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AUTHOR	Fox, Anne W.
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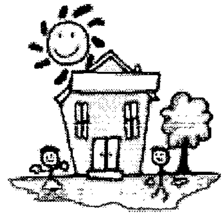
ABSTRACT

This document presents several reports on the practical applications of sustainable design and schools; it includes information about student performance and sustainable design features involving lighting, acoustics, air quality, and student well-being. Three case studies (Washington's Bainbridge Island School District, Texas' Roy Lee Walker Elementary School, and California's Newport Coast Elementary School) are included. These studies illustrate how sustainable design principles may be applied to new school buildings. The studies include observations about some of the challenges and rewards that school districts may encounter in carrying out sustainable design projects. Internet resources are listed for more information on specific sustainable design topics such as site preservation, building enclosure, resource conservation, energy, clearinghouses and databases, renewable energy, buying green power, alternative fuels, transportation, and interior quality. (Contains 84 references.) (GR)



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Sustainable Design For Schools

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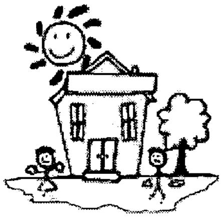

Topical Reports
Sustainable Design For Schools

Introduction

As a result of poor conditions of many school buildings nationally, there is a growing body of support to fund school building renovation and new design initiatives. The rationale behind this support is twofold. First, the argument is made that students need a healthy and safe environment to support academic goals for learning. Secondly, a case is made to repair and build schools that are cost effective to operate so public funds are not wasted and more funds are directly available for student education.

A parallel discussion gaining more recognition centers on "green design," which refers to designing buildings (such as homes, offices, educational centers) and interior spaces with a commitment to merge environmental needs, sound economic decisions, and human needs for healthy, and, in the case of workplaces, productive environments. By linking green design and the national need for new and updated school buildings – there is an opportunity to apply innovative principles of design and, in particular sustainable design, to plans for new school buildings. This, in turn, creates an opportunity to use sustainable design as a tool to help schools fulfill their educational mission. Sustainable design can create an environment conducive to learning. The impacts of poor design and the benefits of sustainable design on student performance have been documented.

Several components may be considered in looking at sustainable design for schools. They include the built environment (buildings and facilities), the learning environment, and the operations and maintenance environment. The built environment includes the outer shell of the building and the systems and materials that go into making the building a safe and protected shelter for occupants. It also includes the site. The learning environment includes the community of people — teachers, administrative and support staff, parents and volunteers – who use curriculum and other teaching materials to help students reach academic and social goals for learning and achievement. The operations and maintenance environment includes the materials and systems that are required to keep the school building and grounds operating safely and cost effectively.

The components - the built, learning, and operations and maintenance environments - are interdependent but, for the purposes of this report, the discussion will focus on the built environment. This report will provide an overview of practical applications of specific sustainable design principles, the impacts of design features on student performance, and three descriptions of experiences from school districts that have incorporated sustainable design principles into new school buildings.

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Sustainable Design For Schools - Practical Applications

Practical Applications: Sustainable Design and Schools

For centuries, buildings have been viewed as a way to live apart from the natural environment. We have grown used to modifying nature and the environment to suit our needs. As population has grown, more buildings have been constructed for shelter, schools, work, and other needs. The environmental footprint of buildings and urban communities has become very large, made more so by technologies that allow us to alter and consume the natural environment at an accelerated rate. Those impacts are further amplified by building designs that lock in inefficiency, consume virgin resources, rely on hazardous materials, and fail to complement surrounding landscapes.

The conventional perspective has been to design human environments in isolation from the larger natural environment. The consequence has been unnecessarily large environmental impacts, but also the construction of buildings that fall short in supporting the purposes of people who use the buildings, be they education, work, or other activities.

A number of architects and designers have demonstrated how the built environment may be designed to counter this traditional view. It may, instead, be designed to mimic and complement natural systems where the outcomes lead to design that is restorative to natural systems and, at the human level, to a sense of well-being. In a book titled **A Green Vitruvius** the authors, members of the Energy Group for the European Commission, explain the reason for their choice of title:

> *"2000 years ago the Roman architect Marcus Vitruvius Pollio wrote the ten books on architecture still referred to in every European architect's education. ....The concept of the architectural pattern book offering design principles as well as solutions is universally familiar. This book is intended as a green pattern book for today.....To the Vitruvian triad of commodity, firmness and delight we postulate the addition of a fourth ideal: restitutias or restitution, restoration, reinstatement: where the act of building enhances its immediate and the global environment in an ecological as well as visual sense (Foreword)."*

Adding the "fourth ideal," restoration, links sustainable design to place by respecting the landscape, the natural systems that support the landscape, and the cultural heritage that is linked to the landscape.

Transferring these ideas to the built environment for schools is the subject of this section. A necessary context is the role of sustainable design in a broad movement to reform education and improve learning. The field of education is under intense scrutiny to adopt methods of instruction to meet the needs of learners. Educators are being challenged to move away from the "factory model" where authority is centralized and flows from the top down. There is a push for national standards and for new roles for teachers and students where facilitation and collaboration are emphasized (Meek, 1995).

Given the pressures for and the nature of changes that educators and others are seeking, it becomes imperative to include thinking about the places for learning – schoolhouses – as part of the formula for change. Anne Taylor notes that, typically, talk of school reform and restructuring have not addressed the physical learning environment as a support system for education. Using architectural elements as tools to enhance children's learning is a relatively new education reform idea. If we intend to transform education delivery practices and processes to enhance the learning environment, then we must put thought into the physical context in which these activities take place (Meek, 1995, p. 68).

The documented need for school renovation and new construction provides a unique opportunity to use design to support the needs of educational reform. Seizing upon the opportunities at hand is particularly relevant for three reasons:

1. Given the scale across the nation of the problem of decaying buildings, there is the opportunity to make real impacts on design, the environment and the communities affected by a project.
2. A second reason to integrate principles of sustainable design is the potential benefits students are likely to realize through improved performance and achievement by attending school in learning environments tailored to support and enhance educational goals.
3. Lastly, use of sustainable design practices in buildings can result in substantial savings in operations and maintenance over the life of a building.

The remainder of this section discusses elements of sustainable design that benefit both the operating performance of schools and the natural environments in which they are built. The following section complements and enhances this discussion by describing the positive impacts certain sustainable design features may have on student performance.

Schools and the Design Challenge

Daniel L. Duke, as a professor and director of the Thomas Jefferson Center for Educational Design at the University of Virginia, is intimately involved with research and design for centers of education. He acknowledges that we have entered into an "era of major school construction and renovation" caused by the combination of growing, shifting populations and aging, deteriorating educational infrastructures. Concurrently, communities across the nation, as well as governmental bodies, are questioning the structures for learning that are in place inside schools. By linking these two observations, Duke makes an important point:

> *"To build or rebuild our schools without rethinking the experiences that take place within them seems as unwise as revamping teaching and learning without considering new designs for learning environments. Together, these trends create an opportunity to redesign both schools and schooling (1998, p. 688)."*

In considering the built environment, a sustainable design approach offers many advantages over traditional design of schools. Those advantages include cost savings through design of integrated systems and plans for multi- and flexible- use facilities. Cost savings may also be realized through use of specific design features such as daylighting, acoustical sensitivity, and use of non-toxic materials that promote learning by creating healthier interior environments. Sustainable design incorporates collaborative and integrative planning processes from the start of a design plan. The benefits gained by communications within a school community are immense. Of greatest interest to educators is the opportunity sustainable design presents to build schools that will support the learning process.

> *" It is not our goal to be a green building. It is not our goal to be an energy efficient building. Our goal is to be an educational facility and be the best educational facility we can be. Green buildings, energy-efficient buildings are strategies to reach that goal (Ohrenshall, 1999, p. 1)."*

These words, spoken by Bill Dierdorff of the North Clackamas School District in Oregon, are important guides to focusing on the reasons for considering sustainable design for new school buildings. Sustainable design is not an end in itself. It is, rather, a way to create a model learning facility through architectural means. This goal is achieved by including specific design features that promote learning, and that create a welcoming, healthy, cost effective and environmentally responsible building. A learning facility is obviously more than just a complex of buildings on a site. It requires a program to support learning, the skills and experience of staff to teach students, and an administrative and operational team that works to provide the resources to keep the school building and programs effectively operating. Although those features are not part of the discussion of this report, it is important to keep in mind that they are critical to the success of any school community.

Just as sustainable design is a collaborative process, so too is the planning for a successful school community. The design of the school, together with the planning for programs, faculty and staff development, and financial and operational management are all essential elements that work together to determine the success of an educational facility in meeting its primary goal of becoming a learning community.

In his thesis entitled "Perceptions About the Role of Architecture in Education," William Scott Bradley lays a foundation for his discussion by offering a definition of architecture and by articulating the role of architecture in education. Architecture itself includes the school building, the learning environments within it, the landscaped site that includes the building, the infrastructure that supports mechanical systems, aesthetic details, instructional equipment, and anything that is created by users to adapt the environment to their needs. He describes five elements that are critical to architectural design if it is to meet the key goal of enhancing education. Those elements are architecture as facility, as place, as signpost, as textbook and as agent.

As a facility, architecture makes learning possible. It is sized, for example to meet enrollment projections and is designed to meet the requirements of and support curricula. As a place, a high value is assigned to the everyday lives of people. The school becomes a place that students and staff relate to in positive ways. It is inviting, aesthetically pleasing, and contains features that promote learning and that help to create an exciting educational environment. By being a signpost a school facility includes features that clearly define important spaces such as entryways, circulation patterns or high activity spaces. A school building is also a textbook by its use of design to support curriculum goals and to help make the learning environment more meaningful. Finally, architecture may be used as a beacon to signify an agent of change. "Applied to education it encourages and provides opportunities for changes in the method of instruction chosen by teachers or approaches to learning taken by students" (Bradley, 1996, p. 105).

Using Bradley's definition of architecture's role in education as a base, it is possible to expand upon his ideas by incorporating concepts of sustainable design into his definition.

Sustainable design may be used as a tool for learning the importance of respecting the dependency of human systems on natural systems and how we should, therefore, design our communities to respect that relationship. It also may be used to show students and the adults who teach those students how collaborative work leads to positive outcomes through innovative approaches to problem-solving. Through sustainable design, a school building may become more than just a "facility." It may become a place that represents a community of learning in more than one sense - a meaningful symbol of respect for the environmental, physical and economic health of a community.

