Dining in Daylight

A study of the use of daylight in a faculty dining hall in Muncie, IN:
Programming, Strategy, and Examples

A Creative Project
By Tyler Sanders

Project Advisor:
Jonathan Spodek

Ball State University
Muncie, Indiana
April 2008
May 3, 2008
Abstract

Human energy consumption is causing a negative impact on our world. While technology and civilization advance into the future, nature is often forgotten as we overindulge in the abundance of current resources. We have the ability to lessen the impact human society has on the Earth, but it is only recently that a push has been made to spread the message of responsibility for our actions. The energy consumption in buildings contributes more than any other single source of consumption; therefore, contemporary architects have, in many cases, become the forerunners of an eco-friendly movement.

One of the ways of achieving a more eco-friendly world is to utilize natural energy sources instead of creating the kind which is moderately efficient and creates waste. The sun is one of these sources, and so it is the goal of many contemporary architects to use natural light to light their buildings, and to understand how to control it so as to minimize the use of mechanical systems. This is the premise for this project.

Using natural daylight has other implications as well. While minimizing waste from mechanical systems and shrinking the impact the building has on the environment, using natural light has also been found to improve human performance. Natural light enhances a space and satisfies human needs.

The purpose of this project is to use lighting as a design determinant for a restaurant in Muncie, IN. This should help in the process of learning how to use natural light as an architect. The following paper contains the programming aspect of designing with light, some strategies for using natural light, some examples of architecture using natural light, and a conclusion, showing how I used natural light in the final design. The CD-R holds images of the presentation boards and scale model of the final design.

Acknowledgements:

-I want to thank Jonathan Spodek for his advisement through this project. He was very helpful in the brainstorming, researching, and editing processes.

-I want to also thank Glen Sweitzer, as he taught the class which inspired me more than anything else to use natural light in my design projects.
Daylight in the dining space

Day-lighting is employed whenever possible in contemporary architecture because of two main factors: energy conservation and human need. Using daylight instead of electricity can drastically improve energy costs in many geographical locations and also satisfy the human need for natural light.

Designing a public dining space for the use of natural light requires an understanding of the activities that are to be conducted within that space. As in any space, the activities within can be anticipated to understand what quality and quantity of light are required; from there one can begin to design the space. In the public dining space, the following activities have been programmed: 1) Eating, 2) conversation, 3) reading/writing, 4) food service, 5) food display/buffet. The following conclusions can be found in the sources by Wilhide and Lechner.

Eating is an activity which requires seeing the texture and color of what one is eating, otherwise it may be an undesirable experience. In order to see the texture, it is best to use light which is not completely diffuse, although a strong, directional light will make the food appear to be flat as well. Therefore in this space, the best solution is a combination of diffuse light and some highlighting to better see one's food. This way, too many shadows will not appear, and there will be sufficient light to see one's food. In terms of light quality, food is best viewed under a slightly warm or yellow light. From daylight, this can be achieved from sunlight, while the light from a clear or overcast sky can be somewhat blue. That light will still be sufficient for eating, though not as desirable; electric lighting may be employed to supplement it in certain cases.

Conversation requires seeing the person with whom one is speaking. People, similar to food, appear healthiest and most attractive in light which is ever so slightly yellow, or from the sun. The contours of a persons' face are also important to see, and so the requirements are the same as for eating. One should use some diffuse and direct lighting, with as much sunlight as possible.

Reading or writing is an activity which requires light from the side or from behind, but never from the front. Shadows make reading or writing difficult, so directional lights are undesirable. The specific color or the light is not extremely important in this case; any type of natural light will work.

Food service is essentially walking through a space with food, so the necessary requirements are simply to include enough light to see where one is going. Shadows may confuse someone about what is ahead, so diffuse light is best.

The final programmed use of the dining space is food display at the buffet. This use requires seeing the food at its best, though not necessarily every texture. The food should also appear warm and slightly yellow, so that it looks natural. These requirements are similar to eating, although there should perhaps be a stronger directional and more yellow light directed onto the buffet surface. Diffused light should be employed to eliminate strong shadows.
There are many other design considerations which lighting, specifically day-lighting, can fulfill, but only the five mentioned programming needs will be considered, as they are the only ones specific to this public dining space.

In designing spaces for daylight use, it is important to know if the strategies employed function as expected. The first type of designing, conceptual design, is a good way of planning for daylight use, but it cannot predict the actual effectiveness of the lighting design. There is a concept called the daylight factor which can be measured in a design to calculate its effectiveness. For the public dining space, the minimum daylight factor is probably appropriately placed at about 1%, although a higher percentage would also be effective, and probably more so. Certain uses like displaying food could use a daylight factor of up to 6%, and if one is attempting to read or write, he or she might enjoy 2% or 3%. Therefore, the design would benefit from a range of daylight factors.

