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It is entitled:
The Integrated Environment: An updated approach to the Montessori learning Environment

This work and its defense approved by:

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The Integrated Environment: An updated approach to the Montessori learning environment

A thesis submitted to the
Division of Research and Advanced Studies of the University of Cincinnati
in partial fulfillment of the requirements for the degree of

MASTERS OF ARCHITECTURE

in the School of Architecture and Interior Design
of the College of Design, Architecture, Art and Planning

April 17, 2006

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ABSTRACT

Combining a specific educational methodology with a specific approach to building can be an effective way to study the impacts of physical environment on learning capabilities. The outcome of this study will create a better understanding of the connection between Montessori teaching and the built environment. This thesis will investigate the relationship between the concepts of Montessori teaching and the process of building high performance sustainable facilities.

The method of Montessori teaching has been used for over one hundred years. This concept involves adapting education for each stage of learning through self-discovery while encouraging children to be active rather than passive in their learning. This distinctive teaching method requires a unique building environment to foster and maximize the learning process.

Over the past decade a new extension of sustainable design has evolved into a process commonly known as “high performance facilities.” These facilities incorporate sustainable design strategies while monitoring student’s test results. High performance facilities have been proven to improve the learning environment while saving energy, resources, and money.

The concept of combining Montessori teaching methods with high performance facilities will be investigated in this thesis to create a better system for learning. The result of this system will advance the Montessori teaching methods by better integrating the philosophies with the physical environment, which will make the overall learning experience more meaningful.
The Integrated Environment: An updated approach to the Montessori learning environment

Submitted by: Charles Jahngen
2005 / 2006
Acknowledgements

This thesis is the result of a great deal of reading, listening, watching, and thinking. I want to thank all of the teachers, students, friends & colleagues I have encountered throughout this process.

A special thanks goes to my wife Abby, who has been the most valuable resource. You serve as my design consultant, proof-reader and best friend. With your help and patience, this thesis can come true.

Finally, I want to thank my family and co-workers at SHP for allowing to put my life on hold at times in order to complete this thesis.
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The Integrated Environment

Introduction:

"The first aim of the prepared environment is, as far as it is possible, to render the growing child independent of the adult."
- Dr. Maria Montessori
**INTRODUCTION**

Students in America spend on average thirteen of their first eighteen years in formal learning and being prepared for the world.¹ During these thirteen years, everything involved with the educational process affects student development. The curriculum, resources, and built environment all play key roles into the growth of students.

The facility in which children learn is one of the most important factors in the equation. When combined with the curriculum, the built school can positively affect learning. The physical surrounding can inspire discovery and assist the teacher in the development of children.

Educational advocate Maria Montessori (1870-1952) coined the phrase “prepared environment.” She defined this term as the environment designed to maximize independent learning.² This definition applies not only to the classroom, but to the school as a whole. Today, Montessori schools are often retro-fits of existing schools and are rarely designed specifically for Montessori education. The goal of this thesis is to explore and document the Montessori Method along with current trends in sustainable design.

Over the past decade, much has been written about sustainable design. Some of these writings are documentations of historical methods while others are about new and progressive ideas. Regardless of the content, there is an abundant amount of information that can be integrated into new school design. These design tactics can have positive qualities for the students, staff and local community. Additionally, there is a vast world of design strategies that can influence educational design. These theories, written by architects and educators, range from visual and tactile to architectural and philosophical. Ultimately, throughout the thesis process, it is a goal to distill these design strategies and to integrate them into a final design project.

**Personal Accounts:**

Throughout the past five years, my career focus has been school design. I enjoy working with school administrators and solving their need to improve their learning environment. The passion of problem solving has driven me to research a different type of teaching method and the environmental concerns of Montessori.

The Montessori Method of teaching has been in use for only one hundred years. The fundamental aspect of this method is to provide encouragement and the physical setting for children to teach themselves by utilizing their natural inclination towards learning. Combining self-teaching tools, an enriching setting, and natural curiosity creates a learning methodology that is unique and has proven success. I am intrigued by this method and more importantly, how the built environment can increase children’s excitement about learning.

Although I did not attend a Montessori school, I have encountered many friends and colleagues who were schooled in the Montessori fashion. Each and every one of these people is successful in their own way and I firmly believe that the Montessori Method of teaching works. By researching the Montessori Method along with sustainable design, I hope to expand my knowledge and also share the discoveries with those who have similar interest.

**Problem Statement:**

Although Montessori Schools use successful methods of teaching that differ from traditional education, both types are typically housed in similar physical environments. Montessori’s need for a specific building type has not been fully addressed in research or design. The main reason is that the Montessori Method is fairly new. In the 1970’s there was a wave of interest in which the popularity of the Montessori Method began to grow. Lately, Montessori has seen dramatic growth; many public schools are revising their curriculum to employ the Montessori Method.
The teaching methods of Dr. Maria Montessori have won world acclaim in the field of education. Dedicating her entire life to teaching, through her experience and scientific training she created a method of education that challenged traditional patterns of schooling. “Schools and teacher education programs throughout the world have implemented her ideas about child development and her approach to teaching.”

Montessori’s method has three components: the teacher, the student, and the environment. The teacher and student are equally trained in the method of Montessori. This method is different from traditional education in that the child teaches him/herself. The Montessori teacher was originally called a “directress.” Her main purpose was to oversee the activities and manage the classroom. The final component of Maria Montessori’s approach is the environment. She described it as “the prepared environment.”

Economic factors and the lack of wide acceptance of the Montessori Method have led to neglect of the prepared environment. Montessori is typically taught in older schools or other buildings that were not built for that purpose. For example, all five Montessori schools within the Cincinnati Public School system are housed in older buildings. The newest of the five schools, Sands Montessori, was constructed in 1970 for another program, and Sands took occupancy in 2000. When Montessori schools are purposely constructed, there are some considerations given to the environment, but generally, there is not enough money to create the ideal Montessori teaching environment.

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4 Gordon, p.13
Despite these obstacles, the Montessori Method of educating is growing in popularity. Throughout the United States, there has been a dramatic increase in interest and enrollment in Montessori education. To support this growth and study of the prepared environment, experimental Montessori facilities need to be developed and shared with architects and Montessori professionals. These professionals can examine what makes Montessori successful and learn how their environments affect learning. Several architects have established philosophies for creating a successful Montessori facility.
Chapter One: Literature Review

“It is significant to realize that the most creative environments in our society are not the ever-changing ones. The artist's studio, the researcher's laboratory, the scholar's library are each kept deliberately simple so as to support the complexities of the work in progress. They are deliberately kept predictable so the unpredictable can happen.”

- Lucy Calkins
**LITERATURE REVIEW**


Dyck argues that there are six physical attributes that should be addressed in the prepared environment: aesthetic, spatial, light, noise, color and thermal. These six attributes have strong effects on the learner. For example, an uncomfortable thermal setting greatly affects student and teacher energy levels. If a room becomes too warm, students tend to fall asleep. Similarly, if a room is too cold, students begin to lose concentration. When these six attributes are carefully considered, it creates a learning environment that is more likely to support work flow and concentration. Although these six attributes could apply to any architecture, they are fundamental to the success of the prepared environment.

Dyck quotes Edward T. Hall: “The first sense developed in a newborn is that of the tactile system. Sight, the most specialized sense to be developed by humans, is the last sense developed. Hall suggests that the visual and tactile spatial experience are intertwined and cannot be separated”

When children react to them, stimulation occurs and the effect on learning can be positive.

Aesthetically, Dyck quotes Mary Banks Jasnoski on the outcome of a “rich” environment versus a “poor” environment. Jasnoski states: “A diversity of locales and features have demonstrated an impact upon mood, cognitive performance and health. These areas include tension, depression, hostility, vigor, fatigue, confusion, relaxation, anger and positive mood.” Aesthetics in a Montessori classroom builds visual appeal and an understanding of respect, but more importantly, positively affects children’s motivation and desire to learn.

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6 Dyck, p. 53
7 Dyck, p. 54
8 Dyck, p. 54
Dyck continues by looking at the spatial characteristics of Montessori schools. He quotes Herbert Kohl as he recalls his earliest experience in school:

...most of or memories when back to Kindergarten or the first grade and an unusual number of them were spatial. I remember my first grade classroom and how confined and box-like it felt. The tables were place in rows and their tops were hard and rectangular. For the most part I tried to disappear into my chair, hide from the teacher, and let my imagination invest the room with wild and secret places.  

