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Architecture as Pedagogy: Designing Sustainable Schools as Three-Dimensional Textbooks

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To the Graduate Council:

I am submitting herewith a thesis written by Ester Ehrlich Schwartz entitled "Architecture as Pedagogy: Designing Sustainable Schools as Three-Dimensional Textbooks." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Architecture, with a major in Architecture.

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Architecture as Pedagogy: Designing Sustainable Schools as Three-Dimensional Textbooks

A Thesis Presented for the
Master of Architecture Degree
The University of Tennessee, Knoxville

Ester Ehrlich Schwartz

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DEDICATION

To my children, Noam and Hannah.

I love you!

ACKNOWLEDGEMENT

I would like to thank everyone who has contributed to this thesis and provided me with feedback and guidance. I especially like to thank my thesis committee for all the suggestions through the many iterations of this project. Thanks to John McRae for being a wonderful thesis advisor and a very supportive friend, and for the valuable comments and positive and helpful feedback on the conception and development phases of this project. Thanks to Mark Schimmenti for his wonderful comments and consistent support. Thanks to James Rose for his expert insights on sustainable design and his confidence in my abilities.

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Thank you all for believing that I could do it.

ABSTRACT

The importance of school buildings has been recognized as a fundamental element of modern society. Today, roughly a quarter of America's population, including our youngest citizens, spend the majority of their days in school buildings. Still, many of our nation's schools are in disrepair, with systems in need of repair or replacement.

Over the years, strong evidence and research have shown that school building impact student's health and their ability to learn. Green schools mean healthier environments for students and staff. Pragmatically, we also know that green schools save money. Energy-efficient buildings help reduce energy costs, which in turn frees up money for crucial academic and student support services.

This thesis proposes a study in which a combination of green school design and educational goals set the stage for the attributes of green schools to become teaching tools that help children develop a conscience of sustainability and complexity of living and built systems around us. Assuming that school facilities, whether functioning well or not, serve as powerful pedagogical instrument, one may argue that if the power of these attributes as three-dimensional textbooks was connected, the impact on learning for the next generation of students would be limitless. School buildings could then provide students with opportunities to connect with themselves, their community and their local environment. Through hands-on, real world learning experiences children could see their learning as relevant to their world, take pride in the place they live and grow to become concerned and contributing citizens.

Through the exploration of themes of sustainable design, ecological schoolyards and environmental education, along with case studies, I will gather creative ideas which schools have successfully developed on their grounds to create opportunities that encourage children to explore the natural environment and learn about sustainability.

Finally, the goal of this thesis will be to demonstrate how architecture can become an important part of educating our children about stewardship and sustainability, setting them to create a sustainable future.

PREFACE

Today our environment suffers from the growing demand of human consumption and waste. As population number rises and resources are depleted, alternative sources of energy and smarter use of resources are imperative to sustain the quality of life we have. Still, changing people's attitudes to the environment is a difficult task. The challenge facing all people concerned with sustainability is how to educate the public about the problems facing the world and create an understanding of the importance of the environmental issues we face. And, while it is hard for adults to adapt and change, environmental education to children and younger people, who are still searching for ideals and principles they wish to follow in their lives may be the best solution to our environmental challenges.

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CHAPTER I

INTRODUCTION

THE SUSTAINABILITY AGENDA

Green is the new gold. "The term 'sustainable development' has generated popular appeal because it implies that the production and consumption of goods and services, and the development of the built environment, can be achieved without degrading the natural environment" (Berke et al, 2006). As Song and Knaap (2007) put it, "smart growth, New Urbanism and sustainable development have now become common terms in the dialogue among urban scholars, land-use policy makers, and the public at large". Still, no consensus among scholars has been reached on how to measure sustainable urban development and researchers continue to study the best ways to counter the impacts of both urbanization and sprawl.

Much research and many publications can also now be found on sustainability issues from politics to business-related interests. As Esty and Wiston analyze in their book 'Green to Gold - How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage', companies are now realizing that the environmental lens is not just a nice strategy tool or a feel-good digression from the real work of a company. It is an essential element of business strategy in the modern world and smart companies now seize competitive advantage through strategic management of environmental challenges (Esty & Wiston, 2006).

Attention on sustainability and climate change issues is rapidly growing in diverse areas of the international agenda too. Evidences of this new 'green wave' are Vice President Al Gore and the U.N.'s Intergovernmental Panel on Climate Change first winning an Oscar award for best documentary film and then receiving the 2007 Nobel Peace Prize for the creation of worldwide awareness of issues of climate change and the measures that need to be adopted.

DEFINING SUSTAINABILITY

Sustainability is considered a global issue and one which requires a sense of global responsibility in relation to ensuring the sustainability of the earth's natural resources. While the concept of sustainability existed long before the 1990s and has been defined in many ways, the most frequently quoted definition is from "Our Common Future", also known as the Brundtland Report , released in 1987 by the World Commission on Environment and Development (WCED):

The report further states that "...the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature. ... The pursuit of sustainable development requires:

- a political system that secures citizen participation in decision making,
- an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis,
- a social system that provides for solutions for the tensions arising from disharmonious development,
- a production system that respects the obligation to preserve the ecological base for development,
- a technological system that can search continuously for new solutions,
- an international system that fosters sustainable patterns of trade and finance, and
- an administrative system that is flexible and has the capacity for self correction."

WHY SUSTAINABILITY MATTERS

Today our environment suffers under the growing demand of human consumption and waste. As population number rises and resources are depleted, alternative sources of energy and smarter use of resources are imperative to sustain the quality of life we have. Still, changing people's attitudes to the environment is a difficult task. The challenge facing all people concerned with sustainability is how to educate the public about the problems facing the world and create an understanding of the importance of the environmental issues we face. And, while it is hard for adults to adapt and change, environmental education to children and younger people, who are still searching for ideals and principles they wish to follow in their lives may be the best solution to our environmental challenges.

CHILDREN, SCHOOLS AND SUSTAINABLE EDUCATION

Teaching children to understand and appreciate their world will make them more responsible about their environment. The good news is that today's children are in a position to be better educated as environmental awareness is increased and is incorporated throughout daily activities. And while many children may be taught about environmental responsibilities at home, schools are in a spotlight position to further this kind of awareness and understanding (Clemson.edu, 2012).

Former president Bill Clinton has also spoken to our responsibility to the environment, and specifically directs his comments to schools: "I think that we should begin in elementary schools teaching people about sustainability… we know that children's instincts always direct them to be more green… We should give every young person the means to maximize the environment of their schools. They're all in school somewhere—public or private. We should be right now engaged in retrofitting every school in America." (Center for Green Schools).

CHAPTER II

SUSTAINABLE ARCHITECTURE

Green design can be defined as "…one that is aware of and respects nature and the natural order of things; it is a design that minimizes the negative human impacts on the natural surroundings, materials, resources, and processes that prevail in nature" (ASHRAE Green Guide). It may also be defined as the art of designing physical objects and the built environment according to the principles of economic, social, and ecological sustainability. Although definitions are broad philosophical statements, and tend to be difficult to articulate into specific design objectives, they are important to emphasize the need for a holistic approach to designing buildings as an integrated system.

Worldwide, during the past decades many industrial sectors have begun to recognize the impacts of their activities on the environment and to make significant changes to mitigate their environmental impact. The commercial building construction industry is one of those sectors that recently begun to acknowledge their responsibilities for the environment, resulting in a shift in how buildings are being designed, built and operated. This shift has been driven largely by a growing market demand for environmentally friendly and energy efficient products and services. Though initiated primarily by the non-profit sector, federal, state and municipal sectors are increasingly committing to the green building cause.

While typically buildings are designed according to local building codes, green building design challenges designers to go beyond the codes to improve the overall building performance and minimize environmental impacts. A few mechanisms now exist to transform this design goal into specific performance objectives and provide a framework to assess the overall design. These tools are called green building rating systems.

Green building rating systems are transforming the construction industry by focusing on high-performance, energy efficient, economical and environment friendly buildings.

All green building rating systems are voluntary in nature, and in many cases, used as design checklists. Although all green building rating systems differ in terminologies, structure, performance assessment methods, relative importance of the environmental performance categories and documentation requirement throughout certification, they seem to focus on the same five categories of building design and life cycle performance:

1. site
2. water
3. energy
4. materials, and
5. indoor environment

Energy-efficient, or sustainable building is a fully integrated, “whole building” approach to design, and operation. This approach differs from the traditional design/build process, with the design team closely examining the integration of all building components and systems and determining how they best work together to save energy and reduce environmental impacts both during construction and throughout the operating lifetime of the building.

A CALL FOR SUSTAINABLE SCHOOL BUILDINGS

Over the years, strong evidence and research have shown that school building impact student's health and their ability to learn (Figuero & Rea, 2010; Heschong, 2003, and Lackney, 2001). Yet, many of our nation's schools are in disrepair, with systems in need of repair or replacement (Baker & Bernstein, 2012). One may then argue that sustainable high performance schools could be a good solution for concerns on student achievement levels, rising energy costs and tightening school budgets.

High Performance School Buildings

Several elements of sustainable building design and operations have direct effects on student performance. These elements include day-lighting, thermal comfort, indoor air quality, and acoustics. Studies repeatedly show that better indoor environmental quality in schools results in healthier students and faculty, which in turn results in lower absenteeism and further improves student achievement (Buckley, Schneider & Shang, 2004). Green schools mean healthier environments for students and staff. Energy-efficient buildings also help reduce energy costs, which in turn frees up money for crucial academic and student support services. According to the U.S. Department of Energy, investing in energy-efficient renovations—replacement of inefficient boilers, lighting, and other systems—could reduce school energy costs by 30 percent.(Kats, 2006; US DOE, 2006).

Sustainable schools also referred to as green or high performance schools, in addition benefit the outdoor environment, by being energy and water efficient and making use of renewable energy and green materials to the fullest extent possible. They also provide environmental benefits by conserving natural resources and reducing pollution and landfill waste. (Olson & Carney, 2006).

CHAPTER III

SCHOOLS AS LEARNING ENVIRONMENTS

The importance of school buildings has been recognized as a fundamental element of modern society. Today, roughly a quarter of America's population, including our youngest citizens, spends the majority of their days in school buildings. As a result, schools have become a contentious and heavily scrutinized part of civil society (Baker & Bernstein, 2012). Still, many of our nation's schools are in disrepair, with systems in need of repair or replacement. The American Society of Civil Engineers, in its 2009 infrastructure report, gave the country's school buildings a grade of 'D' (ASCE, 2009). According to the National Clearinghouse for Educational Facilities, about one-fourth (28 percent) of all public schools were built before 1950, and 45 percent of all public schools were built between 1950 and 1969 (NCEF.org). And the 21st Century School Fund state that the average age of our public schools is 40 years old (21 CSF, 2011). And, though there is no current comprehensive nationwide data on the condition of the country's school buildings, the Department of Education report Condition of America's Public School Facilities in 1999 estimated that to bring schools into good repair would range from a low of at least $270 billion to more than $500 billion (ED, 2000).

Assuming that school facilities, whether functioning well or not, serve as powerful pedagogical instrument, one may argue that when combining green design to educational goals, the environment itself could become a teaching tool, as a three-dimensional textbooks, and the impact on learning for the next generation of students could be limitless. After all, there is no better way to teach than to show children through example.

As places of teaching and learning, school buildings could help pupils understand the impact they have on the planet by providing students with opportunities to connect with themselves, their community and their local environment and nature. Through hands-on, real world learning experiences children can see their learning as relevant to their world, take pride in the place they live and grow to become concerned and contributing citizens. The environment becomes a critical part of the school's curriculum. Differently from the traditional educational literature, where the term "learning environment" refers primarily to the foundations and methodologies of the process of interactions between teachers and students within the context of curriculum and learning outcomes, in this thesis the learning environment is seen as a variety of spaces where children can explore, learn and play freely and safely.

ARCHITECTURE AS PEDAGOGY

Teaching children to understand and appreciate their world will make them more responsible about their environment. Today's children are in a position to be better educated as environmental awareness is increased and is incorporated throughout daily activities. And while many children may be taught about environmental responsibilities at home, schools are in a spotlight position to further this kind of awareness and understanding. (Clemson.edu, 2012).

As Orr proposes in *Architecture as Pedagogy*, design without thought to pedagogy results in buildings that —"show little thought, imagination, sense of place, ecological awareness, and relation to … larger pedagogical intent. What lessons are conveyed through the design of America's schools? Does the dilapidated state of a school facility communicate community disregard for children, devaluing learning? Do we accept carelessness that accompanies inefficiency, and adopt callousness to the degradation associated with the production of energy and materials (Orr, 1993)? If it is desirable for future generations to be better stewards than their predecessors, they will require environments communicating values of environmental stewardship. To educate for sustainability, the built environment will need to illustrate connectedness and responsibility to the larger world community.

CHAPTER IV

CASE STUDIES

GREEN BUILDINGS AS TEACHING TOOLS

The combination of green school design, a green organizational culture, and curriculum aligned with green practices and methodologies sets the stage for a school to utilize their facilities and grounds as a teaching tool. When educational principles are built into the learning environment, the environment transforms itself into a teaching tool.

As Anne Taylor observes in the book "*Linking Architecture and Education - Sustainable Design for Learning Environments*", "architects must integrate many aspects of design to create a whole and wholesome learning environment by not addressing merely a numerical program, however important size and cost, but also a deeper program responding to the needs of the user, the community, and the Earth" (Taylor & Enggass, 2009).

Recognizing that practitioners need to study exemplars, AIA/COTE introduced the Top Ten Green Projects program on Earth Day in 1997. The program, which pioneered a blend of qualitative and quantitative assessment, counts with involvement and support of the Department of Energy and the Environmental Protection Agency's Energy Star. The Top Ten program has a sophisticated online submission process, and, while relying on the display board to give a first impression to the jury, detailed metrics are provided, giving this program its unique qualitative and quantitative framework and providing a critical web site resource (AIA Committee on the Environment).

Two case studies are presented in this document:

1. Sidwell Friends Middle School, Washington, D.C.
2. Ben Franklin Elementary School, Kirkland, WA

The case studies were identified from a list of Top Ten Green Projects according to The Committee on the Environment of The American Institute of Architects (AIA/ COTE).

Case Study 1

Sidwell Friends Middle School

Washington, D.C.

