Designing with Light:
A Studio Investigation

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BACKGROUND

> Every architectural form, every building or group of buildings, regardless of the practical purpose or expressive need that formed it — stability. comfort, economy, or symbolic meaning — is a visible form built from differences of light qualities, created by different hues, textures, opacities, and transparencies of its materials. Without our perception of these patterns of light, our distance sense, our appreciation of the qualities of our wider space would completely disappear and our space would shrink to the reach of our fingertips. [1]

Light and shadow are the primary means by which we perceive and understand the world around us. In architecture, space is defined and comprehended by our perception of light and shadow. At the same time, light and shadow are appreciated and understood as they intertwine with architectural form. Louis Kahn wrote: "The sun does not realize how wonderful it is until after a room is made. A man's creation, the making of a room, is nothing short of a miracle. Just think. that a man can claim a slice of the sun."[2] With an understanding of the mutual dependence of light, shadow, and architectural form, the manipulation of these elements to create space is the intent behind the "Space and Light" multi-level, multi-disciplinary design studio.

The University of Idaho is located in a unique geographic area of the country known as "the Palouse." To live surrounded by the rolling hills and big sky of the Palouse is to have the opportunity to observe continuously changing natural light. The "Space and Light" studio attempts to raise students' awareness of the drama of environmental light and to develop a sensitivity to both the diurnal and seasonal changes of light. As makers of designed environments, students begin to explore both natural as well as electric methods and means to bring the power of this light into designed settings.

It is relatively recently in the history of architecture, particularly with the advent of electric light, that buildings could be designed without a dependence on daylight as the primary lighting source. For an historical perspective. one has only to refer to Vitruvius' *Ten Books of Architecture* from the 1st century B.C. in which the author devotes an entire book to the analysis of the movement of the sun, moon, and stars. The capturing of light was one primary objective of the builders of Gothic cathedrals. Suger of St. Denis was a notable early figure in the development of the Gothic style, religiously dedicating his works to "be conveyed in this material world through richly refractive, light-filled effects – through precious stones, stained glass, and an architecture that reduced matter as much as possible and made the walls transparent."[3] The skill and practice of manipulating daylight in particular diminished somewhat in the early and mid-1900s due to widespread access to electric lighting. Although these skills have been rediscovered and developed in recent years, particularly with enhanced emphasis on energy conservation, daylight is still often supplementary and secondary rather than an essential factor in design.

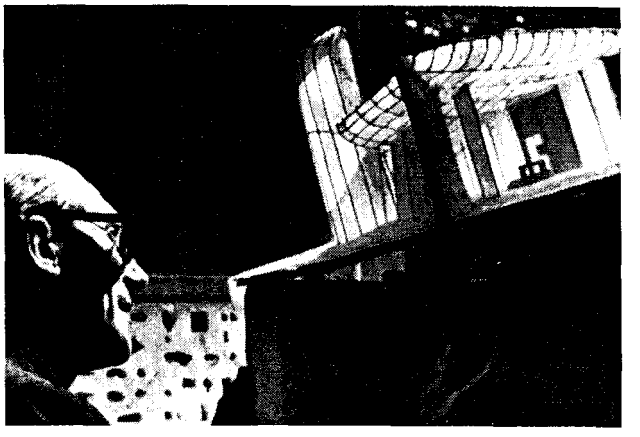

Fig. 1. Le Corbusier.

In addition to the diminished focus on daylighting as a primary light source in design, the methods by which daylighting skills are taught is often disconnected from the design studio. In many contemporary schools of architecture, fundamental teaching about light and lighting occurs primarily in a lecture format. In contrast, design coursework is

generally programmatically driven, with lighting design issues thrust into a secondary role along with a myriad of other elemental design issues. While this is perhaps an appropriate model for most studios in order to professionally train future architects, the studio model presented here offers an example that simultaneously focuses on design while also acting as a supplement to lecture coursework by challenging students to creatively practice the art of lighting design in the studio. While this is not a model intended to replace the typical studio format, it is intended as a studio option to enrich the education of upper division design students.