In June 1998, a group of architects, planners, school board members, teachers and representatives from federal agencies met to discuss and consider best practices in designing environments for learning. The practices were presented in draft form at a national symposium held in Washington D.C. later that year. The results included a set of three conditions and six principles. The conditions were: 1) learning is a lifelong process; 2) design is always evolving; and 3) resources are limited. Of the six principles, five speak directly to elements of sustainable design. The principles for learning environments relevant to this report are listed below:

1. Enhance teaching and learning and accommodate the needs of learners.
2. Serve as center of the community.
3. Result from a planning/design process involving all stakeholders.
4. Provide for health, safety and security.
5. Make effective use of all available resources.
   (United States Department of Education (USDE): Design Principles: Schools as Center of Community, 1998, p. 2)

Reflecting the thinking that is occurring at the national level, these principles offer clear support for the application of sustainable design practices to new school building design. Under the first principle, the summary states:

> *"While most of the existing facilities housing the 86,221 existing public school institutions in America were designed to sustain a model of education characterized by large-group, teacher-centered instruction occurring in isolated classrooms, current knowledge and research about learning calls for new models (USDE: Design Principles, 1998, p. 2)."*

The summary not only calls for innovation to address new models where student involvement is more active, cooperative and project-based, it also calls for an accelerated pace for research on the impact of the physical environment on learning. Efforts in sustainable design to address indoor air quality, daylighting and acoustical needs are all methods that speak to addressing physical conditions that affect student performance.

Considering schools as centers of communities supports the concept that schools are important symbols of "place." They should be welcoming to all members of the community. Children should be welcomed into the community, not set apart in isolation. Schools should represent centers of life-long learning where community members of all ages come to learn. And, by looking to schools as centers of community, resources may be shared and conserved by creating a site that is multi-purpose and open many hours of the day throughout the year.

The third principle speaks to the use of a collaborative process to include all stakeholders in designing an environment for learning. This is important for the support this process lends to inclusion and the resulting commitment of a community to a new building. Significantly, the integrated approach to multiple stakeholder participation in design results in problem solving and design innovations that support the goals of sustainable design practices.

The fourth principle, to provide for health, safety and security supports the sustainable design goal of caring for the physical health and well-being of those who will use the building. The summary for the fourth principle speaks to the need to create an indoor environment free of toxic materials. Interestingly, the summary also points out that schools should be designed to be more human-scale and personal to promote a sense of security and community. Reliance on "cookie cutter" approaches to school design across the nation has clearly been shelved as a relic of the past that is no longer appropriate for today's learning environment.

> *"Attractive, well-designed and well maintained facilities communicate respect for the people and activities housed in them. As such, they contribute to positive school climate, good discipline and productive learning. (USDE: Design Principles, 1998, #4)."*

In stressing the importance of making effective use of all available resources, the fifth principle raises the point that school designs must not only be built for people, but also for the environment. Conservation, preservation, and low-impact use of mechanical and energy systems are all recommended as features that should be part of any design. What are some of the specific elements of sustainable design for schools? A discussion of those elements follows.

Elements of Sustainable Design

The goal behind a new approach to built school environments is multifaceted. An essential component is to integrate a school building's design with the goals for learning while simultaneously recognizing the interdependency of the built environment and its occupants with the natural environment. Attention to this essential component will lead to design that promotes the physical and emotional health of the occupants and supports – rather than works against – a student's ability to learn.

In addition, a building, simply by the nature of its design, may be used as a concrete symbol of learning. A building designed on the premise of our link to and interdependency with natural systems is a statement of our respect for the environment and of our accepting responsibility to care for the environment through deliberate and thoughtful design decisions. Concurrently, by creating a healthy and productive building that is cost effective to maintain, we recognize the importance of meeting the social, emotional, physical and economic needs of the building's users.

A school's built environment includes the outer shell of the building, the systems and materials that go into making the building a safe and protective shelter, and the sites, landscapes and cultural settings into which the building is placed. The built environment is designed with consideration for the environmental quality of elements that are identified and integrated into the plan. The following discussion of those elements provides an introduction to the range of considerations for environmental quality in sustainable design. It is not a comprehensive instruction of how the elements may be technically applied to design and construction.

Buildings resemble ecosystems. They are complex assemblages of interwoven, interacting elements (Rosenbaum, 1999). Traditional schools have been viewed as structures of "brick and mortar" that are designed and constructed under the direction of facilities managers, that are maintained by custodians, and that are used passively by students, teachers and staff. (Center for Environment, Education and Design Studies, 1999). Under that philosophy of design and operation, the elements of a building and site are broken into isolated strategies. Systems that are intended to complement one another actually may end up working against each other.

If more attention is devoted to integrated design during the initial design process, then the potential for realizing cost savings during construction and, over the long term, in operations and maintenance is significantly enhanced. In the 1999 article "Little Green Schoolhouse", Tremain notes that

> *"...architects and engineers who set out by viewing a building, its landscape, and functions as a whole might arrive at the cost-saving idea of having solar collectors serve double duty as sound barriers. Or they might translate marginally higher up-front costs such as natural lighting into significantly reduced over-all costs (1999, p. 19)."*

Commonly, after salaries, a school's largest expense is operating costs. In fact, the U.S. Department of Energy estimates that schools could save $1.5 billion annually, a quarter of the nearly $6 billion spent to cover operating costs, by "greening" themselves (Tremain, 1999). Using sustainable design practices, Gary Bailey, whose North Carolina firm, Innovation Design, is a national leader in creating green schools, calculates that the schools his firm designs consume 30,000 to 45,000 BTUs of energy per square foot compared to typical schools that consume around 100,000 BTUs per square foot. Using the Department of Energy's BTU figures, the annual yearly savings could be as high as $4 billion (Tremain, 1999). ("BTU" stands for British Thermal Unit, a standard of measure used to calculate energy consumption.) The important point behind the number crunching is to realize that sustainable design offers the potential for tremendous savings. For cash-strapped school districts, that potential alone presents a strong argument to consider sustainable design practices in planning for new school construction.

As described in the case study, planning for the Sakai Intermediate School on Bainbridge Island, WA included specifications that a salmon-spawning stream flowing through the site was to be protected. Because this specification was built into the planning, design and construction phases of the project, problems with the original siting of the school were identified early. Modification to the siting and drainage designs was made early enough in the project to keep to the original goal of protecting the onsite portion of the stream. With a coordinated, integrated approach, the challenge to protect the stream was dealt with in the most efficient way - at the front end of the project. It is critical that any sustainable design be based on collaborative, interdependent communications between all stakeholders involved with the project.

Using the same premise of integrated planning, school districts that are faced with building multiple schools can save money by developing a prototype for building. A prototype should not spell "rubber stamp schools," but instead reflect goals for materials use and performance standards that are then translated to be site appropriate. Bailey describes his own experience:

> *"I recently visited Clark County, NV, the fastest growing school district in the country. They are planning 80 new schools. I told the superintendent about our experiences in North Carolina and Texas. I showed him how, for an investment of*

$200,000 to develop prototypes, he could save millions. He was initially reluctant. But he left convinced (Tremain, p.1999. p.19)."

Given the importance of applying an integrated approach to planning, what are the key components of sustainable design? In his "Little Green Schoolhouse" Kerry Tremain borrows from Bailey a list of 13 rules for sustainable design (1999). While those "rules" do not necessarily represent a comprehensive list, they touch on the main areas that are components for consideration in sustainable design. Table 1 represents a modification of the elements listed in Tremain's article. Table 1 includes a listing of additional elements and it is organized by category to highlight important sustainable design functions.

Table 1: Elements of Sustainable School Design

1. **Site Preservation**
   - Site planning and landscape design. Maximize the site's natural conditions and design easy access for pedestrians, bikes, and public transit. Provide site protection during construction.
     internet resources
2. **Building Enclosure**
   - Energy-efficient building shell. Design shell to address energy flows and use windows to maximize winter solar gain while minimizing summer overheating.
     internet resources
3. **Resource Conservation**
   - Energy systems. Consider the wide range of viable passive energy technologies and integrate them into overall design for maximum effect.
   - Water conservation. Harvest rainwater; use low-flow fixtures and native plants.
   - Environmentally sensitive building products and systems. Consider the life-cycle energy of materials and processes; prefer local, recycled, non-polluting materials.
   - Recycling systems and waste management. Encourage contractors to recycle, and to design buildings to facilitate staff and student recycling.
   - Transportation. Use alternative fuel vehicles; discourage single-car employee commuting.
     Where Can I learn more?
4. **Interior Quality**
   - Air Quality: Use non-toxic or low-toxic materials and use natural or high quality mechanical ventilation systems.
   - Day-lighting. Orient buildings to maximize southern exposure; use daylighting to illuminate classrooms and reduce related energy costs.
   - Acoustics. configure building massing, forms and building group relationships to reflect and dissipate sound.
     Where Can I learn more?

5. **Operations and Maintenance**
   - Commissioning and maintenance. Recognize and design for ongoing efforts. (Commissioning is a process to bring a building into operation by testing building systems [mechanical, electrical, plumbing, irrigation, etc.] to insure they are designed, installed and functional according to the agreed upon specifications. Commissioning may occur during design specification, construction and once the building is completed and occupied.)

6. **Education**
   - Eco-education. Design the school as a teaching tool for sustainability and send the message that it matters.

7. **Community**
   - Work with the local community to capture the historical, cultural and environmental importance of place.
   - Collaborate to design the school to function as a center of community.

An additional and very important consideration for sustainable design is the plan to manage the construction process. While the elements listed for sustainable school design obviously impact construction decisions, it is important to address the issue of impacts from construction up front. Looked at nationally, again given the scale of need for school construction and renovation, the potential impacts from the construction process are immense. Kibert recognizes that impact in the following statement:

> *"The construct of human society designed to allocate and provide resources to people is the economy, which, at least for the production of material goods, depends almost entirely on nature for its energy and physical inputs. The built environment is a major sector of the economy and to be sustainable it, like every other sector of activity, must examine its behavior in light of the imperatives and constraints dictated by sustainability. The unsustainable use of land, energy, water, and materials that is characteristic of construction industry must be changed from the present-day open-loop, cradle-to-grave model to a closed-loop system integrated with an overall industrial system that focuses on dematerialization, deenergization, decarbonization, and detoxification (1999, p.1)."*

Susan Maxman, of Susan Maxman Architects, points out that "the construction industry continues to have a major environmental impact, generating at least 20 percent of the nation's solid waste, consuming more than 11 percent of U.S. energy, and producing 30 percent of the country's greenhouse gases" (Zeiher, 1996, p. 42). As both Maxman and Kibert observe, it is important to recognize that sustainable design is about both design for environmental quality in a building and about the impact of that design on the construction process.

Overview of the Process

How does a school district go about planning for new school construction based on sustainable design practices? Is the process substantially different from traditional approaches to building? One of the challenges school districts face is that many administrators begin projects with little or no experience in design or construction. The process can be daunting, particularly in today's world of escalating costs, tight budgets, and conflicting political agendas.