Architects: Kieran Timberlake Associates

Figure 01: Rooftop view of Sidwell Friends School.

The Sidwell Friends School, a day school for students in pre-K through 12th grade, was founded on Quaker philosophy, which includes a dedication to environmental stewardship. The expansion of the school became a catalyst for the institution to enhance its curriculum with an environmental focus and reinvigorate its connection to Quaker values. The renovation of the 33,500-squarefoot 55-year-old school as well as constructing a new 39,000-square-foot addition was completed in time for the 2006-2007 school year and serves 350 students.

Figure 02: Site plan for the Sidwell Friends Middle School (AIA Cote Top Ten, 2007)

Sidwell Friends School is split between two campuses. Children in pre-kindergarten through fourth grade attend the lower school on the Bethesda, Maryland, campus. Older students go to the Washington, D.C., campus four miles to the south, which houses the middle and upper schools.

According to the *2007 Print Issue of GreenSource Magazine*, “a comprehensive master-planning process for both campuses, led by Philadelphia-based Kieran Timberlake Associates (KTA), determined that updating and expanding the 55-year-old middle school was the first priority. Following presentations from several short-listed firms, the school hired KTA to design the project. While studying aerial photographs of the hilltop campus of Sidwell Friends Middle School, the project team recognized the campus also sits atop two watersheds, both of significant ecological value. That insight led to an integrated approach to water management as the centerpiece of a comprehensive appeal to environmental stewardship” (GreenSource, 2007).

According to the USGBC website, “smart water management is central to the project design. A constructed wetland between the new and old wings of the Middle School treats wastewater from the kitchen and bathrooms and serves as a living laboratory where students can learn about biology, ecology, and chemistry.

The treated water is then reused in the toilets and cooling towers. Students grow vegetables and herbs for the cafeteria on the green roofs. Excess water flows to the courtyard’s pond and rain garden while filters and swales in the landscape purify rainwater falling on the site. (USGBC.org, 2008).

Figure 03: Sidwell Friends Sustainability Diagram (AIA Cote Top Ten, 2007)

To take advantage of passive solar design, the design team oriented the building to bounce daylight deep into the building while preventing glare and heat gain. Also, high levels of thermal insulation, combined with operable skylights, windows, and cooling towers, eliminate the need for mechanical cooling on all but the hottest days.

Figure 05: Sidwell Friends Facade Detail (AIA Cote Top Ten, 2007)

Figure 04: Sidwell Friends Solar roof (AIA Cote Top Ten, 2007)

Figure 06: Sidwell Friends Interior View 1 (AIA Cote Top Ten, 2007)

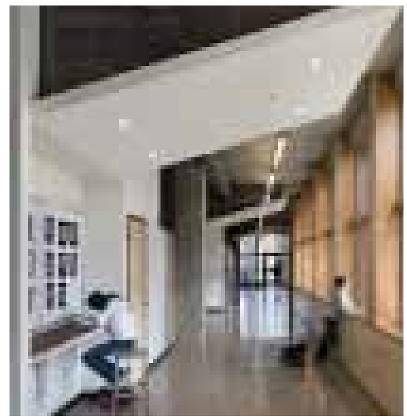


Figure 07: Sidwell Friends Interior View 2 (AIA Cote Top Ten, 2007)

Materials used in the construction and renovation include cladding made from 100-year-old wine barrels as well as flooring and decking made from salvaged Baltimore Harbor pilings. Other renewable materials used are, linoleum flooring, agrifiber casework, and bamboo doors. All interior finishes were screened for chemical emissions.

The project has been recognized by AIA's Committee on the Environment and Committee on Architecture for Education, but the building is just the beginning. Teachers at all grade levels have access to the project's landscape and building systems, and many have designed lessons around this opportunity. The school's green features will continue to teach and inspire, and students will carry their knowledge and appreciation of natural systems, for decades to come (AIA Cote Top Ten, 2007).

Figure 08: West Elevation View of Ben Franklin Elementary School

Case Study 2

Ben Franklin Elementary School, Kirkland, WA

Architects: Mahlum Architects

The Ben Franklin Elementary School serves 450 students in kindergarten through grade six. It is set within a residential neighborhood and shares its 12-acre site with a large wooded area. It was designed as a learning opportunity and creating connections to this rich natural environment became a primary goal in the design process. Students are distributed within small learning communities, each including a cluster of four naturally ventilated and daylit classrooms around a multipurpose activity area.

Figure 09: Annotated Aerial Plan explaining Site and Context of the Ben Franklin Elementary School (AIA Cote Top Ten, 2006)

Figure 10: Master Plan of Ben Franklin Elementary School (AIA Cote Top Ten, 2006)

The large wooded area along the north end of school's site is valued as a community asset while the two-story classroom wings reach like fingers toward the woods and visually connect students with nature.

“Between the wings, landscaped courtyards with native plants feature art installations, bio-filtration areas for storm-water management and a water feature fed by roof runoff. A variety of settings along the courtyards and in the forest are designed for classes to gather, observe and discuss” (Archinovations.com, 2010).

Because daylight and indoor air quality profoundly impact student performance, the school was designed to maximize performance in these areas. The classroom areas of the school are entirely naturally ventilated and daylit. (AIA Cote Top Ten, 2006)

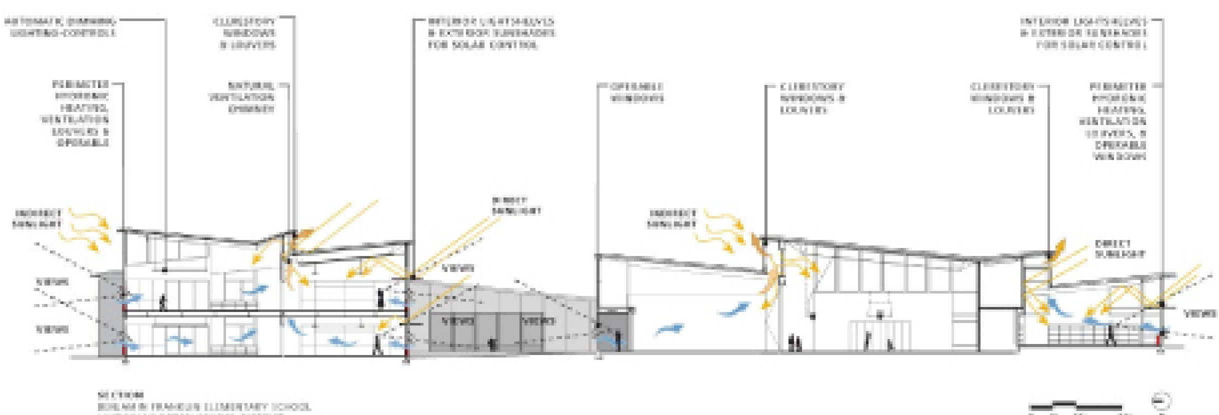


Figure 11: Ben Franklin Elementary School Section (Archinovations.com, 2010)

Figure 12: First Floor Plan of Ben Franklin Elementary School (Archinovations.com, 2010)

Figure 13: Ben Franklin Elementary School Southern Courtyard (Archinovations.com, 2010)

Figure 14: Ben Franklin Elementary School Learning Courtyard (Archinovations.com, 2010)

Durable, nontoxic, low-impact materials were used throughout the project and the use of interior finish materials was limited to the essential. Materials were chosen that could contribute to multiple factors, such as acoustic absorption, light reflectance, durability, and comfort. Applied materials that did not directly benefit the performance of the building were avoided.

Figure 15: Ben Franklin Elementary School Interior Circulation (Archinovations.com, 2010)

Figure 16: Ben Franklin Elementary School Classroom and Activity Area (Archinovations.com, 2010)

CHAPTER V

SITE SELECTION

Launched in 2011, the Department of Education's Green Ribbon Schools program is the federal government's first comprehensive green schools initiative. Green Ribbon Awards recognize public and private schools of all age levels that demonstrate dramatic gains in both environmental literacy and reducing their carbon footprint while improving learning conditions.

This new program is a stimulus for schools nationwide to grow in the 21st-century economy. By encouraging schools to apply for this award, powerful strides will be taken to ensure America meets its goal of greening America's schools within a generation. (Earthday.org, 2011)

On April 23rd 2012 top federal officials, including Secretary of Education Arne Duncan, White House Council on Environmental Quality Chair Nancy Sutley and Environmental Protection Agency Administrator Lisa Jackson, announced the first-ever "Green Ribbon Schools." (Knoxnews.com, 2012)

Seventy-eight schools received the Green Ribbon Award in 2012, after the first year of the program. The winners were selected from among nearly 100 nominees submitted by 30 state education agencies, the District of Columbia and the Bureau of Indian Education. More than 350 schools completed applications to their state education agencies. Among the list of winners are 66 public schools, including 8 charters, and 12 private schools. There are 43 elementary, 31 middle and 26 high schools with around 50 percent representing high-poverty schools. (Earthday.org, 2011)

No Tennessee schools were on the list (Knoxnews.com, 2012). This thesis proposes a design of a new sustainable elementary school in Knoxville. TN.

SITE LOCATION

To select the appropriate site, research was made to identify properties in the city of Knoxville where new schools were either being proposed or constructed.

The site selected is located on 1889 Thunderhead Road in Knoxville, TN. It is located in the Northshore Town Center, a 133-acre mixed-use commercial and residential development located in the northwest quadrant of Knoxville, at the intersection of Northshore Drive and Pellissippi Parkway (1-140). This mixed-use development is anchored by Target and Publix. The center was designed to provide shopping, dining and entertainment options, professional services and single and multi-family housing, in a traditionally design approach. It is divided into two main areas: one general commercial district, with easy access from Pellissippi Parkway; and a pedestrian-oriented Town Center area, which surrounds a five-acre lake, with residences, shops and office buildings.

Currently in this specific site a new school is under construction. The site was identified by The Partnership for Educational Facilities Assessment (PEFA) as one of the most appropriate locations for the construction of a new school in Knoxville. The partnership consists of members from Knox County Schools, the Knoxville-Knox Metropolitan Planning Commission (MPC), and the Public Building Authority (Knox-MPC PEFA, 2007). Parameters used by PEFA on the site selection process were:

1. *Inventory of Land Suitable for School Development;*

2. *Rankings of Fastest Growing School Zones;*

3. *Enrollment Projections;*

4. *Enrollment and Facility Capacity Comparisons;*

5. *Physical Assessment of School Facilities.* (www.knoxmpc.org)

Figure 17: Site Location (Google Earth, 2012)

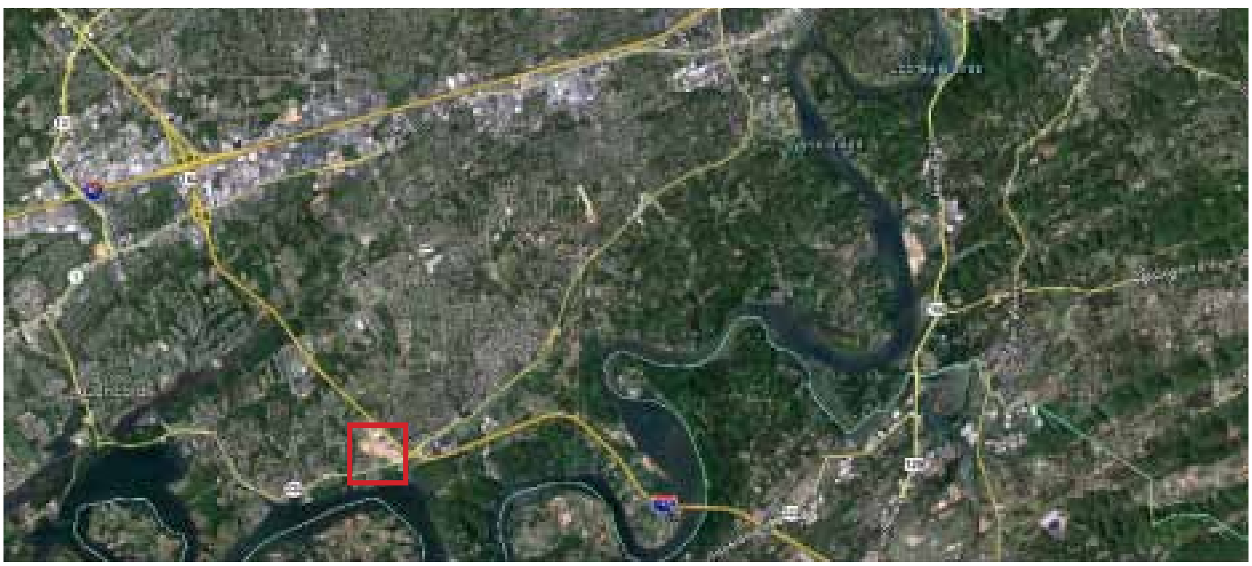


Figure 18: Aerial View of Region (Google Maps, 2012)

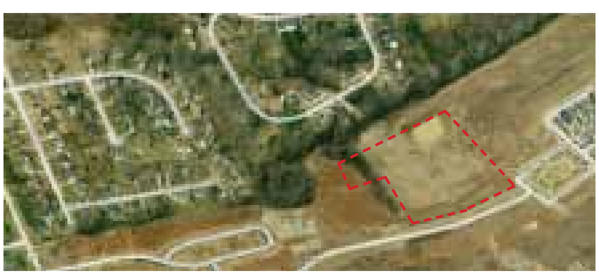


Figure 19: Aerial View of Site
(Bing Maps, 2012)

Figure 20: Site Demarcation
(Bing Maps, 2012)

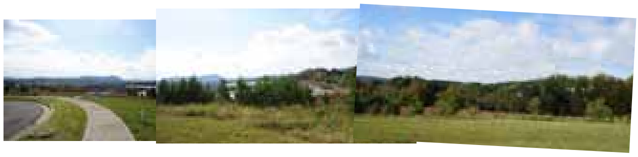


Figure 21: Photos from the site

Figure 23: Photos from the site

Figure 22: Aerial View of Site 2 (Google Maps, 2012)

Figure 24: Photos from the site

Figure 25: Aerial View of Northshore Town Center and Vicinities

SITE ANALYSIS

The site located on 1889 Thunderhead Road is adequate to the construction of a new elementary school not only for responding to the PEFA parameters, but also from a sustainable design stand point. The following criteria were taken from Design Guidelines for Pedestrian-Friendly Neighborhood Schools recommendations by Dover, Kohl & Partners and Chael, Cooper & Associates for the City of Raleigh, N.C. (Dover, Kohl & Partners Town Planning and Chael, Cooper & Associates P.A. Architecture):

1. *Travel Distance: The school site should be in a central location, easily accessible and convenient to the area from which the majority of the school population will be drawn from. Pedestrian and bike accessibilities should be prioritized. For an elementary school, walking distances should be aimed at 1/2 to 3/4 of a mile, or 20 to 30 minutes walking*.