STUDIO DESCRIPTION

This design studio is a multi-disciplinary, multi-level studio, including 4th and 5th year architecture and interior architecture students. The mixture of disciplines as well as academic levels enriches the studio experience, combining different levels of expertise and emphases that students share with one another on the assigned projects. The students that have completed an environmental controls systems course, which includes daylighting studies, have a slight advantage due to their knowledge of the sun's movement as well as an initial understanding of methods to control the sun's effect on a building's internal environment. However, this advanced knowledge is not a prerequisite for the studio and does not appreciably inhibit the students' design solutions, particularly as the emphasis of this course focuses on an empirical manipulation of both daylight and electric light.

PEDAGOGICAL OBJECTIVES

In contrast to the programmatically driven studio, the pedagogic approach for this studio is to investigate and use light and shadow as primary design materials, with the goal of producing dramatic spaces through the manipulation of both daylight and electric light. The programmatic functions of the assigned projects are secondary to the goal of designing with light. In most cases, daylight is the primary light source for these designs, optimizing this source as an effective tool not only to create dynamic spaces but also to promote energy efficiency. Secondary electric lighting sources are examined and chosen to integrate with the daylighting systems, including a critical examination of lamp types as well as light levels. Further, while energy efficiency is not an explicit goal of the studio design projects, it is an implicit by-product of the focus on daylighting design. As such, focusing on the manipulation of daylight in interior spaces supports an energy conscious ideal that is appropriate given an overall global diminution of natural resources.

METHODOLOGY

The studio assignments focus on the aesthetic symbiosis of space, light, and shadow. The series of design assignments progress from the analytical to the investigative to the functional in their foci. The design exercises are supported with assigned readings, lectures, discussions, fieldtrips, and films.

For all of the assignments, the primary media of large and full scale models for design investigation is fundamental (generally 1/2" scale). Required use of three-dimensional computer models is also in experimental stages, primarily utilizing the Lightscape light modeling program, with mixed success.[4] Principally due to limited hardware, computer modeling in this studio is used primarily as a presentation rather than as a design tool. The goal for future offerings of this course is to strengthen and expand the use of computers for designing with light. Also, though accessible computer technology is becoming more readily available that more accurately models light, the tactile nature and the three-dimensional immediacy of the physical examples continue to make the physical models indispensable design tools for the students. These models are not only essential for analyzing light effects, but this method has promoted a highly investigative approach toward spatial manipulation in the studio. As the interior surfaces are modeled appropriately for texture and color, working with the large models focuses students' attention on the importance of materiality and detail in addition to light manipulation. The students also analyze the light manipulation depicted in their models primarily through slide photography and drawing. As with all good physical light models, the exteriors are functional but otherwise unattractive.

To further understand the quality of the light in these exercises, students quantify their results with the aid of handheld light meters and computer-programmed remote light sensors (HOBOS,) to analyze lighting trends.[5] While less important in the exploratory design exercises of the studio, this numeric analysis is important for the more functional exercise as a method toward creating simultaneously usable and dramatically lit spaces.

THE ANALYTICAL

> *I do not believe that architecture should speak too much. It should remain silent and let nature in the guise of sunlight and wind speak. Sunlight changes quality with the passage of time. It may gently pervade space at one moment, and stab through it like a blade at the next. At times it is almost as if one could reach out and touch the light.*
>
> *– Tadao Ando from* ***Buildings,*** *Projects, Writings*

The first assignment involves the construction and examination of large scale models of prototypical dramatically lit architectural spaces, including works designed by Jørn Utzon, Tadao Ando, Renzo Piano, Alvar Aalto, and Louis Kahn. Particularly due to the remote location of the University and the inability to visit several exemplary daylit buildings, the physical construction of these spaces gives students an opportunity to simulate the "experience" of these spaces.