The memory of spaces leaves a lasting effect on children. Children have a special sensitivity to spatial qualities. Dyck states “As an architect, I feel that spatial qualities are a significant environmental factor and that the ‘enhancement’ of spatial experience is a vital design criterion.”

“Good design that considers all six attributes will result in a learning setting that is more likely to support flow and concentration.” The overall effect of a carefully planned prepared environment will be better students.

Many lessons can be learned from the research of design professionals. Dyck’s philosophy on six physical attributes plays an important role in the development of a new school. The question that arises is how do theses attributes get incorporated into a new building design?

**aesthetic:** Use human scale factors, and pleasing colors to make the “aesthetic” feel welcoming and comfortable. This comfort, created by visual and spatial synergies, operates as an indirect teaching tool – when students are comfortable they are more able to learn.

**spatial:** Make the spaces relevant to its use and users. The adjacencies should be organized and each space shall be comfortable to the users. In the case of the proposed Montessori school, the students will be in pre-school through
fourth grade, therefore the spatial organization should reflect the size of the users. The physical space should also reflect the use. For example, large group performance areas need to be spatially larger than small group meeting areas.

**light:** Light the classrooms with the appropriate amount of light to facilitate learning. If a space is too bright, glare will occur and it will become a distraction. Oppositely, if a space is too dark, the lack of light will also serve as distraction to learning. The Council for Educational Facility Planners (CEFPI) suggests that “classroom spaces with direct lighting are illuminated to 50-100 foot-candles (fc), but when indirect lighting is used, only 35 fc are required and it still appears brighter.”¹² Classrooms should not be entirely lit with artificial light. Natural diffused sunlight can provide the best results in a classroom setting. This aspect is expanded when examining the Heschong Mahone study.

**noise:** The noise level in a classroom needs to be controlled to minimize distraction. Often classrooms exceed noise levels and make it difficult to learn.¹³ This can be controlled by using sound absorbing materials such as fabrics & carpets. Along with sounds absorbing materials, sounds reflecting materials can be used to bounce sounds throughout the learning space. This can be accomplished by using a variety of hard materials that are oriented along different planes. This combination, of sound reflecting and absorbing materials, can create a balanced noise level that is fit for a classroom. Another solution often seen today is acoustic reinforcement supplied by a teacher and an electronic system. This microphone and speaker system ensures even acoustics throughout a classroom.

**color:** Color throughout a school can greatly affect the ability to learn and concentrate. For example, bright colors can excite the senses and the ability to learn. When used incorrectly, bright colors can distract and negatively affect learning. Color can also reduce tension and anxiety and produce a home-like atmosphere.¹⁴ So what colors are suitable for education? Based on color expert Frank Manke’s writings, light yellow-orange, beige, pale or light green, or blue-green are good choices for three of the four wall surfaces. Pastel oranges promote cheerful, lively and sociable

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¹² http://www.cefpi.org/issue1.html
¹³ http://www.acoustics.org/press/147th/allen.htm
¹⁴ http://www.isu.edu/ctl/nutshells/IdealClass_files/IdealClass.html
moods. Pastel yellow has a similar cheerful effect. Greens and blue greens in pastels are calming and provide a good background color suited to relaxation into tasks that require concentration. Deep or loud tones are appropriate for trim and what Mahnke refers to as "incidental areas." If used over dominant room areas, deep tones and glaring colors promote irritability. Deep reds, browns (excluding natural wood finish, which is good) and dark blues are particularly detrimental.

thermal: The thermal setting of the classroom is equally as important as the other five physical attributes. This level, generally set between 68° – 74° Fahrenheit (20° -23.3° C), combined with 4 -5 air changes per hour, creates healthy indoor environmental quality (IEQ). This thermal level can be controlled electronically by equipment or by students by utilizing controls and gauges and adjustments of the windows and shading devices. Using the thermal level as a teaching tool can have a lasting affect on the student. Lessons in thermal conductivity can also be taught throughout the year with changes in the season and humidity levels.

Victor Sidy’s text “Buildings that Nurture,” like Dyck’s, argues that the environment in which Montessori is taught strongly influences the quality of learning in that space. Sidy is an architect, inventor, writer, and lecturer. He has also contributed to the North American Montessori Teachers’ Association’s “The Whole School Montessori Handbook.” Sidy’s main thesis is that “good architecture makes good Montessori education.” Throughout the article, Sidy discuss various methods of designing buildings that nurture. They include:

- buildings that relate to the land and surrounding nature
- buildings that care, and shelter their users
- buildings that create community interaction
- buildings that have materials and structure that can teach lessons (pedagogy of place)

To uncover Sidy’s methods of nurturing, he stepped back to the origins of architecture. Sidy quotes the adage

17 Sidy, p.150
“All that is needed for education is a teacher, a student, and a tree.” This quote reminds me of Marc-Antoine Laugier’s frontispiece image from *Essai sur l’Architecture*, 1755. The image is of a young goddess, representing architecture, directing a child to the origins of her craft, the primitive shelter made from trunks and limbs to form a gable. Laugier was an advocate of returning to a purified architecture that omitted all superfluities. He believed that architecture’s essence is contained in the column, lintel and gabled roof. Sidy says that even though Montessori education is only 100 years old, Montessori teachers have been given primitive settings and have made them work.

Sidy feels that parents today require safety and quality education. “Our clients want modern performance and comforts, but also don’t want to be alienated from a nurturing, nature-embracing environment.”

Sidy recently worked with Montessori students and faculty to create an eight-acre masterplan for a school in Dallas, Texas. The master plan included a bio-waste facility, outdoor classroom pavilion, remote nature-study hut, and pedestrian bridge. These spaces will be built on the existing Montessori campus by students and used as teaching tools for the Montessori curriculum. Sidy learned that in working with the Montessori program, “The subtleties of pattern of use and relationship with the physical environment became critically important.”

Sidy concludes that these strategies have been an experiment throughout his journey in architecture. They have evolved and will continue to change throughout his professional career. The crucial lesson he has learned is that without architectural designs that help nurture the students, Montessori schools cannot achieve their maximum potential.

Sidy has established useful points to create a nurturing environment for a Montessori school. The question that occurs is how can these concepts be integrated into a new design?

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18 Sidy, p. 143
19 Sidy, p.146
20 Sidy, p.146
21 Sidy, p.146
Relating buildings to the land can be accomplished in many ways. The first is by carefully integrating the building into the existing topography. By doing this, the building and site can operate in harmony. The second step, which is a result of the first, is to bring the outside into the building and vice-versa. By doing this there is a physical connection to the outdoor space with the indoor space.

Providing care and shelter for the users can be accomplished through the physical appearance of the building. By creating a strong looking building that has a presence, the users can feel safe when entering the space.

Create community interaction by making the building multifunctional with diverse functions. These multiuses help increase the interaction of the building with the community. This can be accomplished by orienting the building toward the street, or creating a welcoming character with the façade. This can also be accomplished by attracting neighborhood residence by providing a public garden or public recycling on site.

Buildings can teach lessons through the built environment. This can be accomplished by using local materials and integrating student work throughout the space. Lessons can be taught through the materials and these lessons will be reinforced when students see them day-in and day-out. A good example is color coding certain mechanical systems throughout the school. Students can learn and understand the process over time. Sidy describes this concept as “pedagogy of place.”

Peter C. Lippman is the Chairman of the AIA Committee on Architecture for Education. He practices with a New York firm and is an

Figure 1.4

Figure 1.5 – Example “Fat-L” classroom plan
instructor at the School of Architecture, Urban Design, and Landscape Architecture at the City College of the City University of New York. In 2004 Lippman wrote “The L-Shaped Classroom: A Pattern for Promoting Learning.”22 He reexamined James A. Dyck’s philosophy in the “Fat-L classroom.” Dyck proposed that the layout of the ‘Fat-L’ is “a design pattern that offers the teacher options in how they might organize their classrooms to facilitate the development of their students in various learning activities.”23 Lippman examined the philosophy in practice and also evaluated various configurations that are conducive to learning. These configurations include the single-loaded corridor, the double loaded corridor, and the stacked arrangements. From this he developed criteria for the modern classroom:

- It has to accommodate the formation and functioning of small learning groups while providing a sense of separation, because groups working together will experience distractions and nonproductive interaction.
- It has to be flexible enough to allow the continual reorganization of the whole class into various sizes and number of small learning groups. This means the space must be free as possible of permanent obstructions.
- It has to be manageable by a single teacher who has command of the entire space. This means the space must be compact and open (Dyck, 1994, p. 44).24

In summary, learning environments are “dynamic places and complex systems where numerous activities may be occurring at any moment (Greeno, 1998).”25

Lippman then analyzes the inside corner of the ‘L’ shape.

