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Green Schools: Constructing and Renovating School Facilities with the Concept of Sustainability

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by

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Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work at Lindenwood University and that I have not submitted it for any other college or university, course, or degree.

Jonathan W. Oetinger

Signature: ____________________ Date: 8/26/10

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Abstract

The focus of this study was to examine the benefits of constructing and renovating school facilities with the concept of sustainability. The overarching questions were: What impact does the environment have on constructing and operating school facilities? What relationship exists between the learning environment and constructing and operating school facilities? The purpose of this study was to determine the value and benefits of implementing energy efficient and sustainable design features in constructing new and renovating existing school facilities. When viewed through the lens of global warming, or the increase of greenhouse gases through the increase in the temperature of the earth's atmosphere, sustainability provided a framework for this study. The increase of greenhouse gases is the result of utilization of fossil fuels. Schools use fossil fuels in construction of and operation of school facilities. In this study, the decreased usage of fossil fuels in development and operation of school facilities was explored. The interest in sustainable building has intensified as the number of green constructed schools increased between 2001 and 2008. It was determined that constructing and renovating school facilities with the concept of sustainability was beneficial. Lowering facility operational costs and renovating or constructing sustainable facilities improved student and staff attendance.

Table of Contents

List of Figures

Chapter One - Introduction

According to Katz (2006), "Approximately 55 million students spend their days in schools that are too often unhealthy and that restrict their ability to learn" (p. 4). A rapidly growing trend to recent design for new and renovated schools include improvements in providing healthy, comfortable, and productive learning environments (Dekovic, 2006). A sustainable, or *green* school, which generally costs more to build, is considered a high performing school in the areas of operation and learning environment. School budgets are limited and student populations are growing, thus creating a major obstacle in allocating additional resources for sustainable schools. (Katz, 2008) According to Corb (2008):

> Green schools are becoming increasingly popular among school districts seeking a way to decrease operation costs, while promoting healthy learning environments for students and teachers. The U.S. Green Building Council estimates that if all new school construction and school renovations went green starting today, energy savings alone would total more than 20 billon dollars over the next ten years. In addition to cutting costs, green schools are also the safest environment in which children learn. (p. 84)

There are approximately 20 billion square feet of existing school building facilities that are in worse condition than prisons (Elzeyadi, 2009). An assessment of these facility conditions is required to understand how energy can be conserved and how improvements impact humans (Elzeyadi, 2009). Studies show that high quality indoor air improves health, which could result in better attendance by students and staff (Corb, 2008). Increased attendance by students and staff allows for improved student achievement (Corb, 2008). Schools, unlike most private facilities, are very public in the amount of usage and visibility by the community (Hoffman, 2008). Members of the community who financially support school facilities typically will support green building initiatives with increased costs because of high expectations for student achievement (Hoffman, 2008).

At a minimum, school facilities should have operable windows in classrooms to take advantage of natural airflow (Willson & Giley, 2008). The movement of outside air contributes to a healthy learning environment (Willson & Giley, 2008). Allowing airflow can alleviate environmental issues associated with spending a lot of time in a conditioned space (Willson & Giley, 2008).

Green Construction and Energy Savings

America's primary and secondary schools annually spend a staggering six billion dollars for facility energy sources, which is more than is spent on textbooks and computers combined (Energy Star, 2009). Integrating basic, sustainable concepts designed to decrease the overall environmental impact will lower operating costs and create a more productive learning environment (Willson & Giley, 2008). Dirr and Hicks (2007) added:

> The green movement, sustainability, and LEED [Leadership in Energy and Environmental Design] are all concepts within the building delivery process that are founded on the premise that efficient use of our natural resources is becoming increasingly necessary. It seems to be a natural extension to integrate ideas to ensure the successful operations of facilities. (p. 36)

Understanding the priority of this concept, Dirr and Hicks (2007) suggested that, "embracing this philosophy provides architects and school district leaders with an opportunity to make a difference in the building delivery process by being held accountable for the ways in which we impact the world and its resources" (p. 36). School district personnel consult green building guidelines for potential savings and improved safety and health. According to the United States Green Building Council (USGBC), the current minimum requirements for K-12 facilities (see Appendix A) are:

1. The project and all other real property must lie within the current boundaries.
2. The entire project must be designed for existing boundaries.
3. The project boundary must include all contiguous land and support normal building operations for the project.
4. The project includes a minimum of 1,000 square feet of gross floor area.
5. The project must serve one or more full time occupant all certified projects.
6. Commit to share all available actual whole-project energy and water data for at least five years.
7. The project building can be no less than 2% of the land area within the project boundary. (2009)

Many current facilities are viable building shells, but are inefficient in their operation (Spencer, 2008). The difference between projects today and the past is the general focus on sustainability, particularly because it incorporates energy saving concepts (Spencer, 2008). In February 2009, the American Recovery and Reinvestment Act was passed and included 20 billion dollars to be dispersed for energy efficiency renovation projects (Energy Star, 2009). In 1992, the U.S. Environmental Protection

Agency and the U.S. Department of Energy joined to develop the energy efficient program, Energy Star, with the goal of reducing greenhouse gas emissions (Energy Star, 2009). Although this program was developed nearly 20 years ago, more recently the guidelines have been honed as sustainability has grown in popularity and become common in construction. According to Energy Star for K-12 Schools (2006) (see Appendix B):

> A study of the following are recommended to save energy: identification of inefficient equipment and systems, installation of lighting upgrades, reduction of energy load facility wide, installation of properly sized ventilation equipment, and evaluation and adjustment or renovation of heating and cooling systems. (p. 2)

All facilities should be assessed to determine if they need to be demolished or renovated. There are significant benefits to renovating schools (Greim, 2005). Older school facilities have sentimental value and enhance the history of the community (Greim, 2005). By improving an existing school with new building systems, overall operational costs decrease (Greim, 2005). Renovated school facilities provide improved learning environments through healthier and safer learning environments (Greim, 2005).

Healthy Atmosphere Benefits

In a report published in 2004 by the American Federation of Teachers (AFT), it was noted that the air in nearly 15 thousand school facilities is not healthy to breathe. Students who attend green schools feel more comfortable and safe in their environment and are more open to learning and achieving at higher levels (AFT, 2004). Hoffman (2008) reported:

> The average worker spends nearly 90 percent of his/her time indoors, and building related illnesses cost organizations tens of billions of dollars each year. Improvements in air quality, lighting, and other high performance green features have shown to increase productivity and reduce absenteeism. As well, when teachers and other staff are considering their employment options, features like natural light and a comfortable, well-designed work environment are variables that are likely to give green schools the upper hand. (p. 54)

School environments play a key role in affecting children's health and learning ability (Pennybacker, 2005). Related studies show, by improving the health conditions of schools, academic performance can improve, absenteeism and retention can decrease, and enrollment can increase (Pennybacker, 2005). Students' daily attendance increases between 5% and 15% in green school buildings (Sackett, 2007). A growing amount of evidence suggests that green facilities can decrease absenteeism from common illnesses such as asthma, colds, and flu (Tobias, 2009). Specifically:

> Case studies cited by Greening America's Schools put reductions in the 15 percent range. Carnegie Mellon University's review of five national workplace studies put green-building related asthma reduction at 38.5 percent. One of ten children in the U.S. suffers from asthma. A broader review of 17 studies by Carnegie Mellon found an average occupant health improvement of 41 percent in green buildings. (Tobias, 2009, para. 4)

Green facilities have been associated with increased teacher retention and improved student attendance (Bardacke, 2009; Pennybacker, 2005). Improved student test scores have been associated with green schools through improved learning environments (Bardacke, 2009; Earthman 2002). According to Bardacke (2009):

> A green school, also known as a high performance school, is a community facility designed in an ecological and resource-efficient manner. Green schools protect occupant health, provide a productive learning environment, connect students to the natural world, increase average daily attendance, reduce operating costs, improve teacher satisfaction and retention, and reduce overall impact to the environment. (para. 1)

Green school facilities lessen the impact of building construction on the environment (Bardacke, 2009). Green school facilities set an example for future generations, showing that environmental quality is crucial to long-term well-being (Bardacke, 2009). Schools designed to incorporate proper ventilation, acoustical quality, and other indoor environmental factors can expect improved student and teacher health along with higher attendance (Bardacke, 2009; Pennybacker 2005). Improvements to site planning and adequate daylighting can heighten student performance by as much as 25% (Bardacke, 2009; Earthman 2002). Sustainable facilities can become teaching tools, featuring concepts of science, math, and environmental curriculum (Bardacke, 2009). Designing visible technology and improvements allows students to study the functionality of the facility (Bardacke, 2009).