The primary goal of this assignment is to physically demonstrate the importance of daylighting as a dynamic and

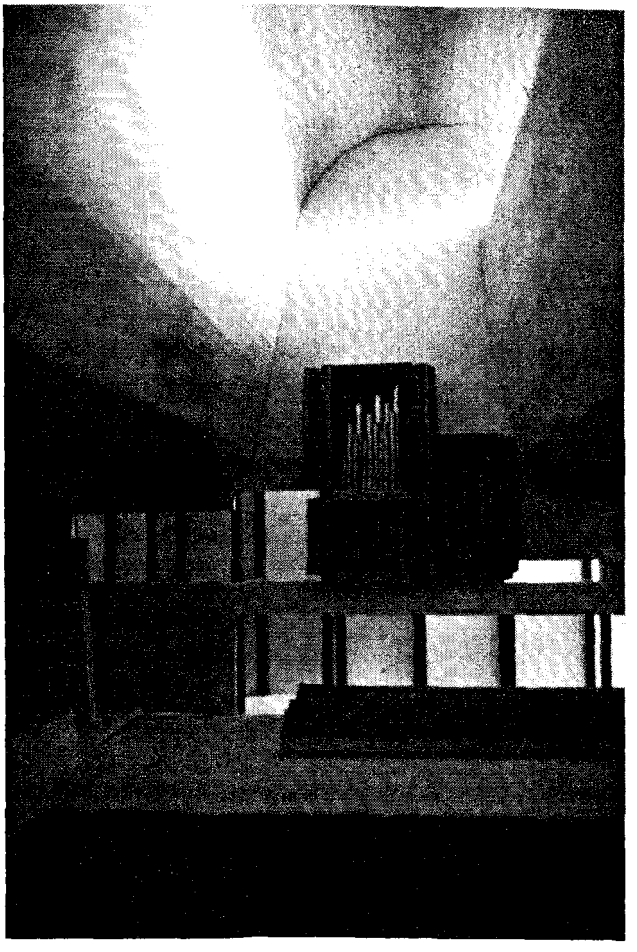

Fig. 2. Bagsvœrd Church, Jørn Utzon. Modeled by students Karl Woods and Bill Futrell.

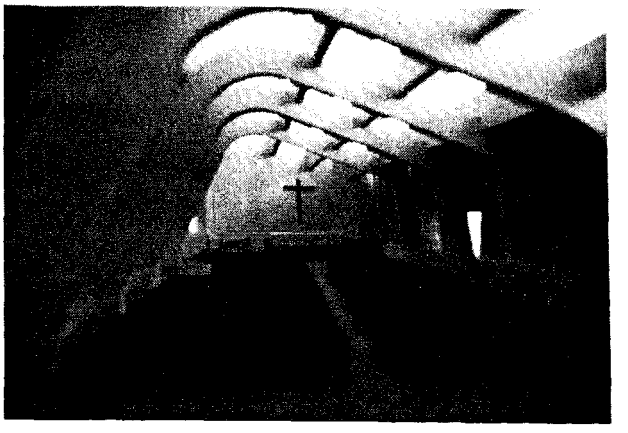

Fig. 3. Riola Church, Alvar Aalto. Modeled by students Chad Alldredge, Wayne Gehring. Scott Mizee, Rudy Olsen, and Lesa Stutz.

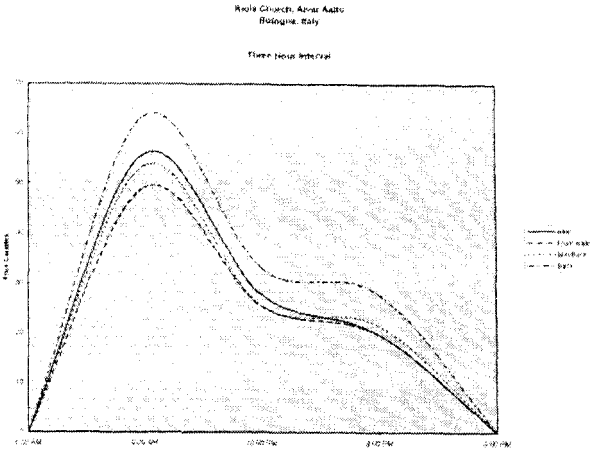

Fig. 4. Hobo analysis of Riola Church.

constantly changing force in architectural design, varying from hour to hour as well as from season to season. Every passing daylit moment presents new colors, positions, and qualities of light. As a dynamic source, daylight offers the designer an opportunity to explore the variety of architectural experiences that its constant motion brings to a space.