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23 Lippman, p.X
24 Lippman, p.X
25 Lippman, p.X
This acts as the meeting point, the area where the teacher stands in a large group, or the dividing point, used to separate when meeting in small groups. The ‘L’ divides the space into five separate corners. These smaller spaces can then become five unique areas where different activities can occur. This is an important concept for the Montessori curriculum, in which learning areas are often divided into five categories: sensorial, math, science, language, and practical life.26

Lippman continues his analysis of the ‘Fat-L’ by looking at built precedents. The Montessori School in Delft in the Netherlands was designed by Herman Hertzberger. Originally built in 1960, the school uses a variation on the ‘Fat-L’ design pattern.

Working with the principal and teachers, Hertzberger designed the classrooms with the notion that students are involved with three types of activities: formal, informal, and creative. These activities require different types of concentration, therefore different types of spaces. To facilitate this need, Hertzberger designed the classroom in an ‘L’ shape to make three areas: each leg of the ‘L’ and the intersection of the two legs. This method provided flexibility and allowed multiple groups to work in the same classroom.27

Lippman concludes that the shape indeed does work in practice when the classroom functions with separate learning areas. These areas can easily be created within the corners and nooks that the ‘Fat L’ offers.

Other than the shape of the "Fat-L" how can this be put into use? When integrating this shape into the design, the designer must respect the shape and

26 Lippman, p.X
27 Lippman, p.X
incorporate it into the plan as is: a Fat-L. The other aspect that can assure the success of the Fat-L is to integrate movable furniture that facilitate in separating the classroom. Small bookshelves and desks can be oriented in a manner that breaks up the classroom into distinct areas. This use of furniture, along with the physical arrangement of the walls for the Fat-L plan, can create a learning space that can accommodate multiple functions at the same time.

One of the most often cited studies about new school design today is Heschong Mahone Group’s “Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance.”28 Lisa Heschong, partner of Heschong Mahone Group, was contracted by the California Board for Energy Efficiency to perform the study. The group compared the variety of educational spaces in schools with standardized tests administered to students. The study analyzed over 21,000 students from three different school districts with different climates: Orange County, California, Seattle, Washington, and Fort Collins, Colorado. Secondly, Heschong Mahone Group investigated over 2000 classrooms and classified the daylight conditions, demographic characteristics, maintenance records and aerial photography.

Working with the school districts for a two-year period, the Heschong Mahone Group examined standardized test scores and school characteristics from all thee school districts. “In order to achieve consistency between districts, we chose to use the data set from two test scores, reading and math.”29 The second data set used was the individual characteristics of the classrooms. “This data allowed us to take into account the age and size of the classroom and school, and the type of classroom (open, cluster, portable, or traditional) as well as the presence and size of windows and skylights.”30

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29 California Board, p. 7.
30 California Board, p. 7.
The results generated from all three school districts were highly consistent: all three showed significant positive effects from daylight.\textsuperscript{31} The group concluded that the magnitude of the effect is less important than the observation that consistent positive results occurred in all three school districts:

- There is uniformly positive and significant correlation between the presence of daylight and better student test scores in all three districts.
- A positive effect of daylighting was distinct from all the other attributes of windows.
- The methodology of using large, pre-existing data sets can be successful and powerful tool for investigating the effects of the physical environment on human performance.\textsuperscript{32}

In summary, The Heschong Mahone Group concluded through improved tests scores, that natural daylight provides higher quality of light than fluorescent fixtures. The group also found that with an abundant amount of daylight in the classroom, student learning progressed 20 percent faster on math tests and 26 percent on reading tests. These numbers are staggering when considering the number of students who study in a school during a fifty-year period. To invest a few thousand dollars more per classroom can greatly affect a large number of students. If more school boards or administrations could see this great effect, more schools across this nation would embrace natural daylight tactics.

How can the designer ensure that the daylight strategies are correct? The first step is to perform energy modeling on the specific proposal. This involves modeling the classroom and running it through a series of iterations that test the daylight in that space throughout and entire year. The modeling test can show if the daylight is proportioned to the classroom depth and if there is indeed and increase in daylight compared to a base model situation. From there, the designer can explore other methods of lighting such as clerestories or adding translucent glazing. There are other steps that can affect the light such as adding shading devices. These can be exterior louvers, interior light shelves, or mini-blinds inside the dual glazed glass.

\textsuperscript{31} California Board, p. 24.
\textsuperscript{32} California Board, p. 24.
“I was trying to get people to see that you can’t just grow for ever and hope that the environment will take care of itself.”

-Tim Flannery
SUSTAINABILITY / HIGH PERFORMANCE REVIEW

Sustainable design methods have been used since man has built. Ancient Greek architects oriented their buildings to maximize sun during the winter months and shade during the summer months. This small design decision produces a lasting effect on the operation and the life of a building. Within the past thirty years, and sparked by the 1970's energy crisis, research and testing has occurred with a large number of sustainable concepts. The result of this research has sparked a movement in the design industry, and sustainability has been steadily growing. Architects, owners, and constructors are embracing the subject and it is believed throughout the industry that the topic is here to stay.

The overall objective of sustainability is to utilize the earth’s natural resources without disrupting the ecological balance of that area and to leave the natural environment to our heirs in a least as good a condition as we found it. Designers and consumers have realized that our natural resources are limited and that current use trends can greatly impoverish mankind. Therefore designers must be responsible and change the decline in natural resources. With responsible design, the design and construction industry can have a great affect on current trends and help change the way we use the earth’s natural resources.

Today, sustainable / high performance design covers the entire life cycle (design, build, maintain) of a building. Design areas of focus include site design, energy effectiveness, material use, and indoor environmental quality. From the overall site layout to the cove base on a wall, these design concerns cover the entire building spectrum.

Sustainable design decisions are also linked closely to each other. For example, maximizing thermal comfort for better improved indoor environmental quality is tied to energy effectiveness of the HVAC equipment. If thermal

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34 http://www.sbicouncil.org/highperformanceschoolonlineresources.htm
comfort is compromised, the HVAC system will change and as a result, the system may not run at its optimal performance. With this in mind, sustainable design decisions need to be based on a holistic, integrated approach.

**Sustainable Principles**

The Hannover Principles were created by William McDonough and Michael Braungart for the 2000 world exposition. The City of Hannover, Germany, host of the 2000 exposition, commissioned McDonough to write the principles for new work involved with the event. The principles were established with the goal to move into the new millennium with a new design philosophy that looked to a sustainable future. The principles were shared with designers, planners, and government officials involved with the project.

Little did McDonough and Braungart know that the principles would be the start of a new design paradigm. Firms throughout the world have adopted the principles and use them as objectives for design. McDonough states, “Today we use a more celebratory language that reflects our evolving goals. Rather than aspire to a respectful co-existence with nature, we aim to celebrate human creativity and the abundance of the living earth with designs that create mutually beneficial relationships between people and the natural world.”

These original statements on sustainable design have inspired the design community.

**The Hannover Principles** (taken from McDonough 1992 submission to City of Hannover, Germany)

1. **Insist on rights of humanity and nature to co-exist** in a healthy, supportive, diverse and sustainable condition.
2. **Recognize interdependence.** The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.
3. **Respect relationships between spirit and matter.** Consider all aspects of human settlement including community, dwelling, industry and trade in terms of existing and evolving connections between spiritual and material consciousness.

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35 [http://www.mcdonough.com/writings/from_principles.htm](http://www.mcdonough.com/writings/from_principles.htm)
36 [http://www.mcdonough.com/writings/from_principles.htm](http://www.mcdonough.com/writings/from_principles.htm)
4. **Accept responsibility for the consequences of design decisions upon human well-being.** The viability of natural systems, and their right to co-exist.

