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# Teaching light

## *Constructing knowledge across multiple dimensions*

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**Abstract.** *Light is a potent condition of architectural ambiance; its many dimensions defy classification as art, science, or function. This paper proposes advancing the teaching of light by utilizing a pedagogical framework grounded in constructivist learning and cognitive flexibility theory. The framework presents multiple representations of light, enabling the learner to develop flexibility in “criss-crossing” its various dimensions while acquiring authentic knowledge for application to unique design problems. The overarching goal is to empower designers with self-constructed knowledge of light’s aesthetic, experiential, physical and functional aspects in order to harness the full potential of light as architectural ambiance.*

**Keywords:** *light, lighting, architecture, pedagogy, cognitive flexibility*

### Introduction

This paper is concerned with advancing methods in teaching light and lighting in ways that empower designers to realize the potency of light in shaping architectural ambiance. Considered both a condition and a modifying element of architecture (Unwin, 1997), light plays multiple roles, layered upon one another, often producing alchemy of unexpected effects. While light is first and foremost a necessary commodity, this paper presumes that light has inherent influence in shaping the visual and affective experiences of architectural space. With design’s tendency toward visual paradigms, the capacity of light to render and compose form, space and material represents critical knowledge for the designer. Architect Jean Nouvel<sup>1</sup> notes: “For me, light is matter, and light is a material... once you understand how light varies, and varies our perceptions, your architectural vocabulary is immediately extended, in ways classical architecture never thought of.” Likewise, light plays a significant role in marking time and place, stirring memory, and communicating meaning.

The ubiquity of light in architectural concerns transcends aesthetic, technological, and functional perspectives. Moreover, each design problem is a unique case, requiring original assembly of concepts and knowledge. Therein lies the pedagogical challenge: how to provide the learner meaningful opportunities that foster deep understanding of the potential of light and lighting. Leveraging Rand Spiro’s theoretical construct Cognitive Flexibility Theory (CFT), this paper considers constructivist methods and presents a framework for consideration of multiple dimensions of light – light as composition, light as experience, light as substance and light as commodity. The goal is to facilitate cognitive flexibility around the complex issues that emerge at intersections of light, design, and the human condition.

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1. [www.post-gazette.com/ae/20020406nouvel0407fnp2.asp](http://www.post-gazette.com/ae/20020406nouvel0407fnp2.asp) - accessed July 2011.

## Pedagogical framework

### *Current curricular practices*

Lighting education is typically assigned to the technology domain of design curriculums. The goal is to provide broad orientation to the science, principles, and practices of light and lighting. Such courses are generally lecture-format, grounded in teacher centered, deductive methods. Learning and assessment is based on recognition, recall, and simple application. This type of course provides adequate methods for introductory learning but problems arise when transferring the knowledge to more complex cases. To illustrate: daylighting strategies in studio projects are often presented with oversized apertures, inadequate sun control, and lack of coordination with electric lighting and interiors. It is apparent that the student has not constructed an understanding of the behaviors or intensity of natural light, nor is he equipped to reassemble a daylighting schema for the particularities of the project. In this case, a basic daylighting schema was retrieved from the introductory course and applied to the design problem in an oversimplified manner, resulting in a flawed transfer of the material. Light's role architectural ambiance is even more challenging. For instance, consider the condition of "ephemeral light". Developing this idea requires conceptual fluency and tools of visualization; unlike the more structured problem of daylighting, there is no pre-packaged schema to draw from. These examples highlight the need for an intermediate stage of knowledge acquisition around light and lighting; this stage requires methods markedly different from those used in introductory courses.

### *Cognitive flexibility theory*

Constructivist learning forms the basis of design studio education. Knowledge is self-constructed through a learning spiral grounded in experiential processes: concrete experiences, reflective observation, formation of abstract concepts, and active experimentation in new situations (Kolb, 1984). The primary method in studio is to guide students in developing personal and disciplinary constructs, building upon previous learning while integrating new information.

Cognitive flexibility theory leverages constructivist methods to support advanced knowledge acquisition in complex, ill-structured knowledge domains. Design, like law and medicine, is considered an ill-structured domain, characterized by many concepts interacting contextually in unique patterns and cases; in other words, the problems are messy and irregular rather than finite and linear. Problems in these fields require "the ability to adaptively re-assemble diverse elements of knowledge to fit the particular needs of a given understanding or problem-solving situation" (Spiro *et al.*, 1992). The learner must develop a pliability of thought (cognitive flexibility) in order to consider novel applications of the available knowledge. CFT recognizes that introductory teaching enables oversimplification and misconstructions of difficult material as was demonstrated with the daylighting example. For advanced learning, CFT promotes multiple representations of the information and contextual applications. Flexible instructional methods help students learn the contours and complexity of the material that they are studying, and it helps them work with that content from several different perspectives (Spiro *et al.*, 1992). This type of learning environment nurtures development of neural pathways that facilitate navigation within multi-faceted knowledge domains.