Located within 1/2 mile walking distance from 970 dwellings and 3/4 mile bicycling distance from 1520 residential units, it provides a safe and accessible learning environment.

2. *Street Connectivity: Schools can be better integrated into their community when connected to the neighborhood by a range of transportation options and treated as community centers. A pedestrian-friendly school begins with a neighborhood that encourages walking.*

Northshore Town Center has a well-connected network of local streets, accommodating all forms of travel, including walking, bicycling and transit. Because traffic can be dispersed over a large network of streets, local streets tend to be calmer and safer.

3. *Completeness of Sidewalk Network: To promote walkability it is important for sidewalks to be on both sides of the street.*

Although the Town Center does not count with a complete network of sidewalks on both sides of the streets on all streets, it provides a much better walking environment that a typical suburban neighborhood.

4. *Greenways or Bike Paths: A pedestrian or bike path, or a formal connection at the end of a cul-de-sac to school may enhance a neighborhood's walkability and provide connectivity throughout the neighborhood.*

5. *Vehicular Access:* The selected site allows for two vehicular access points each on a different side of the property.

6. *Natural Environment: The immediate environment surrounding the school should be safe, pleasant, reasonably attractive and conductive to learning. Soil, water, air, rocks, insects, and plant life on the site can be studied, measured, sampled and experimented with.*

The Town Center area, with numerous parks and publics areas provide an attractive natural backdrop for the community. Through hands-on, real world learning experiences children could see their learning as relevant to their world, take pride in the place they live and grow to become concerned and contributing citizens.

7. *Street Trees: Trees provide comfort and shade for pedestrians. They also form a barrier between vehicles and pedestrian creating a safer environment.*

On Thunderhead Road , regularly spaced trees shade both the road bed and the sidewalk, providing a pleasant environment for travelers and pedestrians.

8. *Street Lighting: Important to increase visibility and safety for students walking to school in the early hours, as well as in the dark, and for before and after hour community activities.*

Illuminated by regularly spaced pedestrian-scaled street lanterns, Thunderhead Road provides a safe environment for students, staff and residents.

9. *Atmospheric Conditions: Smoke, dirt and odors are undesirable conditions to be found near the site.*

10. *Noise Conditions: Preference should be given to sites away from noise activities, such as factories, railroads and airports.* Locate in a residential area with light commerce and office use, atmospheric and noise conditions on the site are appropriate for the sitting of a school.

11. *Mix of Use in the Vicinity: People are more likely to walk in traditional neighborhoods, where grocery stores, parks, neighborhood schools and other destinations are within walkable distances. This in turn creates a sense of security -- "eyes on the street".Students and staff may benefit from having other activities within walking distance. Ex: Perform errands during lunch break, after school activities, parents working close to the school site.*

Figure 26: Initial Site Analysis Diagram- Land Use

Figure 27: Initial Site Analysis Diagram- Area of Influence

Figure 28: Initial Site Analysis Diagram- Traffic/ Vehicular Circulation

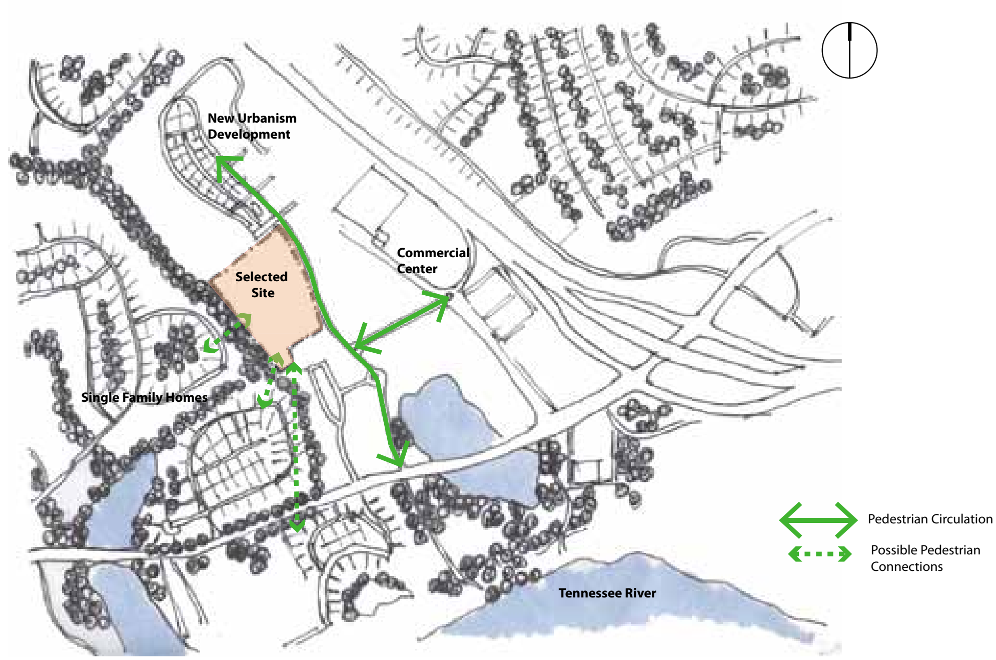


Figure 29: Initial Site Analysis Diagram- Pedestrian Circulation

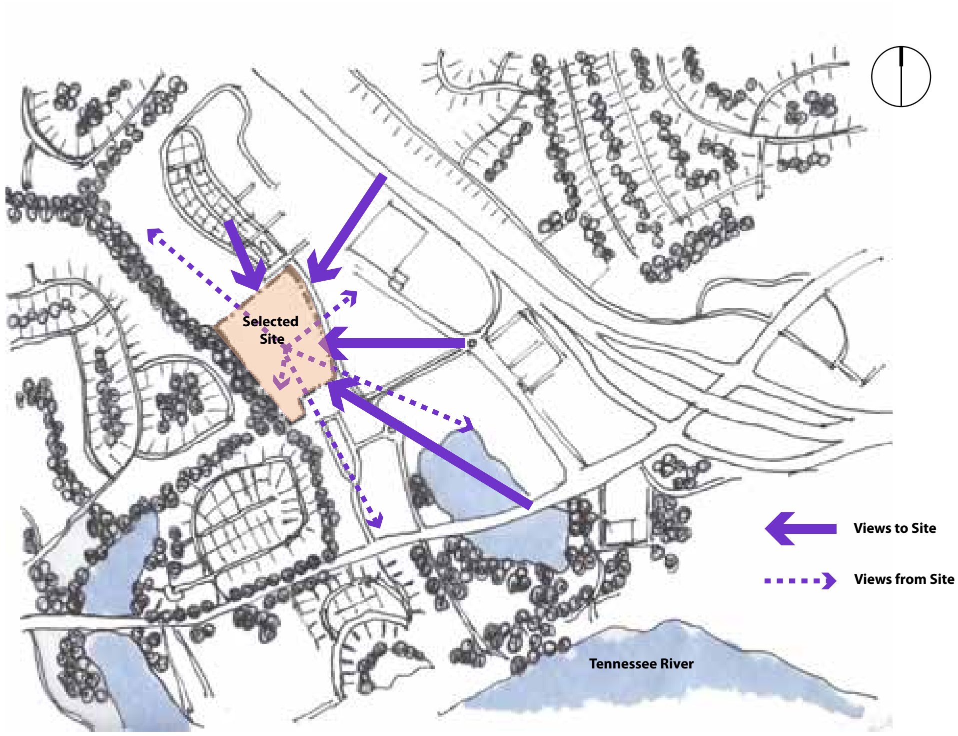


Figure 30: Initial Site Analysis Diagram- Views

Figure 31: Initial Site Analysis Diagram- Low Areas

Figure 32: Final Site Analysis Diagram

CLIMATE ANALYSIS

The site selected for the design of the proposed sustainable school is located on 1889 Thunderhead Road in Knoxville, Tennessee.

Knoxville, TN is located in the southwest region of the United States of America, in latitude 35.8, longitude 84.0 and elevation of 949 feet. Its summers are hot and humid, while winters are cold. The mean temperature range for Knoxville is 20 to 21 degrees Fahrenheit for summer and 18 to 20 degrees Fahrenheit for winter.

Figure 34: Seven U.S. Climate Zone Map (US DOE, 2007)

According to the *National Practice Manual for Building High Performance Schools of 2007 (US DOE, 2007),* and the *Climatic Context: Information for Architectural Design* report by Mark DeKay and David C. Meyers (DeKay & Meyers, 2001), sitting of schools in this region should comply with the following recommendations:

- According to the local solar orientation and prevailing winds. Major windows should face North or South.

- Classroom should be positioned so that light and air can come from 2 sides.

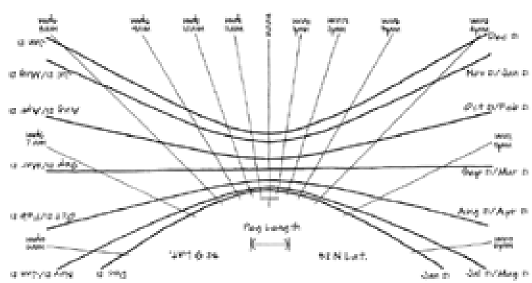
- Heating and Cooling account for 20% of all energy consumption in Schools. Optimal orientation, then, creates opportunities to maximize heat gain in winter and minimize it in the summer, allowing for cost savings in the building life span.

- East-West orientation maximizes daylight opportunities. Well-designed daylighting can enhance student performance by 13-25% higher scores on tests while saving energy use. If designed as a single-story building, it offers topligth opportunities, which can save 40 to 80% electric lighting energy use during daytime.

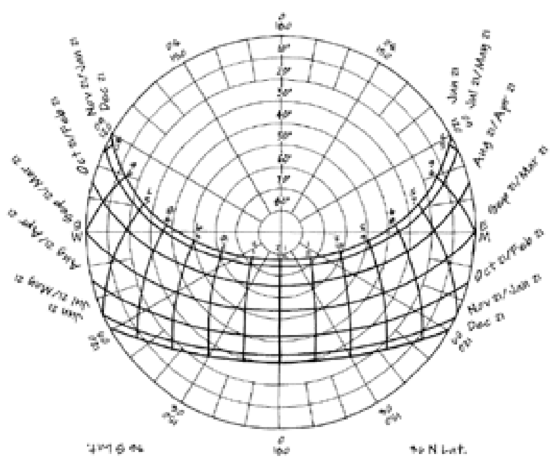
- When designing the landscape area, the designer should minimize the use of impervious surfaces, preferring the use of porous materials.

- The use of natural ad constructed wetlands can provide on-site retention and treatment of storm water.

- Green roofs can help minimize heat gain, while reducing and filtering storm water runoff and allowing for more running and exploring spaces in the school.



Sundial, 36° Latitude



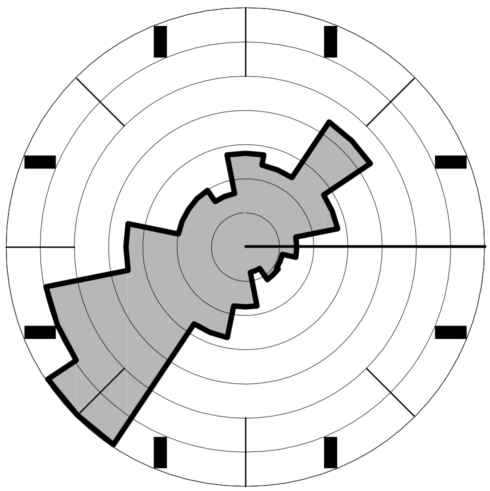
Sun Path Diagram, 36° Latitude

SUN

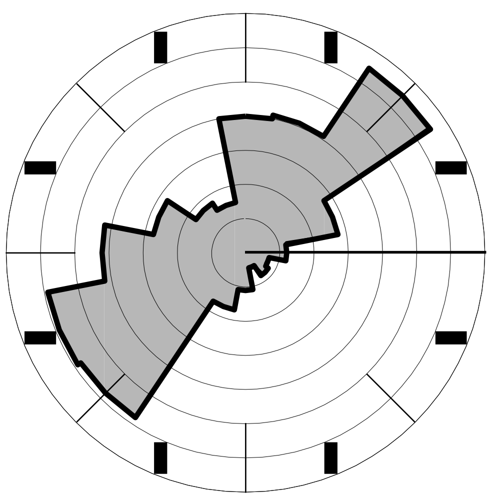
The SUNDIAL is used with a scale physical model to simulate the changing position of the sun and the pattern of shade over the course of the day and throughout the year.

SUN PATH DIAGRAM, with existing site objects plotted, can determine the times of the day and year in which the sun will be available on a particular site.

Figure 35: Sundial and Sun Path Diagrams (DeKay & Meyers, 2001)



Wind Rose: July



Wind Rose: January

Figure 36: Wind Rose Diagrams
(DeKay & Meyers, 2001)

WIND

Buildings in Knoxville should use operable windows on the W and SW side of the building to catch the prevailing wind and outlets on the NE, NW and SE sides.

Stack ventilation outlets should not face SW or NE.

Site design should use seasonally switched elements to block winter winds and reduce infiltration and convective heat loss from the building.

Daytime winds usually have a SW prevailing direction, while nighttime winds usually come from the NE.

The winds are relatively light and tornadoes are extremely rare. Wind speeds are greater than 5 mph almost all year long, offering good natural cooling potential in summer but requiring wind protection in winter.

COMFORT

Outdoor Rooms

- *Cooling: June to August.*
- *Heating: October to April.*

Skin-Load-Dominated Building (SLD)

- *Cooling: May to September.*
- *Heating: November to March.*

Internal-Load-Dominated Building (ILD)

- *Cooling: April to October.*
- *Heating: December to February.*

In summer, as RH increases, cooling by evaporation becomes more difficult. The combination of heat and humidity makes the Knoxville summer a challenge to passive cooling strategies.