5. **Create safe objects of long-term value.** Do not burden future generations with requirements for maintenance of vigilant administration of potential danger due to the careless creation of products, processes or standards.

6. **Eliminate the concept of waste.** Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste.

7. **Rely on natural energy flows.** Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate the energy efficiently and safely for responsible use.

8. **Understand the limitations of design.** No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not and inconvenience to be evaded or controlled.

9. **Seek constant improvement by the sharing of knowledge.** Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity.

The Hannover Principles should be seen as a living document committed to the transformation and growth in the understanding of our interdependence with nature, so that they may adapt as our knowledge of the world evolves.  

Another notable document on sustainability is Sim van der Ryn’s 1996 *Ecological Design*. Van der Ryn wrote that people have been talking about sustainable concepts, but little has been done. “What is needed is a whole new approach to eco-friendly architecture and planning development, not just more band-aids.” Van der Ryn outlines his principles as the fundamental philosophy for the built environment.

**Five Principles of Ecological Design (taken from Ecological Design, 1996.)**

Ecological Design is the art and science of designing an appropriate fit between the human environment and the natural world.

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37 http://www.mcdonough.com/principles.pdf

1. **Solutions grow from place:** Ecological design begins with the intimate knowledge of a particular place. It is small-scale and direct, responsive to both local conditions and local people. If we are sensitive to the nuances of place, we can inhabit without destroying.

2. **Ecological Accounting Informs Design:** Ecological accounting traces the environmental impacts of existing and proposed designs. It is an accounting which links our actions to the health of sometimes distant ecosystems. The information is used to make ecologically sound design decisions.

3. **Design With Nature:** By working with living processes, we respect the needs of all species while meeting our own. Engaging in processes that regenerate rather than deplete, we become more alive.

4. **Make Nature Visible:** De-natured environments ignore our need and our potential for learning. Making natural cycles and processes visible brings the designed environment back to life. Effective design helps inform us of our place within nature.

**Figure 2.2 – Slim Van der Ryn**

Everyone is a Designer: Listen to every voice in the design process. Everyone is a participant-designer. Honor the special knowledge that each person brings. As people work together to heal their places, they also heal themselves.  

**LEED**

The United States Green Building Council (USGBC) has established a series of guidelines to rate building’s sustainable performance. The LEED (Leadership in Energy and Environmental Design) Green Building Rating System process is a voluntary standard to rate high performance, sustainable facilities. The process involves an integrated approach to design and construction. The system is broken down into six categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environment quality, and innovation and design. The six categories have subsets directed toward specific design decisions. If the design, the process, or the material meets the specified requirements, it is eligible to earn points for the specific project. USGBC has established a series of levels that projects can achieve to celebrate their high performance level.

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The advantage of choosing the LEED system is that the building can be graded on its environmental performance. The award levels do not bring monetary rewards; rather they allow the owner, architect and engineer and the public to know that the facility can positively contribute to the health of the users and the environment. Some designers use the LEED system as a design tool, while others try to outdo the standards and go beyond the performance levels. Regardless, the LEED system can be beneficial to the users and the surrounding community.

The High Performance building concept, on average, has been proven to cost 2-3 percent of the construction budget. When compared to the life cycle cost of the building, this expense is minimal. High Performance schools can save energy and improve test scores. Other benefits to schools include:

- High Performance schools have shown higher student test scores because a better physical facility - one with great acoustics, lighting, indoor air quality - delivers better student outcomes.

- High Performance schools provide superior indoor air quality by controlling sources of contaminants and supplying proper ventilation, resulting in fewer student sick days and increased average daily attendance. Since a majority of a school's operating budget is directly dependent on average daily attendance, even a small increase can significantly boost the operating budget.

- High Performance schools are specifically designed to reduce operating costs and to use less water and energy. They are easier to maintain. This means more money into the school's coffers for such important items as books and salaries.

- High Performance schools are good environmental citizens: they reduce environmental impacts by being water and energy efficient and use durable, non-toxic, recycled materials.

- High Performance schools are designed to be pleasant and effective places to work. As a result, they increase teacher satisfaction - an important factor in recruiting and retaining teachers in today's job market.

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40 http://asumag.com/mag/university_spending_paradox/
41 http://www.consumerenergycenter.org/schools/high_performance.html
Ultimately, these facilities are better for the environment and better for the users. High Performance facilities have the capability to reduce harmful effects on the environment and can even reverse damage that has occurred in the past.

**SUSTAINABLE PROPOSAL**

The topic of sustainability has many, many areas of focus. For the sake of simplicity, this thesis will incorporate a variety of sustainable design strategies, but will also focus primarily on site design issues and how they can contribute to a high performance school.

Site design can be as simple as orienting a building effectively to maximize solar access and boost the effectiveness of daylighting. This procedure can also reduce the need for electrical lighting as well as heating and cooling loads. Site design can affect the internal temperature of the building by utilizing shading and protection methods throughout the site. The site can be used a teaching tool to aid in the learning about plants and to explore local animals. The site can also teach about water strategies and the importance of careful treatment and flow throughout the site. With these concepts in mind, the integration of the building and the site can extend the student ecological imagination.\(^42\)

The following items are areas in which site design strategies will be incorporated:

1. **Vegetation:** The site vegetation can be utilized to teach and to reduce building energy use. Students maintaining their own gardens can learn responsible agriculture methods which can also assist in minimizing site erosion. This concept incorporated into a rooftop garden can also serve as a tool to reduce heat gain in the building. Careful incorporation of trees can also further heat gain reduction by shading the south side and protection of the north and west sides of the building from harsh winter winds. Finally, vegetation strategies can assist in protection of the local ecosystem. This is critical to environmentally sensitive site design.

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2. **Hydrology:** The implementation of water-conserving strategies will reduce overall water use. The responsible use of water can be taught by utilizing rain and wastewater technologies. These areas include methods of responsible containment of rainwater with rooftop collection through use of cisterns and swale containment. This area can also maintain natural storm water flow by incorporating the use of vegetated surfaces and open grid paving. Wastewater can be treated and can be reused as a non-potable water resource to use in applications such as toilet and urinal flushing, mechanical systems, irrigation, and custodial use.

3. **Geology / Soils:** Students can incorporate responsible composting strategies into the site that can be reused in agriculture areas. Yard waste, paper waste, and food waste can all be stored on-site and reused at a later point. The teaching of composting can also serve as a teaching tool for the community when investigating new and successful methods to compost. Finally, composting teaches conservation of materials. Users who actively compost realize the amount of waste being generated and tend to minimize the use of material and resources.

4. **Footprint:** Designing the building and parking to minimize the site disturbance. This will be teaching tool for students and can also minimize the amount of runoff onto the site. The reduction in footprint will also help reduce the building's contribution to the heat island effect.

5. **Miscellaneous:** These strategies will involve a variety of other concepts that have learning benefits for students. For example, public art can be incorporated into the site design. Not only is it welcoming to see, it also enables people to think outside of the box and to open up discussion. A second area to be considered is playgardens. “Here the natural features of the site, flora, and fauna are employed to facilitate children’s exploration of nature and their capabilities in...
relation to the environment. The idea of a playgarden enforces the idea of nature as being an integral part of human life.\textsuperscript{43}

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{figure26.png}
\caption{Public Art in New York City, by Christo}
\end{figure}

The Integrated Environment

Chapter Three: History of Montessori: From Formation to Today

"The work of education is divided between the teacher and the environment."
- Dr. Maria Montessori

Montessori was the first Italian female to graduate with a degree of Doctor of Medicine. Completing medical school in 1896, Montessori sought to practice pediatric medicine. While practicing she became heavily involved in the European women’s movement of the early 20th Century. Speaking at conferences and writing essays, she encouraged women to become scholars and scientists. “Montessori urged women to overturn the pseudoscientific antiwomen rationales that justified keeping women in the second-class status.”

Following her own advice, Montessori became a scientist who wanted to discover cures for human illnesses, especially those of the mind. “She joined the University of Rome’s Clinica Psichiatrica as a voluntary assistant to research her thesis ‘A Clinical Contribution to the Study of Delusions of Persecution’.” This was a study of mental illness and psychological disorders. Montessori’s devoted research led her closer to a lifelong dedication to childhood behavior.