Improving Student Performance

Studies of green school facilities across the country were conducted, and improvements in academic performance were indicated (Katz, 2007). Researchers examined overall building conditions and the connection to student performance. According to Earthman (2002):

> Research demonstrates that comfortable classroom temperature and noise level are very important to efficient student performance. The age of school buildings is a useful proxy in this regard, since older facilities often have problems with thermal environment and noise level. The studies have consistently shown that students attending schools in better condition outperform students in substandard buildings by several percentage points. (p. 1)

Berry (2002) conducted a case study of Charles Young Elementary School in Washington D.C., to identify the benefits associated with utilizing green cleaning methods and improving the indoor air quality. Berry (2002) found that "school attendance increased from 89% to 93%, math scores at basic or above increased from 51% to 76%, [and] reading scores at basic or above increased from 59% to 75%" (p. 19).

Statement of the Problem

The cost of operating school facilities has continued to increase as goods, services, and energy expenses have increased (King, 2008). Recently, school leaders have seen expenditures exceed the additional revenue (Dekovic, 2006; Neufeld, 2008). During this same time, schools across the United States want to identify ways to improve education without large additional expenditures (King, 2008). The overarching questions are: What impact does the environment have on constructing and operating school facilities? What relationship exists between the learning environment and constructing and operating school facilities?

According to Katz (2006), "the average national school construction cost is $150 per square foot" (p. 3). King (2008) reported, "Green schools cost a little more to build, generally 1% to 2% extra, than conventional schools but promise payback through lower utility bills and, some studies suggest, better student achievement" (para. 1). Katz (2006) added, "additional construction cost is offset and exceeded with the average cost savings in total energy by $7.00 to $9.00 per square foot" (p. 4). The reduction on building utility usage decreases the need for fossil fuels (Carnahan, Biggert, Evans, Caldwell, & Horwich, 2008; Katz, 2006; Tucker, 2007).

Purpose of the Study

The purpose of this study was to determine the value and benefits of implementing energy efficient and sustainable design features in constructing new and renovating existing school facilities. The value and benefits included energy cost savings and aspects to improve the educational environment.

Research Questions

The following research questions were posed for this study:

1. What commonalities exist between sustainable school facility construction and renovation of LEED certified and Energy Star certified facilities?

2. What cost savings result from constructing or renovating a school facility with energy efficient and sustainability concepts?

3. How have trends in sustainable school facility construction and renovation changed since 2001?

4. What educational benefits were realized from constructing or renovating school facilities with energy efficient and sustainable concepts?

5. What changes have those assisting schools in sustainable construction and renovation of school facilities experienced?

Theoretical Framework

Taking into consideration sustainability, the theory of global warming is explained as the increase of temperature in the lower atmosphere of Earth, resulting from the increase of greenhouse gases (Columbia University, 2005). The theory of global warming was applicable to this study for the reasoning that reducing energy usage in school facilities can assist in reducing greenhouse gases leading to global warming. Scientists have concluded that human activities contribute to global warming (Columbia University, 2005). Activities add extreme amounts of greenhouse gases to the Earth's atmosphere (Columbia University, 2005). Carbon dioxide, a greenhouse gas, builds up in the atmosphere and can trap the heat that would normally depart into outer space (West, 2009). According to Mastrandrea and Schneider (2005):

> The main human activity that contributes to global warming is the burning of fossil fuels. Most of the burning occurs in automobiles, in factories, and in electric power plants that provide energy for houses and office buildings. The burning of fossil fuels creates carbon dioxide. Carbon dioxide is a greenhouse gas that slows the escape of heat into space. (para. 4)

Fossil fuels, taking centuries to form, consist of deposits of once-living organisms (Enzler, 2004). Coal, oil, and natural gas are three types of fossil fuels used for energy provision (Enzler, 2004).

The decrease in usage of energy by school facilities will result in the reduced reliance of fossil fuels and lessen global warming. Tucker (2007) asserted that, K-12 facilities consume excessive energy when operating more than six hours per day. Seven percent of all energy used for commercial buildings comes from public schools across America (Tucker, 2007). Almost one-half of the electricity produced in the United States is created by coal (Energy Information Administration, 2009). Coal burned in power plants creates steam; the steam revolves turbines that create electricity needed for learning environments (Energy Information Administration, 2009; Energy Star, 2009). Natural gas produces electricity used as a heating fuel, which is a common source for heating schools (Energy Information Administration, 2009; Environmental Protection Agency, 2007). Oil creates many different products consumed within the operation of school facilities, such as plastic materials, ink, and crayons (Energy Information Administration, 2009). The uses of oil expand to transportation through the consumption of gasoline and diesel fuel needed for transporting students to and from school (Energy Information Administration, 2009).

Significance of the Study

According to the USGBC (2008), "green schools are healthy for kids and conducive to improving their education. Green schools encourage daylight, high indoor air quality, excellent acoustics, and thermal comfort" (para. 2). Carnahan et al. (2008) reported, the members of High Performance Buildings Congressional Caucus Coalition, met to discuss "how some school districts are building facilities that save thousands of dollars a year on energy costs and are reducing greenhouse gas emissions and environmental impact, creating healthier and safer learning environments" (para. 1). Leaders in the industry of sustainable construction and federal legislators assembled for a briefing on the importance of schools across the country joining the sustainable movement and considered various aspects of design, accessibility, cost, functionality, and preservation of building projects (Carnahan et al., 2008). The study by Carnahan et al. (2008) has assisted educators in understanding the financial, learning, and health benefits of sustainable construction of school buildings.

Definition of Terms

The following terms are clarified for understanding:

Green construction. Efficient use of natural resources in developing communities that make an immediate and positive impact on the planet (Sheehan, 2007).

Leadership in Energy and Environment Design (LEED). A system that measures the efficiency a building or community performs by factoring in improved indoor environmental quality, energy savings, emissions reduction, water efficiency, while being responsible for preserving natural resources (USGBC, 2008).

Sustainability. Environmental actions or impacts of human actions by attempting to decrease the ecological footprint of humans, thus treading lightly on Earth. This equates to the reduction in the quantity of resources used, ending the waste and emissions produced. (Environmental Sustainability, 2002).

Limitations

The following limitations were identified:

1. There have been 119 LEED certified public educational facilities constructed in the United States from 2001 through 2008 (USGBC, 2008). Of the 119 facilities, 98 are K-12 buildings (USGBC, 2008).

2. Many more facilities are planned that could be completed before the end of this study; however, only those that are presently LEED certified facilities will be considered.

3. The movement of green construction is relatively young, and a limited number of K-12 facilities exist (USGBC, 2008).

4. Energy efficient renovations are typically focused on specific measures and individual building needs. Facility renovations can vary as upgrades may not be the same for all renovated facilities.

5. This data may indicate improvements; however, some projects identified are additions to existing facilities and might not represent comprehensive school-wide results.