Daylight Strategies

The general day-lighting requirements for the public dining are established. What strategies are there to daylight spaces, and how effective are they? The following strategies will be discussed in further detail: Orientation, room proportion, shape and massing, room surface conditions, side-lighting, top-lighting, reflecting surfaces, light shelves, and shading devices.

1. Orientation

Building orientation can have a great impact on day-lighting within the building. The sun-path diagram for 41 degrees North Latitude is shown, for Muncie. Using this information, one can find that the greatest amount of light comes from the south. That light is also from higher in the sky. Light from East and West are more Horizontal and less effective for day-lighting because they create too many problems. Therefore a building designed for greatest quality and quantity daylight should have the longer axis East and West, to accommodate the southern exposure.
2. **Room Proportion, Shape, and Massing**

A rule of thumb is that the higher the ceiling, the more even the light becomes. Therefore, ceilings should be as high as possible. Also, the light distribution in a small room with proportions ‘x:y’ will be the same as a large room with proportions ‘x:y’. Because of this, ceilings would have to be much higher in a deep room to match the distribution of light in a shallow room.

The shape and massing of a building also determine how well they can be naturally lit, especially if they are multiple stories. Longer, narrower buildings have greatest access to natural light. Buildings which have less surface area but greater mass will have less potential for natural light.

3. **Room Surface Conditions**

The reflectivity of room surfaces drives how light is distributed. The ceiling is generally thought to be the most important surface for reflectivity. This is because most surfaces receive the most light from above, rather than the sides. Even though the best distributed light comes from all-white surfaces in a room, that option is usually not suitable for other reasons. The best situations (for light distribution) from best to worst are: All white, white walls and ceilings with dark floor, white ceiling and floor and some white walls with dark walls, and white floor and walls with dark ceiling.

Since the amount of light varies and the light-demands of a task vary, only testing can provide information regarding the effectiveness of room surface conditions. Textures and colors can also vary the room perception dramatically.

4. **Side-Lighting**
Lighting from the “side” of a building is usually desirable and commonplace because it offers views as well as light. This type of lighting is often useful for lighting a thin building, because light does not penetrate far enough often to light the entire plan. While myriad window placement options exist, there are some general rules that are helpful when designing window placement.

High Windows – these windows are best for the overcast sky, or skylight (away from the sun), because they see the brightest part of that sky. They can direct sunlight far into the space, but may also allow glare on interior surfaces.

Middle Windows – these windows are not the best placement in any weather, but offer the best views.

Lower Windows – these windows are best for bright sun because they can reflect the light deeply and evenly into the space. Unless it is bright and sunny, however, they will not admit much light.

It is often a combination of these three types of windows which offers the most effective side-lighting strategy. These windows may also be located near an interior wall, and reflect light into the space that way.

5. Top-Lighting

In the case of the public dining space, top-lighting will be an effective way of lighting the space, because it is only one-story. Light wells can penetrate deeper into a multistory building, but that is not necessary for this design. Since side lights are in general effective to an average of 15ft., top-lighting is a good idea to explore.

There are two types of top-lights, horizontal and vertical. Horizontal glazing offers the most light in most cases, although very low angle light will not travel very far with horizontal glazing. Vertical glazing offers good collection of low-angle light, but is less effective when there is less directional light.

Top-lighting should be used where it is needed. Large skylights are less effective than multiple smaller skylights. Top-lighting openings have many forms:
6. Reflecting Surfaces, light shelves, and shading devices.

These three day-lighting strategies are often used in combination. Reflecting surfaces are designed to reflect light further into a space. They can be used on ground level, on the tops of light shelves, or as “sun-catchers”, reflecting light through an opening in the ceiling. Wherever they are employed, they should be white and very reflective for optimum functionality. They can also be angled or curved for different effects.

Light shelves are shading devices and reflecting surfaces in one. They are simply designed by the amount of shading and reflecting they need to do. Vertical fins are based on the same principle, but they are suited for east-west sun, while light shelves are appropriate for southern exposures.

Shading devices differ widely and can be used in a number of different ways. A simple way to think about shading devices is as a system of horizontal and vertical surfaces. These can be screens, egg-crate forms, baffles, light shelves, or even plants.