“Throughout her life, she acknowledged her supreme debt to two earlier French physicians, Jean Itard and Edouard Seguin, who had developed methods for helping mentally deficient and deaf children.” Itard was a pioneer in transferring medical observation of patients to educational observation of children. He concluded that humans went through “specific definite and necessary stages of human growth.”

Seguin, a physician who studied with Itard, worked with mentally impaired children. He applied his methods at
the Hospice de Bicetre, a training school for children from the insane asylums of Paris. Seguin concluded that institutions for handicapped children should become training centers where medical and pedagogical knowledge could be gained.

Montessori became devoted to the work of Itard and Seguin and wrote a series of articles for Italian newspapers and magazines. “In 1898 the chance to test her theories arrived when the Rome authorities began planning a school to train teachers in educating mentally disabled children,” based primarily on the theories of Itard and Seguin. Montessori was invited to become the co-director of the newly formed school.

Montessori worked with mentally challenged students until 1901. At this point in her life, with her experience with mental illness, she decided to study education as a general field. In 1901, Montessori went back to the University of Rome to study psychology, anthropology, educational history, philosophy, and pedagogical principles.

Educational Theory

During Montessori’s early life, theories on education were offered by Jean-Jacques Rousseau, Johann Heinrich Pestalozzi, and Friedrich Froebel. “The French philosopher, Jean-Jacques Rousseau (1712-1754), expounded a theory of natural education in which children were liberated from oppressive social conventions.” Similarly, Swiss educator Pestalozzi (1774-1827) theorized that children could learn using their senses in a comfortable setting. The third theorist who is most commonly compared and contrasted to Montessori was German educator Froebel (1785-1852). Froebel was the founder of the concept of “kindergarten.” This method of early childhood education took place in a specially created environment, known as the “child’s garden.” Froebel felt that these young children had inner spiritual

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48 Montessori, Maria, p. 8.
50 Montessori, Maria, p. 9
51 Montessori, Maria, p. 10.
powers that unfolded in an encouraging educational environment. The environment encouraged learning through self activity.\textsuperscript{52}

Montessori became familiar with these educational theories and found that they were scientifically inadequate. Rousseau, Pestalozzi, and Froebel all relied on speculative philosophy rather than a scientific view of children based on observation. Montessori accepted some useful qualities of their theories and began to form her own ideas on a new educational method. She based her methods on observation of children through observing middle and lower class cultures. Near the end of her life she presented her three main ideas:

- Human development does not occur in a steady, linear ascent but in a series of formative planes
- The complete development of human beings is made possible by their tendencies to certain universal actions in relation to their environment
- Interaction with the environment is most productive in terms of the individual’s development when it is self-chosen and founded upon individual interest\textsuperscript{53}

**THE CASA DEI BAMBINI**

While studying in Rome in 1907, an unexpected opportunity came to Montessori. “In a notorious Roman slum called San Lorenzo, the authorities were trying to clean up the area by building new housing for the poorest citizens.”\textsuperscript{54} They needed a place for the children who were too young for elementary school. The authorities asked Montessori to supervise a classroom for pre-schoolers. Montessori agreed and felt this would be a good place to test her newly formed theories on normal children.

\textsuperscript{52} Montessori, Maria, p. 11.  
\textsuperscript{53} Polk-Lillard, Paula, p. 4  
\textsuperscript{54} Parkyn, John, p. 36
On January 6, 1907, Montessori opened her first school, Casa dei Bambini, or Children’s House. Montessori equipped the room with chairs and tables that reflected the scale of three-year-old to six-year-old children. The tables and chairs were light enough for children to move around freely, so they would not feel constricted. Other equipment such as shelves, closets, and wash basins were designed to accommodate the height of small children.55

“One of the overarching pedagogical principles was that the children’s learning was best accomplished in a structured and orderly environment.”56 Montessori insisted that the children come to school clean and dressed appropriately. She felt that in order for schools to be effective, parents needed to play an active role. In order to achieve this, she had to have frequent communication with them commonly known as “parent-directress” conferences.

The curriculum at the Casa dei Bambini was based on her research and previous experience. She felt that children have certain “sensitive periods” when they were in a high state of readiness for particular learning activities. These activities included exercises for practical life skills, motor and sensory training, and language development.57 To aid in the development Montessori created self-correcting “didactic materials and apparatus.” These tools were self-correcting so the children could teach themselves at their own pace. “The use of self-correcting educational materials was based in Montessori’s belief that children would acquire self-discipline and self-reliance by becoming aware of their own mistakes and repeating a particular task until they have mastered it.”58

**Montessorianism Grows**

By the second half of 1907, news began to spread throughout Europe and United States about the success of Montessori’s newly formed school. She began to document her philosophy in the book titled *The Montessori Method*. This was a tool used to spread her methods and to instruct other teachers on how to operate their classrooms. “In

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55 Montessori, Maria, p. 16
56 Montessori, Maria, p. 16.
57 Montessori, Maria, p. 16.
58 Montessori, Maria, p. 17
1909, Montessori started the first training course for teachers in her method.” Four years later, schools had trained teachers working in Europe, North America, Australia, and Asia.59

With all this success, people wanted to hear Montessori to better understand her theories. In 1913 she visited and lectured throughout the United States. During that period, there were over 100 Montessori schools operating in this country. Advocate groups were forming and were run by prominent individuals such as Mrs. Alexander Graham Bell and Margaret Wilson, daughter of President Woodrow Wilson. These people traveled with Montessori and promoted her method throughout the United States.

Just as the Montessori method had grown quickly, so did it decline. “By 1917, the first wave of Montessorianism was ebbing severely.”60 Due to World War I, there was a shift in the United States against European ideas. Public schools disregarded the idea, and the concept was only occasionally seen in private schools. Montessori would not see success in America until the 1950’s.61

By the early 1960’s the Montessori Method was back in the fold of American educational philosophy. Parents sought to bring the method back as a result of their education-poor experience. “They wanted to provide their children with the ‘golden time’ they themselves had not known.”62 When Montessori passed away in 1952, the flame was still burning. Her son, Mario was running the program, but people across America felt that he was unsatisfactory in spreading her philosophy. As a result many advocate groups were formed, such as the American Montessori Society (AMS) and the International Montessori Association (AMI). These groups sought to transpose the system to be diverse and reflect the students in America.63

Figure 3.3 – Maria Montessori with group

59 Gordon, Cam, p. 6.
60 Montessori, Maria, p. 34.
63 Loeffler, p 11.
This was the first time since its inception that people wanted to change the system. Is this right to change a method that has worked so well in the past? How do teachers address technological changes? Montessori was created for inner-city children; will this system work for middle class suburbanites? These questions and many more have stumped supporters over the past thirsty years.

In *Montessori in Contemporary American Culture*, Nancy McCormick Rambusch states the following about changing Montessori’s concept:

> The evolution of a theory is very much like the process of invention and product development as it occurs in industry. New concepts are framed only in terms of concept displacement. The emergence of the new concept involves, in some sense, treating the new in terms of the old. After all, we have nothing else. But the process that seems at first to involve treatment of the new in terms of the old do not always lead to formation of new concepts. Old concepts may be used that do not generate change.64

This may sound as if the group preferred drastic changes, but the result was to adapt the system to growing technological needs and the evolution of the suburban students, which were affecting the way we lived. Some change is necessary in order to remain successful. Since the 1960’s the Montessori idea has grown slowly, with adaptability and change. Today Montessori is popular, but personally I feel it has not yet reached its peak.

**Montessori Today**

Throughout the world, Montessori is experiencing great success. In Cam Gordon’s book *Together With Montessori* he states that “Today, there are about 3,500 private and 250 public and 50 charter school programs in the United States.”65 These programs offer classes for children ranging form infants to age 18. Some schools are affiliated with larger governing bodies, some are completely independent.