Summary

A growing trend is to design new and renovated schools with the objective of creating productive and sustainable learning environments (Dekovic, 2006). If green construction dominated the landscape of construction and renovation of school facilities today, ten years from now, schools would avoid 20 billion dollars in utility costs (Corb, 2008). In addition to the cost savings, better indoor air quality improves health, which could result in increased attendance by students and staff (Corb, 2008). Integrating basic sustainable concepts, designed to decrease the overall environmental impact, will lower operating costs and create a more productive learning environment (Willson & Giley, 2008). Sustainable school facility construction is a necessary means to decreasing the impact on environmental resources (Dirr & Hicks, 2007). Minimum standards for school facilities were developed by the USGBC (2009). The standards include property boundary requirements and a commitment to share energy and water data (USGBC, 2009).

Construction and renovation projects today differ from the past and now incorporate concepts of sustainability for improving energy efficiency and overall energy savings (Spencer, 2008). In 2009, the federal government allocated 20 billion dollars through the American Recovery and Reinvestment Act specifically for energy efficient renovation projects (American Council for an Energy Efficient Economy, 2009). Energy Star, developed in 1992 by the Environmental Protection Agency to reduce greenhouse gas emissions, continued to develop specific guidelines in 2006 by developing Energy Star for K-12 Schools (Energy Star, 2006). The efficiency measures released for schools focus on decreasing overall energy use by a facility (Energy Star, 2006).

Sustainable schools can directly impact students and staff utilizing the facility (USGBC, 2008). Students learning in a healthy environment achieve at higher levels (AFT, 2004; USGBC, 2008). High performing green features, to include air quality and lighting, have shown to increase productivity and decrease absenteeism (Hoffman, 2008). Improving health conditions in schools can boost academic performance and increase attendance rates of students (Pennybacker, 2005). According to Sackett (2007), student attendance increases in green school buildings. When looking for employment, potential employees consider a healthy work place environment (Hoffman, 2008). Green school buildings have also been associated with heightened teacher attendance and retention (Bardacke, 2009).

Global warming is explained as the increase of lower atmosphere temperatures (Columbia University, 2005). According to Mastrandrea and Schneider (2005), humans' impact on global warming is through the usage of fossil fuels (coal, oil, and natural gas). These fuels are the main source of energy for K-12 facilities, which consumes 7% of all commercial energy (Tucker, 2007). The decrease in usage of energy by school facilities will lead to the reduced reliance of fossil fuels and lessen global warming. Leaders in industry, education, and government gathered in 2008 for a briefing to gain support from schools in joining the sustainable movement (Carnahan et al., 2008). Areas of focus consisted of alternatives in facility design and accessibility, cost, functionality, and preservation of school construction projects (Carnahan et al., 2008).

A review of literature surrounding the benefits of constructing sustainable schools was presented in Chapter Two. The methodology and analysis of data were discussed in Chapters Three and Four. Chapter Five included findings, conclusions, and suggestions for further study.

Chapter Two – Review of Literature

The concept of sustainable construction originated in the United States less than 50 years ago at the private level; then beginning in the early 1990s, the public sector incorporated these concepts (Townsend, 2006). The sustainable movement has grown and improved as operating costs have outgrown revenues (Townsend, 2006). Many schools are now taking part in the movement to generate additional recurring money for educational advances (Katz, 2006). While many progressive states have been involved in the movement for several years, other states lag behind. (Dekovic, 2006). Progressive states, such as California and Oregon, have developed their own sustainability guidelines (Dekovic, 2006). Many states are looking at the United States Green Building Council (USGBC) guidelines as goals to consider when planning a new construction project (Dekovic, 2006).

The cost of operating school facilities has continued to increase as costs for goods, services, and energy have increased (Bardacke, 2009). In recent years, these costs have become higher than the revenue many schools receive (Bardacke, 2009). Schools across the United States continually try to identify ways to improve education without large additional expenditures (Bardacke, 2009). The overarching questions are: What impact does the environment have on constructing and operating school facilities? What relationship exists between the learning environment and constructing and operating school facilities? Chait (2008) reported:

> While buildings and developments provide countless benefits to society, they also have a significant environmental impact. The concept of sustainability is building an earth space that will sustain usage of the space. The number of

> people utilizing the facility needs to be considered as to not over build, creating wasted and unused space. Consideration [must be given] for the following: minimal amount of non-renewable energy; creating a non-toxic environment; and consideration for minimal water consumption. (para. 5)

According to Eckersley (2006), "Environmental degradation caused by human activity has a long and complex history. However, until the period of European global expansion and the industrial revolution, environmental degradation generally remained uneven and relatively localized" (p. 249). To understand more fully the concept of sustainability, as presented in this study, six main themes were examined: history of sustainability, principles in sustainability design, guidelines for sustainable school design, benefits of sustainable schools, return on investment improvements, and alternative building materials.

History of Sustainability

The United States National Environmental Policy Act was legislated in 1969 to foster and promote the general welfare and create and maintain a sustainable environment where man and nature can be productive fulfilling social and economic requirements (Environmental Protection Agency [EPA], 2009). President Nixon and Congress established the EPA in 1970 to address the growing public demand for clean water, air, and land (EPA, 2009). The EPA responsibilities included improving the current conditions of the environment, working to preserve the future of the environment, and protecting natural resources and human health (EPA, 2009). The World Commission on Environment and Development (WCED), organized by the United Nations in 1983, developed a mission to examine critical environment and development problems around the world and cultivate realistic proposals to address concerns (EPA, 2009). The WCED continued to strengthen international cooperation on environmental and developmental issues while raising the level of understanding for commitment to sustainable developments by individuals, businesses, and organizations (EPA, 2009).

In 1992, the United Nations Conference on Environment and Development developed Agenda 21 (EPA, 2009). Agenda 21, also known as an Agenda for the 21st Century, was developed to establish education for all people about their specific environment and assist them in making sustainable decisions (EPA, 2009). According to the EPA (2009), Agenda 21 implemented the following:

> All countries of the world are to undertake a comprehensive process of planning and action to attain sustainability. Local authorities construct, operate, and maintain economic, social, and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and as the level of government closest to the people, play a vital role in educating, mobilizing, and responding to the public to promote sustainable development. (para. 13)

In 1993, President Clinton established the President's Council on Sustainable Development (PCSD) (EPA, 2009). The council, which included members of Congress and leaders in various areas of industry, was formed to create policies for the United States to encourage economic growth, job creation, and protection for the environment (EPA, 2009). Then, in 1996, the council produced the report, *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future*, which focused on seven goals (see Appendix C): developing common goals defining sustainability, reforming environmental management, providing education and increasing awareness, developing a community driven strategic plan, serving as stewards of natural resources, planning for future growth, and serving as international leaders in creating and maintaining sustainable environments (EPA, 2009; PCSD, 1996).

In 2007, President Bush signed Executive Order 13423 which strengthened federal environmental, energy, and transportation management (Federal Register, 2007). Requirements of the order included goal setting in the areas of establishing renewable energy, energy efficiency, reduction in environmental toxins, sustainable building, recycling, and water conservation (Federal Register, 2007). Also addressed were specific requirements for more widespread use of environmental management systems as a framework to manage and improve ongoing sustainable practices (Federal Register, 2007).

During this time period, school facilities were subjected to state and local building codes; however, some states established guidelines for the development and building of sustainable schools (Corb, 2008). California developed the Collaboration for High Performing Schools (CHPS) to facilitate design, construction, and operation of schools facilities, thereby creating educational environments that are resource and energy efficient, comfortable, healthy, and well lighted. (CHPS, 2008). The goals of the CHPS were to increase student performance through better designed and more healthy facilities, along with increasing school energy and resource efficiency (CHPS, 2008). The intent of the designers of these facilities was to raise awareness of the decreased impact and advantages of high performing schools (CHPS, 2008). Since its inception in 1999, the CHPS guidelines have been followed in the development of 46 schools and another 300 are in the design or construction stage (CHPS, 2008).

