow for interconnectivity between performance spaces, social spaces, and learning areas.

Randall Fielding wears two hats, one as a partner with *Fielding Nair International*, an award-winning educational facility planning firm that specializes in holistic, vision-driven designs for tomorrow's learners and the other as the founder and editorial director of DesignShare.com, the world's leading international online forum for innovative learning environments. He can be reached at fielding@designshare.com or through FieldingNair.com.