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64 Loeffler, Margret Howard, p. 11
65 Gordon, Cam, p. 8.
The influence of Montessori can be seen in the number of schools which promote education and child development. Some schools operate just as Montessori wished, while others offer variations on her themes. Regardless of the structure, their development paths are similar: to adapt education for each developmental stage through self-discovery and exploration. Important characteristics used today include:

“Hands-on learning” and manipulatives, particularly for math instruction

Structured learning environments designed to facilitate self-directed learning

Intrinsic motivation and student choice of activities

Multi-age groupings

Peer tutoring and cooperative learning

Self-correcting materials

Ecological studies

Global education

Peace education

Master or outcome-based learning rather than strict curriculum outlines or credit hours

Maria Montessori’s underlying concepts were simple and have stood the test of time. Although her methods have been adjusted to modern conditions, Montessori classroom operations are similar to what they were in Rome in 1907. This is an indication that Montessori methods are successful and will continue to work well into the future.

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Gordon, Cam, p. 8-9.
**Montessori Tomorrow**

As Montessori Schools continue to grow, educators are looking at how and why the system is so successful. A symposium was held in Virginia in April of 1990 to discuss Montessori and the direction in which it is going. Marlene Barron believes, “The Montessori paradigm is culture sensitive and highly adaptable.”67 This adaptability is why Montessori is effective in diverse settings.

Barron wanted to explain why the Montessori Method was so successful and how it will continue to work into the future. First, “Montessori views each human being as a uniquely endowed whole living a whole life in a whole world.” Everything involved with life is about learning. The child learns through his/her self, family, neighbors, and community. This aspect cannot be forgotten. Second, Barron states, “The aim of Montessori is to develop each person’s abilities to the fullest extent.” This creates lifelong learners and problem solvers. These skills are learned at a young age and grown and expand into adulthood. Finally, Montessori will flourish into the future, according to Barron, because “Montessori perspective dictates the inclusion of a rich variety of experiential, meaningful, high content activities.”68 These activities are multisensory, interactive, and engaging. Reflection, problem solving, repetition, and collaboration are some of the skills that children learn while participating in a Montessori program. The combination of the activities and the prepared environment is responsive yet supportive to the children and encourages taking risks, which leads to learning.

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67 Loeffler, Margret Howard, p. 267.
68 Loeffler, Margret Howard, p. 268.
The Integrated Environment

Chapter Four: Precedent Analysis

“To create architecture is to put in order. Put what in order? Function and objects.
- Le Corbusier
Compass Montessori Secondary School
Golden, Colorado
Ewers Architecture

Compass Montessori Secondary School is the first Montessori high school in the United States to be built from the ground up. Completed in October 2002, this school functions as grades 7-12 for a total of 330 students.

“The middle school (grades 7-9) is an Erdkinder school, which means *children of the earth*. This school is a farm school where children raise crops and livestock as well as learn in the classroom.” The philosophy behind the farm school is that the children can step away from society to grow and learn through the work of raising animals and cultivating the earth. The architecture of the Erdkinder school is centered on an agrarian motif. Teaching teams are in separate corners of the school. A central commons serves as public space, and a group meeting place in which the students can develop a sense of community.

The high school (grades 10-12) is developed on the premise that the students will learn independently. As students leave the Erdkinder school they are ready to re-enter society. The philosophy is that students will reach beyond their familiar settings to learn on their own. “The architecture reinforces this independence with an open student plaza, central commons, auditorium, and a coffee shop run by the students.” The spaces allow high school students to be independent in their learning and encourage them to move beyond the classroom to continue their education.

Physically, the Compass Secondary School is a High Performance School, one that teaches and promotes sustainable principles. The use of environmentally sensitive materials, daylighting and conservation of energy, and using the school as a teaching tool all support the high performance classification. Compass Secondary uses

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70 DesignShare Inc.
71 DesignShare Inc.
environmentally sensitive materials and was constructed for 80 percent of the cost for typical schools in the surrounding area. The school also utilizes daylighting techniques and has high levels of insulation. These simple concepts will make the school comfortable, safe, and efficient for Montessori instruction.

The success of Compass Montessori Secondary School can be attributed to a number of factors: the school has total community support; the school functions well with the intended program; and today, the school can serve as a successful model to other Montessori programs. This has been accomplished with integrated planning with the architect, teachers, and students. The design group worked tirelessly to meet the needs of the community and ultimately create a Montessori environment that meets and exceeds their vision.

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72 DesignShare Inc.
Figure 4.4 – Compass Montessori floorplan

Figure 4.5 – Compass Montessori commons
Primary School DeVogels, Oegstgeest, Netherlands
ArchitectuurStudio - Herman Hertzberger

Primary School DeVogels had an interesting challenge: to incorporate the design of an 11,200 square foot school and 32 row houses on the same site. The design competition was won by Herman Hertzberger. Hertzberger is known for his “use of design as a catalyst for social intervention.” Some may say Hertzberger has been overshadowed by a younger generation of architects, but at age 71, his techniques of social design are as relevant as ever.

Hertzberger arranged the houses in a bowlike curve that defined a strong sense of public space. He then positioned the school at the spring point of the curve. This provided views of the school from all points. To minimize the footprint, Hertzberger placed 8 classrooms above the gymnasium. This gave all learning spaces an abundant amount of natural light.

The second story is accessed by an extremely wide staircase that acts as a gathering place for performances or guest speakers. Hertzberger states, “Like everything else in this project, it was designed to become a social place.” At the top of the staircase, 8 classrooms open to a “main street”. Hertzberger placed wide sliding doors to the classrooms to encourage flow and a feeling of openness throughout the classrooms. The doors are often kept open to encourage small group activity to flow from the classrooms into the corridor.

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74 Cohn, David, p.132
The material palette is very simple: steel, aluminum, wood, and glass. Hertzberger wanted to use these materials because he felt they are less expensive than concrete and concrete block. These materials also create warmth with the blend of the natural tones the materials possess.

The creative ideas of Hertzberger have produced a dynamic school that has positive principles that can be applied to the prepared environment. His blend of clean materials and open spaces create a school that is simple yet exciting. Additionally, the school positioning relates to the community and can remind the neighborhood that education is important. The Primary School DeVogels also reminds users that with careful preparation, the school can be a successful tool to assist teaching. Overall, keeping simplicity in mind, Hertzberger created a straightforward, open school that succeeds on a complex and challenging site.

Figure 4.8 – DeVogels main stair
Figure 4.9 – DeVogels Classroom
Figure 4.10 – DeVogels 2nd floor plaza
In 1993, Behnisch & Partners were contracted to design a 350-student Montessori school in which one-third of the students were physically handicapped. The school was to be set up for diverse functions and to be divided into areas determined by the client: kindergarten, therapy area, primary school, secondary school, craft house, and a youth community center. The goal of the client was to create a school that allowed “self-reliance in surroundings suited to children & prepared the environment in a didactical manner.”

Five separate “houses” create a large open green space in their center. This area is used by teachers to intertwine teaching with nature. There is also a farm garden in which the students cultivate the earth. The highest point of this sprawling school is the community center. Behnisch & Partners designed this area to stand out because it serves the school along with community. When community members who do not visit the school on a normal basis arrive at the building, the peak of the building stands out and the entry is recognized.

There are no standard classrooms in this Montessori School. Individual educational areas are created by the juxtaposition of walls which scatter pocket niches throughout the school. These areas become zones in which children can work independently and immerse themselves into the work. In the Montessori curriculum, this is an extremely important concept. These niches allow children to follow their imagination and to enter into another world of learning.

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The classrooms have been described as “cozy”, reminiscent of the students' homes. This feeling of comfort is created by the use of lower ceiling heights & the wide variety of materials. Fabrics, woods, metals and cementicious products give the building a changing texture and appealing material pallet.

Behnisch & Partners have successfully created a Montessori school with a truly prepared environment. The variety of forms and materials combined with the integration of the natural surroundings, greatly assist in the steps of nurturing the students. The success can be measured by the number of students who attend the school but also due to popularity, the school has recently decided to expand. Behnisch & Partners have been commissioned to design an addition to the existing school and is slated for completion in the summer of 2005.