In 2009, Colorado established the Colorado Collaboration for High Performing Schools (CO-CHPS) (CHPS, 2008). Following the original principles of the CHPS, goals were developed to increase student performance in conjunction with increased facility efficiency (CHPS, 2008). CO-CHPS was a variation of the original, developed in California; however, there were differences due to the available natural resources (CHPS, 2008).

Oregon created the Sustainable Oregon Schools Initiative (SOSI) program in 2003 to help interested school districts integrate sustainability concepts into the maintenance and operations of facilities (SOSI, 2008). The goal of the SOSI was to help schools become sustainable through implementation and management of conservation and efficiency of natural resources (SOSI, 2008). Oregon's program developed a sustainable vision for individual school districts which provided a framework for development and implementation (SOSI, 2008). Benefits realized from this program included reduced operating costs, reduced environmental impact, increased student performance, and improved student and staff health (SOSI, 2008).

Principles of Sustainability Design

In 2004, the Institute for Research and Innovation in Sustainability (IRIS) developed the sustainability principles to serve as guidelines for assessment in design of sustainable facilities. The IRIS (2004) ten principles were developed to assess aspects of progress toward sustainable development of a facility (see Appendix D): sustainable vision and goals, considerations of social and ecological systems and the interaction with human activity, considerations of population growth and its impact, timeline and ecosystem impacts, linking visions and goals, providing impact data to stakeholders, creating open communication for development, inclusion of all stakeholders impacted from development to utilization, on-going assessment to allow for change or improvement, and maintaining on-going data to support the aforementioned possible change (IRIS, 2004). By utilizing these principles, the design phase of a project progresses toward a sustainable development (IRIS, 2004).

Guidelines for Sustainable School Development

Leadership in Energy and Environmental Design (LEED).

The certification of LEED for Schools is a new concept of the USGBC (USGBC, 2008). For years, LEED standards existed for buildings in general; however, more recently, the USGBC recognized the need for a specific certification due to the impact these facilities have on the health and well-being of children (USGBC, 2008). The LEED for Schools Rating System recognizes and addresses classroom acoustics, master planning, mold prevention, and environmental site improvements through design and construction (USGBC, 2008). According to the USGBC (2008):

> By addressing the uniqueness of school spaces and children's health issues, LEED for Schools provides a unique, comprehensive [guideline] for schools that wish to build green with measurable results. LEED for Schools is the recognized third-party standard [certification] for high-performance schools that are healthy for students, comfortable for teachers, and cost-effective. (para. 1)

The LEED for Schools rating system is used to identify the unique nature of a facility design and the benefits it offers the environment (USGBC, 2008). The LEED checklist (see Appendix E), provided by the USGBC (2008), serves to address the reduction of a building project's carbon footprint based on its building site, water efficiency, use of energy and impact on the atmosphere, materials and resources used or reused, indoor environmental quality, and design.

Energy Star.

Schools that attain Energy Star certification are encouraged to educate students about the value of becoming energy-efficient (Energy Star, 2009). As a member of Energy Star, schools develop a comprehensive energy management program by evaluating current energy performance of their facilities (Energy Star, 2009). Once evaluated, Energy Star provides ideas for changes and improvements for all aspects of a facility to meet standards (Energy Star, 2009). The following guidelines from Energy Star (2009) are necessary for successful implementation of energy management in attaining Energy Star certification (see Appendix F): commit to energy management and conservation, assess performance initially and frequently, develop performance goals, develop an action plan to improve facility energy performance, implement action plan, evaluate progress continually, and recognize achievements.

Benefits of Sustainable Schools

In related studies of sustainable or green building design, a positive relationship between the improved environment and higher student achievement was found (Iffrig, 2009). Improvements to the environment ranged from the utilization of more natural light and incorporation of materials for healthier indoor air quality to greater stakeholder investment (Iffrig, 2009). In sustainable environments, improved student and staff health have contributed to increases in attendance and concentration (SOSI, 2006). Sustainable educational environments also foster critical thinking and community service through the use of preserving non-renewable natural resources (SOSI, 2006). Districts utilizing this type of construction realized financial benefits by using reduced amounts of resources to operate the facility (SOSI, 2006). Katz (2006) conducted a study in which he observed "green schools use an average of 33% less energy than conventionally designed schools" (p. 4). Katz (2006) concluded:

> Typical energy performance enhancements include more efficient lighting, greater use of day lighting and sensors, more efficient heating and cooling systems and better insulated walls and roofs. Reduced energy consumption in green schools has two distinct financial benefits: (1) direct reduction in school energy costs, and (2) indirect secondary impact from reduced overall market demand and resulting lower energy prices market-wide. (p. 4)

Katz (2006) noted the direct and indirect energy-savings impact. Lower utility bills show a direct impact and the reduced demand for market energy explains the indirect impact. While the indirect impact of reduced demand would be minimal on a small scale, such as an individual school, reduced demand across the country could be substantial (Katz, 2006).

The USGBC researched the benefits of sustainable or green schools. The benefits were broad, ranging from the impact on student health, test scores, and teacher retention to reduce operational costs (USGBC, 2008). Facility improvements directly related to student performance improvements are additional daylight, improved indoor air quality, enhanced classroom acoustics, and comfortable and consistent indoor temperatures (USGBC, 2008).

When considering the staff who educates students in a green school building, the USGBC reported (2008):

> Good acoustics in classrooms ensures that teachers can be heard without straining their voices. Studies show that all building occupants benefit from daylight and access for exterior views, and research indicates that teachers are happier when they have the ability to control their environments. Healthy and happy teachers save schools money. Green schools commonly report reductions in teacher absenteeism and teacher turnover. (p. 3)

Greening a new or existing school not only saves money, but potentially can save enough money over time to pay for original improvements (USGBC, 2008). New efficient operating systems may cost more to purchase, yet save thousands of dollars in lower utility costs during the lifespan of new systems (USGBC, 2008). Green and sustainable learning environments create an atmosphere for students to engage and interact (USGBC, 2008). Learning environments can incorporate visual operating systems for students to study, monitor, and calculate energy savings (USGBC, 2008). Green schools accomplish more by decreasing the environmental impact through utilization of less non-renewable resources, reduced demand on infrastructure, and recycling materials (USGBC, 2008).

Return on Investment (ROI) Improvements

Return on investment is measured by the amount of operating costs saved after improvements have been made compared to the original cost of upgrading the facility (Jeppesen & Pinon, 2009). By improving technology of operating systems and devices in a facility, the cost to operate the facility will decrease (Jeppesen & Pinon, 2009). In the scenario provided by Jeppesen and Pinon (2009), operating costs decrease and an increase in property value is generated by facility improvements:

> Consider a 30 year old 100,000 square foot building near downtown Salt Lake City, UT. A consultant conducted a walk-through of the building and noticed T12 fluorescent lamps with magnetic ballasts (common area lighting that remained on for 24 hours per day) and an antiquated mechanical system. The consultant recommended changing the lighting fixtures to T8 lamps with electronic ballasts. The new lamps and ballasts use 20% to 30% less power while emitting 20% to 25% more light. Another easy change involved installing sensors on the common area lights, allowing them to adjust to available daylight. Finally, the consultant specified a mechanical system overhaul, which would involve replacing the basic equipment with a modern, energy efficient unit and tightening up the ventilation system. (para. 3)

The lighting and mechanical system upgrades cost $180,000 with an annual ROI of 36%, resulting in an approximate three-year payback of the initial improvement cost and an increase in building's capitalized value (Jeppesen & Pinon, 2009).

According to Suttell (2006), the front-end capital cost has to be evaluated in determining the value of improvements to ensure improvements can be paid for in money saved through decreased use in energy. To evaluate if improved technologies add value, Suttell (2006) recommended determining what the savings would be in the utilization of improved technologies. Then, the savings are compared to the original cost of new equipment (Suttell, 2006).

