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Enhancing Building Performance and Environmental Learning: A Case Study of Virginia Beach City Public Schools

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Marketing the Green School:

Form, Function, and the Future

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Chapter 5

Enhancing Building Performance and Environmental Learning: A Case Study of Virginia Beach City Public Schools

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ABSTRACT

School buildings directly affect their natural and socio-cultural environments. They do this through their construction, maintenance, operation, and demolition. Most of the school buildings we have in stock today drain natural resources and inadvertently perpetuate a culture of environmental, social, and long-term economic ignorance and misuse. When approached thoughtfully, however, the design of school buildings can help inform and enrich society. Well-designed buildings can impart environmental knowledge and values. They can foster more effective behaviors among the people who learn in and from them. Effectively designed buildings can also conserve natural resources and—at their best—even help replenish the natural environment. For many school leaders today, participation in green certification programs represents one important step toward improved building and learning performance. This chapter provides a case study of successful learning approaches developed by Virginia Beach City Public Schools (VBCPS).

INTRODUCTION

Aimed toward educators and school administrators, this chapter provides a broad overview of design issues related to sustainability. It proffers concrete examples drawn from Virginia Beach

City Public Schools (VBCPS) to enhance performance at the level of the building, classroom, district, and region. VBCPS's environmental approach integrates educational planning with facilities planning. Its facilities department has been driving change in school design, classroom

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pedagogy, purchasing, transportation, and even regional design standards.

The examples in this chapter provide a snapshot of one moment in an ongoing process. They illustrate how one innovative school system is generating and applying new knowledge for the benefit of its buildings' users, the local public, the wider education community, and the world. Overall, VBCPS strives to provide the best possible environments for learning teaching and living. Its efforts include:

- Integrating environmental issues throughout the curriculum
- Preparing students to bring new knowledge into the community and share it with their families and employers
- Introducing new construction techniques to the region
- Encouraging architects and builders to reach for higher standards
- Monitoring the division's environmental performance and continually seeking to improve
- Disseminating their research and techniques for broad adaption
- Monitoring its own (and its community's) energy and waste flows
- Striving to achieve net-zero carbon emission

In this chapter, we provide rationale and theoretical underpinnings for green school design, and we share successful practices developed by VBCPS. Knowledge in the realm of environmental design and education is continually evolving. As such, any list of "best practices" is in constant flux. In writing this chapter, we seek to provide a description of some of the best practices we have discovered and/or created up to this point in time.

Most environmentalists have adopted the World Commission on Environment and De-

velopment's (1987) definition of sustainable development as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). The "green building" movement fosters new strategies to help overcome outdated construction practices that require vast material resources and cause tremendous waste and pollution. Today, North America's over-reliance on cheap energy has reached crisis proportions (Steffen, 2008; Wackernagel & Rees, 1996). All told, buildings consume 65% of the electric power used in the United States (Landsmark, 2008). They use 36% of all energy used and 30% of all raw materials. Buildings are responsible for half of greenhouse emissions from the US (Gifford, n.d.; Udall & Schendler, 2005). Educational facilities have been among the worst, although higher education buildings seem to waste more energy than K-12 because control systems are looser (Leslie & Fretwell, 1996).

Recently, VBCPS analyzed all sources of emissions within its control, using data from 2006-2010. It found that even though its overall energy consumption had steadily declined across the five-year period, its building-related activity still accounted for 65% of VBCPS's overall emissions. Its second largest source of emissions related to transporting people and goods. Its calculations considered electricity use, combustion from paper/stationary waste, and losses related to the transmission and distribution of electrical power. School leaders are working to address the division's primary sources of emissions, through integrated strategies that involve enhanced building performance, revised vehicle fleet policies, and more informed commuting habits of students and employees. Leaders are also creating strategies to control the 1% of its green house gas emissions that resulted from solid waste, refrigerants, chemicals, and wastewater.

Developing new strategies is vital because, as our nation's population continues to grow, so

does our need for new buildings. Within 50 years, the USA will need twice as many buildings as currently exist (Cortese, 2005). Unfortunately, about a third of our existing building stock suffers from “sick building syndrome” and this exposes occupants to stale, moldy, or toxin-laden air (Roodman & Lenssen, 1995). As we build—and re-build—it is crucial that we work to preserve and nurture our own habitat. To achieve environmental sustainability, we must strive to create beautiful, healthy, and functional buildings that support learning, replenish the environment, and inspire and teach stakeholders to act responsibly and create a brighter future. We must shift the way we look at the world, and acknowledge that recycling and conservation alone cannot address today’s breakneck pace of environmental depletion. We must work together to remake “the way we make things” (McDonough & Braungart, 2002, title page) as VBCPS strives to do. VBCPS takes a constructivist approach, encouraging each and every stakeholder to contribute unique ideas—big and small—and modify his or her own actions to better the natural, built, and social environments around them (Steffan, 2008).

To upgrade available tools, techniques, and standards, facility planners at VBCPS, are generating new knowledge every day. The three-pronged approach to sustainability adopted by VBCPS serves as a basis for day-to-day activities division-wide, which are to:

1. Develop a building infrastructure that is environmentally sustainable
2. Integrate sustainable practices throughout the school division
3. Educate the public about sustainability

Shifting the attitudes and behaviors of the division’s 68,000 students and 15,000 employees can have a tremendous effect on the region and its efforts to achieve sustainability.