The design implications are:

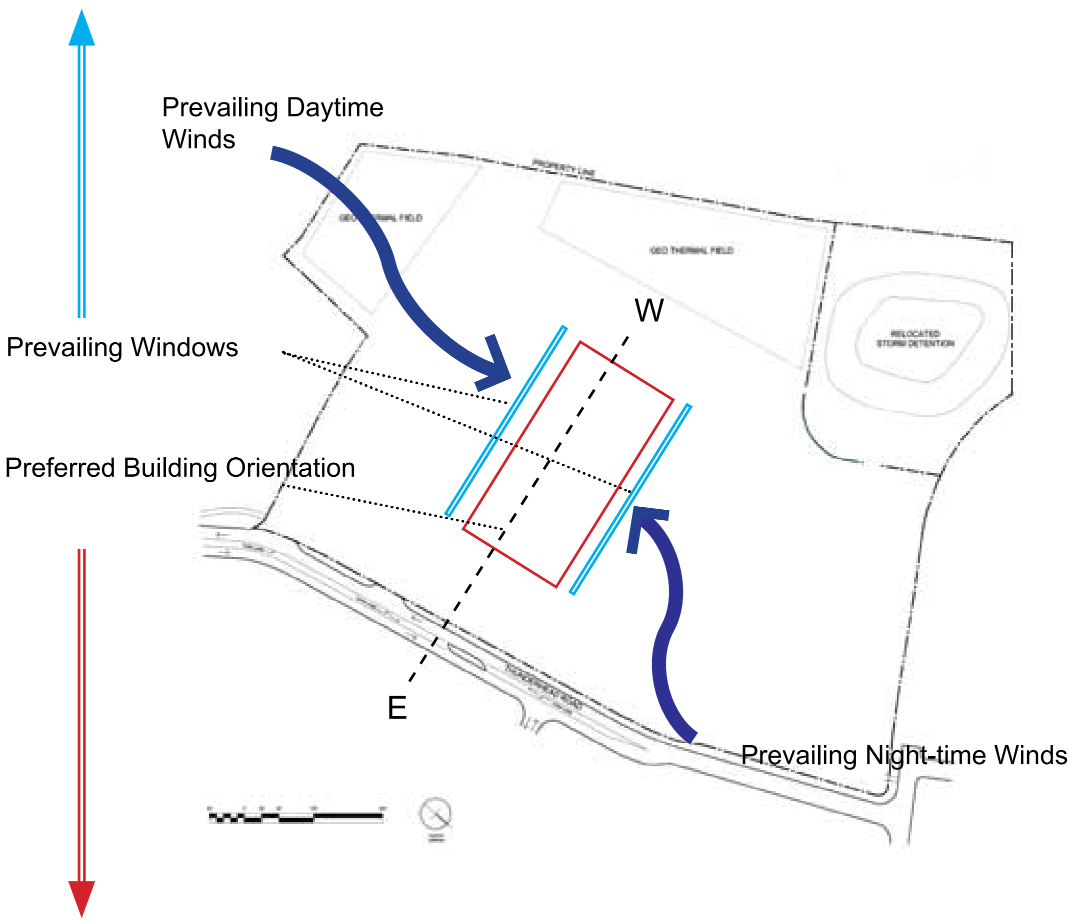
1. good shading to reduce excessive heat gains,

2. maximize cross-ventilation

Diurnal temperature range of 20°F makes night-cooled mass and option.

(DeKay &Meyers, 2001; Brown & DeKay, 2001)

E-W orientation will **maximize daylight** opportunities.



Heating & Cooling account for about **20% of all energy consumption** on School buildings. Optimal orientation create opportunities to **maximize heat gain in winter and minimize it on summer,** saving $ in the building life span.

Figure 37: Climate Analysis Diagram

CHAPTER VI

PROGRAMMING

This thesis proposes a study in which, a combination of sustainable school design and educational goals sets the stage for the attributes of sustainable schools to become teaching tools that help children develop a conscience of sustainability and complexity of living and built systems around us.

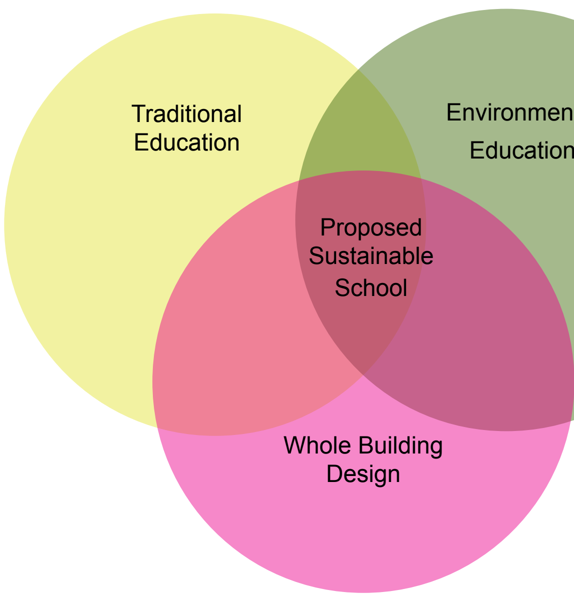


Figure 38: Conceptual Diagram 1

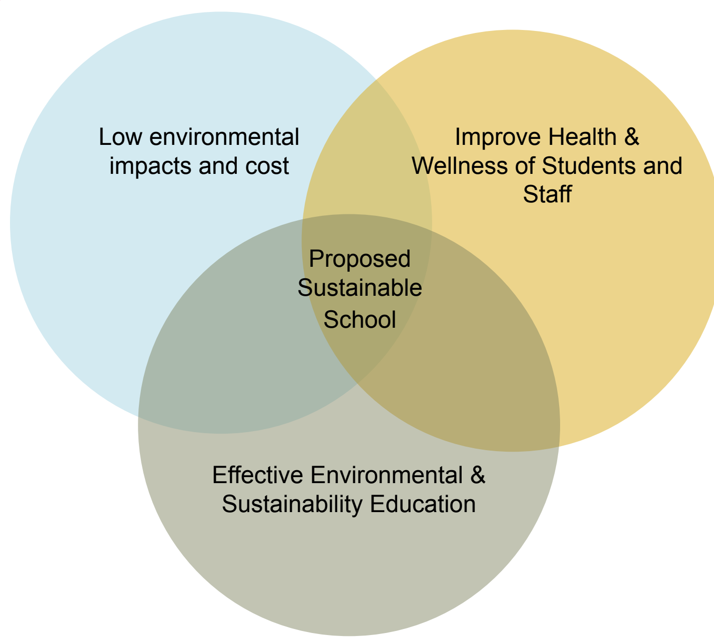


Figure 39: Conceptual Diagram 2

FORMULATING THE PROGRAM

School is a place where teaching and learning go on. It is a place where young people prepare for their future. If we, as a society, collectively agree that a change is needed to protect our resources and allow for a sustainable future, the way we educate our children must also change. Education and sustainability are keys to our economic and ecological future. Teaching children to understand and appreciate their world will make them more responsible about their environment. In order to allow children to appreciate our world and its resources it is important to allow them to see, experiment and take pride in their local communities.

Over the past 30 years children have become increasingly alienated from the natural world. Most children and youth today have little direct experience in the outdoors as a part of their daily lives. While there are always exceptions, for the most part, children today are rarely engaged in unstructured and imaginative play of their choosing in rich and diverse nature-based settings. According to the National Wildlife Federation, in the electronic age that we live in, an average child spends about only seven minutes in unstructured outdoor play and about seven hours in front of an electronic screen every day. A growing body of research suggests that this disconnection, this nature-deficit disorder, may be associated with an epidemic of childhood obesity, childhood diabetes, behavior disorders, depression and a diminished sense of place and community (Children and Nature, 2009)

Nature-deficit disorder is not an official diagnosis but a way of viewing the problem, and describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses. The disorder can be detected in individuals, families, and communities. ***— Richard Louv, Last Child in the Woods***

Reflecting on those matters, one may start to predict that increasing exposure to nature will not only foster sustainability but also reduce stress, sharpen concentration and promote creative problem solving skills for young children. Schools have a particularly important role to play in this shift.

Assuming that spaces do matter, a first goal of this thesis is then to “re-imagine” how classrooms and school spaces can meet this new set of pedagogical goals. The proposed Sustainable School becomes a critical part of the school’s curriculum. Differently from the traditional educational literature, where the term “learning environment” refers primarily to the foundations and methodologies of the process of interactions between teachers and students within the context of curriculum and learning outcomes, in this thesis the learning environment is seen as a variety of spaces where children can explore, learn and play freely and safely.

LEARNING SPACES

Where/ How do children learn?

In this school teachers play the role of facilitators of student learning. Learning is project-based, interdisciplinary. Emphasis is given to group rather than individual tasks. Learning is not a passive mode of behavior: it is active, it is creative.

INDOORS ⟷ **OUTDOORS**

STRUCTURED ⟷ **UNSTRUCTURED**

FORMAL ⟷ **INFORMAL**

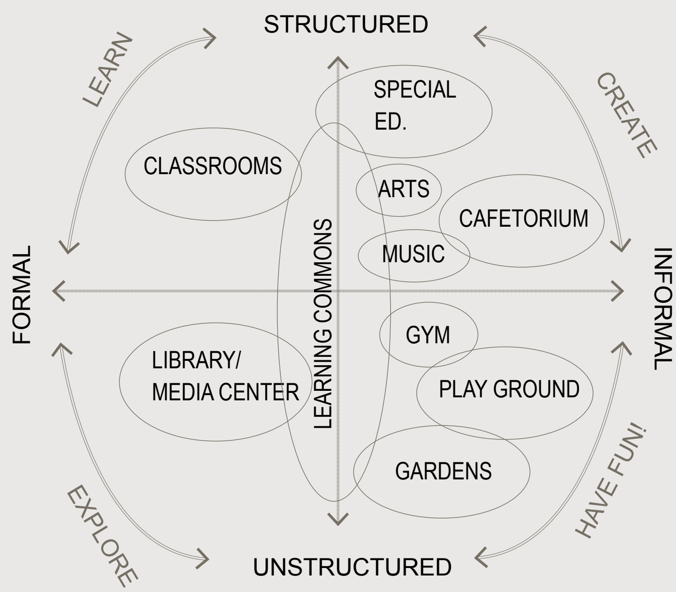


Figure 40: Learning Spaces Diagram

The primary objectives for the design of the proposed school are:

1. Create a school with expressionist form, one that would INSPIRE and TEACH young children about the vales of the natural environment.

2. Design with CHILDREN in mind.

3. Provide spaces that are MEANINGFUL and FUN.

4. Design NATURE-PLAY-BASED environments that are SAFE, STIMULATING and SENSORIAL.

Designing for children one must realize that children understand their environment in different ways from adults. Also, children have different architectural needs and wants, and for the design to be successful it must evolve, be flexible and be able to adapt.

In the book *Design for Kids* , Sharon and Peter Exley convey the essence of what Architecture for Children should be. As they state:

Architecture for children:

- Is sensitive to place and experience;

-Uses relevant iconography in elegant, evocative, and intelligent fashion;

-Brings education and play together - play is a child's vocation and preoccupation;

-Encourages design as expectation, rather than exception, beginning in childhood- setting the tone for a lifetime of awareness;

-Educates, referencing developmental, architectural, educational and inclusive pedagogical theories.

-IS FUN. (Exley & Exley, 2007)

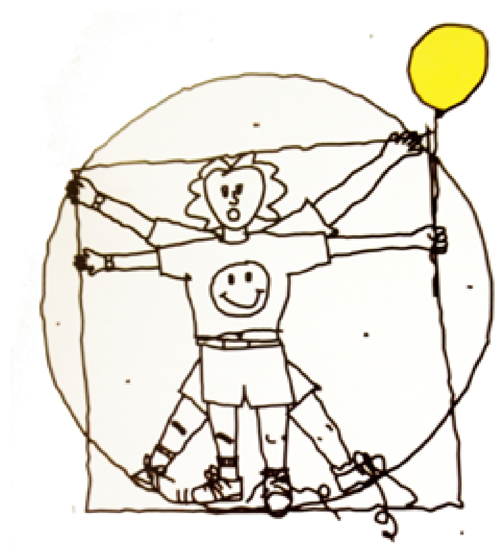


Figure 41: Design for Children
(Exley & Exley, 2007)

To create a school that elevates the standards of the learning environment a new set of criteria is added to the traditional pragmatic criteria of educational constrains.