Alternative Building Materials

Consideration for alternative building materials and processes started several decades ago, yet were not cost effective as many applications took longer than the life span to pay for themselves (Willson, Haxton, Beckstead, & Hjorth-Vlasic, 2008). In 1993, the USGBC formed and developed the LEED concept for researching and utilizing sustainable materials and resources in construction of buildings (USGBC, 2008). In 2007, the USGBC issued a new LEED rating system for schools (USGBC, 2008). LEED for schools focused on improving indoor environmental quality, use of daylight, addressing air born allergens, allowing for alternative transportation, and joint usage by the school and community (USGBC, 2008). The interest in high performing and sustainable design facilities led school administrators to ask questions about the cost of constructing LEED certified facilities, the support LEED can offer education, and the financial benefit to schools (Willson et al., 2008).

Daylight harvesting.

Prior to the development of electricity and the electric light, daylight was the primary source of light (DiLouie, 2006). In recent years, the daylight harvesting movement returned as an effective way to save energy and improve the quality of the environment (DiLouie, 2006). According to Molinski (2009):

> Daylighting is the practice of using natural light to illuminate interior building spaces. Instead of relying on electric lights during the day, this method brings indirect natural light into a building. Daylighting reduces the need for electric lights and may create a more calm and productive environment because it connects people to the outdoors. (para. 4)

Photosensors measure incoming natural daylight and control electrical lighting to be bright or dim, according to lighting level needed (DiLouie, 2008). Natural light is dispersed through the use of additional windows, skylights, lighted shelves, light reflectors, sunshades, and sunscreens (Molinski, 2009). Windows provide direct and indirect light, and various types of windows allow for differing levels of efficiency (Lund, 2002). Skylights, or windows located in the roof of a structure, provide daylight and warmth helping minimize heating, cooling, and lighting costs (Encyclopedia of Alternative Energy and Sustainable Living, 2009).

Light shelves, which are a horizontal reflective surface at or above eye level, are used to channel daylight into an occupied room (Encyclopedia of Alternative Energy and Sustainable Living, 2009). The in-coming light is reflected on the ceiling, thereby providing uniform illumination (Encyclopedia of Alternative Energy and Sustainable Living, 2009). Reflected lighting is an effective way to bring in natural light; however, stationary shelves do not allow for controlling the amount of light needed for the room, especially during the winter months when the sun is lower in the sky and less light hits the shelf for reflection (Encyclopedia of Alternative Energy and Sustainable Living, 2009). Local climate conditions must be considered, as well as the seasons of the year and the angles of natural light (Gleed, 2009). Lighting reflectors are polished surfaces that redirect lighting from the original source (Muller, 2009). The light source must hit the reflector directly to provide additional light (Muller, 2009). Sunshades and sunscreens are structures on the exterior of a building that reflect indirect lighting into a building (Molinski, 2009).

Incorporating daylighting into a building is beneficial (Molinski, 2009). The concept of daylighting came from a design approach that incorporated strategic design with long-term cost savings (Molinski, 2009). According to Gleed (2009):

> It [daylighting] affects the comfort, productivity, performance, health and well-being of occupants. Daylighting has a significant influence on energy efficiency, electrical lighting costs and HVAC climate control. And of course, the green movement and desirability of earning LEED points increasingly inform the daylighting plans for buildings. (p. 33)

Molinski (2009) concluded by incorporating daylight harvesting into a facility, a potential savings of 15% to 40% in energy costs would be realized (Molinski, 2009). According to Westfall (2003), effective daylighting can provide many benefits to schools including: energy savings, increases in student test scores and attendance, and a better learning environment for students. Effective daylighting designed for one facility might not be effective for other facilities (Gleed, 2009). Each facility must be studied before implementing daylighting. Several factors, such as surrounding mountains, trees, and other buildings, affect the amount of daylight a facility receives (Gleed, 2009).

Geothermal energy.

Geothermal energy is provided from the Earth's interior (Geothermal Education Office, 2000). At the Earth's core, temperatures reach over 9,000 °F, and this heat provides power that can be used without polluting the environment (Geothermal Education Office, 2000). Geothermal reservoirs are natural collections of hot water under the Earth's surface (Geothermal Education Office, 2000). Geothermal reservoirs are deep below ground with no visible clues of location above ground (Energy Information

Administration, 2009). A geothermal system is a series of pipes drilled into the ground that water travels through, which brings hot water to the surface and takes cool water to the subsurface to be reheated (Sullivan, 2009). According to the Energy Information Administration (2009), there are three main uses of geothermal energy:

1. Direct use and district heating systems use hot water from springs or reservoirs near the surface.
2. Electricity generation power plants require water or steam at very high temperatures (300 °F to 700 °F). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface.
3. Geothermal heat pumps use stable ground water or water temperatures near the Earth's surface to control building temperatures above ground. (p, 3)

Today, geothermal wells are drilled to bring hot water to the Earth's surface to generate electricity for geothermal power plants. Geothermal systems cost more to install, yet potentially cost as much as 60% less to operate than conventional heating systems (Sullivan, 2009). The benefits of geothermal power include:

1. Geothermal power provides clean and safe energy, using little land. The energy is a renewable source utilizing energy resources under the ground.

2. Geothermal power is renewable and sustainable. The Earth's core provides a fuel source for the energy to regenerate itself.

3. Geothermal power generates continuous, reliable base load power. This energy will continue no matter the circumstances or the conditions of the ground above.

4. Geothermal power conserves fossil fuels and contributes to the diversity of the

energy sources. Geothermal power utilizes the energy from the Earth's core that will continue to replenish itself and does not rely on a resource that has to be excavated and processed to become the necessary resource.

5. Geothermal power avoids having to be imported, and it benefits local economies. This energy source is already in place; it just has to be harvested to generate power.

6. Geothermal power offers modular, incremental development, and village power to remote sites. This energy form already exists below the Earth's surface and can be harvested virtually anywhere it is needed (Geothermal Education Office, 2000).

The United States Department of Energy reported other benefits of geothermal energy, including cost effectiveness, durability, low maintenance, and greater comfort to the surrounding internal environment (as cited in Solar Guide, 2009). Benefits are more specifically outlined by Pearson (2007) to include a potential savings of 20 to 30 cents per square foot and an approximate return on investment of eight years.

Water conservation.

Water conservation occurs in several forms: rainwater harvesting, utilizing graywater, and the use of low-flow plumbing fixtures. Rainwater harvesting is collecting, storing, and purifying water for reuse as it is provided naturally through the environment (Agua Solutions, 2007). Graywater is defined as all the wastewater that drains from washing machines, dishwashers, sinks, and showers or bathtubs (Clark, 2008). Low-flow plumbing fixtures provide the proper amount of water necessary for the unit to operate efficiently (Hounsell, 2008).

Uses for rainwater include drinking water, cooking, bathing, flushing toilets, washing machines, and landscape irrigation (Agua Solutions, 2007). Rainwater is collected with a catchment system that stores the rainwater until it is used (Rain Harvesting, 2006). A building roof catchment area will collect rainwater and divert it into containers which store the water (Rain Harvesting, 2006). When utilizing this water for domestic purposes, the water will be treated or purified (Rain Harvesting, 2006). Rainwater collection systems are efficient for areas where groundwater is scarce or contaminated, local terrain is rugged and not easily accessed, where local water is high in minerals, and where utility service is unreliable (Agua Solutions, 2007). The benefits of rainwater harvesting are:

1. Safe and Sustainable. Rain is a naturally fresh and pure source of water. This source of water is sustainable where underground water sources are limited.

2. Lower Energy Consumption. Utilizing collected rainwater allows for less use of electrical equipment. Rainwater relieves the use of community infrastructure to provide facilities with water.

