LIGHT FollowS FUNCTION:

Shaping a Dynamic Learning Environment with Light

Ball State University    Bachelor of Architecture    Undergraduate Thesis    2002

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“Let there be light.”
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“Light and spirituality go together. Light and architecture go together. Light gives value to walls, windows, materials, textures, and colors. During hours, days, and seasons it changes space and is a fundamental tool for shaping our emotional response. Light, both natural and artificial, cannot be ignored nor used with a technical mind. Light belongs to the heart and to the spirit.”

Ricardo Legorreta
I would like to thank and acknowledge several people who helped make this thesis possible.

First, I thank my parents, Randy and Cathy, for believing in me and providing me with their constant love, support, and guidance. My values and beliefs and everything that makes me who I am today is because of them. Thank you for everything you have ever done for me.

Angie, my fiancé, I can never thank you enough for your dedicated support and abiding love. Thanks for putting up with me especially during my stressful times. I know I can be a pain during crunch time.

Thanks to Jack Wyman for offering daily guidance and challenging my ideas and designs.

Thanks to Rod Underwood for helping push me in the right direction and boosting my confidence. I really enjoyed our weekly meetings even though you made us come in so early.

Thanks to Jeff Culp for answering my questions and helping me with the technical stuff.

Without my friends I wouldn’t be where I am today. When the going gets tough, there is always someone there to help push me through it and lift my spirits. They believe in me and help encourage me to use my talents and follow my dreams. They are always there to help loosen me up a little bit and help me take life a little less seriously. They help me take that step backwards to look at the big picture. Thanks to all of you. You all know who you are.

Thanks to my future in-laws, Richard and Janet Hoeping, for allowing me to visit the schools where you are employed. It was helpful to observe the school environment and learn the pros and cons of school designs from a teacher’s perspective.

Thanks to Wayne Estopinal and the gang at TEG for bringing me on board after I graduate. It is truly rewarding to know that I will soon become part of the team. Thanks for sharing your time and resources and answering any questions I had about my thesis project.

Thanks to James Jackson of Ratio Architects, Harold Rominger and John Byrnes of the City of Indianapolis, and Indy Parks and Recreation for providing me with site information for Garfield Park.

Most importantly, I give thanks to God for everything He has given me including my family, my fiancé, my friends, and my talents. I am truly blessed.

acknowledgements
In architecture, there are many elements to consider and explore through design. To me, the most moving and often least explored component of architecture is light. Light has the ability to animate a space and bring architecture to life. I have always been fascinated with light and how it articulates space. I often find myself inspired by the sudden expressions of light. Some images are so powerful, they are never forgotten. Visualize the way a bright beam of light bursts through a small opening in the curtains of a bedroom at sunrise. Picture the way light penetrates through stain-glassed windows of a cathedral splashing the interior with a colorful cascade of light. Envision those damp spring mornings when the sun is trying to pierce through the layers of dense fog and when it finally does, stunning rays are scattered through the trees and into the vast landscape.

Sometimes I don't think we notice how light is such an alluring and appealing element significantly inherent in our daily lives. In addition to its ability to paint beautiful scenes, light allows us to perceive what we see, effects mood and behavior, reveals depth and texture, and generates the colors we recognize. Light regulates the activities of our daily lives and orients people, plants, and animals to the passage of time through days and the changing seasons. This attraction to light has led me to inquire more about light and explore it for my undergraduate thesis.
New elementary schools are being built across the country to replace aged and inadequate facilities. According to an article in the February 2001 issue of Architectural Record, "the General Accounting Office (GAO) estimated that $127 billion will be needed just to improve the condition of existing schools. As far as new construction goes, 2,400 new public schools will be necessary by 2003 to accommodate rising enrollments and to relieve overcrowding." K-12 enrollment hit a record high 53 million in 2000. Some see these figures as a crisis, while others see this as an opportunity to rethink the way children are taught and reinvent the school environment. In the January 2002 issue of American School and University, the top ten trends in school design were presented which include agility, collaborative planning, community use, cost-effective school design, smaller schools, security, student-centered design, technology, universal design, and sustainable design. The most interesting trend that can directly influence the architecture and design of a school is sustainable design. Currently, architects, educational facility planners, and school administrators are taking the initiative to incorporate daylighting strategies into the design. Daylighting in schools is the first step to building greener and more sustainable schools, a trend that is likely to gain more momentum. Besides the reduced energy costs, daylighting has also suggested a change in the performance of students. Several studies on the effects of daylighting on student performance have been conducted, and the results have indicated positive results.