Since the dining space has been shown to be in need of a mixture of diffuse and some point lights, the types of lighting should be varied. The location (Muncie, IN) also supports that decision, as it is not a recipient of extreme varying temperatures or of very high or low angles of sunlight. It also receives more sunny days than overcast days by about 10%. Testing different methods of lighting will result in some quantitative measures, i.e. the daylight factor, although quality and the exact measure of quantity are open to interpretation. There is no correct answer for day-lighting; it can only be said to be enough, or not enough – pleasant, or unpleasant.
3 examples of Day-lighting

The three following examples were chosen to show some of the strategies previously discussed. While the public dining space being designed has a particular program, it is important to recognize the versatility of certain lighting strategies in lighting different building types. The public dining space has a relatively low minimum daylight factor, but a large range of effective factors. The following will show some good strategies that can provide a range of light quality and quantity.

A – Disney Contemporary Resort Hotel and Convention Facility.

Note the clerestory windows and soft light entering the space.


B – Imation Discovery Technology center Cafeteria

This space hosts a large number of seats and maximizes view and light. Despite its large and institutional feel, this building uses reflective strategies to create space.

Conclusion: Design and Strategies

At this point it would be appropriate to change from preparatory discussion to mention what strategies, from the beginning to the end of the design process, have been chosen, and why.

1. The orientation of the building was key to its development. The site provides great opportunity for good solar orientation, as the site is largely open, so the building can accept sun from all directions. The southern exposure is of special consideration for views, as well as sun. The northern orientation was also chosen as an important exposure because of its even lighting, and good views. The eastern side was hidden, because of an unwanted view and a solar orientation that is relatively unimportant. The western side is open for views, but also because the use of the building will be important when the western sun is present. Each orientation is designed differently.

2. The room proportion, shape, and massing have been kept to certain standards for good lighting. A thin plan, elongated along the east-west axis has been used in most design iterations because of the lighting potential. Some other design options were considered, but keeping to the thin, elongated plan is the most efficient and simple way of allowing natural sunlight into a building.

3. The room surface conditions are much more complicated than the previous two strategies, but no less important. The most important surface has been the ceiling, as it provides the best reflecting surface. The ceiling will remain a light color for reflecting purposes. The floor is bamboo, which is reflective but warm. It is not white, and that will help it to feel more comfortable. The walls are a mixture between solid and void. There is much glass on the exterior of the building, allowing the space to feel larger and better lit. The solid walls are to be either a white, slightly reflective color, bamboo, or brick. Each type is suited for the use adjacent to it, depending on the character of the space and the light required.

4. The next strategy is side and top lighting. In the discussion of the strategies, there were many specific ideas in placing openings. In general, in Muncie, IN, the temperature and sky types are
so even between hot and cold, sunny and cloudy, that the best strategy is one which employs a little of every placement. For side lighting, the southern exposure is left open to receive low, medium, and high level light. The northern exposure is left open to receive all the even northern light. The western exposure is open for views, but is protected by a trellis on the exterior. For top lighting, not much is necessary. Since this type of lighting is best only when needed, I only placed a single clerestory half-way into the building.

5. The final strategy is shading devices and reflecting surfaces. Since the design of the building was somewhat created for lighting, there is a minimized need for these “extras”. The southern exposure, as it is so large, will benefit from a light shelf to shade and reflect, and vertical fins to protect from harsh eastern or western sun. Sun through the clerestory window is not allowed direct exposure to the interior very often; instead, mostly reflected light will enter the space. Elsewhere, shading devices such as screens and rudimentary “blinds” are used.

The strategies employed in the design of this building are often the simplest. Since the design was inspired by lighting needs, the “extras” have been minimized. The building envelope exists only to shield the interior, and it is created for a well lit, spacious interior, with good visual connections to the exterior.

This project is intended to show one way of thinking through the design process using lighting as a determinant. Since this project has other goals as well, it may not present the ideal solutions for day-lighting a building. It did, however, use lighting as a design tool, and aided the designer in creating a unique space that would perform ecologically friendlier throughout the year, and satisfy the human need for natural light.
Bibliography:


DINING on the GREEN
Heliodon Tests

These images were taken using the heliodon camera, showing a closer look into the feet of the building. These are images from the model while it is being tested under the artificial sun of the heliodon. The model performed as it was expected, falling in only very low angle sun light and blocking the harsher hotter sun of summer.

These tests help to understand the actual solar generation that would occur under the specific conditions in Sonoma. They help to verify the design strategies used to achieve and block sunlight that would enter into the space. There are obvious times where sunlight penetrates into the space. In those few conditions, movable shading devices will be available to block the exposure of the user device. There is no permanent shading devices for these conditions, so that the needs of the users can be better met.

Southern Dining Room

Northern Dining Room

Entrance and Buffet Line