BACKGROUND

The United States Environmental Protection Agency [EPA] (2009) defines *sustainable design* as “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction” (p. 1). Unfortunately, much of the construction industry is geared toward simply meeting minimum standards as set forth in building and zoning codes, and doing this at the lowest possible cost (Gowri, 2004). Programs like the LEED Green Building Rating system offer a guide for exceeding these minimums. *Green building* seeks “to improve overall building performance, and minimize life-cycle environmental impact and cost” (Gowri, 2004, p. 56). Today, most environmental advocates seek to create buildings that also replenish the natural environment (McDonough & Braungart, 2002). The passages below are intended to provide a basic understanding of “green building” terms, techniques, and ideals.

Certification Programs

Participating in green building rating programs is one way for school leaders to promote sustainability. These programs are not perfect, but they help us all move together in a healthier direction. Programs like LEED take an incremental approach to improvement—providing a basic road map and continually upgrading requirements as new methods are created and absorbed into standard practice. Participation has benefits that include: saving energy, conserving the natural environment, improving health and productivity for building occupants, promoting moral and ethical behavior, raising social awareness, and increasing awareness through recognition awards. Some of the rating systems that are popular among school leaders include: the Leadership in

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Energy and Environmental Design (LEED) Green Building Rating system operated by the United States Green Building Council (USGBC), Green Globes, Collaborative for High Performance Schools (CHPS), BREEAM, the Living Building Challenge, Energy Star, and product certification programs such as Green Seal, the Environmental Protection Agency's Design For the Environment (DFE), GREENGUARD, Cradle to Cradle (C2C), and the Forestry Stewardship Council programs. Of these, we (the authors of this chapter) have the most experience with LEED, Energy Star, Green Seal, and GREENGUARD programs.

“By undergoing rigorous third party review” such as that offered by LEED, “Virginia Beach City Public Schools can be confident that they are making the best possible use of taxpayer dollars while providing the best possible learning environments for our youth” (VBCPS Sustainability Report, 2012, p. 4). Although some school systems opt to ‘design to LEED standards’ without actually obtaining certification, this has clear drawbacks, according to VBCPS facilities experts. In their experience, too many errors slip through the cracks when the level of monitoring drops. Without conscientious review throughout the entire submittal and construction process, the final product will almost never be as effective and healthy as a certified building. Based on a decade of experience, VBCPS facilities managers see clear value in going the extra mile to achieve certification.

As of December 2013, the USGBC (2013b) had conferred LEED certification on 1,121 school projects. Another 1,933 projects were registered with LEED and thus officially in the process of becoming certified. LEED provides one helpful and well-recognized set of approaches that we (the authors) have been using and tracking. We believe using LEED can help school leaders respond to calls for public accountability, help them gain public recognition, and help them lead change community-wide.

Many of the green building rating systems have similarities. For instance, LEED focuses on seven topic areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority. By using an effective green building program as a framework for action, school leaders can help address environmental concerns, demonstrate fiscal prudence, and show social responsibility. To date, VBCPS has constructed eight LEED-designed buildings (six of these have received LEED certification and two more are registered and in process). The VBCPS LEED inventory ranges from basic certification to Platinum; it accounts for over 1.6 million square feet of building space. Although LEED is the certification method of choice for VBCPS during new construction, sustainability issues with existing buildings are typically addressed through performance contracting, Energy Star, and green cleaning and maintenance practices.

VBCPS is using performance contracting as a tool for handling many existing building projects that would traditionally be funded through the Capital Improvement Program (CIP). Performance contracts are essentially agreements with a private Energy Service Company (ESCO). The ESCO works with school employees to identify and evaluate energy-saving opportunities and then recommends improvements that can be “paid with savings” that will subsequently accrue. The ESCO guarantees that savings will meet or exceed the required annual payments—being enough to cover all project costs—over a set number of years. If savings don't materialize, the ESCO pays the difference, not the owner. A word of caution is needed here, however: many people in the construction industry have marketed themselves as performance contractors over the past few years. To minimize the owner's risk when hiring an ESCO, be sure to hire a company that has a proven track record and years of experience. Facilities managers for VBCPS called to check references. They also spread work between two different firms to make

sure each ESCO would stay competitive on projects. The first round of performance contracting projects involved HVAC (Heating Ventilation and Air Conditioning) and lighting retrofits at 17 schools. The average reduction in kilowatt-hours per square foot (kwh/sf) within the 17 schools was 38.8% (the greatest reduction was 57% and the least was 27%).

Energy Star is another important tool used by VBCPS to reduce emissions and to ensure reductions in energy use. To prompt compliance with Energy Star, VBCPS now requires its design teams to design each new building to use 50% less energy than required by the current Virginia Uniform Statewide Building Code. As an alternative way of meeting this requirement, a building can earn the “Designed to Earn the Energy Star” designation during the design process. This practice is helping the division meet its goals; by February 2014, VBCPS had successfully secured Energy Star certification for 28 schools.

In addition to the sustainable construction practices noted above for new and existing buildings, sustainable cleaning practices and maintenance procedures are a key component to upholding indoor environmental quality. While third-party certification programs like Green Seal, EPA’s Design For the Environment (DFE), and GREENGUARD often don’t carry the appeal of other programs (i.e., those that lower energy cost and yield big returns on investment), VBCPS planners believe these certifications are no less important. Certifications like Green Seal and DFE ensure that each cleaning product provides a better environment—for the custodians who handle the product, as well as the staff and students who inhabit the building. A related problem involves volatile organic compounds (VOCs). Emissions from building materials, furnishings, and casework are a major source of indoor air pollution in most buildings today. GREENGUARD Certification has been widely adopted as a standard for identifying low-emitting products and the program is helping VBCPS eliminate harmful substances.