After performing some research to find a potential client for my thesis project, I chose the Indianapolis Public School System in Indianapolis, Indiana. The Indianapolis Public School system was chosen because of the school system's strong need for new and improved schools. Of the 78 school buildings within the school system, 70 are 25-plus years old, 28 are 50-plus years old, and only 17 are fully air conditioned. An even more alarming fact is that a few of the schools are well beyond their intended capacity. Recent master planning studies conducted by the school system suggested the new schools be located within a strong neighborhood and placed near a city park. After looking at a few potential sites I chose to place a new elementary school within one of the city's parks, Garfield Park.

The main goal of the new elementary school is to provide a creative and dynamic learning environment that is enhanced by the integration of light. Different qualities of light will be applied to different spaces based on their function and overall character. Therefore, it can be said light follows function. The school will enhance the overall quality of a child's education through its built environment, and it will inspire and foster learning while continuing to support the development of the children. The facility should also provide a comfortable and exciting environment that can be shared by the faculty, the students, and the surrounding community.
Light could be studied quite extensively and in a variety of ways. One could study the first applications of light and track its uses as civilization progressed. One could also study the technical and scientific aspects of light. However, I have chosen not to talk about its history or its physical properties. Instead I have chosen to discuss some of the characteristics of light and its physical and psychological effect and the advantages of natural lighting, particularly in learning environments.

First, I think it is important to discuss sunlight and its 24-hour rotation. The rotation of Earth every 24 hours brings sunrise and sunset each day, something vital to life on our planet. The rhythm of our planet coordinates with an internal time keeper within our bodies. This system that regulates our internal clocks is called a circadian system. The events that occur in our bodies occur in relation to an approximate 24-hour cycle. This cycle corresponds with the amount of time it takes our planet to rotate on its axis creating day and night.

Humans and animals are not the only life that responds to these inherent rhythms associated with the earth’s rotation. In addition, plants and even some single-celled organisms regulate in accordance with an approximate 24-hour cycle. A sense of time is essential for life to sustain itself here on earth. Almost all life operates on this cycle to ensure its existence here on earth.

Before the sun rises each morning and we awaken, the circadian system prepares our body for the start of each day. The heart rate, blood pressure, and body temperature slowly rise. The body’s fluids and tissues also operate in accordance with the circadian rhythms. Depending on the time of day, physical and mental capabilities vary. Our performance on certain tasks rises and falls at certain times throughout the day. For instance, according to research, tasks requiring verbal reasoning and short-term memory climax toward the later part of morning or the middle of the day. Research also claims that studying for an exam between the hours of six and twelve in the evening is the best time to study during the day because that is the time when our long-term memory is at its strongest. Factory and assembly line work and other forms of work that involve repetition tend to be the easiest during the late afternoon and evening. Work that involves more mental functions tends to be better before noon. However, in all of these circumstances, the body’s prime time for certain activities can vary between individuals.

In order for our bodies to run precisely as planned by the 24 hours available in each day, our bodies need a cue from the environment to keep our circadian rhythms on track. This cue is sunlight. Sunlight sets the daily internal clock and coordinates the body with the daily cycle of light and darkness. How the body senses and then responds to sunlight is very important. The eyes play a key role in aiding with the regulation of the circadian rhythms. Those who are blind often have a very difficult time stabilizing their circadian rhythms. However, most have learned how to adjust and adapt to this problem.
Researchers believe the time keeper most likely responsible for regulating the circadian system lies inside a portion of the brain called the hypothalamus which consists of two clusters of nerve cells. These nerve cells called suprachiasmatic nuclei, or SCN, are directly connected to the retina in the eyes by a nerve tract. The retina senses light and then sends the light signals to the SCN which in turn send electrical and chemical messages to other parts of the brain and body introducing the time of day. "The SCN is called an oscillator or pacemaker because it sets the pace of the body's various rhythms, keeping them coordinated with one another and with the earth's rotation" (Hyman 12).

In the study of biological rhythms, researchers believe a hormone called melatonin, secreted by the pineal gland, also aids in regulation of the circadian system. Melatonin is secreted in different amounts throughout the day at different times in accordance with the 24-hour cycle of light and darkness.

Studies have shown that when the 24-hour daily cycle of light and darkness is disregarded and hours of rest and work are irregular, the circadian rhythms grow confused. This can lead to a decrease in health and alertness. The body's performance can be greatly hindered. Even little deviations in our daily schedule can affect the body's rhythm. This is one reason why some people have trouble dealing with Monday mornings because their bodies are trying to adjust from the weekend. Traveling by plane across different time zones is another example of deregulating the body's rhythm. According to Jane Hyman, author of The Light Book, "some people take up to 18 days to readjust to a trip across six time zones—in other words, three days per hour of time change." To compensate for this problem, some researchers are studying possibilities to reduce jet lag, such as light therapy or taking the hormone melatonin.

On a different note, light has also been suggested to regulate or influence a variety of other behaviors. Some of these behaviors include fertility and childbirth, sleeping and waking habits, eating and drinking, and mood and behavior. In addition, studies illustrate that light affects skin and bones, wellness and disease, and aging and death.