Considering light's inherent overlapping knowledge domains -- aesthetic, technological, and functional -- layered unto the ill-structuredness of design problems, the CFT model provides an insightful perspective for advancing pedagogy in this area. First, it establishes that introductory courses alone are insufficient in preparing students to work with the material within complex problems. Second, it promotes methods of study that are familiar to design educators including discovery, knowledge construction, and case-based instruction. Lastly, it rec-

ognizes the need to access multiple knowledge domains to develop original constructions and applications of the material.

## Methods

Humans have untold experiences with light; it is the primary means we use to “know” our world. Yet this immense range of exposure is primarily passive and ironically, does not often result in retrievable knowledge about light’s physical behaviors, impacts, qualities, or intensities. Branston (2008) observes: “My experience in teaching at several universities these past 40+ years has proven to me that most of the students who came to learn lighting had never first learned to see... it seemed they had no power of observation... it was simply that no one had taught them ‘to see’”. He argues that the “process of learning to see” is the “simplest defining characteristic of lighting” and suggests that disciplined observations of light will build “a databank of real knowledge which can serve in any capacity as we design our lives”. Therefore, the method is fundamentally grounded in developing powers of observation and analysis.

The proposed method of teaching varies considerable from introductory courses; rather than deliver information, the method employs the idea of cognitive scaffolding to support student learning through direct encounters with light. The scaffolding conceptually mediates four dimensions of light: composition, experience, substance, and commodity. The emphasis is to encourage discovery through tools: tools of observation (the eye), of recording (the camera, the mind), of measuring (meters, the eye, the mind), and of representation (modeling). The premise is that by actively engaging these tools, the mind will consciously and flexibly build constructs around light and lighting, connecting new observations with past experiences. The intent is to empower the student with new uses of familiar tools to both to enable light to be considered in broader design contexts.

### *Light as composition*

*“Through light the physical world is able to undergo a heightening of existence, its lifeless chunks turned into ravishing and incandescent fabrics.” (Plummer, 1993)*

The first dimension, *Light as Composition*, focuses on the two-dimensional aesthetic and compositional potential of light. Based on Ching (1979), light is considered through the context of building blocks of design; as a primary element (point, line, plane, volume); as a visual ordering principle (rhythm, repetition, patterning hierarchy, symmetry, transformation); as contributing to spatial organization (centralized, linear, radial, grid, clustered); and as a modifier of space and form (expansion, contraction, privacy, directionality, temporality, performance, animation). This tactic builds on the familiarity of basic design concepts while introducing light as a primary visual media in the designed environment. With models, the eye and hand are conjoined in iterative abstract experimentation, building literacy around light as it encounters form, illuminates space, and is filtered by material. Photography builds skills in observation and encourages reflection. The emphasis is on developing the ability to “see” and to “make” through codification and appreciation of light’s visual impacts.

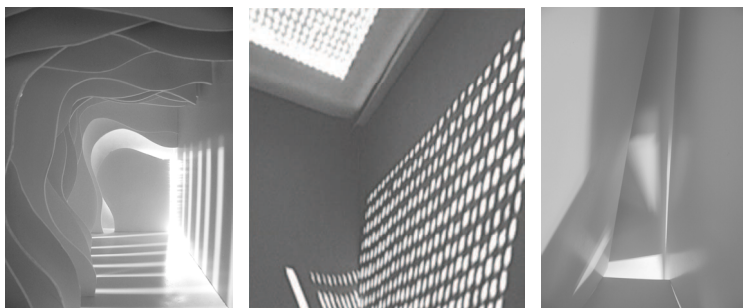


Figure 1. Models studying light as a compositional element

### *Light as experience*

*“Light gains character as it touches the world; from what is lighted and who is there to see. I associate the significant moments of my life with the character of the light at the time.”*  
Wilmarth<sup>2</sup>

The second dimension, *Light as Experience*, focuses on three-dimensional environments, emphasizing atmospheric impacts on the human psyche. Drawing from phenomenology, light is part of the circumstance, the moment, the message, and the place. Light is metaphorical, poetic, situational, and temporal. Light provides cues on how to act, where to go, what to feel. A successful tactic for this dimension of light is to use literature as an inspirational starting point. Fiction and travel writing is particularly rich with descriptions of light and experience; deft narratives challenge the designer to develop similar skill in shaping the ambiance of architectural space. Drawing, model making and photography are used to study this dimension, creating intimacy with the material and processes. Computer tools are less useful. Pallasmaa (2005) observes: “The computer creates a distance between the maker and the object, whereas drawing by hand as well as model-making put the designer in to a haptic contact with the object or space.”