Historically, design has been determined by professionals in charge of managing budget and design processes for a building. A typical team may include the client (in the case of schools, perhaps the facility manager), the architect, engineers, consultants, and contractors. In this scenario each group works linearly, passing the task on to the next group once their responsibilities are complete. Decisions are driven by cost, time and the quality of the product desired. There has, traditionally, been no link made by decision makers to "....be aware of the connections between environmental stewardship and the life cycle cost implications of long term investments in building costs" (Commonwealth of Pennsylvania, 1999, p. P3). In addition, pressure to accept low bid contracts and minimal quality standards for materials and construction techniques often ends up resulting in higher operating and maintenance costs over the life of the building.

Traditional design and construction processes for the built environment have not been created in a contextual framework with consideration for the surrounding community. A design may be submitted for public "input" but at that point it is so far down the road, more than cosmetic changes become difficult if not impossible to manage for reasons of economic and schedule restrictions. Public forums may be prolonged and antagonistic because communications with the community come so late in the process (Pollard, 1994).

In describing the outcome of a planning process in Vancouver, B.C., Pollard comments on the importance of the initial, collaborative design charrette to guarantee sustainable practices are incorporated into a design and carried through to project completion. (A "charrette" is an intensive design workshop that involves people working together over the course of several days.)

> *"In addition to underscoring the notion that environmentally sensitive approaches can be positively integrated into community planning philosophy and demonstrating this through three design options, the charrette .....underscored the critical fact that a multidisciplinary and holistic design philosophy is essential to achieving a sustainable paradigm.*
>
> *"This arguably has been the most important point to be reinforced with this exercise. Without the equally weighted, simultaneous input from engineers, landscape architects, students, ... researchers, development consultants, planners, regulators and architects into the design process at the outset, the interrelationships and interconnections between natural, economic and built form aspects of a community would not have been fully and properly explored and exploited (Pollard, 1999, p. 7)."*

A critical point of recognition, then, in any sustainable design process is that the initial stages of planning are most critical if the educational, environmental, economic and community benefits of the design are to be fully realized. The demands on design team time and the opportunities to save money are both high at the start of the design and construction planning process. They are at their highest at the point of team-building and goal setting. As the design and construction process progresses through its various phases to completion, the time demand on the planning team and the opportunities to save money both decrease (Commonwealth of Pennsylvania, 1999).

Table 2 summarizes these steps in a list format. It is important to note that Table 2 is not intended to be a complete checklist of steps in planning and building a school. To detail that process is beyond the scope of this paper. However, Table 2 is intended to provide the reader with an understanding of the scope of planning elements that are important to sustainable building and that should be used as an alternative to traditional approaches to planning, design, and construction of schools.

Table 2: Sustainable Design Process for Planning, Design and Construction

1. **Predesign**
   - Assemble Green Team
   - Develop Green Vision
   - Establish Project Goals and Seek Public Input
   - Establish Green Design Criteria
   - Set Priorities
   - Develop Performance Based Building Program
   - Establish Energy and Lighting Budget
   - Develop Partnering Strategies
   - Develop Project Schedule
   - Review Laws and Standards
   - Conduct Research

2. **Design**
   - Seek Public Imput
   - Confirm Green Design Criteria
   - Develop Green Solutions
   - Evaluate Green Schedules
   - Check Cost
   - Integrate Systems
   - Refine Green Solutions
   - Check Cost
   - Document Green Materials and Systems
   - Verify Material Test Data
   - Seek Public Imput

3. **Construction Documents and Specifications**
   - Insure clear statement of design intent
   - Check design intent against building rating systems
   - Include performance goals for systems and materials

4. **Construction Bidding and Process**
   - Closely consider merits of design and construction by team as opposed to the conventional, linear bidding and construction process.
   - Closely moniter process to insure integrity of goals for Green Solutions

5. **Commissioning**
   - Mechanical

- Plumbing
- Electrical
- Other

6. **Occupancy**
   - Regularly confirm system performance, perform maintenance
   - Conduct post-occupancy evaluation and continue commissioning as needed.

SOURCE: GUIDELINES FOR CREATING HIGH-PERFORMANCE GREEN BUILDINGS, COMMONWEALTH OF PENNSYLVANIA, 1999, P. P4.

Summary

In its essence then, an integrated approach to sustainable design incorporates considerations for site preservation, energy efficiency, resource and material conservation, indoor air and light quality, and water quality and conservation. The entire planning, design, construction and post-construction evaluation is interdisciplinary in that all parties are involved in the sphere of the project. Goals are established early and are clearly stated. Cost analyses are built into plans to understand the full scope of up-front and longer term operating and maintenance costs. A coordinator to oversee the process is designated and supported. Table 3, a description of a "Green Building" from a publication by the Commonwealth of Pennsylvania, summarizes many of the concepts.

Table 3: High Performance Green Buildings

- A project created via cooperation among building owners, facility managers, users, designers and construction professionals through a collaborative team approach.
- A project that engages the local and regional communities in all stages of the process including design, construction and occupancy.
- A project that conceptualizes a number of systems that, when integrated, can bring efficiencies to mechanical operation and human performance.
- A project that considers the "true costs" of a building's impact on the local and regional environment.
- A project that considers the "life cycle costs" of a product or system. These are costs associated with its manufacture, operation, maintenance and disposal.
- A building that creates opportunities for interaction with the natural environment and defers to contextual issues such as climate, orientation and other influences.
- A building that uses resources efficiently and maximizes use of local building materials.
- A project that minimizes demolition and construction wastes and uses products that minimize waste in their production or disposal.
- A building that is energy and resource efficient.
- A building that can be easily reconfigured and reused.
- A building with healthy indoor environments.
- A project that uses appropriate technologies, including natural and low tech

products and systems, before applying complex or resource intensive solutions.
- A building that includes an environmentally sound operations and maintenance regimen.
- A project that educates building occupants and users to the philosophies, strategies and controls included in the design, construction and maintenance of the project.

SOURCE: GUIDELINES FOR CREATING HIGH-PERFORMANCE GREEN BUILDINGS, COMMONWEALTH OF PENNSYLVANIA, P. iii.

Randolph Croxton, an architect deeply involved with environmentally conscious office design, puts these elements into the context of sustainable design by describing the architecture of his company, Croxton Collaborative:

> *"If one word could summarize (our) architecture, it would be 'optimization,' says Croxton. 'There are enhanced levels of energy efficiency, indoor air quality, pollution and CFC (chlorofluorocarbons) avoidance, solid waste management, water conservation, visual comfort, light quality, thermal comfort, and an enhanced awareness of time of day, seasons, and orientation to the sun, achieved within an overall market rate budget' (Zeiher, 1996, p.37)."*

Laura C. Zeiher (1996), in The Ecology of Architecture, explains that sustainable design results "less from right or wrong solutions than from a full exploration of complex subjective issues, "sustainable design" not only respects natural resources, but also embraces human, cultural, and historical distinctions" (p. 30). Sustainable design is not a finite formula available as a model set in concrete. It offers a spectrum of design solutions that must fit the needs of a client, the site and the surrounding community. The key is that the spectrum of solutions work within an overriding framework that reflects a respect for resources so they are not depleted or permanently damaged. It is a process of innovation and restoration with respect to the natural environment, materials use and enhancement of human health, well-being and performance.

The Rocky Mountain Institute's (RMI) A Primer on Sustainable Building (1998) suggests five principles that should be considered in any use of sustainable design.

1. The work completed at the front end of the design process is critical to the successful outcome of the building product.
2. Sustainable design is more a "philosophy of building rather than a building style" and, as such, may be "invisible" as a building feature. It is rather, integrated into a design style which will vary according to the needs of a site and a client.
3. Sustainable design, by definition, does not assume excess expense or complicated design.
4. An integrated approach is critical.
5. Minimizing energy consumption is central and should be translated into energy- efficient mechanical and appliance equipment and materials.

In building new schools, the purpose of linking an integrated design approach to sustainable design practices is to create a building of high quality. The elements of a high quality building mean that it is secure, durable, cost-effective, aesthetically pleasing, environmentally sound, and site sensitive. In addition, methods and practices for resource conservation are employed both during and after construction. Design decisions within the context of designs for schools center on the educational goal of creating an environment that supports and enhances a student's ability to learn. Just how the elements of sustainable design may benefit a student's learning skills is the subject of the next section.

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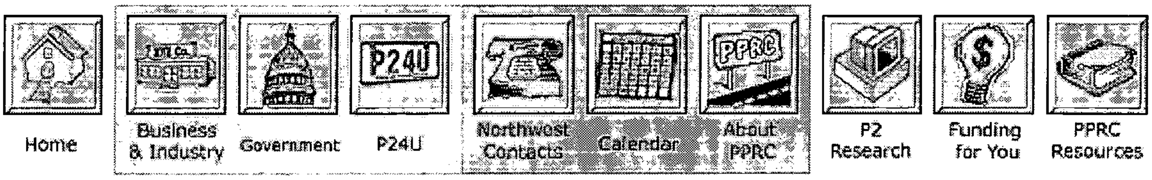

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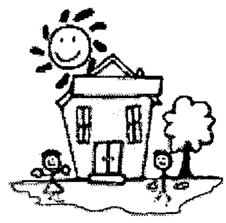

Topical Reports
Sustainable Design For Schools

Sustainable Design and Student Performance

> *"The environment of a given educational facility has a considerable effect on the daily activities of those using the facility. Students, teachers and staff can't always verbalize what they like about the physical details of a building but they recognize the effect the building has on them. Research has shown that the condition of a school building definitely affects student achievement and student behavior and that there are elements of facility design that are perceived to improve the learning climate (Maiden, 1998, p.40)."*

Increasingly, research is demonstrating that the quality of a building, the materials used, indoor air quality, interest-grabbing design features, use of daylighting, acoustic designs and more, impact the performance of those who use a school building. The conclusions seem self-evident. Would we want to work in an environment that was dark, unevenly heated or poorly ventilated?

It is critically important that the design, planning and construction of any school be based on the understanding that the physical facility influences the learning climate. A convincing argument may be made for the use of sustainable design practices in planning for new school construction precisely because that practice is so intimately tied to the whole design of a school and its siting both within a community and on a particular piece of land. By using a holistic approach to design, a sustainable design process is able to more fully consider the needs of all stakeholders who will be using the school. This approach to new school design and building stands in contrast to the more traditional emphasis on cost containment - a primary responsibility of administrators - and on technical design - a primary responsibility of architects and builders. Under a traditional scenario, the idea of building to create a learning environment would most likely be stated as the goal, but the process used to meet that goal could preclude achieving it.