So far, I have discussed mostly the physical effects of light on the body. The characteristics of light and how it makes one feel are also very important. As mentioned in the introduction, light brings a space to life. Lighting alone can dramatically change the appearance of a space. The character of an entire space can be altered by changing the quantity, the intensity, or even the quality of light. By simply increasing the brightness along the perimeter of a space, the space will appear larger. Certain materials in combination with light can greatly influence the character of a space. Applying highly reflective materials will create an entirely different experience than using materials heavy in texture. Depending on their orientation to a light source and the angle at which an observer is looking, textured materials can look entirely different. Alternating patterns of light and shadow can add drama to space. Contrast in light is important; for without contrast, the environment would have the quality of a cloudy, overcast day. The environment would appear very mundane and unexciting.
Everything we perceive is because of light, whether artificial or natural. Without light, we would also see no color; they are inseparable. Created by light, color has the ability to dramatically affect mood and behavior and how someone feels in a space. The dramatic play of color and light is what brings architecture and the environment to life. For example, exposure to red light stimulates and excites the body. It has been known to raise blood pressure and increase respiration and heart rates. Blue light is the exact opposite of red in the way that it behaves. Blue tends to be calming and therefore reduces pulse and respiration rates and lowers blood pressure.

Light also affects the behavior of plants and animals in a very unique manner referred to as phototropism. Phototropism refers to the movement of plants and animals toward light, an often necessary function for growth and development. People also participate in phototropic behavior. Some psychologists have observed humans demonstrating this behavior. When any light suddenly appeared or an increase in brightness occurred in a person’s field of view, the person would move his or her head or body in the direction of light. Studies have also been conducted on infants and their response to light. They observed that even infants at a very early age display a natural response to light.

Higher illumination levels help increase the visibility of tasks and may also help increase the efficiency of the people performing tasks. The quality of light received from daylighting is significant due to its distribution within a space and its excellent color rendering capabilities. Daylighting has been linked to improved health. People tend to feel better around the presence of daylight. Most people will agree daylight improves their mood. It helps reduce stress levels and improve attention spans. Some researchers have observed that daylight improves overall behavior. Understanding all of the influences and effects of daylighting can help shape a space that enhances the overall quality of life.

The effects and advantages of utilizing natural daylight make it a hot topic among school designers today. The school is a place of huge responsibility and importance because the children of our nation are educated within these facilities so they can some day become responsible and well-educated citizens. The physical environment of the school has a direct influence on the educational process. A well-designed learning environment helps support and encourage teaching and learning. A poorly designed learning environment could hinder learning. Therefore, due to the utmost importance of the function a school serves, the learning environment should stimulate and enhance learning at a high level of fun and excitement. With all of the positive effects and advantages of natural light, incorporating daylighting strategies into the design of schools is a logical decision.
The effects of daylighting on school children and how daylighting may influence their performance has been an interesting topic in the design of learning environments for the past several years. Adequate lighting is an important feature in the design of a learning environment for children must be able to perform tasks such as reading and other forms of visual learning. Researchers believe that lighting affects student’s performance, behavior, and health.

In August of 1999, an extensive report sponsored by Pacific Gas and Electric Company and conducted by the Heschong Mahone Group was released and titled, “Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance.” In this comprehensive report, student performance data was collected from three elementary school districts located in Orange County, California, Seattle, Washington, and Fort Collins, Colorado. In addition, the amount of daylight provided in each classroom of each school was collected. The researchers used this data to find a correlation between the amount of daylight available in each classroom and the academic performance of each student in those classrooms. The study proved there was a direct correlation. Students exposed to more daylighting within their classrooms progressed significantly faster than students exposed to the least amount of daylighting. It is important to understand that even though all three districts had different curricula and teaching styles and different school building designs located in varying climates, the results were consistently the same for all. This study supports the idea that daylighting does have a direct effect on student performance. Even though the researchers were able to determine a positive correlation between daylighting in classrooms and increased student performance, they could not prove that daylighting causes student performance to be higher. The researchers are uncertain why daylighting may cause this to happen. Their explanations why this may happen suggest that it may be due to improved visibility due to higher illumination levels or improved light quality, better distribution of light, better color rendition, absence of light flicker, improved health, improved mood and behavior, decreased daylight deprivation, and higher levels of alertness. In addition to increasing student performance, researchers found that daylighting also increases student and staff attendance and achieves cost savings in school building operations over time by lowering energy costs.