The students analyze these exemplary spaces not only for the dramatic manipulation of daylight but also for the science behind this manipulation. The models provide an opportunity to examine the architectural mechanics of the light manipulation in a more direct way than two-dimensional drawings or photos. This analysis provides an excellent "warm up" for the succeeding design assignments. In addition, students also measure the light levels in these spaces, thereby assembling a quantifiable translation to the visual and experiential quality of the light in the prototype models.

The capstone to the analytical exercises is a fieldtrip to a nearby metropolis to visit buildings and lighting design professionals. Students examine both daylight and electric lighting conditions during the various site visits. Continuing the exercise begun with the prototype models. students measure illuminance levels at the site visits in order toquantify the quality of light in the spaces.

THE INVESTIGATIVE

> Night and day: the daily cycle of the sun and the moon creates a rhythm of changing light – shadows advance and retreat, sweeping the ground like the hour-hand of a clock; the mountainside which was dark against the dawn sky catches the last rays of the evening sun....Seasons: the cycle of summer and winter is reflected in the growth and decay of the earth's vegetation, transforming the landscape in colour and form....[6]
>
> With light as the palette, architecture can be supreme in the arts. It is a source of expression that we tend to ignore and the one aspect of architecture that we cannot divorce from meaning in our determined nihilism as long as night and day and sun and moon work their pattern upon us. It is with light that we can bring soul and spirit back into architecture and perhaps find our own souls in the process.'

Following the prototype investigations, students are asked

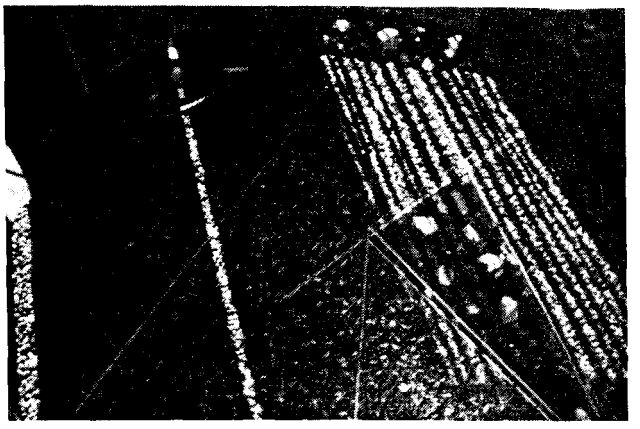

Fig. 5. Student: Perryl Gray. An investigation of light movement and material texture.

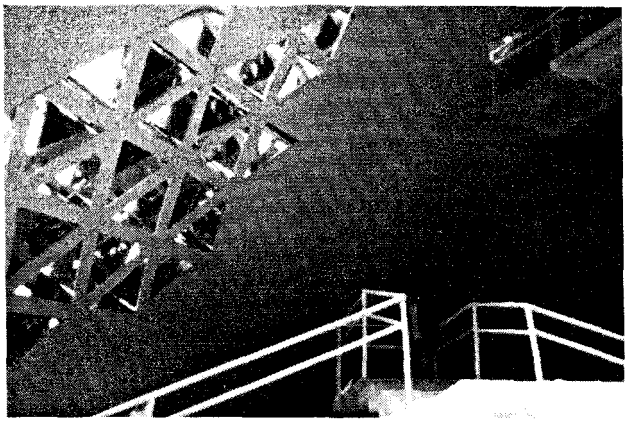

Fig. 6. Student: Mario Paiz. Exploration of the interior effects of a seasonally changing exterior environment.

to design an architectural "timepiece" in order to understand and to capture the power of the sun as a dynamic light source. In addition to the stipulation that the designed structure is required to "tell time," students also investigate the manipulation of structure, texture, depth, distance, direction, and color in relationship to environmental light.