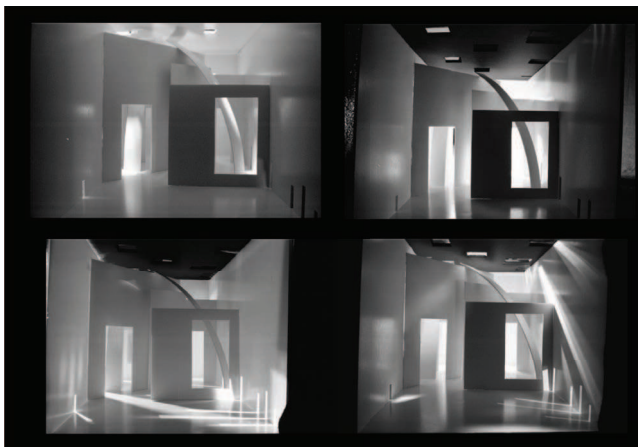


Figure 2. Model studies inspired by literary description (Singleton)

2. <http://research.the-bac.edu/neologism/index.htm>

### *Light as substance*

*“Space remains in oblivion without light. Light’s shadows and shade, its different sources, its opacity, transparency, translucency, and conditions of reflection and refraction intertwine to define or redefine space.” (Holl, 1991)*

The third dimension, *Light as Substance*, focuses on the physical nature and behavior of light. The first emphasis is on the light source itself: color, intensity, directionality, movement, and heat. The second emphasis is concerned with the gathering and transference of light through apertures, filters, and surfaces. This study is grounded in structured observation and experimentation; empirical data is collected with meters and photography. Students are encouraged to use visual representation for comparative analysis. The goal is to develop a “feel” for the physical variables of light and the ability to quantify and predict properties and behaviors of light.

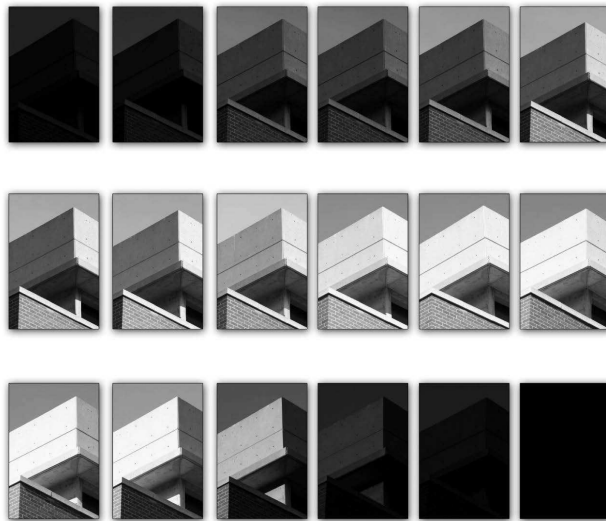


Figure 3. Photographic documentation of shifts in color and directionality throughout a single day (Dompier)

### *Light as commodity*

*“Experience indicates that it is essential for architects to personally appreciate the luminous environment of a space and to compare several solutions quantitatively and qualitatively. This intuitive appreciation obtained by scale models and the 3D perception of the light distribution cannot currently be obtained by use of computer simulations.” Bodart<sup>3</sup>*

The final light dimension, *Light as Commodity*, is concerned with the complex integration of natural light with architectural, interior, and functional needs. The focus is on developing knowledge and processes that can help designers to “get it right”. Simple physical models, built to scale and with representative materials, provide immediate and tangible feedback on daylight quantity and distribution. Using the sun and sky as source light provides accurate and realistic predictions of a full-scale space. Students are encouraged to reiteratively test architectural and interiors strategies to discover the nuanced impacts of design decisions. Meters and photography provide evidence of light intensity and distribution.

3. [http://da.velux.com/ar-LB/Documents/PDFs/DA06\\_complete.pdf?brochurepoints=0](http://da.velux.com/ar-LB/Documents/PDFs/DA06_complete.pdf?brochurepoints=0)

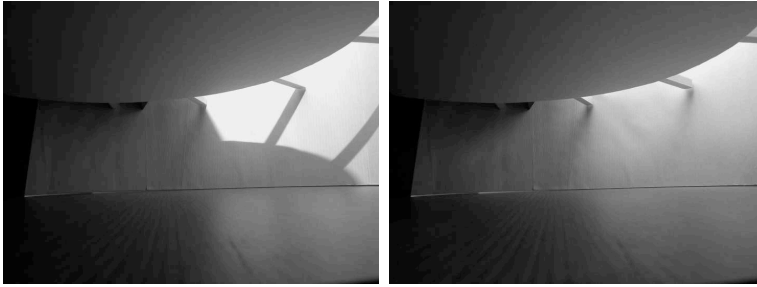


Figure 4. Model studies comparing conditions of sunlight and skydome

## Reflections

Light presents as an unusual and elusive subject to study: paradoxically, it is invisible until revealed by physical matter while simultaneously modifying the matter itself. In doing so, it becomes a primary condition of architectural ambiance, profoundly affecting the aesthetics, character, mood, and message. The point of this paper is to reinforce and expand pedagogies to promote advanced skill in conceptualizing and integrating light within ill-structured architectural problems. Importantly, students need opportunities to build multi-dimensional constructs around light in order to develop the flexibility needed to assemble schema appropriate to the concept or problem at hand. The framework presented is designed for initiation into multiple areas of the curriculum: as short studio projects, as exercises in subject courses, as charettes, or as a stand-alone course. The tools and approaches are available at all levels of design education. While it might be argued the methods are simple, perhaps even reductive, the intent is to develop learning habits that are constructivist in nature, thereby encouraging a continual process of knowledge acquisition.

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