With all of these positive effects related to daylighting, it is hard to ignore the advantages of incorporating daylighting strategies into school building design. The main focus of my thesis design was to make use of the knowledge I obtained about the benefits associated with daylighting and incorporate daylighting strategies into a school design that ultimately shaped a successful and dynamic learning environment.
Predock references the buildings he designs to the surrounding contexts, both physical and historical. Situated in the desert, the block-like form of the school composed of a series of courts and passages surrounded by a two-story library resembles the Catalina Mountains in the distance. "I thought of the school as a city for children—particularly its scale and the variability of that scale relative to children's bodies." Predock recognizes the smaller scale of children; he provides small punched openings for children to view through and coves for children to crawl inside.

The classrooms are organized into villages, which include two grade levels. Each village has access to its own outdoor court with available seating for gathering in small groups.

Daylighting strategies are evident from the use of punched openings in the classrooms to the skylights in the gymnasium. However, Predock takes the celebrations of light one step further through the "solstice wall." This wall was designed so that the sun illuminates plaques on the ground referencing significant days or events throughout the year.

Predock designed a variety of spaces throughout the school to provide unique learning environments. He wanted the design of the school to facilitate and enhance learning and exploration through the architecture. This idea was one of the main objectives of my design.
Nelson Fine Arts Center, Arizona State University, Tempe, Arizona
Antoine Predock

Containing a museum, theater arts, and dance departments, Predock defines a journey through the interior and exterior spaces. Through these different sequences, he incorporates a variety of daylighting strategies. Inside the galleries, small light coves in the ceiling reflect sunlight inside without direct light falling upon the artwork. He incorporates a wire mesh into the treads of a staircase allowing light to penetrate inside an interior courtyard. On the perimeter galleries, thick walls and punched openings filled with glass block allow the light to be diffused inside the gallery without the harshness of direct light.

Gateway Center, University of Minnesota, Minneapolis, Minnesota
Antoine Predock

The Gateway Center is a ceremonial gathering place and welcoming center for the campus and its visitors. The glazed fractures bring sunlight into the interior of Memorial Hall adding drama to the space. At night, the hall becomes a beacon of gleaming light.
Church of the Light, Ibaraki, Japan
Tadao Ando

The Church of the Light is an example of the power and emotion light can evoke. The cross is cut into the concrete wall allowing sunlight to glow amid its darker background. The extreme contrast of dark versus light is key to this compelling celebration of light so carefully designed by Ando.

Chapel of St. Ignatius, Seattle, Washington
Steven Holl

The Chapel of St. Ignatius represents what Holl calls, “bottles of light.” The design concept reflects the influences and concepts of St. Ignatius who wrote about one choosing different paths within our lives. The shifting of ourselves is represented by the interior movement from one bottle of light to another within the chapel. Furthermore, each of these bottles emphasize a different lighting experience to correspond to the different parts of Jesuit Catholic worship. The different play of light is further enhanced by the combination of a colored glass and a field of reflected color. Within each “bottle of light” a colored baffle is constructed opposite the colored glass windows. Each of the baffles are back painted in a bright color that is complementary to the colored glass. For example, the choir area has a “bottle of light” which expresses a green field with a red lens while the reconciliation chapel expresses a purple field with an orange lens. The effects of these bottles of light play a very important role in heightening our experience of the spaces. The light invites the worshiper into a deep and closer feeling of sacredness within the chapel.
In order for myself to better understand educational facilities and the behavior of children, I had the opportunity to visit a couple of elementary schools. The school presented, Mary Castle Elementary, is a public school in the Castleton area of Indianapolis. The school is arranged with the library located toward the center of the facility and the classrooms arranged in grade level pods surrounding the library. Exterior courtyards are created between the different pods. Recent additions to the school include a new front entry/lobby, a large group meeting room, an art classroom, a music classroom, and a science classroom.

During my visit to the school I had the opportunity to observe a classroom of fourth graders led by their teacher, my future mother-in-law. It was helpful to observe the school environment and learn the pros and cons of the school's design from a teacher’s perspective. From her I was able to learn about some of the problems and issues present in the school. The biggest problem was overcrowding. The classroom I observed had a very large class of thirty. I made sure that would be a concern when I designed a new elementary school for Indianapolis.

The most appealing characteristic of the school is the organization of classrooms into grade level pods. Each pod shares a common resource area and conference area. The hallway acts as a gathering space and as a storage area for coats and backpacks. The circulation through the school operates very smoothly. The classroom pods branch off the main corridor that surrounds the library. The larger spaces like the cafeteria and the gymnasium are grouped together along the main corridor for its high volume of traffic. For some added flexibility, the two spaces are separated by a large movable partition that can be removed to accommodate large group functions such as a school assembly.

