# Architectural Lighting Design Education: Teaching Science to Designers

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**Abstract:** Architectural lighting design education integrates educational practices from both design and science. These can be challenging to reconcile, particularly since intuition is valued in design and conceptual change is an important aspect of learning science. 

## 1. Architectural Lighting Design Education

Architectural lighting design, or illumination design, is a field of study concerned with the provision of light to occupants of the built environment. The primary aim is for the light to enable the visibility of illuminated surfaces, rather than to be directly viewed by occupants. Lighting is often considered to involve (or to even *be*) both art and science [1].

Though higher education programs in architectural lighting design are uncommon, those available tend to be offered by architecture/design or engineering schools/colleges. Graduates work in a variety of roles within the field of lighting – some positions involve developing plans for illuminating architectural spaces (e.g., lighting designer, specifier, illuminating engineer, consultant), while others involve developing or supplying lighting products (e.g., product designer, sales representative, manufacturer).

### *1.1. Diversity, Depth, & Breadth*

Many lighting professions do not have particular educational barriers to entry and attract people with diverse backgrounds. This diversity extends to the formal education programs that do exist – they vary considerably in approach, scope, and focus, often depending on the education and disciplinary backgrounds of those responsible for curriculum development. For instance, the current curriculum of the Master of Architectural Science (Illuminance Design) at the University of Sydney was developed by an academic with a background in visual neuroscience, so the relationship between light and visual perception is emphasized. Programs elsewhere, led by academics with different backgrounds, such electrical engineering or architectural design, typically highlight different aspects of the field.

Possibly due to limited and inconsistent educational opportunities in the field, lighting design is often practiced in a rather superficial way. When this is the case, designers execute design techniques that lead to successful outcomes without truly understanding why or how those results were achieved. For several decades, lighting technologies had not drastically changed, so lighting products and practices had become fairly standardized, enabling a superficial approach to design. However, when light-emitting diodes (LEDs) became feasible for general illumination applications in the mid-‘00s, superficial design techniques were no longer sufficient for successful lighting design – lighting practitioners now need to understand the casual relationships between the different aspects of an illuminated environment. Because of the multi-disciplinary nature of lighting, lighting professionals must be able to the integrate and apply knowledge from a broad range of cognate disciplines, including optics, visual neuroscience, solid-state physics, electrical engineering, architecture, mathematics, chemistry, and the visual arts. When designing curricula, lighting educators face challenges with respect to both depth and breadth.

### *1.2. Art & Science*

Design education has a number of distinct traditions and approaches, such as the value placed on studio-based learning [2], an emphasis on the iterative design process [3], and the cultivation of design intuition [4]. While the latter can be useful with respect to the aesthetic aspects of lighting design, it can make conceptual change, a key component of science education [5], more challenging. When responding to a problem or situation intuitively, students often accept their existing conceptions of the scientific and technical aspects of lighting, some of which are incorrect.

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## 2. Conceptual Change in Lighting Education

Since architectural lighting is intended to support the vision of building occupants, an understanding of the human visual system is important for understanding how lighting affects visual perception. However, students have significant personal experience with both light and the use of vision, and this *experience* is often mistaken for *expertise*. As a result, misconceptions about the ways in which light influences visual perception are common.

### *2.1 Color Vision*

Regardless of whether students have a technical or design background before studying lighting, they have inevitably learned that the spectrum of light determines its color. Students typically interpret this information to mean that the human visual system perceives color by encoding the spectrum of light and that differences in the spectral power distributions between different light sources will necessarily yield differences in color appearance. This conception leads to a number of conclusions, most notably that any particular wavelengths of light that are not present in a light source's emission will negatively affect the color appearance of illuminated surfaces. In practical lighting applications, this has important consequences.

However, the visual system does not actually encode the spectral power distribution of light that enters the eye. While the light's wavelength composition affects the probability that it will be absorbed by photoreceptors (and, therefore, generate a neural signal), the neural signals generated when photons of different wavelengths are absorbed are indistinguishable [6]. The visual system combines and compares the neural activity of the different photoreceptors to ultimately perceive color [7], but no spectral information is captured in the neural signal.

This is a crucial concept for architectural lighting design. It means that light sources do not need to have identical spectral power distributions to have the same color appearance. It also means that illuminated surfaces can have appropriate color appearances even when light sources do not emit all wavelengths of the visible spectrum. At the University of Sydney, these color vision concepts are taught in a traditional lecture format. Students are challenged to apply this knowledge to realistic lighting situations in an assessment task.

### *2.2 Visual Adaptation*

Most lighting students have been exposed to, to at least some extent, the concept of visual adaptation prior to commencing their studies. They have learned and/or experienced that the visual system becomes less responsive to particular attributes of a visual stimulus or scene after sustained exposure to it. Presumably relating this phenomenon to their own experiences of being unable to continuously maintain particular activities, the perceptual consequences of adaptation are often assumed to be the result of fatigue of the nervous system. As a result, it is often presumed to be a deficit or shortcoming of the visual system.

In most cases, visual adaptation does not arise from a depletion of neural resources or other form of fatigue. Instead, adaptation reflects the ways in which the visual system calibrates to the visual environment [8]. This enables the visual system to amplify changes and differences in visual scenes, as well as maintain relatively consistent perception of stimuli in different viewing conditions. Visual adaptation has important consequences for architectural lighting design, as the visual system is tolerant of substantial variations in visual stimuli caused by differences in illumination.

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