Participating in certification programs like these can have exponential benefits. As new techniques are developed, tested, and improved, they become increasingly affordable. Once they reach economic viability for a broad spectrum of users, they can be adopted into widespread practice across the community.

Cost Considerations

Adopting green practices can help school leaders enhance their “triple bottom line – financially, environmentally, and socially” (Patelski & Poling, 2008, p. 125). Specifically, they can use these techniques to promote health, save money, preserve the environment, and model good behavior, and demonstrate social responsibility (Bartlett & Chase, 2004; Steffen, 2008).

When the design and construction process is approached holistically, the initial price of construction of green schools can be comparable to conventional buildings. All of the VBCPS LEED buildings cost less to build than the average, non-LEED building of similar type and size in the region. (Our data are based on comparative analysis with School Planning and Management’s Annual School Construction Report.) From the outset, facility managers made sustainability their own goal; they worked within the standard budget they had been allocated and did not seek additional funding or variance from accepted standards. They simply looked for ways to improve performance, and did so within budget. Ultimately, they met the standard objectives, *plus* their own environmental goals, within budget. Once they had achieved and could document a sufficient level of success, they announced their intentions more publicly.

There can be impressive cost-savings following construction as well. Vittori and Guenther (2013), reported that LEED-rated hospital buildings had “reduced length of stay, [improved] patient and staff well-being, increased staff retention and reduced absenteeism,” (§ 6) and they also reduced the consumption of energy and water. These all

yield positive return on investment. Green buildings have the added benefit of lower operating costs. Using day lighting, solar gain, controlled shading, and natural ventilation costs less vis-à-vis equipment installation and operation.

It is difficult to quantify the environmental cost of producing and transporting products, and constructing and operating buildings (Bradley & Crowther, 2004; Patelski & Poling, 2008). Most people focus on up-front purchase prices. They fail to calculate the true cost and overall environmental toll of harvesting, mining, processing, packaging, operating, and maintaining industrial products (McDonough & Braungart, 2002). Sticker price is a poor indicator, as it fails to account for environmental clean up, depletion of resources, and destruction of species and habitats (Wackernagel & Rees, 1996).

Scholars are working to identify and measure long-term costs using principles of Lifecycle Cost Analysis and/or Life Cycle Assessment (LCA). These techniques quantify and compare environmental effects that result from manufacturing, operating, and maintaining a building or product (Scheuer & Keoleian, 2002). VBCPS conducts this type of research. It is creating programs to achieve net-zero carbon emissions, to collect and effectively handle old cell phones, and to teach students about gardening and various environmental principles. School leaders are fostering a mindset of sustainability among teachers, students, and the local public.

Raising the Bar

Integrated approaches are crucial. Wilde (2007) asserts that school buildings “being constructed today are a 200-year asset, and the only way to reduce their environmental footprint is to make them *replenish*, rather than deplete, natural resources” (p. 50). Even net-zero is not a good enough goal for new construction, he insists. “A broad industry goal is to create buildings that produce more energy than they consume, and consume

more waste than they produce” (p. 50). Making the transition from a culture of disposability to a mindset of regeneration requires a great deal of ingenuity and research (Iverson & Chance, 2007; McDonough & Braungart, 2002).

In general, the USGBC’s approach to fostering incremental, market-driven change has been highly successful. Because the organization has learned to collect data, analyze performance, and invite and respond to criticism, it demonstrates learning at the organizational level (Chance, 2012). This type of learning is notoriously difficult to achieve. Nevertheless, the USGBC’s LEED system is frequently criticized for providing users with an overtly simplistic checklist. The checklist format allows many users to adopt a fragmented, linear approach to problem solving. As a result, many LEED users can meet their primary objective—public recognition—by simply achieving certification. However, without a sincere effort to properly install and commission systems, operate buildings effectively, track performance and recalibrate systems periodically, many owners never achieve optimal performance. The checklist mentality limits positive effects and, because it inhibits synthesis, can add to the cost of construction. The USGBC’s new category for Integrated Process (adopted in 2012) represents an effort to discourage add-on approaches and encourage holistic ones.

HOLISTIC APPROACHES TO SCHOOL DESIGN

Fortunately, many individual LEED users embrace the deeper goals of LEED—as exemplified by VBCPS. This section discusses specific ways to upgrade performance: enhance operations of existing buildings, track and respond to performance, learn from experience, create buildings and landscapes that teach, model sustainability, impart values, and help shift behaviors.

Enhance Operations of Existing Buildings

VBCPS is implementing a range of new approaches to operations. For instance, when proposed renovations and modifications to existing buildings have any impact on energy consumption, planners currently use the *K-12 Advanced Energy Retrofit Guide (AERG)*. Future projects will record energy consumption 6-12 months after completion of the work, and compare measures of current performance with prior. With the goal of reducing the district's overall energy consumption by 20% in the next ten years, facility managers have developed a comprehensive plan. It involves identifying, designing, and implementing energy performance upgrades. New techniques include retro-commissioning, new energy recovery and energy management systems, and repairing/upgrading lighting and mechanical equipment. Planners also are developing a web-based Building Maintenance Plan for each facility and working to train their own maintenance personnel to conduct retro-commissioning. The division is also setting new Energy Star goals and introducing a division-wide sustainable procurement guide to help individuals make informed purchasing decisions.

Track and Respond to Performance

Providing the public with proof of performance is key to sustaining change. Leaders in VBCPS have been able to justify their approach by providing solid evidence of success. They track the performance of buildings over time—including water and energy use and occupant productivity—and compare the performance of new buildings with that of older buildings using district-wide averages. They also compare performance by building type.