Daylighting was not a design initiative in the design of this school. Organization seemed to be the key design component. Because of this, daylighting opportunities were limited. A few skylights are located near the main entry. The placement of these skylights near the main entry allows the lobby to feel more inviting due to the soft and comfortable diffused daylight. The courtyards provide an opportunity for glazing on each of its four walls. Although the south side is the only wall to receive direct sunlight, the other three walls receive a pleasant amount of indirect light. The picture to the left demonstrates this example and how the indirect sunlight brightens the corridor.
Garfield Park is the oldest park (est. 1873) in Indianapolis consisting of 128.5 acres. The park was originally used as a horse track under the name Southern Park. It was later renamed to Garfield Park in 1881 in honor of Hoosier native President James Garfield who died earlier that year.

The park offers shelters, a recreation center, several playgrounds, a basketball court, soccer and football fields, softball diamonds, horseshoe pits, tennis courts, an aquatic center, an outdoor amphitheater, a conservatory, and sculptured gardens with fountains. The Burrello Family Center offers a variety of activities including recreational leagues, exercise programs, weight training, and many other activities. The conservatory was first built in 1913 and replaced with the current one in 1955. The amphitheatre was built in 1921 and is still used for outdoor concerts. The park was also the first home of the Indianapolis Children’s Museum.

The serene beauty of the park offers a picturesque landscape. Some of the physical features include a meandering stream that cuts through the center, towering trees, rolling hills, and large open fields of rich green grass.

Within the surrounding context, there are several other schools and a branch of the Indianapolis Public Library System. Emmerich Manual High School is located just west of Garfield Park. The Shelby Library is located on the southeast corner of Garfield Park. With Raymond Street being a main road and an exit for Interstate 65, there is a high volume of traffic.

According to one resource, the neighborhood was once very rich in ethnicity, with a high percentage of Germans. Today, the surrounding neighborhood context is a middle income urban community of mixed ethnicity.

With so much to offer, I thought Garfield Park was the perfect location for a new elementary school.
view of the Burello Family Center located in the northwest quadrant of Garfield Park

view of Raymond Street looking west from the corner of the northeast quadrant of Garfield Park

view towards northwest from inside the site

view of the fire station located near the northwest corner of Garfield Park

GARFIELD PARK
2450 SHELBY STREET

LOCATION MAP

1. FIRE STATION
2. BURELLO FAMILY & AQUATIC CENTER
3. GARFIELD PERFORMING ARTS CENTER
4. PAGODA/PLAYGROUND
5. McALLISTER CENTER
6. GARFIELD PARK
7. SHELBY LIBRARY
8. TENNIS COURTS
9. HORSESHOE PAVILLION
10. VETERANS MEMORIAL
11. WEDDING AREA
The proposed location for the placement of the school is at the top of the hill or plateau. The valley is a possible place for a much taller feature. By placing the gymnasium in the valley, the overall scale of it will look reduced from the road.

Heavy vehicular traffic exists along Raymond Street which is the northern boundary of the park. Noise from the traffic is moderate. Very light traffic occurs along South Garfield Drive, the eastern edge of the northeast corner of the park. The driveway that runs through the park has little or no traffic.

Views from the top of the hill toward the park are plentiful. Views to the east include a residential neighborhood of small townhouses and one story ranches.

The small playground that exists along the stream may be jointly used by the new school. The greenway that runs through the site presents a unique opportunity to the new school.
view of the residential neighborhood toward the east across South Garfield Drive

view of the bridge placed over the stream that leads to other features in the park

view of the hill looking east-southeast

view of the hill looking north along the edge of the hill

panoramic view of the site looking south-southwest along South Garfield Drive, immediately east of the site
“No space, architecturally, is a space unless it has natural light.”

Louis Kahn
The Indianapolis Public Schools Corporation is the largest public school district in the state of Indiana serving over 40,000 students. The school district ranks first in the state in assessed value, enrollment, and the number of students transported. Since 1975, IPS has closed 36 elementary schools primarily due to the changing demographics of the school district population and redistricting implemented from two Federal Court desegregation orders. However, since 1998, students sent to the surrounding districts are now being allowed to return to IPS and will continue to be phased in over the next 18 years. In the next several years, many changes need to be made to guarantee there is room for the influx of new students and to provide quality educational facilities that meet today's needs. Currently, of the 78 school buildings in IPS, 70 are 25+ years old and 28 are 50+ years old. In the past ten years only three new schools have been built. So, there are concerns that some of the current facilities are too old and may not be able to accommodate for today's programmatic needs.

Over the last year, an extensive facility study was conducted to evaluate all current school buildings within the school district. Several public meetings were held to discuss facility condition, program space needs, grade level configuration, school size, community space/facility use, safety/security, support space needs, alternative school calendar, school locations, and other topics. Based on age, inadequacy, and growing numbers of neighborhood population, the studies suggested to rebuild five new schools by the year 2004. Eleanor Skillen School #34 is one of those schools scheduled to be rebuilt in 2003. Some suggestions for locations included acquiring land from the city parks and building new schools within some of the city parks.