We have invested enormous amounts of time and money in building schools. We have a vested interest in keeping those who attend school for work, learning and play productive and healthy. Investments in sustainable design will pay off in improvements in performance, productivity and attitudes. Those investments are rewarded by meeting needs on a number of different levels.

Health is multi-dimensional and includes not only physical factors but also psychological and social well–being. We have, as humans, basic instincts for both "survival needs" and "well-being needs." Survival needs include environmental health factors such as air, water and acoustic levels. Well-being needs include factors that affect both social and psychological health.

There are several design features that are becoming recognized as important contributors to enhanced student performance and to a sense of well-being on the part of students, teachers and staff. The premise behind inclusion of those features is that the better people feel about their personal health and their work environment, the more able they will be to work productively. The following discussion explores the features that translate into positive results for school occupants. Those features include daylighting (use of natural lighting), acoustic design, attention to materials and mechanical systems that affect air quality, and incorporation of natural environment features to enhance well-being.

Lighting

Adequate lighting is an important feature of any learning environment. If lighting is insufficient, students will be less able to perform "visual learning tasks" (Maiden, 1996, p. 42). On the other hand, lighting that is too intense may interfere with the learning environment by creating excessive glare and/or heat. Considerations of lighting, therefore, become not just an issue of how much, but also of quality. Quality of light is related to brightness, width of spectrum and glare (CAE: Does Design Make a Difference?, 1997). Quality is affected by both the source of lighting and the finishes of interior spaces. For example, how is the quality of the light affected by wall painting and other interior finishes such as flooring and furniture?

In an article entitled "School Sense," Üllik Rouk states that: "The effect of lighting in a learning environment has to do with a lot more than students' visual comfort. There is mounting evidence that lighting also affects student behavior, health, and academic performance" (Probe, 1997, p. 41). This attitude toward lighting, and in particular daylighting, did not always prevail. For many years, particularly during the energy crunch in the 1970s, schools were designed without windows. The goal behind this design was to save energy, reduce vandalism and remove outside distractions. Districts reasoned that windowless buildings would stay cooler in warm climates, demand less energy for cooling and, thereby, translate into budget savings.

Subsequent studies showed that windowless classrooms were more of a deterrent than a benefit to student learning. For example, rather than being a distraction to students, "transitory window gazing" actually offers benefits from what is described as "soft" attention. Without windows to provide a "soft attention" break, students will seek a break from attentive listening by perhaps doodling in a notebook. This is considered a "fixed focus activity." According to Rouk, it is much easier for students to refocus their attention on the teacher after a few moments of soft attention than it is after engaging in activities that require a more pointed focus (Probe, 1997).

The first research on the positive effects of light occurred in the early 1980s. More recent research by the Alberta Department of Education, from 1987 to 1991, considered the effect of different lighting types on the children's health. The study compared differences in children's health in rooms with full-spectrum fluorescent light, full-spectrum fluorescent with ultra-violet enhancement, cool-white fluorescent, and high-pressure sodium vapor (HPSV). Full-spectrum light, although still artificial, has all the spectrum characteristics provided by daylight, including activation of the skin's precursors for vitamin D, an essential nutrient. Because the other types are less than full-spectrum, their benefits are reduced.

The text of the Alberta study did not specify the controls used to insure the validity of the study's conclusions. However, the results that were put forth indicate a benefit of full-spectrum lighting over other, more limited spectrum types and, in particular, HPSV. Under full-spectrum light, students attended school 3.2 more days per year, had less tooth decay, showed more growth gain in height over a two-year period, and achieved better academic performance than students attending schools with other types of lighting (Hathaway et al., 1992).

Rouk describes another study conducted in the latter part of the 1990s by Michael Nicklas and Gary Bailey of Innovative Design. They compared student achievement in three middle schools they had designed for a county in North Carolina to achievement scores in other schools in the same county. Achievement was measured by using two different standardized test scores from the years 1987/88 to 1991/92 for one test and 1992/3-1994/5 for a second test. Results between the two testing systems were not compared. In addition the authors noted that, to minimize the problem of false comparisons, relative (percentage) improvement within each school was used for significant comparison, not the actual average scores between schools. Nicklas and Bailey found that students in classrooms with large windows and skylights that let in natural light outperformed other students in their school district by 5 to 14 percent on end-of-grade tests. (Nicklas and Bailey, 1995).

The Innovative Design study looked at the benefits of daylighting because more people are coming to the conclusion that natural light is an important part of school design. It has two benefits that are significant to the management of a school district: it helps to minimize energy use and increase performance and productivity. In a separate study of the daylit schools' energy performance, Nicklas and Bailey concluded that the daylit schools used 22 to 64 percent less energy than non-daylit schools. They also noted that the payback on all the new daylit schools was below three years, a significant benefit to the school district (Nicklas and Bailey, 1995).

Additional research continues to document these benefits. The CAE article entitled "Does Design Make a Difference?" (1997), describes the results of a study conducted by Paul Grocoff, Ph.D., to measure impacts of different lighting environments on student behavior and perceived behavior. The description of his results does not include any detail about the size of the study, the parameters and controls, or a clear definition of the terms used to describe student and teacher behavior and reactions to the varied lighting environments. The summary description does, however, indicate how students and teachers may respond to varying levels and qualities of light intensity.

Grocoff found that under the lighting systems he tested the students felt "the worst" under the traditional classroom lights – those with warm white fluorescent lamps at a power of 3000 kilowatts. The teachers also felt their behavior was "not at its best." The students felt "the best," and the teachers felt they behaved at their best, under skylights, or natural lighting. The students found the natural light to be "comfortable," and the teachers appreciated the low glare, good color rendition, and good behavior demonstrated under the conditions created by skylights (CAE, 1997, p.16).

Daylighting, allowing natural light into buildings through use of windows and skylights or other specially designed means, offers many benefits to schools. Research documents improved student performance and significant energy savings – up to 50 percent according to Barbara Erwine formerly with the Lighting Design Lab (Ohrenshall, 1999). Daylighting helps fulfill emotional needs for a connection to natural environments by allowing visual viewing. It enhances colors, renders them more "naturally" to the human eye. By paying attention to lighting, provisions for daylighting and glare control, school districts will be more successful in designing a school that, through conscientious design decisions, supports and enhances the learning environment.

In August 1999, a rigorously documented study looking at the effect of daylighting on human performance was made public. The study, entitled "Daylighing and Productivity Study," was sponsored by Pacific Gas and Electric Company and conducted by the Heschong Mahone Group. The study looked at "the effect of daylighting on human performance and focused on skylighting as a way to isolate illumination effects from other qualities associated with daylighting from windows, such as view and ventilation" (Heschong Mahone Group: Condensed Report, 1999, p. 4). Rigorous controls were used to insure the quality of the data collected. Careful analysis was conducted to select the grade levels and schools to use for the study. Elementary schools were chosen from three school districts in different regions of the western United States. Math and reading test scores were analyzed for over 21,000 students from those districts. In Seattle and Fort Collins, Colorado school districts, scores from the end of the school year were measured. Scores for a third district, in San Juan Capistrano, California, were measured over a school year to track the amount of change from the beginning of the year. A summary of the findings follows:

> *"Controlling for all other influences (in the Capistrano school district), we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26 % on reading tests in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room and which allowed teachers to control the amount of daylight entering the room, also improved 19-20% faster than those without a skylight. ...students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows.*
>
> *"Students (in Seattle and Fort Collins) in classrooms with the most daylighting were found to have 7% to 18% higher scores than those in rooms with the least.*
>
> *"The three districts have different curricula and teaching styles, different school building designs and very different climates. Yet the results of the studies show consistently positive and highly significant effects. This consistency supports the proposition that there is a valid and predictable effect of daylighting on student performance (Heschong Mahone Group, 1999, p.2)."*

The reason why natural lighting improves student performance has not been ascertained. What is it about daylighting that might cause such an effect? The authors of the "Daylighting in Schools" study offered a number of informed guesses. They are listed below.

1. Improved visibility due to higher illumination levels
2. Improved visibility due to improved light quality, including better distribution of light, better color rendition, absence of flicker and sparkle or highlights on three-dimensional objects
3. Improved health
4. Positive occupant response due to decreased daylight deprivation
5. Improved mood
6. Higher levels of alertness
7. Improved behavior

In the past, schools have often used a standard layout of artificial lighting to illuminate classrooms and other areas of school use. Now, in keeping with the principles of sustainable design, it is important to create lighting plans that are suited to individual schools, sites and locale. Lighting requirements will vary significantly across the nation depending on the hours of direct available daily sunlight and the intensity of that sunlight in each different locale. The influence of daylighting and artificial lighting has been documented. The challenge for school districts is to take that information and fit the design to meet the needs of their school sites.

Acoustics

Another design feature that impacts student learning is acoustics. Because younger children learn language through hearing sounds, it is important that acoustics designs account for this need by designing spaces that will meet noise level standards. This need is also relevant in environments with hearing impaired children. For those children, poor acoustic design that results in noisy, reverberant classrooms may create barriers to learning. Major sources of noise levels are heating, ventilation and air conditioning (HVAC) systems and insufficient or poor use of sound-absorbing materials.

A report by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), April 1999, includes summaries from three people who spoke at a conference about the effect of acoustical barriers in the classroom. Peggy Nelson noted that typical classrooms often have background noise levels between 35-45 decibels. The high/low range corresponds to whether the HVAC system is on (high) or off (low). When the rooms are occupied, the decibel numbers rise to 58-62. Based on acoustical studies this range is considered to result in poor hearing conditions. For comparative purposes, and to better understand the impact of the higher decibel numbers, it is interesting to note that the City of Seattle sets a noise standard of 60 decibels for commercial use areas (Saperstein, 2000).

Nelson also notes that a study of an acoustics condition rating index shows that the age of listeners has little impact on score results when acoustics are within an acceptable decibel range. However, when conditions swing to the higher noise levels, the ratings index drops for younger children compared to adults in the same space. This suggests that younger children have a harder time comprehending and listening when background noise levels are too high.

Another speaker, Sigfrid Soli, supported Nelson's information by concluding that low-background-noise environments provide a "level playing field" for many (if not all) students. In contrast, high-background-noise classrooms impose barriers to hearing for a range of students. Because a child's ability to sort "signals" from among noises is not fully developed until teenage years, the ability to learn is compromised by ambient background noise. Soli listed a number of factors that, through a calculation of decibel "penalties," create poor hearing conditions for children. Those factors are age, hearing status, lack of language proficiency, ranges of individual differences in hearing and excessive reverberance in a room. For any one of those factors, higher noise levels exacerbate the ability of children to learn. Combine those factors into one room and the result is to severely compromise a child's ability to learn.