The levels of improvement they have found are impressive. During the 2009-10 fiscal year, district-wide sustainability actions yielded more than \$2.4 million in savings related to building performance and operations. Performance con-

tracting has born savings in all 17 schools where it has been implemented. Some schools realized savings of 57%. And, although VBCPS has *increased* its overall square footage of built space by over 5% since 2005, its overall electricity use has actually *decreased* by 25%.

VBCPS also tracks waste. Since September 2008, it has diverted over 7,000 tons from the waste stream. In addition, VBCPS now conserves fuel by coordinating and combining schedules for pick-ups and deliveries across the division. Its new 'no-idle' policy for buses has not only improves air quality, it has also yielded approximately \$50,000 in fuel savings each year since its implementation.

The division is starting to track health data as well. Leaders intend to study relationships between attendance patterns and building attributes. Based on observation plus anecdotal evidence, leaders believe that the number of respiratory-related incidents has decreased division-wide as a result of both using Green Seal certified cleaning products and implementing an integrated plan for pest management. Tracking data, using it to achieve/confirm/enhance success, and celebrating achievement are important to creating a culture of sustainability.

VBCPS is also developing a plan to reduce emissions division-wide. Part of this plan involves encouraging all the design teams it works with to either (a) design each new building to consume 50% less energy than the state code currently requires or (b) design to earn the Energy Star designation during design. In its experience with Energy Star, VBCPS has found that Energy Star schools cost less to operate. The average energy cost per square foot is \$1.53 for its standard buildings but just \$1.33 for those certified through Energy Star. (The true savings is higher than this number indicates, however, because a number of VBCPS school buildings are now ready to be classified as Energy Star, but because they have not formally completed the rating process they have been included in standard building category for the time being.)

Learn from Experience

Historically, the environmental education movement has utilized experiential learning as a core principle. Learning from experience is as important to groups and organizations as it is to individuals, yet it has been notoriously hard to achieve. “Organizational learning” occurs when organizations learn from their own experience. With regard to environmental sustainability, both VBCPS and the USGBC have shown themselves to be models of organizational learning (Chance, 2010, 2012). The USGBC has been learning from past experience and continually revising its policies in response to the increased capacity of (a) the market and (b) applicants to use and understand the system. The system’s users seem to be learning too. Applicant success is on the rise with regard to priorities identified by the USGBC. Today, applicants are using the LEED system more effectively (President and Fellows of Harvard College, 2010). Academic leaders can benefit from contributing to the development of new LEED programs and by supporting new programs that supplement and extend LEED.

VBCPS uses the experience of each project to enhance and inform the next. Over time, VBCPS facilities managers have learned they must educate occupants about specific building systems and help constituents understand, respect, and operate their buildings more effectively. Leaders are continually developing more and more ways to achieve this.

VBCPS’s Renaissance Academy was the first building in the division to earn LEED Gold certification. Following an incremental approach, VBCPS facilities managers implemented a number of new techniques in this facility, and then tracked performance. Techniques that worked well over time, such as the patch of green roofing, were implemented more widely in subsequent projects. Remarkably, construction cost for the Renaissance Academy was approximately \$3.50 less, per square foot, than the average for similar schools in the region.

VBCPS’s new Kellam High School building represents a synthesis of past experience, new research, constituents’ ideas, and applications of emerging techniques. The school was envisioned as a prototype for 21st century learning. The design team—which included VBCPS employees, students, architects, planning and educational facilities experts, engineers, and contractors—developed four major objectives at the outset. As quoted from HBA Architecture and Interior Design, Inc. (n.d., p. 1), key objectives were to:

1. Involve a full spectrum of stakeholders in a collaborative planning and design process to achieve user and community “buy-in”.
2. Design a high school facility that will facilitate and support the implementation of a new curriculum and assessment model founded on the principles of challenge-based learning.
3. Create challenge-based learning opportunities for students that are integral to the planning and design process for the new high school and that are collaborative efforts with the design team.
4. Incorporate planning processes and design elements into the school facility that will encourage students to be “sustainable citizens”.

During design, the architects led a series of workshops, discussions, and hands-on learning and planning activities that allowed stakeholders to collaborate in and to contribute to the design of the school facility and its curriculum. Stakeholders learned about and discussed site design, building design, educational specifications, furniture, and equipment. The final building, opened in January 2014, serves approximately 2000 students on a 108-acre site. The 350,000 square foot building cost \$77 million to construct, which equates to \$220 per square foot.

Create Buildings that Teach

Green construction provides a way for school leaders to communicate environmental values to students. The K-12 sector has been an active part of developing and using the *LEED 2009 for Schools* program. Today, many schools include features explicitly designed to impart knowledge and instill desired behaviors and values in students. Built features can, for instance: (a) convey information and ideas, (b) explain systems, (c) encourage reflection or engagement, and/or (d) make operations and maintenance activities visible to students.

VBCPS has developed many different approaches to teaching through built form. In the Renaissance Academy, pedagogical features are included in seemingly unlikely places such as the roof, mechanical room, and bathrooms. The vegetative roof (i.e., green roof) provides opportunities to study plants. Learning space on the roof also allows occupants to see how the light monitors, water collection, and mechanical systems work. One of the building's most straightforward didactic teaching features involves rainwater. At the Renaissance Academy, rainwater from the roof is collected, filtered, dyed blue, and cycled through the building for reuse in toilets and urinals. Water collected on the school's parking lots is filtered through engineered rain gardens. These systems are highly visible to building occupants; rainwater runs through clear tubes in each cafeteria to remind students of the role of water throughout the building.