The Indianapolis School System has several aged, overcrowded, and inadequate school facilities. After facility studies and several public meetings, the look of IPS schools is looking for change. Renovation and rebuilding of selected school facilities is planned beginning with a $250 million upgrading for school improvements over the next few years. The rest of the requested $832 million is still being sought after for upgrades over the next ten years. Elementary School #34 was identified as one of the facilities to be rebuilt in 2003. Suggestions for school sites include acquiring park space. For my thesis project, a site for the new Elementary School #34 was chosen on the northeast corner of Garfield Park on South Garfield Drive in Indianapolis.

The facility program establishes criteria for selected interior spaces to be included in the new elementary school. These spaces include kindergarten classrooms; classrooms for grades 1 through 5; teacher prep areas; a health clinic; a speech, language, and hearing room; a media center and computer lab; a visual arts classroom, a music classroom and a science classroom; a gymnatorium with platform; a cafeteria with food service area; an administrative area; and small gathering spaces for alternative activities. The accumulative square footage of these spaces is approximately 53,850 net square feet with a total gross square footage of 77,840.

A cost estimate was conducted and based on current construction industry data and estimates resulting from typical patterns associated with educational facilities and elementary schools. The total projected estimated cost is $10,042,900.
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<tr>
<td>Learning environment for young children</td>
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<tr>
<td>Typical Classrooms (grades 1 - 5)</td>
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<td>Learning environment for grades 1 through 5</td>
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<tr>
<td>Teacher Prep Area / Workrooms</td>
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<tr>
<td>Area for teachers and staff members to work and prepare for class</td>
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<td>Health Clinic</td>
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<td>Space for the injured or ill</td>
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<td>Speech, Language, &amp; Hearing Room</td>
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<td>Variety of administration spaces that support school function</td>
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<td>Media Center with Offices and Computer Lab</td>
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<td>Resource and Information Gathering Area</td>
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<td>Visual Arts Classroom</td>
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<td>Learning environment that explores visual arts</td>
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<td>Music Classroom</td>
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<tr>
<td>Learning environment that explores musical and performance arts</td>
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<td>Science Classroom</td>
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<td>Learning environment that explores science</td>
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<td>Gymnatorium</td>
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<td>Gymnasium and auditorium combined with movable platform</td>
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<td>Cafeteria / Student Dining</td>
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<td>Small Gathering Spaces</td>
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<td>Alternative gathering spaces for grade or individual class meetings</td>
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</tr>
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building cost
77,840 sf @ $80 per sf
$ 6,227,200

fixed equipment
8% of building cost
$ 498,200

site development
15% of building cost
$ 934,100

total construction cost
$ 7,659,500

movable equipment
8% of building cost
$ 498,200

site acquisition/demolition
estimate
$ 200,000

professional fees
programming
1.5% of construction cost
$ 114,900

architecture
7% of construction cost
$ 536,200

interiors
1.5% of construction cost
$ 114,900

contingencies
10% of construction cost for unexpected costs
$ 766,000

administration costs
2% of construction cost
$ 153,200

total projected estimated cost
$ 10,042,900

* estimated cost is in November 2001 US dollars
These conceptual sketches illustrate the possible organization of the school all of which are drawn with north facing up. The yellow spaces refer to the classroom pods and the other classrooms like the visual arts, science, and music classrooms. The blue areas are administration space. The large red areas refer to the large gathering spaces like the gym and cafeteria areas. Finally, the orange areas signify possible media center locations.

These conceptual sketches are pod explorations. Pods, one for each grade level, consisting of three classrooms each would be located along the main corridor. The pod hallway would become a gathering space for the individual classrooms. In addition, two pods would share a common gathering space located across the main corridor. This space could be used for small group discussions, reading time, or even mini lectures. Not only do these small gathering spaces provide an additional learning environment, but they also allow visitors and other classmates to see what is going on if they pass by.
To take advantage of daylighting strategies, the organization of the plan is essential to the design of the new school facility. By orienting the school north-south and the classrooms east-west, I am able to maximize daylighting to the south in the classrooms.

Individual pods of four classrooms each were explored to incorporate a varying scale of spaces. As one would enter the pod from the main corridor, he or she would be channeled through a short, narrow corridor with display cases on each side. This would lead to a large gathering space shared by all four classrooms of a particular grade level. This space could serve as a meeting place to discuss a grade level activity, a field trip, etc. Each pod would also contain a teacher workroom for all four teachers to share.

These are conceptual sketches of the proposed school with two entries, one from the east along South Garfield Drive and one from below the site along the driveway that runs through the park. Faculty would enter from the lower level below on the west side and come up to the main level through a lobby/entry area. Spaces accessible from the lower level would include the gymnasium, cafeteria, and service and mechanical areas.
The diagrams to the right were initial explorations of how light would be introduced into the classroom pods. The inside walls of the classroom adjacent to the corridor would be transparent at the upper third of the wall. This would allow diffused light from the central light monitor to filter into the individual classrooms on the north and south sides.