Figure 4.12 - Ingolstadt-Hollerstauden Montessori School site plan
Figure 4.13 - Ingolstadt-Hollerstauden Montessori School classroom

Figure 4.14 - Ingolstadt-Hollerstauden Montessori School exterior
Figure 4.15 - Ingolstadt-Hollerstauden Montessori School exterior
The Prairie Hill Learning Center was completed during the summer of 2005. The 3,700 square-foot building is extremely simple, yet it has some complex attributes. James A. Dyck A.I.A., leading partner of The Architectural Partnership, designed this facility to be energy efficient, utilizing the earth’s natural resources, and to be sensitive in human scale. Not only is Dyck the designing architect, he is also the co-founding member of the Prairie Hill Learning Center.

The Prairie Hill Learning Center has initiated a building plan to demonstrate the use of natural energy resources in an educational environment, preparing children to preserve their future. To accomplish this with their new building, Dyck has incorporated the use of straw bale construction, passive solar daylighting and heating, rainwater collection system, wind generated electricity and photo voltaic solar generated electricity. These sustainable principles all effect the environment in a positive manner, but more importantly, they can be used as a teaching tool for the students.

The first method of energy efficient construction can be found in the walls, commonly known as straw bale construction. Straw is traditionally a waste product that farmers do not till into their soil. It is generally sold as animal bedding or burned, which creates air quality problems. At the exterior face the straw is coated with three coats of stucco to create

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76 Prairie Hill Learning Center (http://www.prairiehill.com)
a moisture barrier. On the inside face, an earthen plaster is applied to create a clean, flat surface. This type of system can generate an R value of R-30 and up to R-50.

The second method of energy efficiency in the Prairie Hill Learning Center is the use of natural daylighting. This concept reduces the amount of electric lighting required by utilizing natural lighting from the sun. This is accomplished by orienting the building on a North-South axis. Light shelves are then used to reflect light into the classroom during the summer months and to shade the classroom from the lower sun angles in the winter months. Dyck faced the two main learning spaces south so they can both utilize natural daylighting.

Another aspect of daylighting that Dyck used is the material selection and paint color in the classrooms. The interior plaster is painted with light colors to reflect the incoming light. This concept, along with the window position is a great energy saving mechanism and more importantly, is a design tool used to improve student learning and test scores.

The third method of sustainable design is the rainwater collection system. Two large above-ground basins are located on the North and South sides of the building. They are connected underground to a pump system that supplies collected water to gardens and lawns throughout the property. This system is also used to clean the outside of the building and any other non-food water cleaning application.

The final energy savings principle the Prairie Hill Learning Center employs is through electricity. Two methods, wind generated electricity and photo voltaic solar panels, are used to provide a net 100% of electrical power for the 3,700 square foot building. Wind generated electricity is captured through a wind mill power system. This system means less smog, acid rain, and greenhouse gas emissions. Similarly, the photovoltaic panels collect sunlight and convert that energy into electricity. Both methods, wind mill power and photo voltaic, store the electricity in a battery system. Excess electric is also shared throughout the rest of the campus.
Finally, Dyck has paid careful attention to human scale. The building’s users are all elementary students, so the space can not seem grand and become intimidating. The entry is nestled between the community room and the classrooms. This modest entry leads directly into the classrooms, from which the users then enter into a space that has varying volumes. The play in volumes provides a constant feeling of comfort throughout the classroom. This transition of space allows elementary sized students to ease into a classroom which is often shocking for new students to experience.

It is evident that this building will serves as a successful exemplar for the prepared environment. Dyck has incorporated many physical aspects into the space that facilitate the growth and learning of a Montessori student. When the combination of physical attributes such as aesthetic, spatial, light, noise, color and thermal are carefully integrated with environmentally sound design concepts, the prepared environment can succeed as a positive tool in Montessori learning.

![Figure 4.18 – Floorplan and section](image-url)
“When we heal the earth, we heal ourselves.”
- David Orr
RESEARCH CONCLUSIONS

This research has produced a greater understanding of sustainable design and the Montessori philosophy. The sources draw upon years of others’ experiences in the fields of ecological study and educational design. Some of the experts’ ideas are original while others ideas have stemmed from previous research. What needs to be understood is that the overall goal is to improve the learning environment and to enhance students’ opportunities to learn.

Furthermore, some of the discoveries presented apply to architecture in general, while others are specific to educational facilities. The important key is that all the ideas revealed need to be carefully woven together to take full advantage of the Montessori learning environment. This educational philosophy can be turned into a built form that is diverse and more powerful than traditional schools.

Additionally, High Performance Schools can improve student test scores while saving the school district money and helping the local environment. With added focus during the design phase, small design strategies can create a win-win approach for the students, staff, and local community. These design strategies can then be used as a tool to teach the students on an ongoing basis and this can reinforce the goal of being a High Performance School.

Finally, the concepts of Montessori will change over time. As a result, the design concepts created will be expected to change accordingly. To stay abreast of current teaching and design trends, much can be learned by studying other successful Montessori schools. This can be done by looking at new Montessori schools throughout the United States and beyond. Montessori has the benefit of being taught throughout the world and it is important to look at how other cultures are addressing the need for new Montessori schools. While some designs may not translate to a given situation, they will nonetheless impact our thinking of school design. What is understood is that we must continue to learn and examine at home and beyond.
Chapter Six:

Proposition

“When we build, let us think that we build for ever.”

- John Ruskin
PROPOSITION

As the ideas are assembled and move toward implementation, it is necessary to establish ideas for the design of a new Montessori school. This thesis project is a 180-student Montessori School in Wyoming, Ohio focusing on High Performance design principles. The incorporation of Montessori with High Performance concepts will procure an environment that can produce improved learning for the students. Within that overarching idea, four architectural principles will guide the design of the thesis project.

Five sensorial attributes - aesthetic, spatial, light, noise, color and thermal - are fundamental to the success of the Montessori environment. These attributes stimulate children and enhance the Montessori experience. For example, a classroom for third grade students could encompass the following characteristics:

**Aesthetic:** colorful tools for students to teach themselves on low shelves which are easily accessible for short arms and smaller students.

**Spatial:** a sloped ceiling to create varying spatial volumes of low and high for different tasks and for flexible space.

**Light:** an abundant amount of natural, diffused light along with a variety of light levels for different tasks and situations.

**Noise:** materials to absorb and reflect sound during louder periods along with materials that help create a low noise level.

**Color:** purposeful color placement using the psychology of color; using color as a teaching tool

**Thermal:** a comfortable setting at 72° Fahrenheit – not too hot, not too cold; along with being adjustable when necessary.

When integrated into the design these attributes help make the overall effect better and students who are more attentive which results in improved learning and success in the classroom.
**Classroom configuration** - The Montessori classroom can be arranged to enhance the learning potential of Montessori students. The shape of the classroom can allow multiple uses throughout the day. For example the “Fat-L” shape can be broken into separate teaching areas, or be used as one large classroom. The ability to vary the space according to the lessons being taught creates a dynamic environment that can accommodate numerous activities. The L-shape flexibility is required because the Montessori classroom is a diverse, ever-changing learning environment.

**3D Classroom** – The built form of the school can become a teaching tool for the users. The best way to teach is through example. If schools can teach children with environmental strategies incorporated into the curriculum and integrated into the architectural fabric, they will not only understand these concepts, but they will gain an increased awareness and appreciation for the environmental lesson. This appreciation can move into the home environment and encourage their families and community on the positive benefits of a sustainable lifestyle. This ongoing learning and sharing can be the loop that spreads the ideas of sustainable living. The built school being used to teach lessons can also apply academic, social, and economical principles.

The 3D design applications need to have simple and complex lessons. This can accommodate the young students while also intrigue the older students who need to be challenged. For example, a simple lesson could be caring for fish in a small pond located on the school property. A more complex system could be a rainwater collection system that collects and stores rainwater that is then used as grey-water to flush toilets and urinals.

**High Performance Schools** can positively affect learning. This statement is best understood by looking at the result of natural daylighting. Through testing and research, daylighting, a keep component to the high performance school model, is proven to improve student test scores. This is accomplished by providing natural, diffused lighting through rooftop monitors or clerestory windows. This diffused light has been proven to be a higher quality light compared to traditional fluorescent lighting. The result of this cause and effect (daylighting and improved tests scores) creates a building that is High Performance; aspects of the building improve the performance of the users. With careful planning...
and focus on the orientation of a school classroom, student learning can be increased through daylighting and can have a great effect on the overall performance of the individual school.