In an effort to support hands-on integrated learning, Kellam High School's design team aimed to optimize transparency, utilize daylight effectively, and provide plenty of short- and long-term flexibility. Spaces in the school can be adjusted over time to support changing techniques. In keeping with the principles of Problem- and Project-Based Learning, the building has six distinct "learning communities" that include spaces for instruction and hands-on learning. Each learning community

has a vibrant learning commons at the core. The learning commons provide break out-spaces that support chance encounters, small-group meetings, and various forms of informal and collaborative learning. These are essentially extra-wide corridors equipped with standing height desks, nodes with couches and computer tables, and plenty of comfortable oversized beanbag chairs. They connect all of the learning community's instructional spaces and experiential labs. Collectively, the spaces within each community encourage and support learning by small and large groups. They are designed to facilitate collaboration, presentation, demonstration, and discussion. Cutting edge instructional technologies provide multiple avenues for presenting work and sharing ideas.

Kellam's instructional spaces are interconnected. Each pair of adjoining L-shaped classrooms shares one central glass-enclosed breakout space that also connects to the learning commons. Similarly, each pair of science labs shares one greenhouse space that is located on the exterior wall of the building. The greenhouse supports (wet and/or messy) experimentation. In the design process, care was given to provide places for learners to focus, research, plan, show, think critically, evaluate and reflect, and make (specific consideration was given to facilitating "draft, try, and fine-tune" aspects of making). Each Learning Community was designed with removable (i.e., non-load-bearing) walls. This feature will allow people to completely reconfiguration of space over time, if necessary, and to do so in an economical way.

Within each instructional space, movable walls and furnishings allow occupants to reconfigure their learning areas quickly and easily. Individual classrooms can be joined together for events involving two different class-sized groups. Every pair of classroom spaces also includes a collaborative workroom (that serves as a sort of hinge between the two rooms) for break-out activities. The design team worked with Kellam teachers to determine appropriate amounts of transparency

between the classroom, break-out, and Learning Commons spaces. Glass provides visual connection between spaces, promoting interaction and collaboration among stakeholders. It is designed in such a way as to control sound and promote security.

Likewise, the Commons at Kellam (where dining and very large-group events occur) is joined to a two-level learning space known as the “schola.” These two multi-level rooms can be used separately or joined together to support various types of learning events. Various zones of the school (gymnasiums and physical education, music and performing arts, commons, gardens, and the six learning communities) can be individually secured and opened to the public.

Create Landscapes that Teach

Several of the division’s new school buildings include landscapes designed for interaction, learning, water filtration, and the like. In two cases (College Park Elementary and Kellam High School, students were heavily engaged in programming and designing educational courtyards/landscapes for their new school buildings. The process helped the community build environmental values and become more intentional and purposeful in its behaviors.

Design activities for the new Kellam High School involved stakeholders in various ways. Planning activities engaged 120 students in five different Advanced Placement (AP) environmental science classes. The students were charged with designing an educational courtyard that serves as the heart of the new school. The challenge-based learning activities included schematic design, presentation and open dialogue about the attributes of each proposal, followed by evaluation and synthesis of design ideas into a final solution. The students’ ideas were incorporated into the final design and then constructed.

Kellam’s educational courtyard provides dynamic opportunities for building occupants to

learn, explore, and interact with various natural features (water, plants, soil, sunlight, and other natural elements). They also interact with design elements (bridges, amphitheater, compost and water collection systems), and various aspects of operations and maintenance. The courtyard itself provides three distinct gardens: one focused on cultivating edible plants, a second for public gathering, and a third for rainwater infiltration.

The Edible Garden includes an outdoor classroom, planter boxes, compost bins, and a greenhouse. The design incorporates sustainable materials. Culinary arts classrooms are located adjacent to this garden and their curricula will integrate garden planning, planting, maintenance, and harvesting.

Rainwater collected on the Kellam site is being used to irrigate the sports fields and to teach students about the water cycle in the courtyard’s ‘infiltration garden.’ The garden’s marsh environment, which includes decks and seating areas, allows students to see and experience the flow of water from adjacent roofs, to the marsh, and into the soil below. Along its path into the Infiltration Garden, the water passes through rainwater runnels in the Gathering Garden. These runnels amble through the garden’s outdoor amphitheater, gathering areas, and outdoor dining area. The overall site design, which includes infiltration gardens located between aisles of vehicular parking, helps control storm-water run-off. The overall site was designed to retain 100% of all storm water up to a ten-year storm and allow it to percolate into the local ground water table. Some of the rainwater is collected through a visible series of gutters and downspouts. Water flows into large storage cisterns before being used to irrigate the sports fields. Cisterns located beside the major entries serve as clear reminders of the importance of water to this community.

All these features will help the Kellam High School building achieve LEED standards for site design and water use, but they also reinforce desired values and teach students new ways to

understand, respect, and interact with the natural and built environment. The architects intended the educational courtyard to serve as a “living model of sustainable growth and irrigation, recycled materials, and bio-retention/water infiltration” (HBA Architecture and Interior Design, Inc., n.d.).