This sketch is a section through the gymnasium. A raised light monitor would introduce diffused daylight into the gym without producing the negative effects of glare.
These sketches are studies of the gathering/celebration space. Each space would be located across the main corridor from each pod. These spaces are additional learning environments. These spaces would be used for small group discussions, reading time, acting out, etc. Each space would inhibit a unique light quality through the manipulation of light and shadow.
After a disappointing mid-review, I decided that my design was too focused on responding to the context instead of my thesis. I realized I needed to further explore how the building responds to daylighting. The organization of the building and the individual pods were controlling the design instead of daylighting. So, I decided to scrap almost everything I had and re-design. I eliminated the pods and instead created wings, one for each grade level of four classrooms a piece. These wings were located off of the main corridor as in the previous design. Secondary corridors on the northern side of each wing branched from the main corridor leading to the classrooms. All classrooms could then take advantage of maximum southern exposure, a more consistent daylighting source.

The space created between classroom wings created a unique opportunity for landscaping and exterior learning environments. Each courtyard could serve as an exterior learning space. Teachers could take a movable writing surface outside and children could sit on the exterior seating provided and participate in a classroom activity. The courtyard space could also be a place for planting and growing gardens by the children.
In addition to the arrangement of the classroom wings, the orientation of the building in relation to the path of the sun throughout the year was the next critical issue I addressed. I skewed the overall plan of the building ten degrees west of north. The reasoning behind this design decision was based on the hours of school operation. During the hours of normal school operations, children are in attendance from around eight in the morning until around three in the afternoon. The diagram to the left illustrates that during these hours the sun is positioned slightly more towards the east. Therefore, by positioning the school building the way I did, maximum daylighting exposure can be achieved.
Each classroom incorporates a band of clerestory lighting that would allow light in the winter time to penetrate deeper into the classrooms while eliminating direct sunlight during the late spring and summer months. Windows for view and natural ventilation are located along the edges of the classroom where direct light would not fall upon the students.

Daylight from the north is essentially filtered twice into the classrooms. Daylight is brought in from clerestory lighting created by the roof forms. The light is diffused within the space located just outside each classroom entry and into the small nook in each classroom where the computers and reading stations are located the upper left corner on the diagram to the left).
The quality and intensity of light changes throughout the building based on the function and characteristics of the space. The main corridor is one of the brightest spaces with natural daylight spilling in from the clerestory lighting on the east and west walls. A higher concentration of light defines each entry into a classroom wing or a space like the media center. The secondary corridors along the north sides of the classroom wings display a soft comfortable level of northern daylight which remains constant throughout the day. The classrooms offer a comfortable level of daylighting where little or no artificial lighting is necessary. The large gathering spaces located toward the end of the wing offer views to the park through punched openings that fill the outside perimeter of the space with daylight. A celebration of light through light and shadow is expressed on the eastern half of the large gathering spaces.

Light calculations were conducted to determine how much space was needed in between the classroom wings in order for light to reach the next classroom wing. To maximize daylighting, it was important that the shadow of one classroom wing would not cast onto another classroom wing.
These are some renderings that were presented at the final presentation. Each of the gathering/celebration space is represented by a different color on the exterior. This gives each grade level an identity for their classroom wing. This allows children to locate which classroom wing is theirs from the outside if they pass by the school. It allows them to understand where they fit in relation the overall scheme of the building.

After, final reviews, I was still unhappy with a few of my design decisions. So, I continued to explore alternatives and different solutions for a few elements that I felt needed some work.
These were the drawings presented at the final review. The floor plan (north facing up) consists of two levels that coordinate with the topography changes on the site. The lower level meets the main level at the secondary entry to the north. During the school hours, both levels would be used. However, after school hours the facility has the ability to be separated into zones. The lower level could be shut off completely from the rest of the school for after school activities for the students and the surrounding community. The lower level is at the same elevation as the driveway that runs through Garfield Park. It serves as the activity zone of the school with the gymnatorium, cafeteria, music classroom, visual arts classroom, and science classroom. The cafeteria and the gym can be combined as one or separate by a movable partition. A movable platform for performances can be placed in between the cafeteria and gym, offering some flexibility. The area also houses the mechanical space for this zone of the building. The food service area is located adjacent to the cafeteria. On the first floor, the administration is located to the lower right. The classroom wings run north-south perpendicular to the main corridor. The kindergarten is located near the main entry, furthest south on the plan. The media center is located toward the center of the building along the main corridor and to the east. Mechanical space for the main level is located within the space above the main corridor. This area is covered with a skylight roof system like Kalwall. An increase in the amount of daylighting occurs where the corridors intersect. Light is being used to define the entries into other spaces. The increase in daylighting occurs from an opening that is punched through the ceiling of the main corridor. Daylight is diffused through the Kalwall and into the skylight that is overhead the intersections in the main corridor.
I felt that the connection between the celebration/gathering spaces and the classrooms could be simplified and more aesthetic. The way the roof of the classrooms met the celebration/gathering space was unpleasant. So, I explored with creating a large wall that allowed for a cleaner connection and a better defined zone within the wings.