According to the ASHRAE report, new federal rules are likely to be developed in 2001 in response to complaints regarding poor classroom acoustics and the obstacles to learning those classrooms present for hearing-impaired students. The article suggests that those regulations, if implemented, are likely to change design approaches to HVAC systems. Interestingly and particularly relevant to sustainable design practices, one of the speakers, Jerry Lilly, spoke directly about the contribution of HVAC systems to classroom noise. He was quite clear in stating that low-first-cost HVAC systems will result in problems. The implication, then, is that if HVAC systems are to be used, consideration of the impact on all school operations must be weighed against the purchase and installation costs.

Air Quality

Between the ages of 5 and 18, a student may spend 14,000 hours inside a school building (Environmental Defense Fund, 1999). In consideration of the amount of time children spend indoors, it is important that the air quality in schools be good. In addition, according to the American Academy of Pediatrics, children are more severely affected by air pollution than adults. "Air pollution affects children more than adults because of their narrow airways, more rapid rate of respiration, and the fact that they inhale more pollutants per pound of body weight" (Environmental Defense Fund, 1999, p. 1). Air quality, then, is another factor for the school community to consider in order to create a school with a healthy environment for the children and adults who will use the facility.

Similar to the 1970s decision to eliminate windows as one means to reduce energy costs, school officials also sealed the buildings tightly to reduce air flow that might increase the need for energy expenditures. This decision resulted in air quality problems for schools because ventilation was reduced and pollutants sealed in. The U.S. General Accounting Office acknowledged this problem by reporting in 1995 that more than half the nation's schools had experienced indoor air quality problems (Environmental Defense Fund, 1999).

Any new school building must be designed with careful consideration to assure a high level of air quality. Problems that are not anticipated can result in expensive repairs for school districts. The Bainbridge Island School District, for example, experienced air quality problems in some of its schools and, as a result, specifically included air quality performance standards for a new school building in order to avoid similar problems. Their experience is described in the case studies section.

In an Environmental Defense Fund article entitled "Making Our Children's Schools Safer and Healthier" (1999) several steps are suggested for achieving better air quality in schools. They include minimizing exposure to toxic materials through careful selection of furniture, paint, adhesives, floor coverings and supplies, and providing high quality systems for ventilation.

An article in School Planning & Management (1999) warns about the national escalation of allergies and asthma among children. The article describes the problem as a "national crisis." Although the article points primarily to old and decaying schools as the major source of the problem, it also points out that, although outdoor pollution has improved over the last 20 years, pollution levels indoors have increased. These factors make it imperative for schools to pay careful attention to the design and use of HVAC systems.

Well-Being Needs

Up to this point, the discussion has centered on particular environmental hazards that, if not addressed in planning for new school construction, can reduce the quality of a building's environment. Because communities and the schools within them are so intensely invested in the children and adults that use the facilities, it makes sense to create a building that keeps people productive and healthy. In a paper entitled "Toward a General Theory of the Human Factors of Sustainability," Heerwagen, Winn and Hase (1999) argue that those features are necessary but not totally sufficient to generate...

"the kinds of positive impacts envisioned in the green building community....we argue that successful green buildings will integrate sustainable technologies with design features that sustain human emotional, social and cognitive needs (p. 1)."

The authors use the terms "well-being needs" as opposed to "survival needs" to frame their argument. They borrow the terms from a 1971 article by S. Boyden entitled "Biological Determinants of Optimal Health." Survival needs deal with aspects of the environment that directly affect human health, such as clean air and water. Well-being needs relate to quality of life and psychological health. Because so much attention has been given to environmental factors that affect survival needs, the authors focus their attention on the benefits of incorporating the "psycho-social components of health" into building design. Although their study is not specifically centered on schools, its arguments are easily transferred to a school environment.

The authors argue that if sustainable building practices are aimed at influencing health in a comprehensive way, then the notion of health as multi-dimensional must be recognized. Sustainable design and green-building discussions have centered most commonly on the physical components of health. The authors document research from a diversity of sources and note the importance of "biophilia." Biophilia refers to "humanity's innate attraction to and affiliation with nature. Taken as a whole, this diverse body of research suggests that buildings which incorporate features of preferred natural settings will be more supportive of human well being than settings which lack these features" (Heerwagen et al., 1999, p.2).

If we consider that buildings are habitats for people, then, by extension, it makes sense that people will choose the "habitat" that is most suitable to their survival. They will gravitate towards a "preferred environment." The authors, using references to support their argument, provide a table that lists habitat and natural feature attributes of preferred environments. It includes "key dimensions" such as "prospect" or the ability to see into the distance, "refuge" or a sense of enclosure or shelter, and "vegetation" that includes large trees with spreading canopies for refuge and shade, flowers and shrubbery (p. 4).

The authors' argument makes a link between nature and preferred environments and the resulting outcome of "positively toned emotions" on the part of people who work in buildings with preferred environmental attributes. In other words, sustainably designed buildings, if they take into consideration natural habitat attributes along with attributes that promote physical health, can positively influence well-being and productivity.

"A significant body of research compiled by Alice Isen and her colleagues at Cornell University (Isen 1990; Isen et. al., 1987) have found that positively toned emotions can have surprisingly strong impacts on cognitive performance. Positive moods facilitate creative problem solving, decision strategies on complex tasks, discriminative learning, and memory. Although the exact mechanisms by which these cognitive effects occur are not known, Isen and others (LeDoux 1996) suggest that positive moods:

- *generate neural patterns associated with broad searching*
- *promote novel juxtapositions of ideas, concepts, and memories'*
- *enable people to "break set" more readily and see additional features and associations*
- *create a more complex cognitive context associated with a broadened focus of attention and greater access to materials store in memory (p. 6)."*

The paper presented by Heerwagen et al. argues that sustainably-designed buildings that incorporate features and attributes of preferred natural settings and nature stimuli can have a significant impact on human well-being and productivity. The authors call for further research to more specifically document the beneficial links. The studies cited and the arguments made by the authors are not school-specific so any design needs to be modified to take into account the special needs of schools and children. The benefits, however, to linking physical health and well-being to design outcomes is clear. Schools need to address the health of the whole child as well as the health of adult employees. Believing that health is multi-dimensional, physical, emotional and social health are all factors that need to be included in making design choices for a school building.

The next section features case studies that illustrate sustainable design and its application in school settings.

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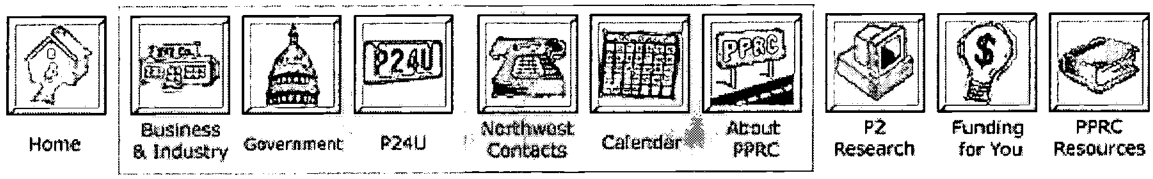

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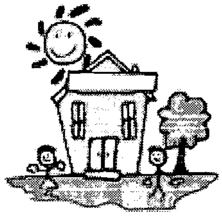

Topical Reports
Sustainable Design For Schools

Making it Happen: Three Project Descriptions

Introduction

Planning for and studying about sustainable design does not necessarily translate into the design and implementation of a project that meets all of the anticipated requirements of sustainable design goals. The realities of time and budget restraints as well as the political support behind a project will more often than not result in compromises to the design process. School districts faced with shrinking levels of government funding and contentious operating environments may be hesitant to try new approaches to building. Knowing this, and despite the risk of breaking new ground, many districts have studied the prospective benefits offered by sustainable design and subsequently chosen to embark on projects that embrace that design philosophy and application.

This chapter includes descriptions of sustainable design projects from three school districts. The descriptions provide the reader with real-life examples of how sustainable design principles may be applied to new school buildings as well as observations about some of the challenges and rewards school districts may encounter in carrying out sustainable design projects. The three schools discussed in this chapter are the Sonoji Sakai Intermediate School in the Bainbridge Island School District (Washington), the Roy Lee Walker Elementary School in the McKinney Independent School District (Texas) and the Newport Coast Elementary School in the Newport-Mesa Unified School District (California).

Three primary means to gather information about the school projects were used in researching this chapter. Research was conducted on the Internet, managers for the projects were interviewed and, in the case of Sakai Intermediate School, a site visit was made. Interviews were conducted by phone, e-mail or in person.

It is important to note that the following descriptions are intended as overviews of the projects. In all cases, one to three participants in the projects were contacted. In the case of the California school project, information was gathered exclusively through discussions with the project manager from Southern California Edison, the utility responsible for coordinating energy efficient-designs with the school district. The overviews provide basic information that will help school districts understand the goals, implementation issues, and outcomes of the three projects.

Sonoji Sakai Intermediate School

Sonoji Sakai Intermediate School (Sakai), constructed over the course of 1998 and 1999, is a fifth/sixth grade school that was occupied in January 2000. It is located in the Bainbridge Island School District (BISD) in the state of Washington. Bainbridge Island is located in Puget Sound, a 35-minute ferry ride west of downtown Seattle. The Island is connected to the Kitsap Peninsula on its north end by a bridge that spans a quarter mile waterway, Agate Pass. Bainbridge is approximately seven miles long and covers an area close to 20 square miles. It has a year-round population of approximately 20,000 people.

Responding to a growing influx of families to the Island, BISD has built two new schools and remodeled portions of all the other District schools within the last five years. The Sakai Intermediate School is the latest school to be built in the district. With its completion, the District now includes three elementary schools, the intermediate school (Sakai), a middle school (grades seven and eight), a high school and a number of K-12 optional programs. Approximately 3,600 students are currently enrolled in the District's schools.

The BISD experienced serious indoor air quality problems in one of its previously built schools, and stream and watershed damage at another school site. The School Board was therefore highly sensitized to the need for respecting environmental planning in setting its goals for the Sakai project. The School Board sensitivity was strengthened as well by the knowledge that the Sakai school site included a stream that was affected by the federal designation of Puget Sound chinook salmon as a threatened species. Based on its previous experience and the knowledge of existing conditions on the Sakai building site, the School Board set three environmental goals for the site and building design. Those goals were:

1. to insure that ecosystems on the site were minimally impacted
2. to insure high indoor air quality in the completed school
3. to employ resource conservation where sustainably designed materials and practices were used and followed during construction and in the completed building

Planning for the new school began in April 1997. The approach to the project was fairly traditional in that it followed the normal progression of schematic drawings, design development, construction documents, bidding and contractor awards, construction and post-construction evaluation and follow-up. Unlike traditional projects, however, the level of coordination by Richard Best, the Capital Works Director, was much higher. Best was hired, in part, because of his previous work with environmentally sensitive projects. He was a champion for Sakai and managed the project to include collaborative meetings and dialogs with the various groups who would be responsible for designing and building the site as well as those who would be occupying and using the building.