Model Sustainability

Educational organizations must provide a vision for achieving sustainability. They must model sustainable behaviors for their students (Rowe, 2004) as the Kellam High School building attempts to do. Teachers (be they instructional staff, school leaders, or school buildings) can foster transformative change by modeling constructive behaviors and presenting a healthy ethos. In order to shift society’s operating paradigm, citizens need to see options for sustainability expressed repeatedly—and in many different ways—so they can understand environmental complexities and internalize the need for change. Green schools must teach aspects of traditional disciplines in addition to teaching students environmental stewardship and helping provide an identity for the community (Building Operating Management, 2005).

The VBCPS facilities team gathered a community of supporters and developed holistic strategies for achieving sustainability. It was important for the people who build, operate, and maintain VBCPS facilities to lead by example while moving the division towards a sustainable model. A Sustainable School Committee (SSC) was formed in 2006 to evaluate how the various departments throughout the division move forward towards identifying sustainability goals. The SSC interacts with a sustainability liaison at each of the division’s 85 schools who helps collect and generate ideas that can be used division-wide. This liaison also introduces new approaches to his or her home school. In a qualitative research study, Higgs and McMillan (2006) investigated four secondary schools that are dedicated to sustainability. They discovered “modeling” was a powerful common

theme at these schools. The schools modeled sustainability in four main ways: (1) individuals modeled positive behaviors, (2) school facilities and their operations imparted knowledge and values, (3) school governance modeled social equity and successful conflict resolution, and also fostered ownership of issues, and (4) school culture created and reinforced positive values and behaviors. Higgs and McMillan asserted that the four schools they studied each provided all four forms of modeling and this provided consistency in the messages they sent to students.

Effective modeling, Higgs and McMillan (2006) say, eliminates the need to “preach or proselytize” (p. 50) about sustainability. It helps students transfer abstract concepts into tangible, personal applications. Student involvement in operations “makes waste, consumption, inequities, governance, and economics of the school more visible and tangible” (p. 45). Moreover, peer-to-peer learning among faculty, staff, and students can be highly effective in prompting change at the individual and organizational levels (Sharp, 2009).

VBCPS seeks to model sustainability through design and operations as well as curriculum expansion and enhancement. In addition, facilities planners at VBCPS have been creating resources for teachers to use in educating students about science, technology, engineering, and mathematics (STEM) subjects. VBCPS’s “STEM and the Built Environment” programs include specific hands-on activities teachers can implement. Leaders have developed tools to guide classes in applying mathematics concepts—such as calculating how features of school design facility achieved various LEED performance standards. Today, such calculations involve soil and storm water volumes, solar hot water quantities, and geothermal effectiveness. Students are using LEED standards to investigate the intent of various LEED credits and the strategies that were used to achieve them. Applications within their schools become vehicles for tracking and evaluating performance and learning to make various calculations. Planners hope to implement

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more building performance (i.e., dashboard) data in class activities in the future. They have encouraged vendor and software interface designers to upgrade their offerings to aid understanding and enhance usability.

The Renaissance Academy, which was designed by RRMM Architects, uses another holistic approach to design that exceeds LEED requirements. This facility includes a middle school and a high school that serve alternative education students who do not fit the traditional educational setting, as well as adult education classes that are conducted in the evening. During design, the school district consulted with behavioral psychologists as well as sustainability experts to develop a well-integrated approach. The building and the curriculum integrate sustainability and help meet the distinct educational needs of the students who attend. To provide hands-on environmental education, for instance, the culinary arts program includes a sustainable aquaponics program where students raise tilapia. The aquaponics system uses effluents from the fish to fertilize plants in the school's greenhouse. Students specializing in culinary arts learn to prepare meals with ingredients cultivated in the aquaponics program. Moreover, students studying building trades at the Renaissance Academy have the tools available to learn sustainable construction techniques. This program can potentially prepare students to go into green construction, filling a workforce need in the region. Such "reorientation of K-12 and higher education programs toward sustainability and green building is critical to preparing students for a broadening green marketplace," the USGBC (2009e, p. 2) argues.

Today, VBCPS planners are also developing brand new courses that focus on energy and sustainability. In addition, they intend to coordinate "community-based learning courses" that: (a) meet needs defined by the community, (b) integrate sustainability principles within adaptable assignments, and (c) utilize community partnerships. The facilities planning team is doing all this to

encourage collaborative, case-based, experiential learning assignments. They aim to gather ideas, techniques, and findings and to make them available in a public database (so teachers and students can share resources easily).

As a prototype, Kellam High School was specifically conceptualized as a model for future school designs. It makes visible: effective design and decision-making processes, sustainable site and building design features, effective collaborative learning spaces, and integrated curriculum strategies.

VBCPS planners are also working with pockets of interested teachers and with departments of curriculum and instruction at the local and state levels. They aim to integrate environmental topics into coursework in ways that help to meet the state's official Standards of Learning. Activities are anticipated to involve measuring, monitoring, and/or calculating a building's energy and water use and comparing it with benchmarks and prior predictions.

Leaders are also creating opportunities for students to integrate and reflect upon things they learn outside the classroom (through extracurricular and volunteer activities, internships, and the like) and to help stakeholders connect outside learning to classroom learning. They have started developing sustainability-related competency criteria. They are also setting up a Sustainability Science Fair that will allow students at all levels to propose long-term sustainability projects and gain recognition for their work. This can serve to supplement the annual Sustainability Expo that VBCPS hosts for the local community. That event provides a forum for residents to learn about sustainable materials, practices, and products.