3. Protection of Local Waterways. By capturing water runoff from buildings, there is less water to run into local waterways. This also allows for less stormwater retention infrastructure (Rain Harvesting, 2006).

Graywater, collected from washing machines, dishwashers, sinks, and showers or bathtubs, was typically laden with detergent agents found in the detergents used (Clark, 2008). Water collected for reuse from these sources caused concern from individual states resulting in requirements for recycling, containment, and usage (Zimmerman, 2008). Ingredients used in washing machines and dishwashers contain amounts of phosphorus and nitrogen (Clark, 2008). Soaps used in sinks and showers or bathtub are very mild and safe for human skin, thereby causing less concern for local governments (Clark, 2008).

The continued study of graywater, on behalf of local governments, focused on the amount of fecal matter from dead skin draining into sinks (Clark, 2008). Sporadically, across the United States, governments have placed requirements on graywater containment and uses (Zimmerman, 2008). Clark (2008) determined since 15% of all fresh water is used for irrigation, utilizing graywater to irrigate is one of the biggest benefits (Clark, 2008). Another common use for graywater is flushing toilets (Zimmerman, 2008). While there is no need for fresh water to dispose of sewage, many manufacturers will not warranty products when low quality water, or graywater, is used (Zimmerman, 2008).

Water conservation is a focus of sustainability because water shortages are expanding, the cost of water is increasing, and environmental concerns of polluting water tables continue to impact facility development (Hounsell, 2008). Constraints on water usage have led to the development of fixture technology that lowers gallons per minute usage (Opitz, 2006). According to Hounsell (2008), low-flow plumbing technology development improved from early developed models, as technology reduced the amount of water used without reducing the performance of the equipment. Some states have already incorporated requirements of low-flow technology in commercial construction and renovation of facilities (Hounsell, 2008). Additionally, the EPA (2010) pointed out the replacement of outdated equipment with Energy Star appliances will conserve water. Regions with requirements are also those that have concerns for low fresh water supplies, while regions without concerns of water conservation work to develop appropriate regulations before implementation (Hounsell, 2008).

Summary

Many schools are now participating in the sustainability movement in an effort to battle increasing costs of utilities and to generate additional money for educational advances (Katz, 2006). Progressive states have been involved in sustainable construction for several years while other states have barely scratched the surface of sustainable construction (Dekovic, 2006). Progressive states have developed their own sustainability guidelines while those not on the cutting edge of sustainability consider the USGBC guidelines as goals when planning a construction project (Dekovic, 2006).

The United States National Environmental Policy was established in 1969 to foster and promote the general welfare for man and nature to co-exist and be productive by fulfilling social and economic requirements (EPA, 2009). Over the years, since the creation of the EPA, several states developed specific school facility programs (USGBC, 2008) such as the Collaboration for High Performing Schools in California (CHPS,2008), Colorado Collaboration for High Performing Schools (CHPS, 2008), and the Sustainable Oregon Schools Initiative (SOSI, 2008).

Principles were developed to serve as a guide for assessing the design and development of a sustainable facility (IRIS, 2004). These principles included developing a mission, incorporating human interaction with facility development, timelines for completion, and goals to obtain (IRIS, 2004). The principles extended to the involvement of stakeholders, communication to community, participation of stakeholders, and on-going assessment and support of developed project (IRIS, 2004).

Guidelines for sustainable school facility development include LEED and Energy Star. The certification of LEED for schools was a new concept (USGBC, 2008). The USGBC (2008) recognized the need for this specific certification because of the impact these facilities had on the health and well-being of children. The LEED for Schools Rating System includes classroom acoustics, master planning, mold prevention, and environmental site improvements through design and construction (USGBC, 2008). Attaining Energy Star certification has prompted schools to educate students concerning the importance of energy efficiency (Energy Star, 2009). Energy Star member facilities are evaluated for current energy performance, and once evaluated, ideas for facility improvements are provided in an effort to attain certification (Energy Star, 2009).

Iffrig (2009) found a positive relationship between the improved environment and higher student achievement in sustainable school facilities. Improvements to the environment ranged from the utilization of more natural light and incorporating materials for healthier indoor air quality to greater stakeholder investment (Iffrig, 2009). The financial benefit was studied by Katz (2006) who found that "green schools use an average of 33% less energy than conventionally designed schools" (p. 4). According to the USGBC (2008), the benefits of sustainable school facilities are broad, such as, making a positive impact on student health, improving test scores, increasing teacher retention, and reducing operational costs.

In 1993, the USGBC formed and developed the LEED concept for researching and utilizing sustainable materials and resources (USGBC, 2008). Common sustainable technologies utilized in LEED school facility development included daylighting, geothermal energy, and water conservation. Daylighting, or using natural light to illuminate the interior of a building, is a sustainable technology which reduces the need for electrical lighting and reduces the need for energy usage and cost (Molinski, 2009). Effective use of daylighting can reduce the need for electrical lighting during the school day (Westfall, 2003).

Lying within the Earth's interior is geothermal energy (Geothermal Education Office, 2000). The main uses of geothermal energy, as identified by the Geothermal Energy Information Administration (2009), included feeding heating systems with hot water from beneath the surface and electrical generation from geothermal power plants. According to Pearson (2007), schools utilizing geothermal systems typically save between 20 and 30 cents per square foot in utility cost.

Water conservation, or rainwater harvesting, is accomplished by collecting, storing, and purifying water for reuse (Agua Solutions, 2007). Water is conserved by collecting and reusing graywater generated from washing machines, dishwashers, sinks, and showers or bathtubs (Clark, 2008). Schools can incorporate low-flow plumbing fixtures and limit the amount water used (EPA, 2010: Hounsell, 2008). Additional water conservation measures can include replacing outdated equipment with Energy Star appliances (EPA, 2010: Hounsell, 2008).

The methodology utilized to examine the sustainability of schools was presented in Chapter Three. The analysis of data was presented in Chapter Four. The findings, conclusions, and suggestions were presented in Chapter Five.

Chapter Three – Methodology

School district personnel are challenged by escalating costs and decreasing budgets. School buildings are in various stages of disrepair, and consideration must be given in how to solve this problem. A relationship exists between a healthy school environment and increased student achievement (Katz, 2006; King, 2006; Tucker 2007). Therefore, the overarching questions which emerged where: What impact does the environment have in constructing and operating school facilities? What relationship exists between the learning environment in constructing and operating school facilities?

In this study, the benefits of constructing and renovating school facilities with the concepts of sustainability were examined. The purpose of this study was to determine the value and benefits of implementing energy efficient and sustainable design features in recently renovated or newly constructed school facilities and to ascertain if educational and financial benefits resulted after the school population moved into and operated sustainable school buildings. This study investigated the connection between learning and operating in a sustainable school facility. Quantitative data were collected from school districts' standardized reading scores to determine if students in the new or renovated facilities achieved at a higher rate after occupying the sustainable facility. Two architects were interviewed, providing qualitative data, to garner information surrounding the costs, benefits, and design aspects of renovating and constructing sustainable school buildings.

Research Questions

The purpose of this study was to determine the value of implementing Leadership in Energy and Environmental Design (LEED) certified, energy efficient, and sustainable design features in constructing new and renovating existing school facilities. The following questions guided this study:

1. What commonalities exist between sustainable school facility construction and renovation of LEED certified and Energy Star certified facilities?

2. What cost savings result from constructing or renovating a school facility with energy efficient and sustainability concepts?

3. How have trends in sustainable school facility construction and renovation changed since 2001?

4. What educational benefits were realized from constructing or renovating school facilities with energy efficient and sustainable concepts?

5. What changes have those assisting schools in sustainable construction and renovation of school facilities experienced?