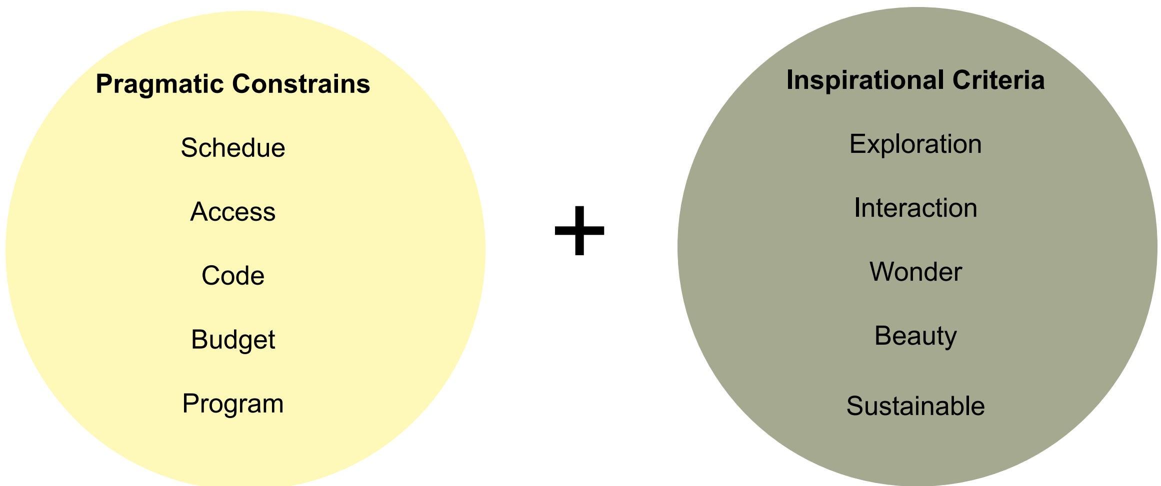


Figure 42: Conceptual Diagram 3

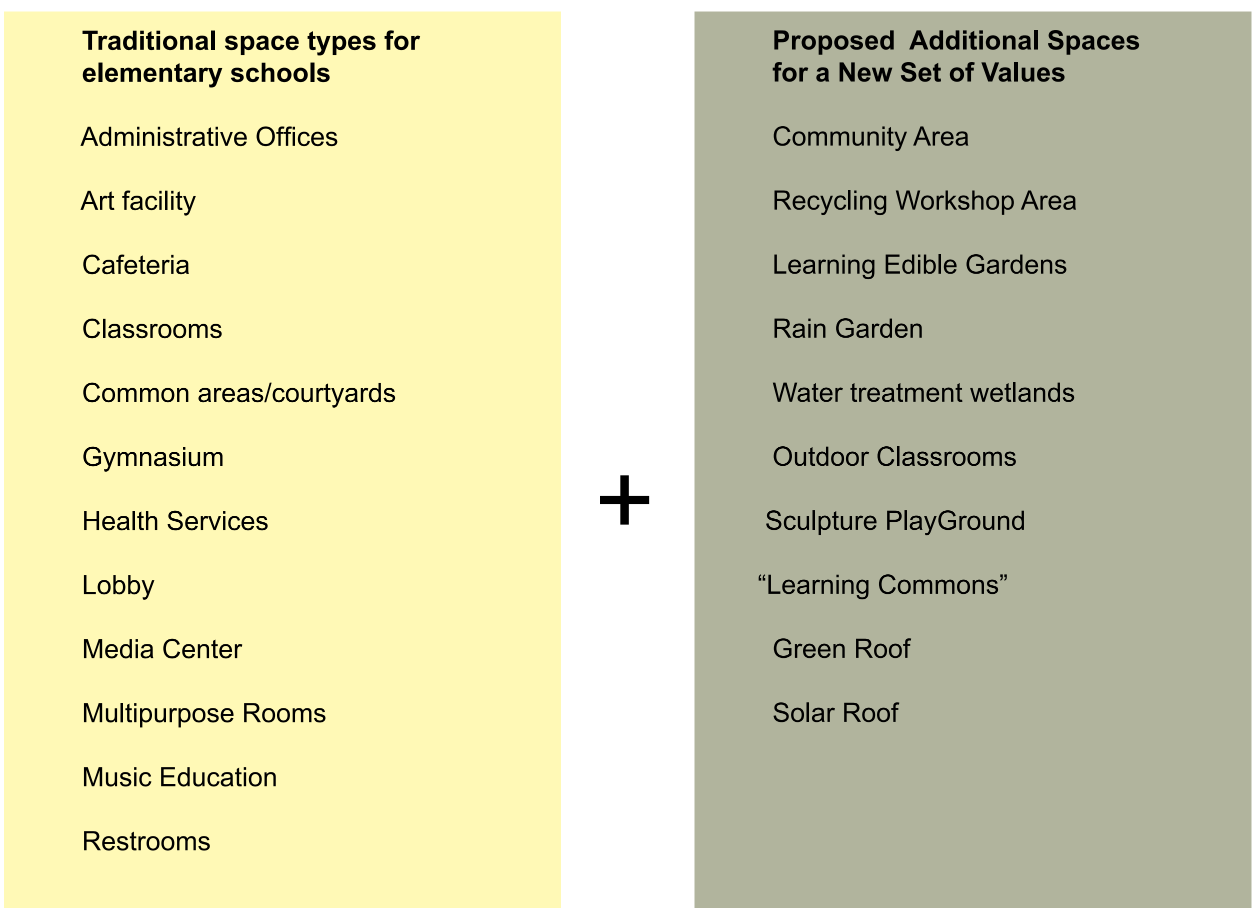


Figure 43: Initial Program Diagram

The program crafted for the design of this thesis is based on the principles stated before. Through understanding of the site and site analysis (based on number of dwellings within 3/4 mile radius of the site), I determined that the capacity for this school should be for 540 students with the capacity to hold 660 students if needed.

Architectural Program

Research supports that a good size of an elementary school is in the range between 200 to 730 students, with a preference to a school size of 350 to 600 students (DeJong, 2000). Most elementary schools perform either as self-contained, grade level teams, or in a multi-age model of education. Self-contained is the most common. The proposed school follows this methodology. Additionally, classrooms in the same grade are arranged in specific pods or clusters, to promote more integration between same level students and teachers. Class size is based on a range of 18 to 22 students.

Square footage of spaces were based on the recommendations for schools in Montgomery County, Hawaii, and Tennessee (DeJong & Associates, 2000; DOE State of Hawaii, 2008; TN State Board of Education, 2008)

Classrooms: 25050 sqf

6 *kindergarten @ 975 sqf each*	6 *3rd grades @ 800sqf each*
6 *1st grades @ 800sqf each*	6 *4th & 5th grades @ 800 sqf each*
6 *2nd grades @ 800sqf each*	

Classroom Clusters Break-Out Space: variable

Special Education: *960 sqf*

Music: *1580 sqf*

Art: *940 sqf*

Library/ Media Center: *3100 sqf*

Cafetorium: *3900 sqf*

Kitchen: *735 sqf*

Gym : 4600 sqf

Medical Assistance: 450 sqf

Administration: *3000 sqf*

Main Office: 500 sqf	*Conference Rooms: 290 sqf*
Principal's Office: 300 sqf	*230 sqf*
Assistant Principal's Office: 140 sqf	*230 sqf*
Teacher's Lounge: 600 sqf	*Records Room: 110 sqf*
Counseler: 260 sqf	*Storage Room: 110 sqf*

Restrooms, HVAC & Circulation: 8000 sqf

Learning Commons: variable

Outdoor Spaces: variable

CHAPTER VII

THE SCHOOL AS A THREE-DIMENSIONAL TEXTBOOK ON SUSTAINABILITY

Through the literature review and case studies one can deduce that there can not exist one single blueprint for the design of learning and teaching spaces. However, some clear messages are discernible in these examples and from these the design of this Thesis evolved.

First several design iterations tested the program within the site. Next, by combining the final programmatic solution to inspirations drawn by the site, the region and nature, I arrived at the final design solution for the building. Finally, I looked at how the design of each of the programmed spaces can grant more effective learning environments.

SITING DIFFERENT USES IN THE SITE

The first important conclusion derived from the literature review and case studies is that the school building can be divided into three major programmatic uses. I chose to call them:

1. **LEARN** - learning environments: classrooms;
2. **PROTECT** - entrance area, administrative spaces;
3. **ENGAGE** - areas to be used by the school and by the community, such as the gym, cafetorium, library and outdoor spaces.

Additionally, two other conceptual programs were identified:

4. **EXPLORE** - learning commons: a space where all students come together to explore and engage in learning experiences;
5. **NURTURE** - a protected outdoor space that provides a safe environment for young children to learn, explore and play.

Several iterations were designed to produce the final design solution for this site.

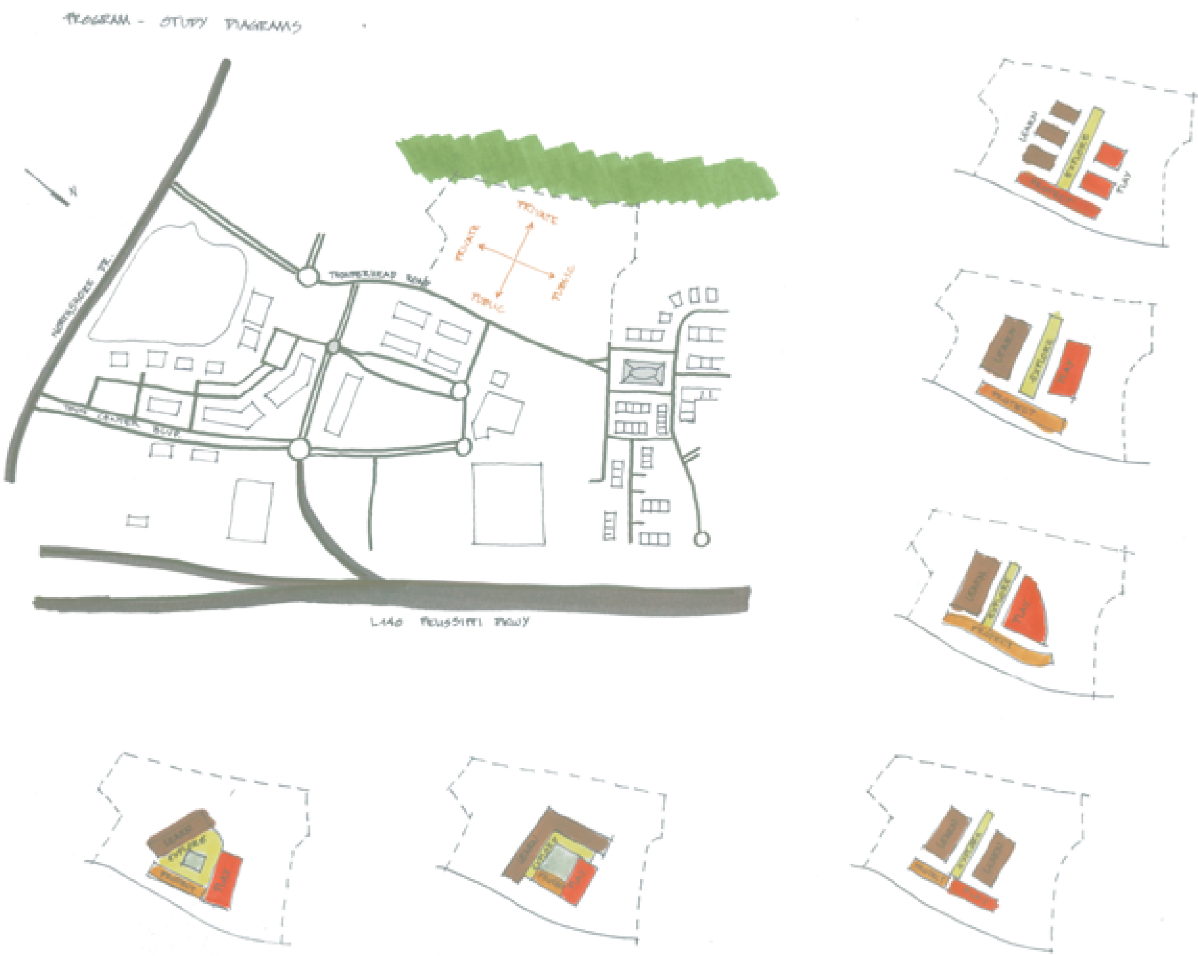


Figure 44: Programming Spaces in the Site iterations

The final approach can be summarized like this:

1. **LEARN** - classrooms - respond to solar orientation;
2. **PROTECT** - Entrance and administration - respond to the street;
3. **ENGAGE** - Gym and Cafetorium - respond to the nearby community;
4. In between spaces shape the Learning Commons (**EXPLORE**) and Courtyard Area (**NURTURE**).

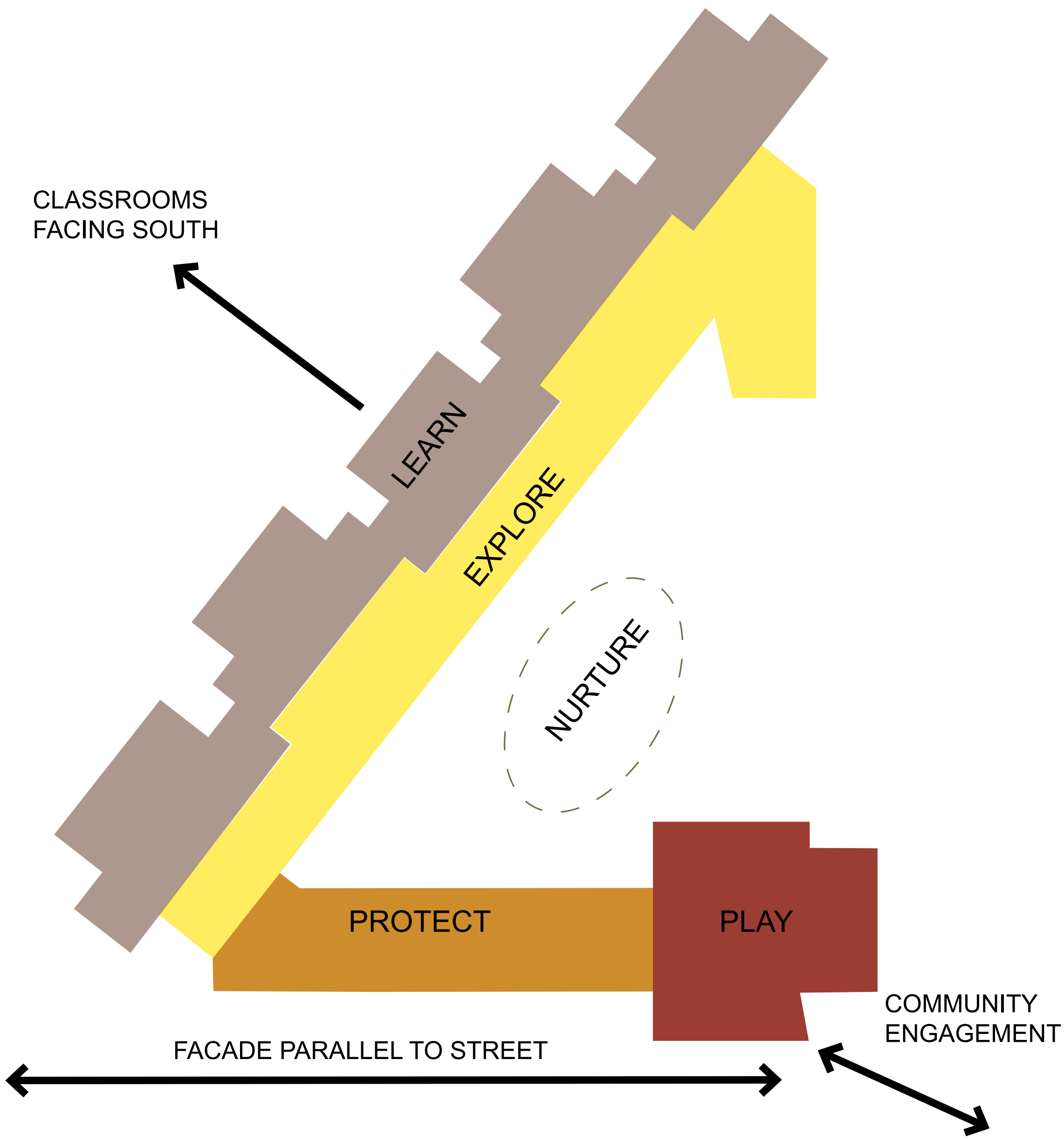


Figure 45: Programming Spaces in the Site Final Design Diagram

MORPHOLOGY

Working with the final programming diagram the massing of the school was inspired both by nature and the new conceptual understanding of how and where children learn (see Figure 40).