Impart Values

Environmental education is about fostering a sense of ownership and empowerment (Palmer, 1998), just as planners and architects at VBCPS have been doing in their work with students. The col-

laborative design process has increased students' understanding of environmental design issues and has generated new knowledge. Such efforts promote environmental ethics and help build a culture of sustainability. This is exceedingly important because most American citizens lack basic understanding of energy, climate, material resources, and sustainability. Reynolds, Brondizio, and Robinson (2010) claim:

the American educational system has been turning out 'environmental illiterates,' ill-equipped to understand emerging information about the environmental, social and economic dimensions of human-environmental interactions and make informed choices on the suite of issues, from lifestyle to politics, that will decide whether and how society moves toward a more sustainable economy." (p. xiv)

We, as educators, must help instill more effective values and behaviors in our students. We must help rebuild a culture of material ethics (Fox, 2007). The school buildings our society creates will be with us for decades to come.

VBCPS is trying to implement proven strategies in the design of all new facilities. It is successfully introducing new strategies into a region where they have not yet been used. Its efforts help spur innovation and the generation of knowledge at the local level. VBCPS works hard to educate designers and builders as well as the larger public about important sustainability issues. Leaders aim to reach constituents within and beyond the school system (such as parents and other community stakeholders). Administrators view the 15,000 employees and 68,000 students in the system's 85 schools as an ideal platform for directing change locally and on a larger scale.

The school division seeks to improve the environment and to alter behaviors across the region. Today, 62 of the 85 schools in VBCPS have cell phone recycling programs, 72 have environmental clubs, and 64 have teaching gardens.

In other efforts to affect values, VBCPS is developing food-composting programs for outdoor gardens, to deal with waste in a healthy, productive way that also makes waste cycles visible to constituents. Planners are expanding classroom and office recycling programs, with a goal of reducing waste pick-ups. Moreover, leaders endeavor to serve locally grown food, and they help students track the distances food travels to reach their cafeteria trays. The school division's sustainable schools website provides tips for sustainable living and information about the school system's projects and programs. The school division hopes to expand the website to include interactive campus maps that highlight environmental performance.

Help Shift Behaviors

To shift behaviors related to energy consumption, VBCPS has created outreach strategies. Planners encourage the architects they hire to be thoughtful in the placement of light switches, for example. Blank switches placed at the entrance to a room lead users to thoughtlessly turn on all lights. Distributing the switches encourages people to use what they need, where they need it. Labeling the switches also helps people understand their intended use. It helps occupants become more intentional in their use of artificial lighting. VBCPS has found that a fairly simple decision regarding the placement of even one light switch can make a profound difference in the building's energy consumption over the long term. Therefore, planners there believe design work must involve careful analysis of day lighting. In both Kellam and the Renaissance Academy, common spaces are awash in daylight and each classroom has lighting controls (sloped ceilings, light shelves, and/or light diffusing transoms) that effectively distribute daylight. Artificial lights are operated in individual sets, making high levels of occupant control possible. Day lighting systems are intended

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to reduce energy consumption and increase occupant productivity.

At the Renaissance Academy, light monitors bounce light into cafeterias and interior classrooms and light shelves bounce indirect light deep into classroom spaces. These features help prevent the building from overheating by blocking direct sunrays from passing through the glass. In addition, light tubes provide free illumination for the guidance offices embedded deep within the school's interior.

At the Renaissance Academy, sun is also used to heat water. Solar heated water is channeled to the cafeterias. The school also features an interactive kiosk at the entry, so students and visitors can access data about solar energy, photovoltaic and geothermal systems, and other green features.

Aiming higher over time, VBCPS will require each of its architectural design teams to summarize its strategies for altering occupants' behaviors in addition to summarizing the its strategies for conserving energy (with a goal of achieving 50% better than the state's minimum requirements). The facilities team will soon require architects to plan for future performance upgrades as well. Architects working with VBCPS will be required to document all the steps that will be necessary when the facilities team decides to bring the building to "net-zero" energy consumption at some point in the future. The effectiveness of the projected strategy will need to be confirmed by either (a) earning official designation as "Designed to Earn the Energy Star" or (b) through analysis using an energy simulation model.

VBCPS seeks to create educational programs that will prompt behavior change. It is creating a system of "prompts and rewards" regarding sustainable behaviors. Leaders are doing this with the help of local foundations. Today, they offer "Pearl School Awards" in collaboration with the Lynnhaven River Now organization and "River Star Awards" with the Elizabeth River Foundation. Since 2008, 64 schools have garnered awards that recognize sustainable stewardship. In the future,

they intend to create incentives for students and employees to use alternative transportation options. Related efforts include increasing the availability of Safe Routes to Schools to encourage walking and biking. Such programs help galvanize a shared culture of environmentalism.

To encourage more sustainable consumption and disposal behaviors among faculty and staff, some VBCPS schools donate produce from their Teaching Gardens to local homeless shelters. Planners are also evaluating cafeteria activities to eliminate unnecessary waste and to promote reuse wherever possible. This includes food waste as well as trays, silverware, and the like. They intend to study and make customized plans for each school. They are also moving from paper to electronic communications in their libraries, offices, classrooms, and communications with parents and community partners.

The overall site design for Kellam High School helps shift behaviors in positive ways. The focus of the site design process was on minimizing negative impact on the environment and on providing passive security. The design retains the site's existing forested area. It provides a 100 foot-wide reforestation buffer (between the school and the adjacent neighborhood), which also serves as a migration corridor for native animals. Bridges over the existing wetlands in this buffer facilitate cross-country activities and help minimize disturbance of exiting natural features. A geothermal well field provides energy efficient heating and cooling to the school. Clear separation of areas for busses, staff parking, student parking, and visitor parking—as well as controlled entrances for cars and people—promote visibility and safety.