In June 1997, one year before the planned ground breaking for the school, a program planning team was appointed. The Team included representatives from the teaching and administrative staff for the new school and the school administration. The Team met with the architects in their Seattle offices as well as with various representatives of the Bainbridge community, including school staff and residents of the community. The team also met with federal grant makers to explore possibilities for funding a "teaching project" for students to learn about the priority assigned to environmental goals for the building project. The Team was asked to consider future use of the building, taking into consideration the use by community as well as the possibility of Sakai being used as an elementary school five to ten years into the future. The Team was coordinated by Best to maintain consistency with the overall planning process and to insure the goals of the planning team were incorporated into the building design.

As Capital Works Director, Best was responsible for the overall management of the project. As part of those responsibilities, he monitored the project to insure the three environmental goals remained in the forefront of the design and building process. In keeping with those goals, he tracked site development, construction practices, and specification of materials and mechanical systems. The following discussion summarizes some of the sustainable design elements used in the project to meet the District goals during the design and construction of Sakai. The summary serves as an example of how goals for sustainable design may be put into practice. The elements are listed by number and are identified by use of the category headings from Table 1 earlier in this report.

1. **Site Preservation (Minimization of Sedimentation Flow)**: During site development, construction was phased to protect the on-site watershed and salmon habitat by minimizing sedimentation flow. Seeding of the site perimeter to hold loose soil was completed prior to initiation of building construction. Paving of the outer areas was completed next, to create building stage and worker parking sites, thereby avoiding excessive mud and pooling of water and silted runoff caused by the heavy use of construction equipment. The asphalt paving created a "moat" around the perimeter of the building and building pad to contain sedimentation. Three sedimentation ponds were built to filter and distribute the final flow of stormwater runoff into undisturbed natural areas within the watershed buffer areas.

2. **Site Preservation (Watershed Protection)**: In addition to reducing construction impacts, attention was also directed toward the impact of the building itself on the stream and watershed. A geotechnical analysis revealed that the building, as sited, would act as a dam to groundwater flowing into the ravine and stream and could, consequently, create conditions that would adversely impact that portion of the watershed. In response to this analysis, an interceptor trench was designed and built around the building to collect groundwater and disperse it to replicate the natural site flow and, thereby, protect the wetland area associated with the watershed.

3. **Site Preservation (Contaminant Control)**: The BISD applied another environmentally sensitive practice to the Sakai project by adopting a strict "no pesticide rule" for the school because of its proximity to the salmon stream. This designation is even more stringent than the District's current policy which requires use of "integrated pest management" (IPM) at all its schools. (An IPM policy states that pesticide use will be avoided whenever possible.) To further mitigate any possible harm from contaminants, areas with asphalt pavement were designed to drain into three catch basins where the water was then shunted through a lawn area for filtration prior to entering the sedimentation pond. This option was chosen as a more ecologically friendly approach and a more effective solution in contrast to piping the water directly to the sedimentation ponds.

4. **Site Preservation (Protection of Natural Vegetation Cover)**: A community review of the site development plans raised concerns about potential negative impacts to the site that could result from extensive soil cuts around the sedimentation ponds. The cuts were made to achieve the correct grading slope. Citizens were concerned that the severity of the cuts would result in loss of natural vegetation cover and cause, because of the loss of a canopy cover to provide shade, increases in streamwater temperatures. Those increases could potentially harm salmon. In response to the concerns, plans were made to replant

native vegetation extensively around the ponds and to monitor, over time, the water temperature at both the pond and at the point of outfall from the pond.

5. **Quality of Interior Building Environment (Air Quality)**: To insure that goals for high levels of indoor air quality were met, Best specified that the higher performance Canadian ventilation standards (20 cubic feet per minute of outside air per occupant) be used instead of the U.S. air standards (15 cubic feet per minute of outside air per occupant). A number of methods were used to meet IAQ goals with the intent that the cumulative effect of those methods would result in a high level of air quality in the completed building. To assist in meeting that goal a consultant was hired to provide and write detailed specifications of material use standards for the project.

   The specifications for low toxicity or non-toxic materials were, for example, built into plans for purchasing furniture, carpets and building materials such as gypsum board. In addition, recycled content percentages were specified for many of the building materials. Extensive testing was done on paints, adhesives and caulks to insure non-toxicity. The mechanical venting and filtration system for the school was built above standard. In addition, the mechanical system was designed to be located as a walk-in, easily accessible room to allow maintenance to occur on an ongoing, efficient and consistent basis.

   Efforts to achieve high standards for IAQ met with success in the initial testing upon school completion. In the 30-day off-gassing period air quality measures were below industry allowed levels by up to 84%. (Off-gassing is the period of time set aside before occupancy of a completed building to allow dispersal of toxins from materials used in the building.)

6. **Education**: Using the school as a learning tool became another goal of the project team and, in particular, the teachers on the team. A small government grant was received to create two signs to describe the environmental features that were consciously built into the design and construction of the school. The grant also supported curriculum design to teach the Sakai students about green-building topics such as sensitive site development, integrated pest management and resource efficient buildings. The goal behind the curriculum design was twofold. First, it was to help children become familiar with the environmentally friendly aspects of the Sakai Intermediate School. Second, it was to inform teachers and parents about sustainability concepts that were integrated into the design and construction of the school.

7. **Community**: The Sakai project captured the importance of place in the naming of the school and in a stone sculpture that was designed and made for installation in the school's courtyard garden. Sonoji Sakai came to Bainbridge from Japan in 1915 and started one of the Island's early farms. During World War II, Sakai and his family were interned in relocation camps for four years. He returned to the Island and, with his wife, raised six children, all of whom graduated from Bainbridge High School. He was grateful for the education his children received and showed that gratitude, in part, by a providing land for one of the District's schools at a nominal cost. The Japanese-American community on Bainbridge Island designed and donated a garden for an inner courtyard at the school and a large stone from the original site was included in the garden design.

Observations

Sakai Intermediate School was designed to meet specific goals for environmental health and resource conservation. Leadership at the top was critical to insure that the project met stated goals. The project was championed by the School District Board. It was also championed by the project manager, Richard Best, and supported by a committed group of project planners and coordinators. Coordinated planning led to a clear statement of goals that were visible throughout the project to insure continuity of actions. Budgets were clearly set and managed. O'Brien & Co., specialists in the field of sustainable construction and development, and other specialists, were used to provide educational and technical training of sustainable design. To move incrementally towards achieving environmental goals, performance indicators were built into specifications to give contractors and the builders a clearly stated direction about the quality of materials that were to be used.

With the successes, challenges also arose. Several of those challenges are summarized below.

1. Tradeoffs were discussed throughout the process. Some materials, such as the low Volatile Organic Compound (VOC) carpet, had a higher initial purchase cost but was still selected for installation because it was shown to cost less to maintain over time. (VOC's vary in toxicity and can include chemical compounds that are carcinogenic.) Compromises were made in other parts of the building to keep the overall budget in line with projections. For example, to reduce costs, metal paneling was utilized at the gables on the building's exterior, to replace split faced concrete. Savings gained through that modification helped free up funds to purchase other, more expensive materials that were deemed critical to successfully meet environmental goals for the site.
2. Although a materials specifications book was made for the project, it became apparent that it was not detailed or extensive enough to always provide clear direction for contractors or for those coordinating the project.
3. Teachers chose wall space for display purposes over more extensive daylighting. Although there are at least two large windows in each room, the decision to limit their use goes against the findings of previously mentioned studies that favor more daylighting because of its positive impact on student performance.
4. The education program for the newly configured 5th/6th grade program was not clearly defined going into the building design phase for the school and, as a result, design occurred before detailed program definition. This posed challenges and frustrations for some of the teaching staff.
5. One teacher expressed some frustration over the unknown, or less predictable factor of future enrollment projections, especially in light of anticipated population growth in the school district. Her concern, in part, related to a realization that teaching staff might lose the flexible open space areas built into the design if those spaces were needed at some future date to accommodate a growing student population.

Having completed the Sonoji Sakai Intermediate School, BISD is in a good position to build on the knowledge gained in its design and construction. With more construction likely in the future, the District has the opportunity to take that knowledge and to expand its commitment to sustainable design.

Roy Lee Walker Elementary School

Roy Lee Walker Elementary School is in the McKinney Independent School District in the City of McKinney, Texas. McKinney, located about 50 miles north of Dallas, has been one of the fastest growing cities in the Dallas-Fort Worth metropolitan area during the 1990s. The population of the City has doubled to 44,000 residents since the 1990 census. This growth has an obvious impact on the school district. At the end of 1999, 10,900 students were enrolled. By 2003, the enrollment is projected to grow to 16,000 students. The McKinney Independent School District (MISD) has one high school, two middle school campuses, nine elementary school buildings, and three facilities that offer alternative education programs.

The MISD has a history of involvement with sustainable design for schools dating back to a $5.5 million grant it received in 1992 from the U.S. Department of Education to design a K-12 school utilizing integrated curriculum and technology. The school, originally built as a Works Progress Administration project in the 1930's, was remodeled with the intention that it be a first attempt to incorporate sustainable design features into a new building. Before that work, a number of the District schools had been retrofitted for energy systems upgrades that are more cost effective to operate and environmentally responsible.

With its history of exploration and involvement, the MISD was poised to pursue sustainable design for schools in a more comprehensive manner than it had previously. In 1997, the District was one of two to receive a $200,000 grant from the Texas State General Services Commission/State Energy Conservation Office. The grant fell under a program called "The Texas Initiative on Sustainable Schools." McKinney was selected from a list of 99 districts that were identified as the fastest growing districts in the state. Two other identifying factors were that the districts had bond money available for new schools but had not yet started the design process.

Having received the grant, the MISD moved ahead with plans to build a sustainably designed school. The project was championed by many - the state conservation office, the School Board, the school superintendent and the assigned project manager, Wyndol Fry, Executive Director of the District's Facilities/Construction Group. A conscious decision was made to integrate the design fully with sustainable practices rather than to concentrate on one particular piece such as energy efficiency or indoor air quality. Realizing they needed to learn what it meant to build a "green school," the District chose to turn to others who were experts in the field. As a result, Innovative Design, a consultant group with extensive experience working with schools and sustainable design, was hired to work closely with the district, the architect (SHW Group), engineers and the contractor.