Located in the Appalachian region of the United States, the surrounding mountains inspired the conceptual design of the building. The new conceptual model of education, inspires a design that blurs the distinction between indoors and outdoors, transforming the design of the building, its structure and systems into manifestations for learning.

Layering the program, the ideas of privacy versus public spaces, and the philosophical inspirations, shape the building. The resulting geometry forms continuous spaces for learning inside and new public and learning places outside. Places that relate not only to the school but to the community and neighboring streets.

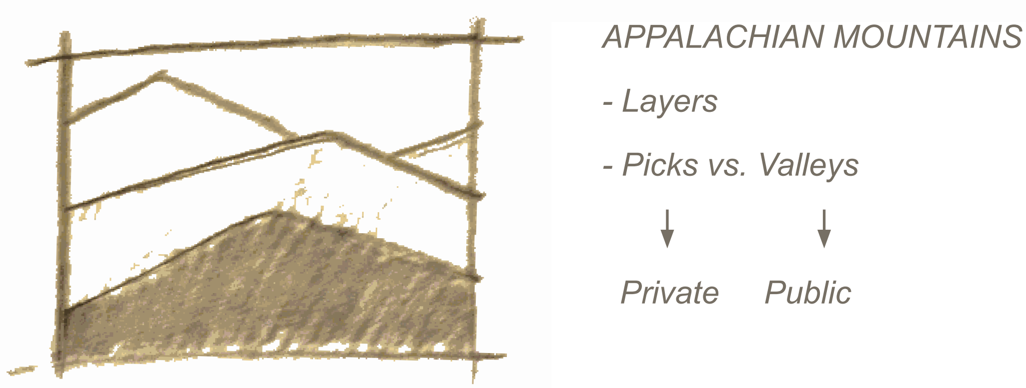


Figure 46: Appalachian Mountains Inspirational Diagram

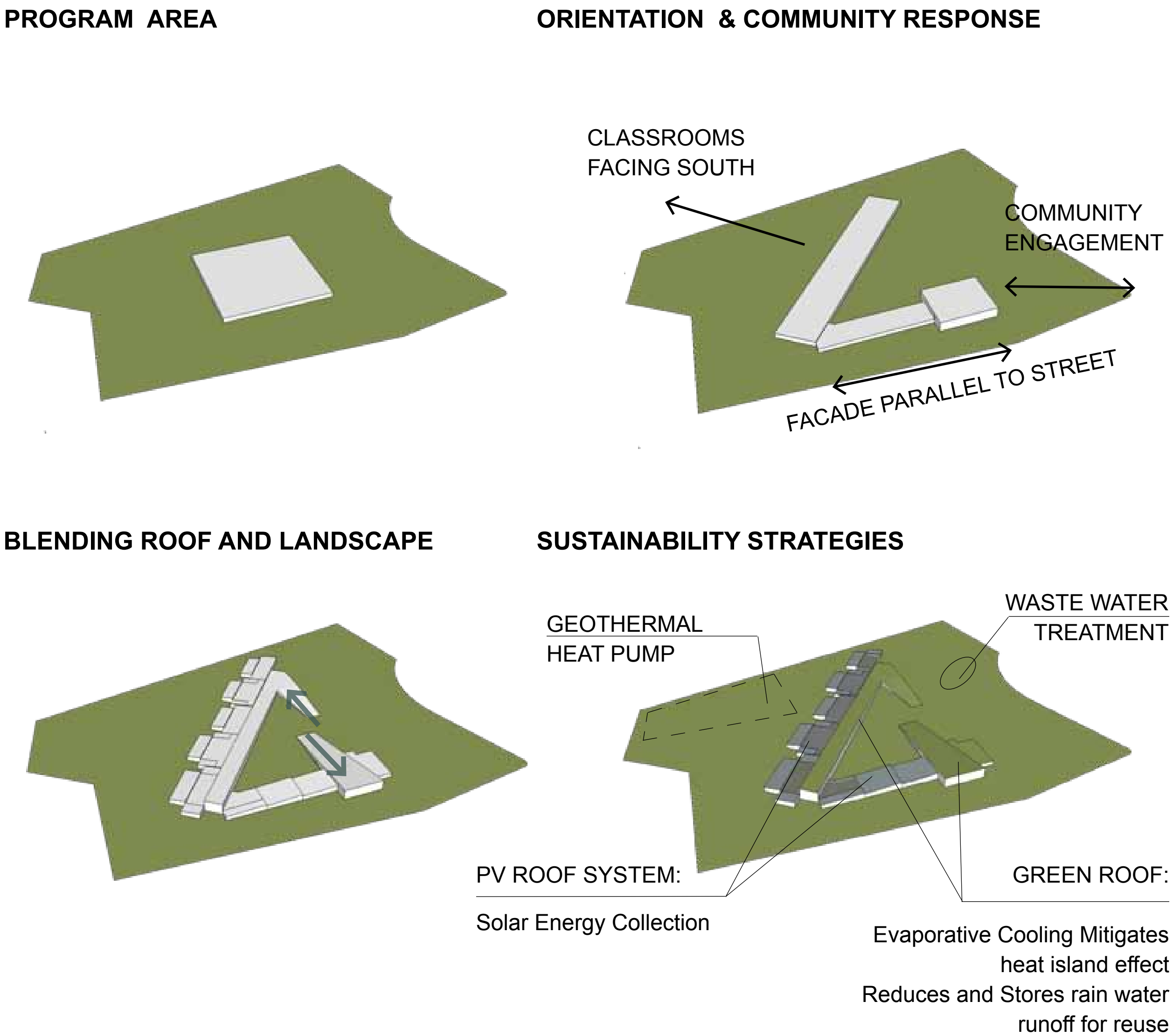


Figure 47: Massing Diagram

Figure 48: Aerial View

Figure 49: Section 1

The Living Roof

The school's green roof is seen as a seamless extension of the landscape. In that way, it blurs the boundaries between school and nature, private and public, man-made and natural. It is stimulating, provides different views and experiences, and allow for a deeper observation of the grounds and surrounding areas.

The green roof is divided into two bands, like two arms embracing the interior courtyard space. One is an open public linear garden, which is both recreational and educational, with gardens and testing grounds for plants growing, solar experiments and bird watching activities. The other roof is essentially an outdoor amphitheater where outdoor classes can take place.

The ecological contribution of the green roof in the sustainability scheme of the building is immense. Acting as thermal mass, it absorbs the heat of the summer sun while creating an isolation buffer in the winter. It collects rainwater which is then transferred to the learning pond and stom-detention pond where greywater is cleansed to be reused in toilets and for landscaping irrigation.

Building Facades

The building has three distinct facades that react to the program, orientation and context.

The "learning side" - The south facing facade, which houses the classrooms is a traditional brick facade. The "community side" - The north-east facade, facing Thunderhead Road, has a more predominant appearance. Terracotta rainscreen louvers define the school street edge. The terracotta has a common language with the bricks used in the adjacent residences and buildings while creating an interesting translucent panel that allows for natural light while preventing glare and solar gain. Variations in the louver density enhance the lighting effects in the interior areas. The “nurture space” - The north and south-west facades, facing the courtyard, a curtain-all system that blurs the distinction between indoors and outdoors, allowing natural light and continuos surveillance of the activities in the courtyard as well as in the learning commons area.

Figure 50: Rendered view of entrance from Thunderhead Road

Figure 51: Rendered view facing Thunderhead Road

Figure 52: Rendered view of the main entrance

Building Systems

Designed to foster an ethic of social and environmental responsibility in each student, the building design demonstrates a responsible relationship between the natural and the built environment.

A green roof and constructed wetland reduce stormwater runoff, improve the quality of infiltrated runoff, and reduce municipal water use.

The wetland treats wastewater for reuse in the toilets and cooling towers

The green roof reduces heat-island effect while filtering and slowing stormwater discharge, and at the same time contributing to better air quality in the area, providing habitat for birds and insects and allowing different sensorial experiences for the users.

Because daylight and indoor air quality profoundly impact student performance, the school was designed to maximize performance in these areas. Operable windows minimize the need of mechanical cooling. Louvers in the glazing areas respond to the orientation of the façade to maximize daylight and minimize heat gain. The classroom areas of the school are naturally ventilated and daylit.

Ample views and daylight increase the indoor quality for the occupant. Individual task lighting reduces the need for ambient lighting. To minimize the use of electricity in the building passive solar design, in form of photovoltaic panels on the roof top, electric lighting occupancy sensors and use of daylighting systems were designed in this project.

The mechanical system is comprised of a VAV system together with a Geothermal heat exchange system, and allow for different cooling and heating needs in the different zones of the building.

The large number of open spaces in the interior of the building allow for flexibility for future changes.

The choice of materials focused intently on durability and ease of maintenance. Polished concrete flooring was employed in high traffic areas and ceiling materials were minimized through design choices to expose ducts and ceiling structure. The insulated window units are regionally fabricated and local materials and manufacturers sourced.

Structural System

The final design solution is a one-story high building with two different structural systems employed. In the classroom pods, traditional CMU walls and steel beams hold the metalic roof with photovoltaics panels as well as the translucent photovoltaic-pannel-roof on the classroom clusters. The structure used on the rest of the school building is a steel structure of columns, beams . Three-dimensional trusses hold the sloped roof above the learning commons and the gym/cafetorium spaces.

DESIGNING EFFECTIVE LEARNING SPACES

As stated by UK's educational research organization JISC "an educational building is an expensive long-term resource. The design of its individual spaces needs to be:

• Flexible – to accommodate both current and evolving pedagogies;

• Future-proofed – to enable space to be re-allocated and reconfigured;

• Bold – to look beyond tried and tested technologies and pedagogies;

• Creative – to energise and inspire learners and tutors

• Supportive – to develop the potential of all learners

• Enterprising – to make each space capable of supporting different purposes

A learning space should be able to motivate learners and promote learning as an activity, support collaborative as well as formal practice, provide a personalized and inclusive environment, and be flexible in the face of changing needs" (JISC, 2006).

This section details the architectural design approach to each of the programmed spaces in the school. The Figures are a representation of the inspirational concepts, initial design sketches and final architectural design solution.

Classrooms

- Movable partitions : classrooms can be expanded to include larger groups of students.
- Variety of ceiling heights (different acoustics).
- Variety of light sources. Natural light: windows, toplight, etc.
- Variety of scales.
- Variety of floorscapes: risers, stage, benches that fold from wall...
- Views to outdoors.
- Furniture at child scale.
- Living wall.
- Transparency to Learning Commons and break-out space.
- Areas for small groups.
- Storage/ Lockers inside the classroom.

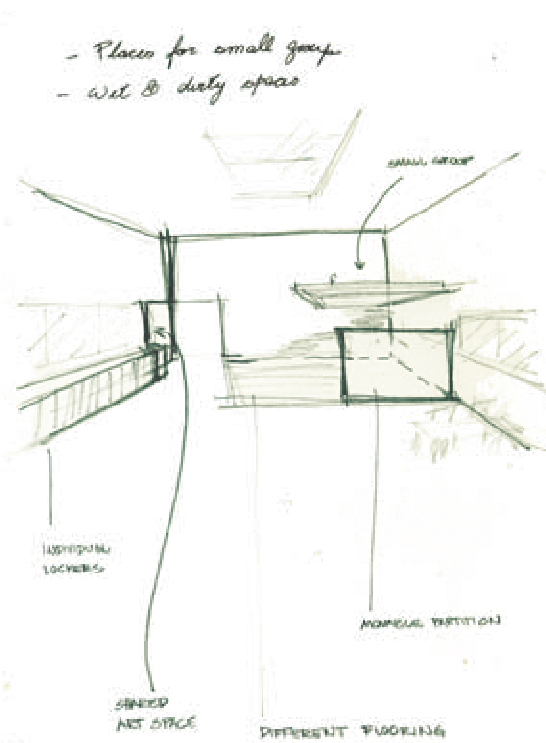


Figure 53: Classroom Design Initial Sketch

Figure 54: Rendered view of the Kindergarten Classroom

Figure 55: Rendered view of two Kindergarten Classrooms combined

Classroom Clusters and Break-out Space

Classrooms in the same grade are arranged in specific pods or clusters, to promote more integration between same level students and teachers. Bringing the classrooms together is a break-out communal space for same grade classrooms, where students from different classrooms can work together on projects and presentations. A space where teachers can bring together different groups to share learning and experiences.

- Gathering spaces.
- Presentation Space/ Stage.
- Natural light: windows, toplight, etc.
- Comfort through furnishings.
- Transparency to Learning Commons.
- Furniture at child scale.
- Storage area
- Toilets for same grade classrooms.
- Wet and dirty room.
- Room for small group.