Research Design

This study was a mixed design comprised of quantitative and qualitative data. Quantitative data determines how much of a particular thing exists (Gill & Popp, 2009). Quantitative data consisted of a survey sent to LEED Certified and Energy Star Certified school facility personnel. Additional quantitative data were obtained by collecting district testing data to determine if students in the new or renovated facilities achieved at a higher rate after occupying the sustainable facility.

Qualitative data were collected through face-to-face interviews with two professional architects. Qualitative data is defined by Fraenkel and Wallen (2009) as "direct quotations capturing people's personal perspectives and experiences" (p. 424). The advantages of using qualitative data, according to Bligh (2005), is to understand depth and detail with an emphasis of how and why, not just what.

Population and Sample

This study involved recently renovated or newly constructed school district facilities from across the United States. Ninety-eight LEED certified school facilities completed at the time of this study and 98 Energy Star school facilities were selected to participate in this study. Quantitative and qualitative data were obtained from school facility personnel at the various LEED and Energy Star facilities.

Quantitative.

Fraenkel and Wallen (2009) determined a purposive sampling allows researchers "to select a sample … [that] will provide the data they need" (p. 99). For this study, the purposive sample consisted of LEED certified K-12 facilities. According to the National Clearinghouse for Educational Facilities (2008), from 2001 through 2008, 119 school facilities were constructed that were LEED certified. Of those LEED certified facilities, 21 were early childhood or higher education facilities that do not have adequate yearly progress statistical data; therefore, these were not considered in the sample for this study. The LEED certified group was limited in number, as there were only 98 possible facilities in this group. For accuracy, the entire sample was surveyed (see Appendix G).

School facilities that met criteria for Energy Star exceeded LEED schools by several hundred (Energy Star, 2009). For the purpose of this study, an equal number of LEED and Energy Star school facilities was selected. Identification of these two groups was completely different. The Energy Star certified group was identified in the following manner:

1. Identifying the states in which Energy Star certified facilities were located.
2. Identifying the number of Energy Star certified facilities in each state.
3. Identifying all Energy Star construction in the corresponding states as LEED certified construction.
4. All facilities corresponding with the aforementioned criteria were considered. The field was narrowed down to 98 by random sampling. Selected Energy Star certified facility school administrators were given the survey, with respect to renovation in lieu of new construction, and testing data were gathered (see Appendix H).

Qualitative.

The population for the qualitative portion of this study was comprised of licensed architects located in a mid-western state. One architect practices in the Southwest Missouri region and the other in the Eastern Missouri region. A purposive sampling (Fraenkel & Wallen, 2009) was chosen to assure the architects possessed knowledge of green construction and renovation of facilities, and were "representative of the population" (p. 99). Two experienced architects were interviewed to acquire an understanding of the importance of sustainable design, the complexity of design, and additional costs involved. The responses from the architects contributed to a further understanding of the necessary components to construct or renovate an energy efficient school facility (see Appendix I).

Instrumentation

Quantitative.

Electronic consent forms were sent to all participants prior to the data collection process. This consent form met the approval of the IRB Committee at Lindenwood

University. A survey for sustainable school facility administrators and testing data of students in sustainable schools, was designed and field tested. The survey was presented to school facility administrators in districts where projects have met LEED certification and Energy Star certified efficiency standards. The questions were formatted to address the status of the facility prior to construction or renovation and after completion. School facility administrators were asked to provide information about the planning process, as well as what considerations were given to the decision of using sustainable construction. In addition, school facility administrators were questioned about the financial benefits and attendance rates of students and staff. Student data were accessed from state public-accessed databases to obtain statistical testing data for the students occupying the facilities participating in the survey. Once identified, the financial benefits, testing, and attendance data of these facilities were compared to the data on the facilities prior to construction or renovation. The findings were summarized and analyzed to determine the benefits of green schools.

Qualitative.

Interview questions were developed to gather specific information from the architects. Face-to-face interviews conducted on-site were audio-taped and then transcribed for accuracy. The interview questions were framed to illicit responses from the architects concerning sustainable training and understanding, experience with energy efficient design, perspective of interested school district clients, cost estimating, project timetables, and long-term cost savings. According to Fraenkel & Wallen (2009) qualitative research shows the interest in the quality of a particular topic, as opposed to how many or how often.

Data Collection Process

Quantitative.

The response rate for the surveys sent to LEED Certified facilities was 44.9%. The response rate for the survey sent to Energy Star Certified facilities was 52%. Results were confidential as the survey was sent through an electronic communication with a link to the survey. The survey did not include any personal or identifying questions which would divulge the identity of the participant.

The school facility administrator, responsible for overseeing facility construction from each school district, was contacted through electronic communication. The administrator was sent the survey for completion. Another electronic communication was sent two weeks later to initiate additional response. Statistical data of adequate yearly progress were accessed through school district websites or state department websites.

Qualitative.

Interview responses were electronically recorded with the participant's permission. A transcript of the interview was prepared to assure accuracy of responses. The responses to each of the interview questions were coded to identify key words and main themes.

Data Analysis Procedures

Quantitative.

Data were sorted into the two groups: LEED certified and Energy Star certified facilities. Next, the survey responses were categorized by the following: (a) completion date, (b) project team composition, (c) project timeline, (d) type of facility constructed or renovated, (e) total cost of project, (f) size of facility after the project was complete, (g) student population, (h) utility cost prior to the project and after completion, (i) student attendance prior to the project and after completion, and (j) staff attendance prior to the project and after completion. Figures were developed to show the number of responses to each survey question. Similarly, Adequate Yearly Progress (AYP) data were presented with respect to LEED certified and Energy Star certified school facilities.

Qualitative.

Data from the interviews were used to support information gathered from the survey and testing data. Open-ended questions were used to allow the participants to freely express their opinions and perspectives (Fraenkel & Wallen, 2009). A data coding system was established to insure responses remained confidential. Responses were categorized to determine common ideas and themes.

Ethical Considerations

This study was conducted using quantitative and qualitative data to determine the value and benefits of implementing energy efficient and sustainable design features in constructing new and renovating existing school facilities. There were no risks or sensitive topics related to this study. Confidentiality and anonymity of participants were respected by assigning a data code to each architect.

Summary

This study was conducted from January to June 2010. Once the sample population was identified, information regarding testing data of selected schools was gathered. The survey was disseminated to obtain project planning, size, cost, financial benefit, and staff and student attendance. The educational testing data were analyzed and summarized to determine if students achieved at a higher level after moving into the sustainable facility.

This study examined the development of sustainable school facilities. The purpose of the survey was to determine statistical information about LEED certified and Energy Star certified construction and renovation projects and to examine fiscal savings for utilizing sustainable construction measures. At the time of this study, there were 119 LEED certified school facilities of which 98 were K-12 facilities. School facility administrators in all 98 facilities were sent the survey electronically. Energy Star certified facilities number in the hundreds and 98 were randomly selected to participate in this study. Utilizing testing data, the scores were studied to determine the educational benefit(s) of learning in a sustainable facility. In addition, two certified architects were selected to participate in the study to share their experience and expertise in the development and building of sustainable school facilities.

The analysis of data was presented in Chapter Four. Figures were provided to further illustrate the results of the survey. The findings, conclusions, and suggestions were presented in Chapter Five.

Chapter Four – Analysis of Data

The purpose of this study was to determine the value of implementing Leadership in Energy and Environmental Design (LEED) certified, energy efficient, and sustainable design features in constructing new facilities and renovating existing school facilities. According to the USGBC (2008), "green schools are healthy for kids and conducive to improving their education. Green schools encourage daylight, high indoor air quality, excellent acoustics, and thermal comfort" (para. 2).