In addition, the roof scheme for the spaces located east of the main corridor was also reconsidered. Originally, the roofs sloped away from the main corridor. The connection between the main corridor and the spaces east of the corridor appeared awkward. From the outside, the media center and administration spaces looked tacked on to the rest of the building. They didn’t have the same language as the west side of the building where the classroom wings are located. Therefore, I reconfigured the main floor plan and applied the same design language on the east side as the west side. By “extending” the wings to the east side, the media center, restrooms, and administration spaces appeared to have a closer relation with the main corridor and the rest of the building. In addition, the wings projecting onto the east side also changed the scale of the east facade. The imagery reflected the contextual imagery of the residential neighborhood across the street to the east.
The placement and organization of the kindergarten wing in the original design appeared to be problematic. The kindergarten did not reflect the same language as the rest of the classrooms. Its location also made it appear like it was forgotten and added on last minute. Also, I did not feel that it was safe enough being so close to the main entry. So, I decided to place the kindergarten along the east side of the main corridor with the media center and administration. This was a much cleaner and safer design. No one would be allowed access to any part of the school without first passing the reception desk in the administration area.

The next issue I addressed was the main entry. In the original design, people would enter a tall solid cone-like shape. This idea raised some security concerns. The reception area should be able to see who is approaching and entering the school. Therefore, I changed the materials of the main entry and completely enclosed it in glass. The doors were moved to the south side facing the parking lot. This was a much better solution than the original awkward entry from the east that made guests take a ninety-degree turn to enter into the school.

The celebration/gathering spaces were also slightly altered. The proportions were changed and windows were placed along the west side to allow daylight into the space. The cone shape rises above the space and terminates with an opening/skylight, sloped toward the south, unique to each individual wing. The exact shape of this opening was not explored, however, I imagine that as light pierces through the top a single beam of light is created that shines against the interior sloping walls of the cone. Some of the wings may have an opening that allows light to cast a pattern of shadows onto the wall.

In addition to the other design changes, the width of the main corridor was widened. The twelve-foot wide corridor of the original design was too narrow and the height of the space made the corridor appear even narrower. The new widened main corridor acts as an internal "greenway." Small trees are placed inside to add life to the corridor and reflect the outdoor landscape of the park. Daylight filters through clerestory lighting from the east and west walls. The way the light filters into the building and distributes through the interior row of trees and into the space creates a feeling of being outside.

The main level of the new floor plan is included on the opposite page. The lower level remained unchanged. A sketch of a section through the main level along the east-west axis reflects the new design changes.
design process
“Light attracts people. It shows the way, and when we see light in the distance, we follow it. We seek light.”

Ricardo Legorreta
It is difficult to believe my years here at Ball State are finally completed. It has been a challenging five years here, but at the same time I have had a lot of fun too. Most of all, I am so glad the all-nighters and lack of sleep is all over, well I think. My mind and my body cannot handle doing that any more. I feel this thesis year has been a very rewarding experience. I feel competent enough in my abilities to now go into the real world and experience architecture first hand in the profession. I will soon be joining The Estopinal Group in Jeffersonville, Indiana and cannot wait to start my professional career there. I hope to apply all that I have learned from Ball State and this thesis including daylighting and school design. One of my goals as a professional is to introduce daylighting strategies into the designs that I create. Maybe I will even have the opportunity to take daylighting in schools one step further and introduce other sustainable design applications to my designs. Daylighting strategies in schools do not have to be located in California or North Carolina. They can be done here in the Midwest too. Someone has to take that first step and I plan to do it.

After my final thesis reviews, my colleagues told me that it was time to relax because I was finished. However, I was not pleased with my design. I wanted to continue exploring. I knew my design had more potential. Being the perfectionist that I am, I continued to design and modify my design even after this thesis report and the thesis plate were scheduled to be turned in. My friends and colleagues thought I was crazy and told me I just need to stop with what I had and finish. Well, I can honestly say I am glad that I ignored them and their negative comments. There are a few things that I did not get to explore, but overall I am very pleased with the final result. Several people have mentioned my design is much stronger now. I feel all the extra hard work paid off. Maybe now I can relax a little.

**Reflections**

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http://www.ips.k12.in.us/
http://www.pge.com/003_save_energy/003c_edu_train/pec/daylight/daylight.shtml

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**References**