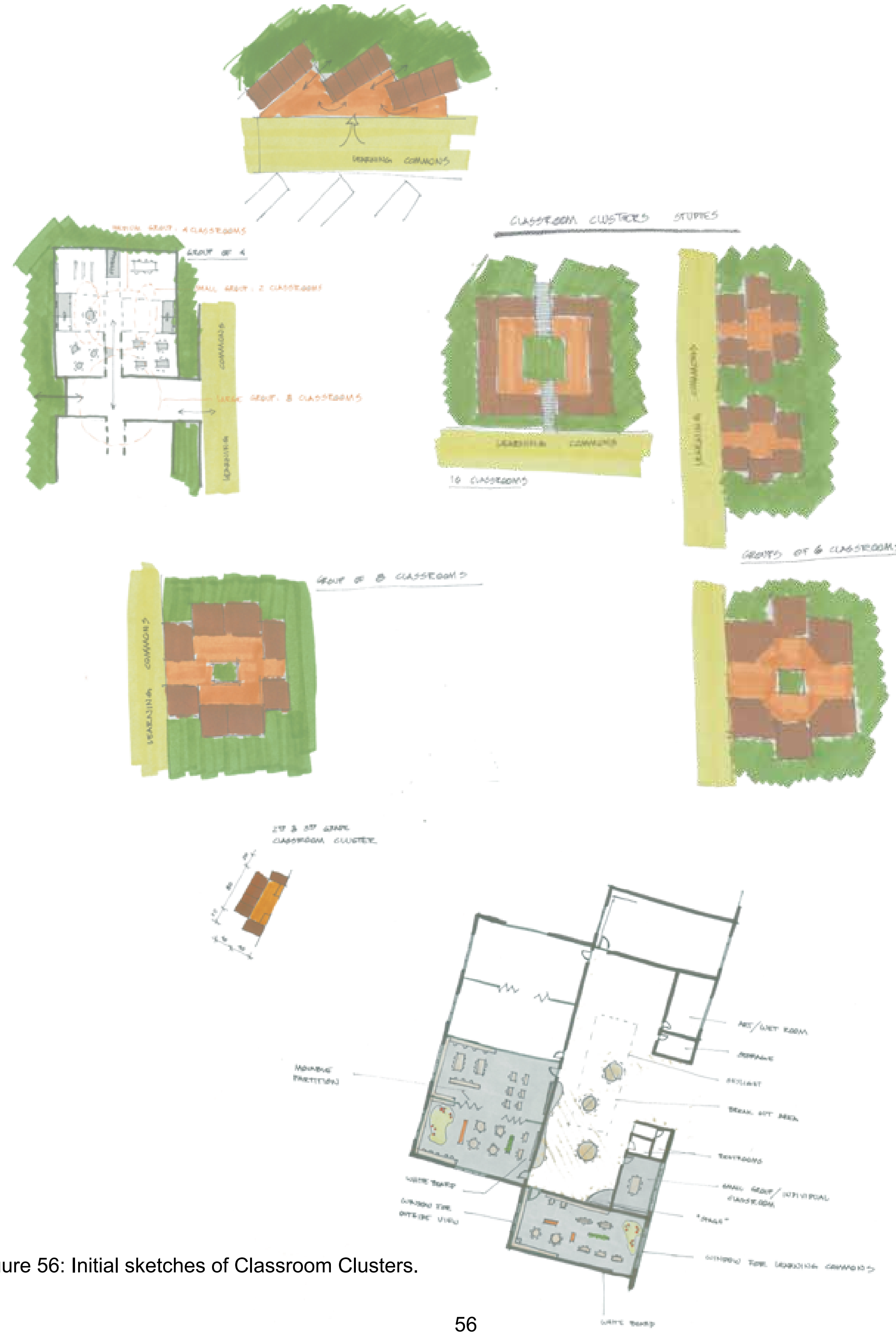


Figure 56: Initial sketches of Classroom Clusters.

Figure 57: Rendered view of the Kindergarten Custer break-out space

Library/ Media Center

Magnetic		collaborate
Flexible	⟷	reflect
Comfortable		discover

-Merging indoors and outdoors

-Variety of ceiling heights (different acoustics).

-Variety of light sources.

Natural light: windows, toplight, etc.

-Comfort through furnishings.

-Sensory experience.

-Gathering spaces.

-Kid-size bookshelves.

Figure 58: Rendered view of the Library

Cafetorium

Hybrid room: Cafeteria, Performance Area & Community gatherings.

-Located near the music and art classrooms

-Double height ceiling

-Welcoming to community - accessible.

-Adjacent to a community kitchen (link to outdoors)

-Inspire wellness

-Create openness through light, air and sounds.

-Good flow of indoors - outdoors.

-Integrate food cycle: roof garden, compost and recycling areas.

-Attention to acoustics on performance area.

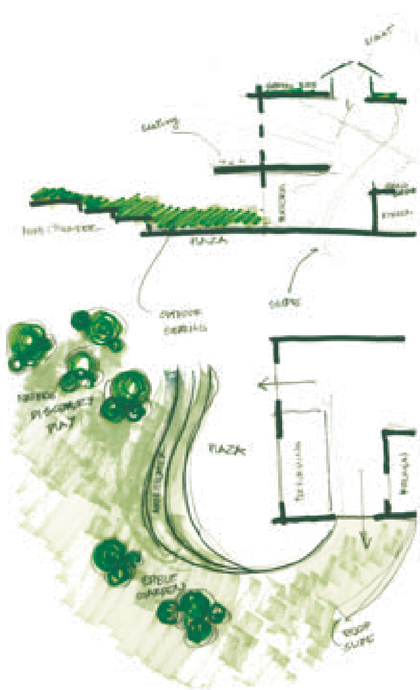


Figure 59: Initial sketch of the Cafetorium and adjacent outdoor area

Figure 60: Rendered view of the Cafetorium

Figure 61: Rendered view of the Music Classroom

Entrance/ Lobby Area

- Creates a sense of excitement about learning.
- Double height ceiling.
- Provide a sense of safety and security.
- Offer clear accessible information about the school.
- Touch-panel screens allow for information about sustainable practices in the school (ex:how daylighting, PV panels and geothermal energy collectors save energy use in the school).

Administration

- Inviting / Open to public.
- Transparent to circulation and Lobby areas.
- Efficient.

Teacher's Spaces

- A place to recharge and learn.
- A place to ask for and give help.

Gym

- Elementary basketball court (40'x 60').
- A place for a variety of physical activities.
- Designed to hold community recreation programs.
- Variety of light sources.
- Close to lockers and medical facilities.

Learning Commons

-Pathway that doubles as an active learning space.

-Double height ceiling

-Supports visual and interactive learning.

-Encourages social interaction.

-Inspiring.

-Create openness through light, air and sounds.

-Good flow of indoors - outdoors.

-Integrate students from different grades.

-Provides unique spaces for learning and sharing.

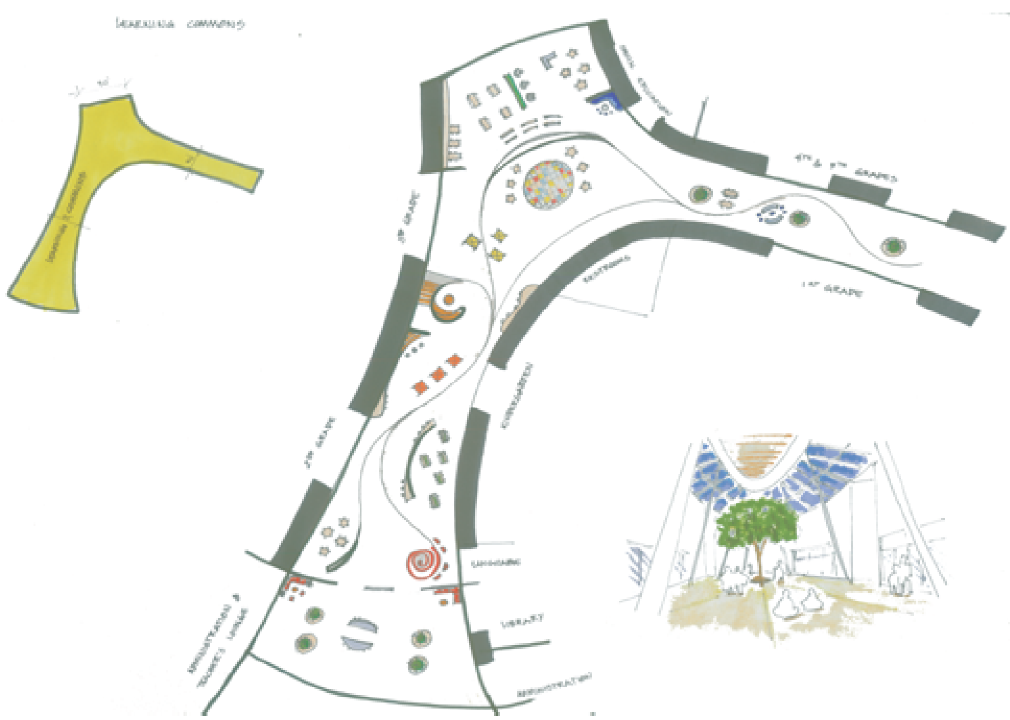


Figure 62: Initial sketch of the Learning Commons

Figure 63: Rendered view 1 of the Learning Commons

Figure 64: Rendered view of the Learning Commons looking at the entrance

Figure 65: Rendered view 2 of the Learning Commons

Figure 66: Rendered view of the presentation space at the Learning Commons

Outdoor Spaces

School grounds should be designed with the same attention as the interior learning environment. Designing spaces for outdoor learning experiences through informed landscape design, school grounds are transformed into learning landscapes that reflect our culture and values. Outdoor spaces can be used for teaching and "learning math, science, history, art, literature, ecology and stewardship. They are teaching and learning tools that go beyond the undisrupted benefits of relaxation, physical exercise, sports,, and fresh air to act as organic, three-dimensional textbooks. They are resources for readily accessible, real-life study, and an inspiration for curriculum development as well" (Taylor & Enggass, 2009).

- Design with natural elements.

- Multi-sensory elements: variety of textures, colors, patterns, smells, sounds, etc.

-Different gardens: edible garden, rock garden, flower garden, herb garden, etc.

-Play structures built with natural elements like rocks and logs.

-Design outdoor classrooms: amphitheaters, weather stations, sundials, nature trails, recycling labs, etc.

- Transitional spaces: open courtyards, green roofs, transparent photovoltaic panel roofs, living walls, etc.

Figure 67: Master Plan initial sketch

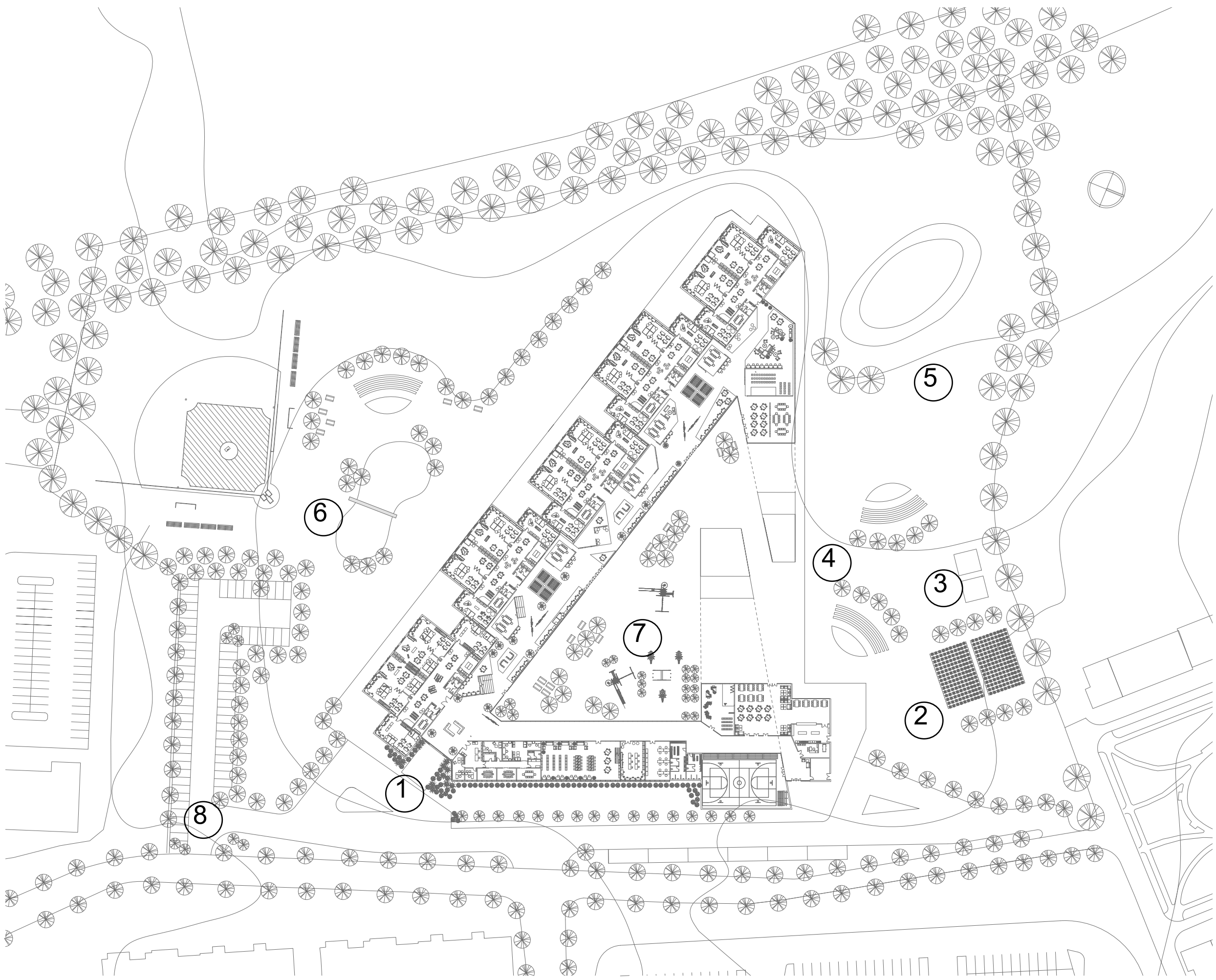
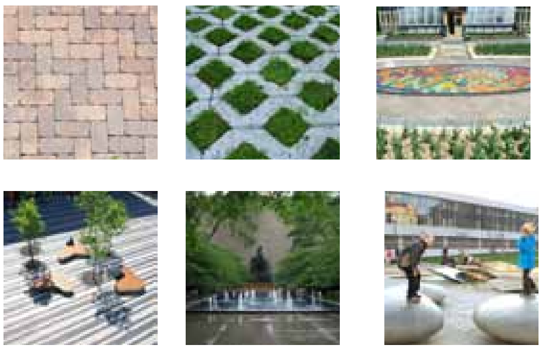


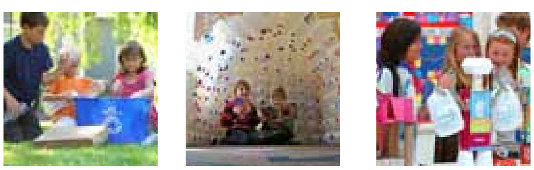
Figure 68: Final Design Master Plan

① ENTRY PLAZA



② EDIBLE/ COMMUNITY GARDEN

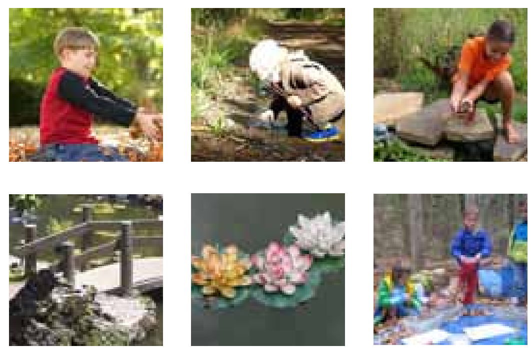
③ RECYCLING STUDIO/ STORAGE



④ AMPHITHEATER/ OUTDOOR CLASSROOM

⑤ WATERLAND FOR RECYCLING WATER

⑥ EDUCATIONAL POND



⑦ COURTYARD/ PLAYGROUND

⑧ STAFF/ VISITOR PARKING

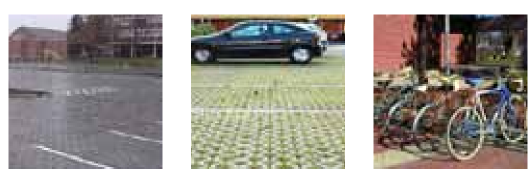


Figure 69: Final Design Master Plan legend

CHAPTER VIII

CONCLUSION

The narrative of this Thesis presents a model or process of thinking about the future, the rights and wonders of children and the qualities of environments that support learning in the 21st century. It exposes a variety of philosophies, concerns ad interesting ideas that can provide a base point for communities and school boards to engage in efforts to design and build schools according to a more sustainable practice.