During the course of planning, different methods were used to educate District personnel and the community about sustainable design and making the planning process inclusive. District representatives, including Fry and two school principals, visited schools in North Carolina that had been designed by Innovative Design using sustainable principles. The architect held meetings to bring together a cross-section of people who would be involved with the school. Those meetings included teachers, staff, students and members of the community. The group met over three to five days to discuss the design process, their needs and the needs of the educational program. The contractor was included in the meetings from the start. The inclusive nature of the planning process was intentional to insure that all parties with responsibility for managing the project or those who would be directly impacted, were informed about the sustainability goals and given the opportunity to work for those goals from the project's inception. Meetings were held over the course of the design process and a project manager from SHW worked closely with Fry to insure that the integrity of the design documents was maintained from inception through construction.

Roy Lee Walker Elementary School opened in the 2000-01 school year. The school is designed for 680 students, grades K-5. It totals 70,000 square feet and is built on a 11.3 acre site. Although designed using sustainable principles, the design was built around the needs of the educational program. The basic design represents a "finger plan," where each "finger" is a wing for two grade levels and ten classrooms. Three finger wings feed into a main building that includes a dining room, gym and library. Specific sustainable design features included in the school plan are listed below. The features are listed by number and are identified by use of the category headings from Table 1 earlier in this report.

1. **Resource Conservation (Energy Efficiency)**: The building is oriented to maximize southern exposure and minimize east-west exposure. Solar panels were installed to heat water for the school. A windmill is used on site to raise the level of water in the main cistern. Although geothermal energy systems were evaluated, a decision, based on cost estimates, was made to use an efficient but conventional heating, cooling and ventilation energy system.

2. **Resource Conservation (Water Usage)**: Rainwater is channeled through special gutters to four cisterns where it supplies water for campus irrigation. Hose bibs were built into each cistern to make the water available for use by children when they help to plant gardens around the perimeter of the school at some future date. Native grasses and plants will be used for landscaping to minimize water use and to limit mowing. Red cinders will be used on walkways instead of concrete because it is a more pervious and natural material and, unlike gravel and dirt, will not turn to mud in the rain.

3. **Resource Conservation (Environmentally Sensitive Building Products) and Quality of Interior Building Environment (Air Quality)**: Low-toxic or non-toxic materials were specified for the project, as well as products with high recycled content. Specifications covered use of such products as plastic laminators, adhesives and paint. Furniture and athletic products were also evaluated for their environmental health and efficiency of their manufacturing. Site construction was managed to require separation of building material waste during construction. An effort was made to buy locally.

4. **Quality of Interior Building Environment (Daylighting)**: Daylighting is used extensively throughout the design. Fry described it as "more than just old-fashioned skylights in the ceiling. It involves utilization of the sun to assist the lighting in the school." Light monitors "scoop" the sunlight in, bounce it off baffles, and send evenly distributed, non-glaring daylight into learning spaces. As the light enters through the monitors it is directed by rectangular shaped sheets of hanging fabric (baffles) that are hung in parallel formations to catch and evenly distribute the light.

5. **Education**: Staff will receive training to learn how concepts of sustainability were applied to Roy Lee Walker. A sundial at the gym and in the courtyard will help students learn to identify winter and summer solstices and to read time using the sun as their watch. An eco-pond, part of a man-made stream, was built for use as an outdoor habitat classroom. A hand-pump is located next to the pond. A greenhouse and outdoor amphitheater were eliminated from the budget although the foundation for the greenhouse was built. In time, the community may raise the funds to build the amphitheater.

6. **Community**: The school site is adjacent to a city park. The city and school district agreed to share the on-site school parking spaces and to allow the park to be used as a playground extension during school hours.

Observations

The design and construction of Roy Lee Walker Elementary School has been advertised and promoted by the School District as an important benchmark in new school design. The school received national recognition when the American Institute of Architects selected it as one of the 1999 Earth Day Top Ten award recipients in recognition of architectural design solutions that protect and enhance the environment. It represents the first effort by the MISD to intentionally design a school using an integrated and collaborative approach throughout the planning and construction management phases.

The budget for school design and construction came in higher than budgets for conventional building designs in the District. Daylighting was the most significant cost factor because of the steel used for construction. Alternative materials will be considered in the future. In addition, because this project served as a prototype for the district, first time costs for planning, logistics and materials use were expected to be higher to some extent.

Fry made significant cuts to eliminate $1 million from the budget. A large portion of that savings resulted from the elimination of daylighting in the gym. After making the cuts, because the budget was still higher than the School Board's projections, Fry had to argue further to defend the design. He successfully made the argument by explaining that initial costs should be recovered over time due to significantly reduced operating costs. Those cost savings are expected to result from the use of highly efficient applications of lighting and energy systems, resource conservation, and materials use throughout the building.

The MISD is in a unique position to test this argument because it is building two new elementary schools simultaneously, Roy Lee Walker and a second, conventionally designed and built school. The District will study the two schools over time to compare operating costs, paybacks and differences in student performance. To seek funding in support of this effort the District applied to the Department of Energy, through the Texas State Energy Office, for a two-year, $350,000 grant to run a comparison study of the two schools. The study is intended to provide information about the effect of school facilities on the health and productivity of students. It is also intended to validate the need to design and build sustainable school facilities that "provide a safe and healthy atmosphere to educate our future generations." (Texas State Energy Conservation Office, 2000, p. 3). The study will be designed and administered by the University of North Texas and Texas A & M University's Energy Systems Lab.

Newport Coast Elementary School

Newport Coast Elementary School is part of the Newport-Mesa Unified School District in California. The school district includes the cities of Newport Beach and Costa Mesa. It is approximately 30 miles south of Los Angeles and 90 miles north of San Diego. It is located in the third most populous county in California and covers 58.83 square miles. The District was established in 1966 and currently has 22 elementary schools (including Newport Coast Elementary), two intermediate schools, four high schools, one alternative education center, and one adult education center. Approximately 21,138 students attend schools in the District.

In June 1996, the District purchased land for construction of Newport Coast Elementary, its first new school in 25 years. The land, purchased from the Irvine Company, is located in the midst of a residential development built by the company. In 1997, Southern California Edison (SCE) approached the School Board and proposed that the school be designated an energy and environmental showcase facility to demonstrate cost-effective uses of energy-efficient technology and operations. The School Board approved the proposal, leading the way towards coordinated planning and design between the architects, SCE, the District, and the community. Ground breaking for the school occurred in September 1999 and occupancy is targeted for September 2000.

SCE, an investor owned energy company, collects "public goods funds" from ratepayers to promote energy-efficiency as part of their regulated activities dictated by the California Public Utilities Commission. The utility carries out one portion of this program through its Design and Engineering Services Group (D&ES), which is involved in showcase work with SCE customers. Deborah Weintraub, an architect and employee of SCE, works with D&ES. She, with her co-worker Tony Pierce, a mechanical engineer, were the two coordinators for the energy and environmental showcase portions of the Newport Coast project. Information about this project was gathered through a phone interview with Weintraub and by reading the paper "Mainstreaming the Sustainably Designed School." Weintraub co-authored the paper with Pierce and presented it at a "Mainstreaming Green" conference held by the American Institute of Architects Committee on the Environment in Chattanooga, Tennessee in 1999.

Although the original intent of SCE was to support planning for an integrated, sustainably designed school campus, the project was modified to focus on sustainable design of energy systems. To meet that goal, D&ES facilitated an integrated design approach for all building systems in the school to optimize energy usage and to improve the environmental performance of the school's buildings. Given the temperate climate of the school's locale, the specific goal was to reduce the need for electrical lighting while minimizing solar heat gain, using natural ventilation to achieve comfortable temperatures. Going into the project, D&ES agreed to provide a number of services to assist in both energy systems design and materials use planning. Some of those services included energy modeling and natural ventilation systems studies using computer simulation programs, a "green materials" referencing source with specifications for materials that have low- or non-toxicity content, physical modeling for daylighting, energy-efficient lighting design and controls, and post-occupancy monitoring and results reporting.

A team planning approach was used for meetings with architects, members of the D&ES group, and school district and community representatives. Certain compromises to sustainable design were made up front. For example, the architects stipulated that the building should have a physical presence on the site to the west, leaving siting less flexible in terms of planning for energy efficiencies. The developer stipulated that to maintain consistency with the visual theme of the overall development, the homeowners in the surrounding development should look down onto a red tile roof. This requirement eliminated some options that may have been considered to enhance the overall energy efficiency of the design.

D&ES worked with a Design Committee that included teachers, administrators and parents. Members of that committee spoke to the need for flexible learning and teaching environments, systems to accommodate new computer technology, classrooms with individual control over space conditioning, good storage and "commodious" teacher work spaces. D&ES, through the Rand Corporation, ran focus groups to understand the goals of teachers and administrators and to gauge the interest in energy and environmental priorities for the new building. In general, teachers and administrators wanted multiple means to control temperature, ventilation, lighting and daylighting systems for individual classrooms. They also looked for flexibility in furniture arrangement and technology use.

Interestingly, D&ES found that educators viewed the building as a means to demonstrate lessons on energy efficiency, but not necessarily as a resource to contribute to student learning through specific sustainable design features. "Principals did not view renewable energy as a cost savings because their schools are not considered cost centers, since utilities are billed to the district office. Principals saw the benefit as one of virtue: modeling conservation for students" (Weintraub, 1999, p. 4). Because the sample from Newport Coast was small, Rand checked the responses against a national telephone survey that was conducted in 1998 by Heery International, a research company. The results and opinions documented for the Newport Coast focus groups were similar to those recorded in the national survey (Weintraub, 1999, p. 4).

Observations

The design goal for Newport Coast Elementary School was a combination of traditional and sustainable design proposals. That factor led to a number of design compromises. The intensive participation by SCE's D&ES Group led to specific energy-efficient and sustainable design features that are integral to the overall design plan. Community participation was encouraged and facilitated to support those goals. The added benefit of D&ES's access to highly technical methods to design, test and manage energy systems was clearly a benefit. Information from the community and national surveys also was beneficial because it identified specific levels of knowledge and awareness that school administrators and teachers hold pertaining to sustainable design features and concepts.