The project assignment highlights the example of Stonehenge as a structure that acts as an intermediary between man and earth, sun and time. In this spirit, students are challenged with rhe design of a meditative space that glorifies both light and the passage of time. Although our relationship to the earth and sun is just a vital as it was to the Stonehenge builders, contemporary society is generally disconnected from man's essential dependence upon the sun and its movement. This assignment asks students to ponder this general lack of connection to the cosmos and to design a building form that refocuses our attention on the sun's movement. Apart from creating adramatic space that captures the movement of the sun, there are few programmatic requirements. Students are given a site on the local landscape. Because this is intended as a three-dimensional exercise, the students were restricted to a maximum volume for their designs (25,000 cubic feet).

THE FUNCTIONAL

> The art of chiaroscuro is a skill of the master architect as well. In great spaces of architecture, there is a constant. deep breathing of shadow and light; shadow inhales, and illumination exhales, light.....In our time light has turned into mere quantitative matter....[8]
>
> So benumbed are we nowadays by electric lights that we have become utterly insensitive to the evils of excessive illumination."

To reinforce the idea that the dramatic use of light can be applied to a "functional" space, an existing space is used as a basis for this final exercise. Applying their accumulated knowledge, this exercise challenges students to transform an existing structure using light as the primary formgiver to meet some given programmatic parameters. This design problem further highlights the functional requirements of light for specific tasks, the influence of different light types on perception, and the effect of episodic manipulation of high and low intensity light. Part of this assignment also includes the design and construction of a full scale "light" fixture (using daylight or electric light) in one case and the simultaneous physical and computer modeling of the space in another.

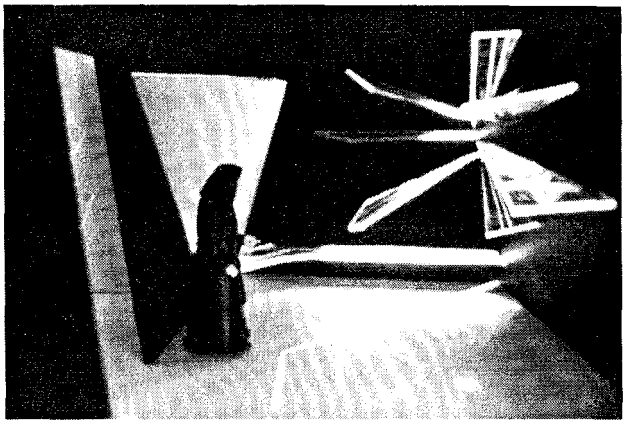

Fig. 7. Student: Rudy Olsen. Investigation of reflected and refracted light.

To highlight one example, a local existing warehouse structure was used for the final exercise. With the primary objective of creating a dramatically lit and usable space, the students were to design the space to function as a food cooperative. The existing building was a 13,000-square-foot warehouse structure originally designed as a small grocery store. The most significant lighting features in the existing structure included large south facing windows (the only daylight for the building) and open strip fluorescent electric lighting.

To determine how much light would be practical in this new grocery store, students were asked to measure illuminance levels of several different types of local grocers. They discovered that the illuminance levels in many of the larger