The Montessori Method has always integrated nature into the teaching lessons, based upon Maria Montessori’s initial philosophies. By incorporating sustainable design principles, the teaching method can utilize nature in a new manner that improves student results. Overall, with an integrated design approach that incorporates the human senses, the earth’s natural resources, and careful design decisions, this new model for Montessori schools can create better learning environments. Therefore, I present “The Integrated Environment: a modern approach to the Montessori learning environment”
Chapter Seven: Site Analysis & Program
SITE ANALYSIS AND PROGRAM

The site selected for the design portion of my thesis is 16.08 acres in Wyoming, Ohio. The site is located approximately one-quarter mile west of Springfield Pike, Wyoming’s main thoroughfare. This area, west of Springfield Pike, is known as “the hill” for its rolling terrain. For maps of Cincinnati, Wyoming and the site, refer to Appendix A.

The site was donated to the City of Wyoming in 2002 from the Sterns Family, co-owner of the Sterns and Foster Mattress Company. The area is commonly called “Sterns Woods”. When donated, the land was to be used as a nature preserve. Because of shortage of available land, I am proposing a dual-use as a Montessori school located within a
nature preserve. This combination fits perfectly within the Montessori curriculum and the high performance component. The ability to house a school within a great teaching tool such as a nature preserve is priceless.

Currently the site is seventy-five percent wooded and twenty-five percent open field. The topography steadily drops fifty-seven feet diagonally across the site. Throughout the wooded area, there is evidence of residential life from the past. A broken driveway, old walking paths, and an ornamental fountain can be found when traversing the site.

The vegetation on the site is very rich consisting of a variety of grasses, wildflowers, shrubs, vines and deciduous and evergreen trees. Majority of the site has not been touch by man therefore the trees are very old. This is an important feature to keep in mind with the proposed design. The design needs to respect the vegetation and to keep the nature preserve in tact.

The climate of the proposed site is mixed throughout the year. Cincinnati, Ohio features a wide range in temperature throughout the year. The coldest months are December through February averaging temperatures between upper-teens to low-forty degree Fahrenheit. The summer months, June through August, the temperature averages in the mid to upper-eighty degree Fahrenheit. The precipitation in the Cincinnati region is very consistent. The month of July has the least amount of precipitation, 2.3 inches, while May is the wettest with 4.7 inches of rain. Refer to Appendix for temperature, precipitation and wind charts.

The neighborhood of the proposed site is located in an area that is one-hundred percent residential. A variety of home style and ages can be found surrounding the proposed property. These styles include Craftsman, Traditional, seventy's contemporary and Tudor homes. The date of construction of the surrounding homes range form early 1900’s to the late 1990’s. The homes vary in size from 1,500 square-feet one-story homes to 6,000 square-feet three-story homes. Because of the varying styles and periods, a variety of material and forms can be found throughout the neighborhood.

77 www.climate-zone.com
The neighborhood is fairly quiet throughout the day. Students who live within close proximity can walk to the school and parents can feel safe allowing their children to do so. The traffic surrounding the site is average. The northern boundary, Oliver Road, is used as a cut-through to western area of Wyoming and sees steady traffic throughout the day. The east boundary, Glenway Avenue, may have twenty cars total throughout the day.

The site is located within the Wyoming City School District. The school district currently has a rating of Excellent. The numerical rating is 108.2 which is the highest of any public school system in the State of Ohio. Due to this positive rating, enrolment in the Wyoming School District has risen steadily in the past 15 years.

Enrollment History
1995 - 1,683
1999 - 1,866
2000 - 1,908
2001 - 1,915
2002 - 1,952
2003 - 1,971
2004 - 1,997

Ethnic Data
12.58% African American
1.81% Asian or Pacific Islander
0.75% Hispanic
2.47% Multi-racial

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79 Ibid
82.39% White
0.0% American Indian or Alaskan Native\(^{80}\)

**Facts & Figures**

Area of City (square miles): 2.87
Population (2000 census): 8,261
College Grad: 56 percent
Families w/Children: 78.95 percent
Median Family Income: $57,356
Non-white population: 12.7 percent

Housing Units: 3,227
Single Family: 2,881
Condo/Townhomes: 178
Rental Units: 347
Percent Owner Occupied: 86.6 percent
Median Home Value: $133,800\(^{81}\)

\(^{80}\) ibid
## Proposed Montessori School Program

<table>
<thead>
<tr>
<th>Grade</th>
<th>Students</th>
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</thead>
<tbody>
<tr>
<td>PK</td>
<td>30</td>
</tr>
<tr>
<td>K</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
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<tr>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>TOTAL</td>
<td>180</td>
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</table>

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<tr>
<th>Spaces</th>
<th>Amount</th>
<th>Sqft</th>
<th>Total</th>
<th>Use</th>
<th>Aprox. Volume</th>
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<tr>
<td>Montessori Classrooms</td>
<td>6</td>
<td>1200</td>
<td>7,200</td>
<td>General education - math/language/science</td>
<td>varying ceiling heights (9'-15')</td>
</tr>
<tr>
<td>Outdoor learning</td>
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<td>400</td>
<td>2,400</td>
<td>Outdoor education</td>
<td>porch adjacent to classroom - with canopy (8')</td>
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<tr>
<td>Gymnasium</td>
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<td>1500</td>
<td>1,500</td>
<td>Physical education</td>
<td>20' high ceiling</td>
</tr>
<tr>
<td>Music</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>Music and performance practice</td>
<td>varying ceiling height (9'-12')</td>
</tr>
<tr>
<td>Art</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>Art education and instruction</td>
<td>12'-15' ceiling height</td>
</tr>
<tr>
<td>Media Center</td>
<td>1</td>
<td>1500</td>
<td>1,500</td>
<td>Research material and computers</td>
<td>12'-15' ceiling height</td>
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<tr>
<td>Science</td>
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<td>900</td>
<td>Science experiments and testing</td>
<td>10'-12' ceiling height</td>
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<td>Dining Area</td>
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<td>2000</td>
<td>2,000</td>
<td>Lunch and snack area, community gatherings</td>
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<td>Kitchen</td>
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<td>600</td>
<td>600</td>
<td>Lunch and snack preparation</td>
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<td><strong>SUBTOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>17,700</strong></td>
<td></td>
</tr>
</tbody>
</table>

| Administrative      |        |      |       |                                          |               |
| Admin Office        | 1      | 800  | 800   | Principal, nurse, and admin staff       | 10' ceiling height |
| Teacher Resource Rooms | 2  | 200  | 400   | Teacher preparation and resources       | 10' ceiling height |
| Technology          | 2      | 100  | 200   | switches and servers                    | 10' ceiling height |
| Storage             | 1      | 1000 | 1,000 | Misc. storage of seasonal items         | 10' ceiling height |
| **SUBTOTAL**        |        |      |       | **2,400**                               |               |

| Mechanical          |        |      |       |                                          |               |
| Boiler / Electrical | 1      | 1400 | 1,400 | Hot water, electrical room, maintenance area | 15' ceiling height |
| Mechanical Room     | 1      | 1100 | 1,100 | HVAC equipment                           | 15' ceiling height |
| **SUBTOTAL**        |        |      |       | **2,500**                               |               |
| **TOTAL**           |        |      |       | **22,600**                              |               |
| Circulation         | 15%    |      | 3,390 |                                          |               |
| CONSTRUCTION FACTOR | 10%    |      | 2,260 |                                          |               |
| **TOTAL SQFT**      |        |      |       | **28,250**                              |               |
The Integrated Environment

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Figure 4.4: Compass Floor Plan, http://www.designshare.com/portfolio/project/details.asp?projid=418&projview=img&projimg=2
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Figure 4.18: Prairie Hill Learning Center, AMS Chicago 2005 Presentation.pdf, Slide 85

Figure 6.1: Thesis Diagram, Image by Author.

Figure 7.1: Site Diagram, Image by Author
The Integrated Environment

Appendix:
Appendix A: State of Ohio Map – Map by Charles Jahnigen, 2005
Appendix B: Map of Greater Cincinnati – Map by Charles Jahnigen, 2005
Appendix C: Map of Wyoming, Ohio – Map by Charles Jahnigen, 2005
Appendix D: Map of Wyoming, OH indicating site location – Map by Charles Jahnigen, 2005