CONCLUSION

VBCPS provides a vibrant example of applied research and ongoing knowledge generation. It serves as a model of organizational learning and of creating holistic approaches to sustainability.

Many of the projects it has underway (as discussed in this chapter) provide excellent avenues for future research and the development and application of new techniques. In light of VBCPS's experience, our recommendations for contributing to the sustainable building movement involve

- Learning through experience
- Commissioning your buildings
- Tracking performance
- Adjusting systems in response to findings
- Contributing new ideas and sharing effective applications
- Helping upgrade formal programs like LEED for Schools, the Living Building Challenge, and LEED for Existing Buildings: Operations & Maintenance (LEED-EBOM)

In the coming years, LEED-EBOM is likely to gain popularity, because older buildings will soon require attention. Facility planners can use LEED-EB to enhance environmental performance in operations and maintenance and to plan renovations.

More and more educators are getting involved in tailoring environmental education and green building programs for their own use. In K-12, many leaders are piloting new rating systems and helping customize mainstream approaches. By contributing their insight, school leaders can help develop programs that are more useful to them. Just as VBCPS leaders are doing, school leaders elsewhere can gain from, generate, share new ideas, and extend their professional networks by participating in USGBC summits and programs operated by the USGBC's Center for Green Schools.

It should be incumbent on all facility planners to share the knowledge they are generating. In doing so they can infuse new approaches into the community and learn from each other's successes and failures. Ultimately, school leaders can spread knowledge by involving students, staff,

and community stakeholders—and by providing them with healthy, instructive places to learn and collaborate. After all: great teachers don't simply teach, they provide an environment where learning can take place.

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KEY TERMS AND DEFINITIONS

BREEAM: An environmental assessment method and rating system for buildings, used primarily in the U.K. and Europe. Breeam was first launched in 1990.

Center for Green Schools: The Center for Green Schools was established by the U.S. Green Building Council to drive the transformation of

all schools into sustainable and healthy places to live, learn, work, and play.

Collaborative for High Performance Schools: CHPS: CHPS is specifically designed rating system for K-12 schools. C HPS provides information and resources to schools in order to facilitate the construction and operation of high performance institutions.

Cradle to Cradle: The term Cradle to Cradle is a registered trademark of McDonough Braungart Design Chemistry (MBDC) consultants and refers to a biomimetic approach to the design of products and systems.

Deconstruction: The dismantling of a building in order to reduce construction waste, reuse material where applicable, and recycle material that cannot be repurposed.

Design for the Environment: (DFE) Program: The DFE Program is a United States Environmental Protection Agency (USEPA) program, created in 1992, that works to prevent pollution, and the risk pollution presents to humans and the environment. The EPA DfE program provides product information regarding best environmental practices.

Energy Service Company (ESCO): An Energy Service Company is a commercial or non-profit business providing a broad range of energy solutions, including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management.

Energy Star: An international standard for energy efficient consumer products and buildings. It was created in 1992 by the Environmental Protection Agency and the Department of Energy.

Environmental Protection Agency (EPA): The United States Environmental Protection Agency (EPA or sometimes USEPA) is an agency of the US federal government which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

Green Building: A structure and/or process that is environmentally responsible and resource-efficient throughout a building's life-cycle—from siting to design, construction, operation, maintenance, renovation, and demolition.

Green Globes: A building environmental design and management tool which delivers an online assessment protocol, rating system, and guidance for green building design, operation and management. In the United States, the Green Building Initiative (GBI) operates Green Globes.

Green House Gas Emissions: A greenhouse gas is any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. Emissions caused by the burning of fossil fuels during building construction, operations and maintenance, as well as transportation, are a focus of VBCPS's efforts.

Green Seal: A non-profit that develops life cycle-based sustainability standards for products, services and companies and offers third-party certification for those that meet the criteria in the standard. Green Seal has been actively identifying and promoting sustainability in the marketplace, and helping organizations be greener in a real and effective way since 1989.

GREENGUARD: GREENGUARD Certification is part of UL Environment, a business unit of UL (Underwriters Laboratories). GREENGUARD Certification helps manufacturers create—and helps buyers identify—interior products and materials that have low chemical emissions, improving the quality of the air in which the products are used. UL Environment acquired GREENGUARD in 2011.

LEED EBOM: This is the USGBC rating system for Existing Buildings Operations and Maintenance.

Life Cycle Assessment: A technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials

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processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

Life Cycle Cost: Sum of all recurring and one-time (non-recurring) costs over the full life span or a specified period of a good, service, structure, or system. It includes purchase price, installation cost, operating costs, maintenance and upgrade costs, and remaining (residual or salvage) value at the end of ownership or a product's useful life.

Net Zero Carbon Emissions: A result of a building with zero net energy consumption—meaning the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site.

Performance Contracting: A turnkey service, which provides customers with a comprehensive set of energy efficiency, renewable energy and distributed generation measures and often is accompanied with guarantees that the savings produced by a project will be sufficient to finance the full cost of the project. A typical performance contracting project is delivered by an Energy Service Company (ESCO).

Schola: A small auditorium space.

Triple Bottom Line: Also referred to as People, Planet, and Profit, the triple bottom line refers to how an individual, business, or government's actions affects the balance between social, economic, and environmental issues.

USGBC: A private 501(c)3, membership-based non-profit organization that promotes sustainability in how buildings are designed, built, and operated. USGBC is best known for its development of the Leadership in Energy and Environmental Design (LEED) green building rating systems.

Vegetative Roof: A roofing system that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

Volatile Organic Compounds (VOC): VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.