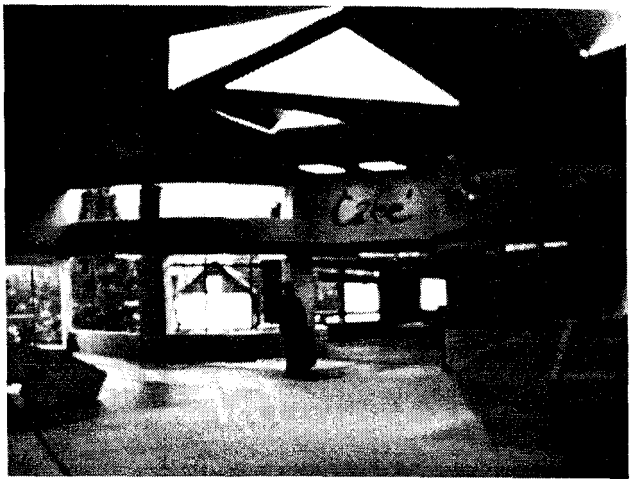

Fig. 8. Student: Derk Garlick, Food Cooperative Design

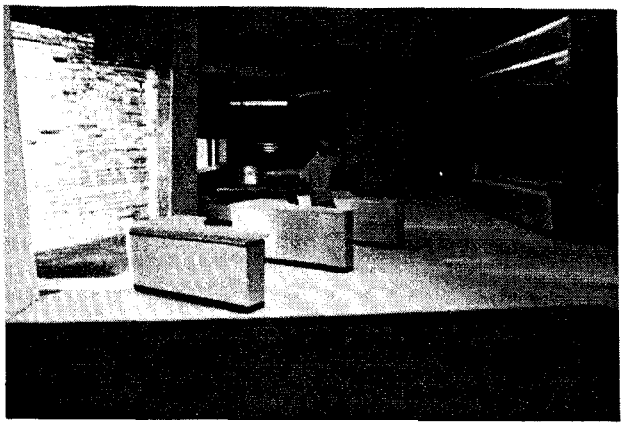

Fig. 9. Student: Mario Paiz, Food Cooperative Design

"chain" stores were generally high with very little fluctuation. As a result of these examinations, several of the student designs proposed moderate episodic fluctuations from higher to lower light levels according to the activities occurring in the space. Several students also questioned the high light levels in some of the measured spaces and as aresult, reduced these levels in their final designs."'

As another warm-up exercise for this design problem, students were assigned different generic electric light sources as well as different food groups to examine firsthand the effects of the light sources on perception. The assignment included altering the perception of the assigned food display to either make it appealing or distasteful. Though not designed to be a scientifically controlled experiment, the exercise did succeed in demonstrating to the students the dramatic effect that light can have on perception, and in this case, particularly the effect of light on the marketing of food.[11]

A primary objective for the overall design exercise was to use daylight not only as a dramatic device but also as an energy saving light source. Rather than mimic the typical American grocery store design that relies heavily on general electric lighting, students strove to utilize electric lighting as a supporting and not a primary lighting system. Several discussions in the studio centered on the topic of daylight as a medium to connect people (in this case, shoppers) with the environment. The question became, "Do people need (or want) the same amount and quality of light regardless of time of day or season?" In general. the student design solutions offered an alternative to the clinically lit grocery spaces that the students had analyzed. To reinforce their qualitative design proposals, students again measured illuminance levels in their large scale models using handheld instruments and remote data loggers.

In another example, students were asked to transform a former retail carpet warehouse into College of Art and Architecture facilities. The new space included galleries, studios, offices, as well as common work and gathering spaces. While many of the supporting exercises were similar to the previously described assignment, the notable difference for this assignment was the required use of a three-dimensional computer model using Lightscape in conjunction with the 1/2" physical model. While the success of the computer modeling was mixed as noted earlier, it was a valuable learning experience to compare and contrast the light modeling in the two model types, using each for their particular strengths. This area of the course will be developed further in future offerings.

CONCLUSIONS

The series and sequence of the assignments for the "Space and Light" studio, from the analytical to the investigative to the functional, enhances the students' level of creative investigation and their understanding of light as a building material. This is particularly apparent by the time they reach the final and most functional of the assignments. In modifying an existing structure to meet a functional program, the students demonstrate their ingenuity in the manipulation of architectural form to capture light and shadow with a level of skill and creativity that the preceding exercises helped to cultivate. By focusing the design assignments on the quality and aesthetics of daylit spaces with supporting electric lighting systems, the overall studio experience is an excellent forum for assisting in the development of vital design skills for creating effective, dramatic, and efficiently lit architectural spaces.

By emphasizing the use of light as a design material, the implicit goal of the studio is to transcend formulaic lighting solutions by encouraging the creative manipulation of light in design. There are many benefits to this approach towards designing with light, ranging from the creation of dynamic design that appeals to the senses, to the promotion of energy efficiency. In addition, by utilizing primarily a dynamic source of light – the sun – for the projects in the "Space and Light" studio, the result is dynamic design solutions. Even with the "functional" problem, each of the student design solutions capitalized upon the dynamism of environmental light. By using the omnipresent and "free" material of daylight, students begin the process of connecting their archi-