In sum, this project is about how architecture can help on preparing the next generation to a brighter future. For this we need to look at two main issues. First, we must change our ways of living, producing and consuming to a more sustainable manner, or our future generations are set to a doom future. Second, we must prepare our children to the new economy, which is not the same as the industrial revolution era, but one of connections and collaboration. This Thesis proposes a sustainable school design that allows for this type of collaboration, awareness and exploration. It is also seen as a community center, with spaces that can be used other than the typical 8:00 to 17:00 daily period.

As stated by UC Berkeley Professor Bruce Fuller, traditional schools are designed for an efficient way of building. “Concentrating students into larger school plants and using a factory model to attempt to educate more students at a lower expense produced the “one best system” concept in education, which does not engage students well today” (Center for Cities & Schools, 2008). As architects, builders and community members, we should be thinking of BUILDING MINDS and not so much on MINDING BUILDINGS (American Federation of Teachers, 2006; 2008). Looking at the dollars spent for quality of education, not on the number of students.

I here propose an innovative school design that blurs the distinction between indoors and outdoors, transforming building systems and ecologic design into manifestations for learning. A school with different types of spaces that allow teachers to teach kids in multiple styles, allow children to explore themselves, and give students the skills they need to succeed in the new economic environment. A design that reinforces a shift from the teacher-centered educational delivery system into an inventive, flexible, collaborative and sustainable conceptual way of teaching and learning. A school that fosters learner participation, where learning becomes not a passive mode of behavior, like in the teacher centered approach, but it is active and creative.

Through this Thesis analysis one can deduce that there can not exist one single model for the design of learning and teaching spaces. The final design and case studies in this Thesis show a variety of approaches, indicating that designs of physical spaces depend on the program, the site and the community. However, some clear messages can be identified in these examples and from these it is possible to arrive at some broad points of guidance. The following diagrams represent these points:

Siting the School

The school site should be in a central location, easily accessible and convenient to the majority of the school population. For an elementary school, walking distances should be aimed at 1/2 to 3/4 of a mile. People are more likely to walk in traditional neighborhoods. Students and staff may benefit from having other activities within walking distance.

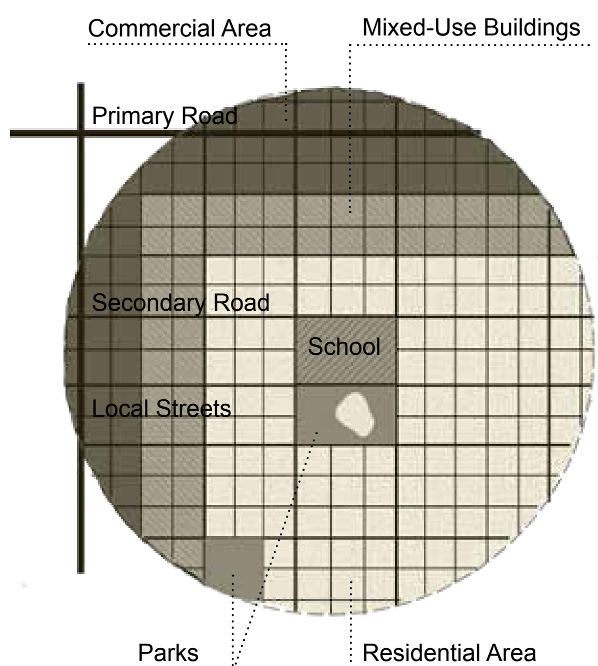


Figure 70: Siting the School Diagram

Blending Content & Context

A school design that transforms building systems and ecologic design into manifestations for learning.

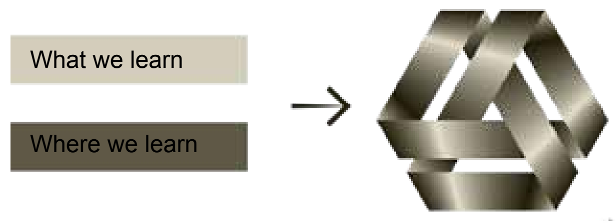


Figure 71: Blending Content & Context Diagram

Blending Indoors & Outdoors

A school design that blurs the distinction between indoors and outdoors.

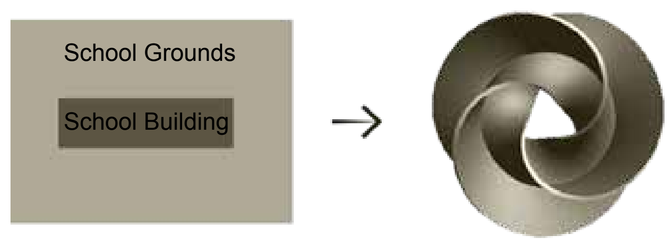


Figure 72: Blending Indoors & Outdoors Diagram

Learning Landscapes

Design the landscape as interdisciplinary manifestations for learning.

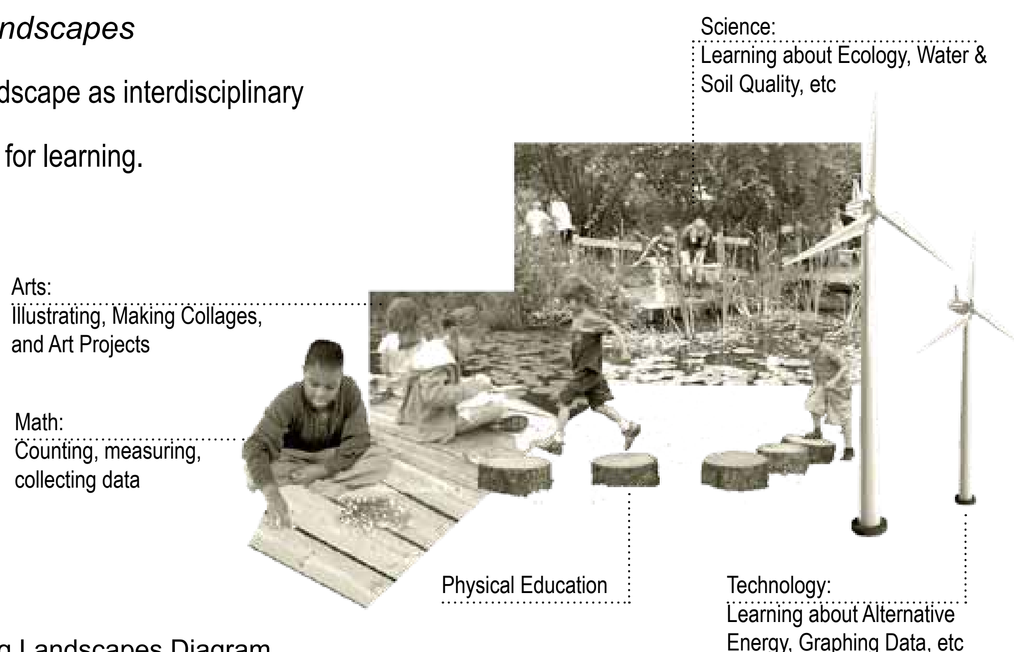


Figure 73: Learning Landscapes Diagram

Learning Commons

Design pathways that double as an active learning space. One that supports multiple learning styles, connections and collaborations between students and teachers.

Figure 74: Learning Environments that Support Multiple Styles Diagram

21st Century Classrooms

Design integrating technology and sustainable design techniques to create classrooms that are healthy, flexible, creative and support multiple styles of learning and teaching.

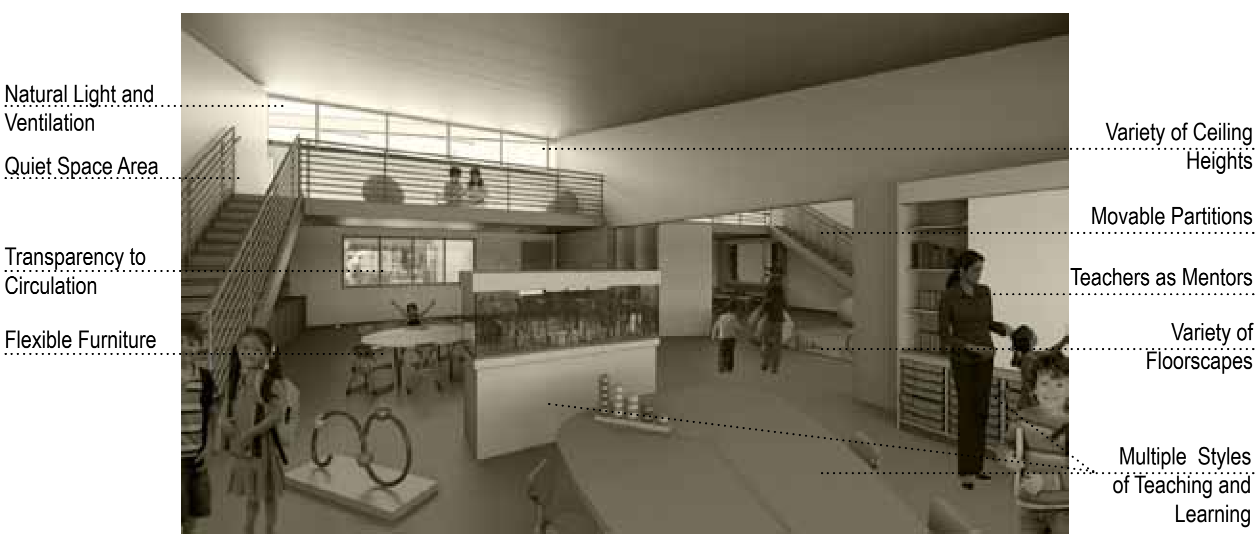


Figure 75: 21st Century Classrooms

Natural Surveillance

Natural surveillance is the capacity to observe activity without having to take special measures to do so. Proper design can provide opportunities for natural surveillance. Students are less inclined to misbehave when they know that they can be seen and intruders can be detected more easily, improving safety and security in the school.

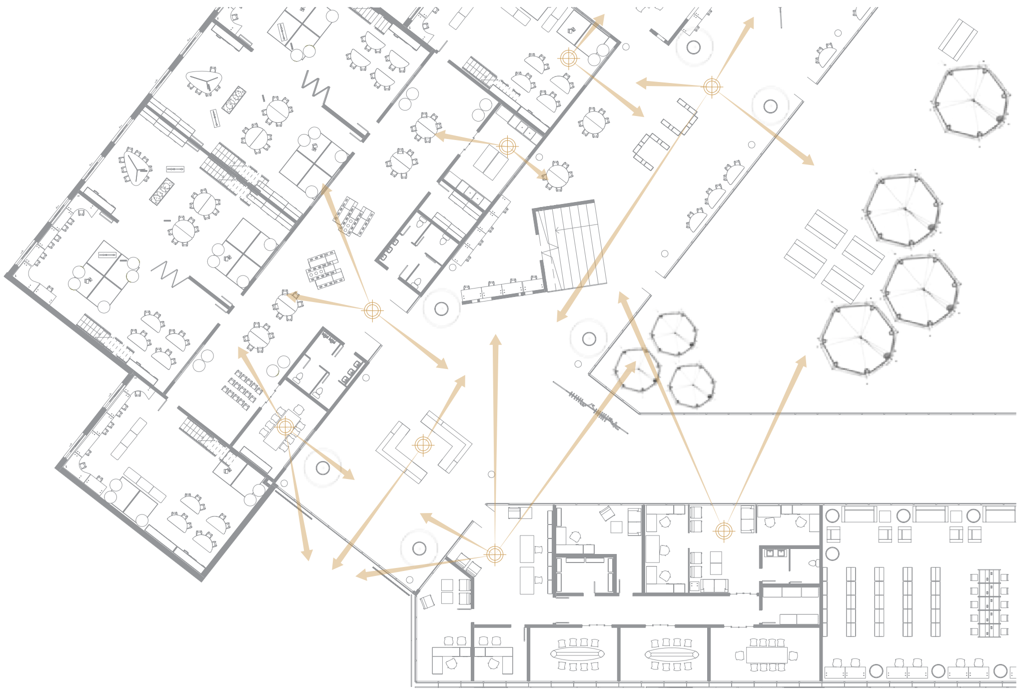


Figure 76: Natural Surveillance Diagram

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VITA

Ester Ehrlich Schwartz graduated in 1998 from the Federal University of Rio de Janeiro, Brazil, with a Bachelor's of Architecture and Urbanism. After working in top architectural studios in Rio de Janeiro, in 2003 she opened her own architectural studio, Ester Ehrlich Arquitetura. In 2005 she moved to North Carolina, USA, with her newly wed husband. While there, she obtained a Master in City and Regional Planning at the University of North Carolina, Chapel Hill. Her degree had a focus on Urban Design and the Preservation of the Built Environment. In 2011 she started a Master of Architecture at the University of Tennessee. She expects to receive her degree, with concentration on Sustainability and Urban Design, in May of 2013. She currently resides in Knoxville, Tennessee, with her husband and their two adorable children.