In the concluding pages of their presentation to the Chattanooga conference, Weintraub and Pierce (1999) offer some thoughtful comments about the challenges participants face in working with schools on goals for sustainable design. Their comments follow:

> *" The issues of energy use and the environment are primary issues for school design, and the Newport Coast Elementary School represents a test case of the benefits of integrating current energy modeling and analysis techniques into the school design process. It should not be forgotten, however, that other very fundamental design issues are of equal significance during this current opportunity to rethink our schools. Apart from issues of sustainable design, any discussion of new schools must include imagining the best environments for learning and for integrating developing minds into our society. ....Optimization of a campus' operations is of little value if the fundamental underlying questions on how to improve education through new school design have not been asked and discussed.*
>
> *"Often a design project seems in retrospect to only vaguely have approximated all of the lofty intentions of the participants in the process, participants that include everyone from the architects and consultants, to the District officials, to the students and the teachers. It is always a challenge to maintain higher goals*

through what is often a bruising process. With the design assistance that D&ES brought to this process, an added effort was required by the design team to integrate an entirely new set of intentions into a complex process. The design team was consistently responsive to these added pressures, and graciously balanced competing interests when they arose. Ultimately, it is clear that without a client's early dedication to energy efficiency and environmental issues, little value can be derived from the sophisticated analysis tools used in this project. Setting a clear and widely supported sustainability agenda early in the process will go further to meeting the goal of reducing a building's impact on the earth than all of the sophisticated engineering tools used here (p. 26)."

Summary Observations

Each of the three schools described in this section included varying degrees of sustainable design elements in their design and building projects. Despite the variation however, the coordinators for all the projects each worked from similar philosophical foundations in their application of sustainable principles to design and project management. It is critical to embrace those principles to realize the benefits that result from successful application of sustainable design features.

The three cases present examples of how differences in support from decision-making levels of leadership can affect the outcome of a project. Each project clearly shows that leadership at the top is critical if a school is to be designed to minimize its impact on the earth, to be a healthy and enjoyable environment for occupants, and to be a cost-effective building to operate. In the Sakai and Roy Lee Walker projects, the school boards were behind the decisions to use sustainable design. Coordinators who understood and supported those goals were assigned to manage the projects. The Newport Coast project also had champions to follow through on goals for sustainability. However, because of client concerns, the scope of those goals were narrowed to specifically address energy-efficiency.

While both the Sakai and Roy Lee Walker projects were comprehensive in their embrace of sustainable design applications, the Roy Lee Walker project led to a more comprehensive application of certain features because of the direction set from the beginning of the project. Leadership at Sakai clearly stated three environmental goals that were to be met by design decisions. Those goals were pursued comprehensively and with sensitivity. In contrast, in Texas, the goal was set to build a "sustainable elementary school." That decision resulted in a planning process that questioned every conventional design application from energy use to landscape design. The architect was brought into the process with the understanding that the total design should be based on sustainable principles. The Roy Lee Walker project perhaps represents the one where the intent to totally embrace principles of sustainable design is best represented.

It is important to note that in all three projects experts in the field of sustainable design and in the use of sustainable materials were brought in as consultants, or in the case of Newport Coast, as project coordinators. Understanding of applications of sustainability is an evolutionary process. Participants in the process will learn from both their own and others' applications. It can be useful, and also very effective, to use experts in the field to help with the education and guidance that leads others to understand that the application of sustainable principles can result in both successful and cost-effective design.

Collaboration across teams of project participants, including community participation, was also clearly an important component of all three projects. Commentary and analysis by the community led to more open discussions of the plans and, in some cases, extensions in the time it took for plan review and approval. All the project participants interviewed for this paper were supportive of the public process while also acknowledging the reality of the frustrations that may accompany it. The use of the building as a teaching tool for students to learn about environmental stewardship was also an important element of each project and it represents another means of realizing community involvement.

As with any project of the scale these represent, realities of budget constraints arose in all three cases. The project coordinators were faced with making compromises while still working to keep intact the goals for sustainable design. Decisions were made based on least-impact to sustainable principles while also considering the reality of the particular dynamics at play for each of the school districts.

Finally, each school represents its own unique design that is appropriate to the site. While that may seem like an obvious point, it is important in that it points out that sustainable design is not a particular design style. It represents, instead, a philosophical approach to building that is sensitive to the needs of the site and of the client. The architect and project participants may be creative in any number of ways to create a design that meets the requirements of the principles of sustainable design.

For additional information about sustainable design in schools, the bibliography includes additional useful resources including many online documents.

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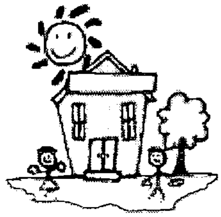

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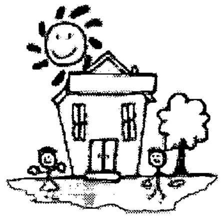

Topical Reports
Sustainable Design For Schools

Internet Resources

Site Preservation

- **Salmon Friendly Seattle Design Charrette: Urban Schools**
  http://www.ci.seattle.wa.us/util/charrette/schools.htm
- **City of Seattle - Natural Landscaping**
  http://www.ci.seattle.wa.us/util/RESCONS/plantNaturally/default.htm
- **Portland Native Plant Selection Guide**
  http://www.enviro.ci.portland.or.us/npsg.htm

Building Enclosure

- **Energy Star Buildings**
  http://www.epa.gov/buildings
- **Energy Efficiency and Renewable Energy Network**
  http://www.eren.doe.gov/EE/buildings.html
- **Energy Smart Schools**
  http://www.eren.doe.gov/energysmartschools
- **CADDET**
  http://www.caddet-ee.org/
- **Energy Ideas Clearinghouse**
  http://www.energyideas.org

Resource Conservation

Water

- **WaterWiser** - The Water Efficiency Clearinghouse
  http://www.waterwiser.org
- **City of Seattle Technical Assistance**
  http://www.ci.seattle.wa.us/util/RESCONS/default.htm
- **Center of Excellence for Sustainable Development**
  http://www.sustainable.doe.gov/efficiency/weinfo.htm
- **Rocky Mountain Institute**
  http://www.rmi.org/sitepages/pid15.asp
- **Colorado Office of Water Conservation**
  http://www.cwcb.state.co.us/owc/freefa.htm

- **Water Alliances for Voluntary Efficiency (WAVE) - US EPA**
http://www.epa.gov/owm/faqw.htm

Energy

- **Building America Program** - U.S. Department of Energy
http://www.eren.doe.gov/buildings/building_america/
- **Rebuild America Program** - U.S. Department of Energy
http://www.eren.doe.gov/buildings/rebuild
- **Exemplary Buildings Program**
http://www.nrel.gov/buildings/highperformance/
- **EPA Energy Star Programs**
http://www.energystar.gov/
- **Energy Star Buildings and Green Lights Program**
http://www.epa.gov/greenlights.html/
- **American Council for an Energy Efficient Economy (ACEEE)** ACEEE recently published the "Guide to Energy-Efficient Commercial Equipment" which provides practical, up to date information on how to reduce energy consumption, improve building systems performance and increase worker comfort and productivity. The Guide covers lighting, heating, ventilating and air-conditioning (HVAC), and motors, as well as other energy using equipment. The $40 guide is available by phone at 202-429-0063 or Email: ace3pubs@ix.netcom.com.
http://www.aceee.org
- **Energy Program** - Washington State University
http://www.energy.wsu.edu/wwwep/program-areas.htm
- **Northwest Energy Efficiency Alliance**
http://www.nwalliance.org/
- **The Energy and Environmental Building Association (EEBA)**
http://www.eeba.org/
- **Lighting Design Lab**
http://www.northwestlighting.com
- **Guidelines: Tips for Daylighting**
http://windows.lbl.gov/pub/designguide/designguide.html
- **Environmental Energy Technologies Division**
http://eetd.lbl.gov/

Clearinghouses and Databases

- **Residential Energy Efficiency Database - Energy Efficient Housing Construction**
http://www.its-canada.com/reed/eehc/index.htm
- **Energy Ideas Clearinghouse**
http://www.energyideas.org
- **Energy Information Clearinghouse**
http://www.lgc.org/energy

- **Energy Efficiency and Renewable Energy Clearinghouse - U.S. Department of Energy**
  http://www.eren.doe.gov/cities_counties
- **Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET)** - Case Studies in Energy Efficiency
  http://194.178.172.86/register.htm

Renewable Energy Information Links

- **State Guides on Renewable Energy and Energy Efficiency**
  http://solstice.crest.org/efficiency/state-guides/
- **Sustainable Buildings Industry Council (SBIC)**
  http://www.sbicouncil.org/
- **The Renewables Program at Washington State University**
  http://www.energy.wsu.edu/renewables/
- **The American Solar Energy Society (ASES)**
  http://www.ases.org/
- **Alternative Energy Engineering Catalog and Design Guide**
  http://www.solarelectric.com/welcome.htm
- **Solar and Wind Products Available through the EcoMall**
  http://www.ecomall.com/biz/solarcat.htm
- **Net Metering**
  http://www.homepower.com/netmeter.htm

Buying Green Power

- **Portland General Electric (PGE)**
  http://www.pge-online.com/ (click on "Renewable Power")
- **Benton County PUD**
  http://www.bentonpud.org (click on "Green Power")
- **Tacoma Power**
  http://www.ci.tacoma.wa.us/Power/greenpower/default.htm
- **Pacificorp Blue Sky Program**
  http://www.pacificorp.com/bluesky/bluesky.html

Alternative Fuels

- **Alternative Fuels for Fleets**
  http://www.pprc.org/pprc/pubs/topics/altfuels.html
- **Clean Cities Program**
  http://www.ccities.doe.gov/
- **Oregon Office of Energy**
  http://www.energy.state.or.us/bus/tax/betcbrtx.htm
- **Alternative Fuels Data Center**
  http://www.afdc.nrel.gov/

Transportation

- **Location Efficient Mortgages**
  http://www.locationefficiency.com
- **Transportation Connections**
  http://www.transconnect.org
- **Washington Commute Trip Reduction**
  http://www.wsdot.wa.gov/pubtran/CTR/
- **Tri-Met Programs for Employers** (Portland area)
  http://www.trimet.org/business.htm
- **Cities for Climate Protection** - Commuter Calculator
  http://cities21.com/games/comcalc.htm
- **Environmental Defense Fund** - Commuter Calculator
  http://www.environmentaldefense.org/cgi-bin/tailpipetally.pl
- **Benefits to Employers of Bicycle Commuting** (Portland)
  http://bicyclesource.com/you/commuting/employer-benefits.shtml
- **The Bicycle Transportation Alliance (BTA)**
  http://www.bta4bikes.org

Interior Quality

Air Quality

- **EPA's IAQ Page, Tools for Schools**
  http://www.epa.gov/iaq/schools/index.html
- **Healthy Buildings and IAQ**
  http://www.eren.doe.gov/femp/greenfed/lit_rev/lr3.htm

Daylighting

- **Guidelines: Tips for Daylighting**
  http://windows.lbl.gov/pub/designguide/designguide.html
- **Northwest Lighting Design Lab**
  http://www.northwestlighting.com

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