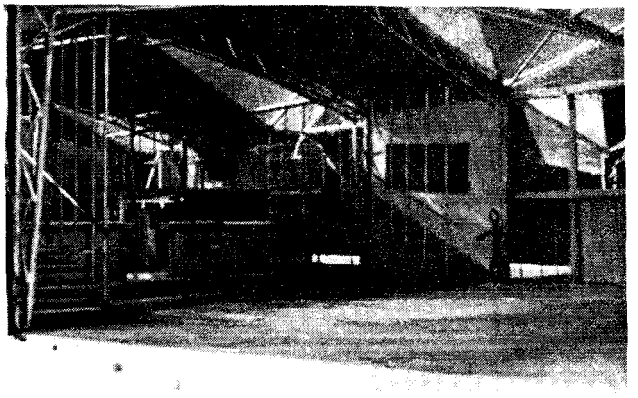

Fig. 10. Students Gerry Doering and Chris Dillard, Adaptive Re-Use Project.

tectural designs to the external environment in a manner similar to the ancient builders of Stonehenge. Thus, students in this design studio begin to comprehend architectural light as something greater than a man-operated, switch-controlled element, and more as an dramatic, active, and defining force within architectural design.

> Architecture being the masterly. correct and magnificent play of masses brought together in light.....[12]

NOTES

1 Gyorgy Kepes. "Design and Light." *Design Quarterly* 68 (Minneapolis: Walker Art Center. 1967).

2 John Lobell, *Between Silence and Light* (Boulder: Shambhala Publications, 1979), p. 38.

3 Spiro Kostof, A *History of Architecture: Settings and Rituals* (New York: Oxford University Press. 1985), p. 323.

4 A number of factors are inhibiting expanded use of computer modeling for this studio. A general lack of sufficient computer hardware represents the most significant barrier. Further, while our initial experimentation with *Lightscape* has produced excellent results, the steep learning curve to become proficient with the program has thus far limited its use in the design studio.

5 The weaknesses of Hobo technology limit their expanded use in the studio, as the sensors are not as reliably accurate in measuring exact light levels as handheld meters. However, they are useful for understanding and analyzing lighting trends in a space over a given period of time.

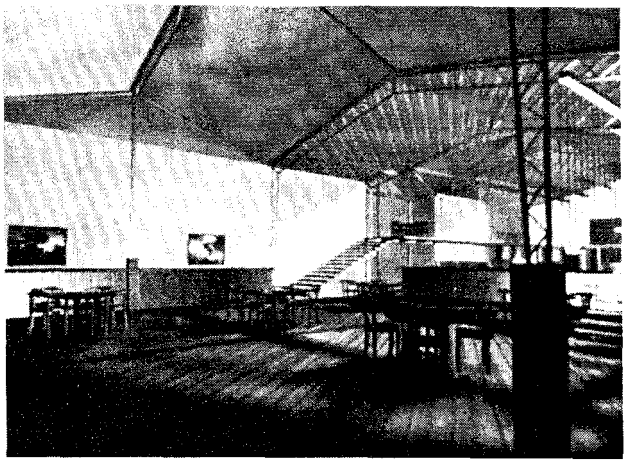

Fig. 11. Students. Gerry Doering and Chris Dillard, Computer modeling of an Adaptive Re-Use Project.

6 Nichlos Humphrey. "Natural Aesthetics," *Architecture for People* (Holt Rinehart Winston, 1980).

7 Arthur Erickson. "The Weight of Heaven." *The Canadian Architecture* 9 (1964). p. 50.

8 Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses* (London: Academy Group Ltd., 1996).

9 Junichiro Tanizaki, *In Praise of Shadows* (Stony Creek: Leete's Island Books. 1977).

10 As a class we discussed the differing biological requirements for light levels according to age and particularly the need for higher light levels for the elderly. However. the slight lowering of light levels in some student projects was not significant. particularly given the broader focus of this studio.

11 Though this test was rather rudimentary, the results were predictable. Students generally discovered that "warmer" lights performed the best in their food lighting displays (halogen, incandescent, and even candlelight!), while the poorer performers included cooler fluorescents and "blue" lights.

12 Le Corbusier, *Towards a New Architecture*, (New York: Dover Publications. Inc., reprinted 1986). p. 37.