The cost of operating school facilities has continued to increase as goods, services, and energy expenses have increased (King, 2006). Some schools have seen expenditures exceed the additional revenue many schools receive (Dekovic, 2006). During this same time, schools across the United States try to identify ways to improve education without large additional expenditures (King, 2006). King (2006) reported, "Green schools cost a little more to build, generally 1% to 2% extra, than conventional schools but promise payback through lower utility bills and, some studies suggest, better student achievement" (para. 1). Katz (2006) added, "additional construction cost is offset and exceeded with the average cost savings in total energy by $7.00 to $9.00 per square foot" (p. 4). The reduction on building utility usage decreases the needed fossil fuels (Katz, 2006).

This study was conducted using LEED Certified and Energy Star Certified school construction projects. Across the United States, from 2001-2008, there were 98 Leadership in Energy and Environmental Design (LEED) certified K-12 schools constructed. During this same time period, there were hundreds of schools certified as Energy Star. Since the number of Energy Star schools outnumbered LEED Certified schools, the Energy Star Certified schools were randomly selected from the Energy Star registry of schools. Of the surveys sent out, 44 of 98 (44.9%) of the surveys sent to LEED Certified schools were returned and 51 of 98 (52%) of the surveys sent to Energy Star Certified schools were returned.

Organization of Data Analysis

This chapter was designed to present the data collected regarding the benefits of constructing or renovating school facilities utilizing sustainability design features. The results presented are for the 44 LEED and 51 Energy Star schools across the United States. Interviews conducted with licensed architects were presented to determine experiences and commonalities of sustainable construction and renovation projects.

Research Questions

The following research questions were posed for this study.

1. What commonalities exist between sustainable school facility construction and renovation of LEED certified and Energy Star certified facilities?
2. What cost savings result from constructing or renovating a school facility with energy efficient and sustainable concepts?
3. How have trends in sustainable school facility construction and renovation changed since 2001?
4. What educational benefits were realized from constructing or renovating school facilities with energy efficient and sustainable concepts?
5. What changes hove those assisting schools in sustainable construction and renovation of school facilities esperienced?

Analysis of Quantitative Data

Survey questions were posed to 196 LEED and Energy Star certified schools across the United States. The results were used to determine trends, characteristics, and benefits in constructing sustainable schools. Then, the data were converted to figures.

Survey Question 1. What was the completion date of your LEED or Energy Star facility?

According to one architect, A1, the green movement started to gained momentum ten years ago. In 2001, of the schools surveyed, only one was built or renovated to meet LEED certification and two were built or renovated to meet Energy Star certification (see Figure 1). Compared to 2008, of the schools surveyed, 29 were built or renovated to meet LEED certification and 28 were built or renovated to meet Energy Star certification. Over the course of eight years, there were 2,900% more LEED school facilities constructed and 1,400% more Energy Star school facilities constructed.

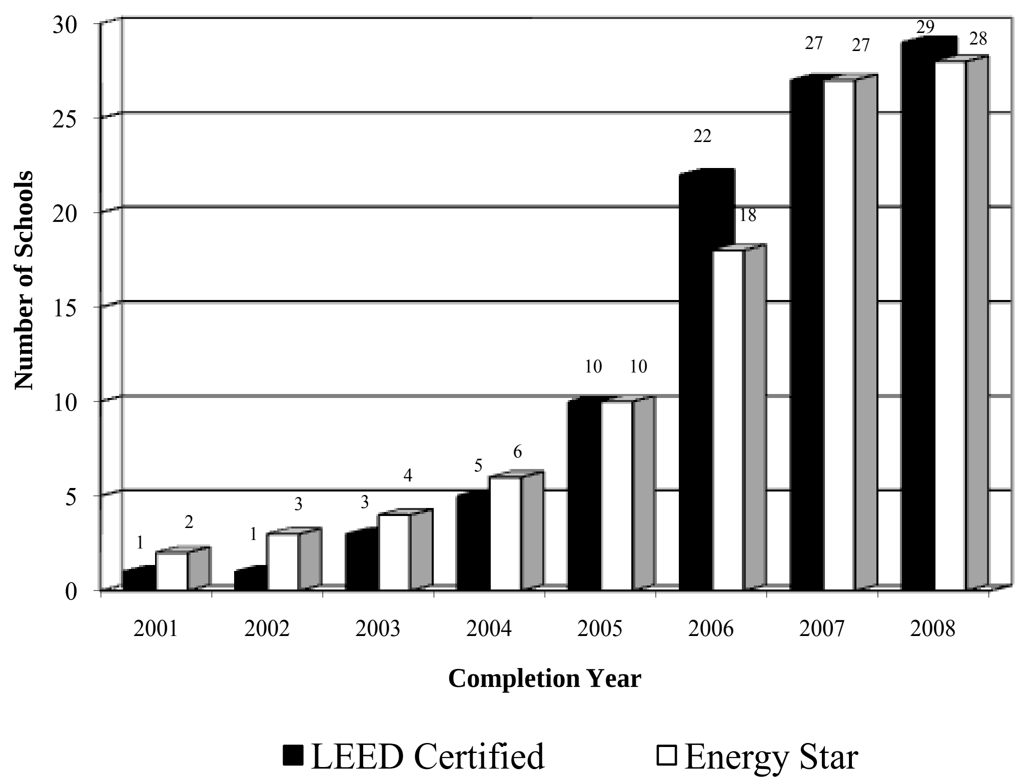

Figure 1. Completion year of projects.

Survey Question 2. Who was included on the project planning team?

The type of participant involved in the planning process for LEED and Energy Star school facilities varied from school to school (see Figures 2 and 3). The majority of all project planning teams for LEED (88.64%) and Energy Star (62.75%) schools included a member of the district central office. LEED facilities included a large percentage of staff (59.09%) and board (65.91%) members, followed by the facility director (47.73%), others (43.18%) which could include architects, engineers, and/or consultants, followed by community members (31.82%). Energy Star facilities included a large percentage of staff members (72.55%) and facilities directors (60.78%), followed by board members (41.18%) and an equal number of community members and others (27.45%).

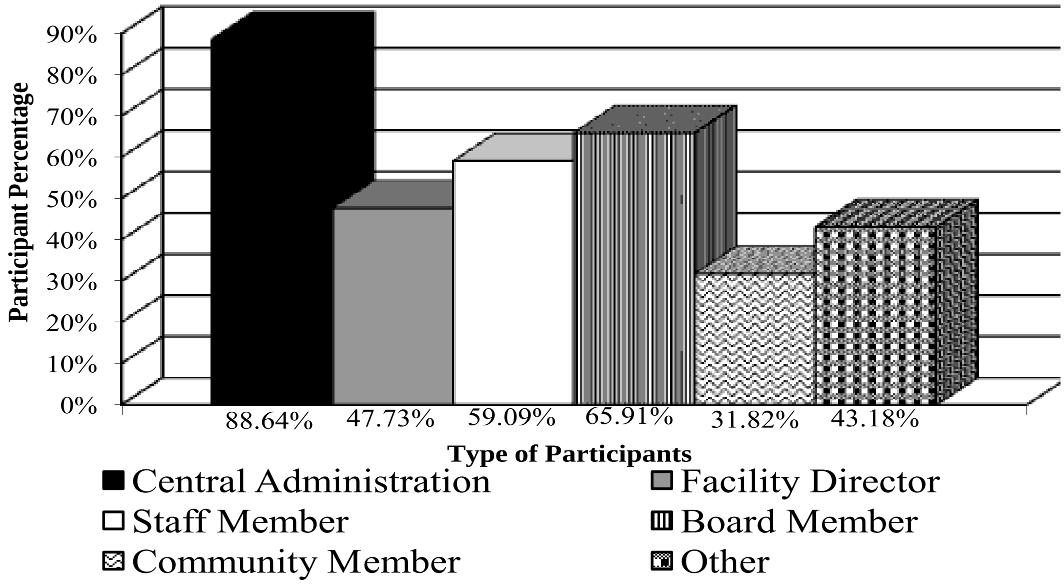

Figure 2. Planning team for LEED facilities.

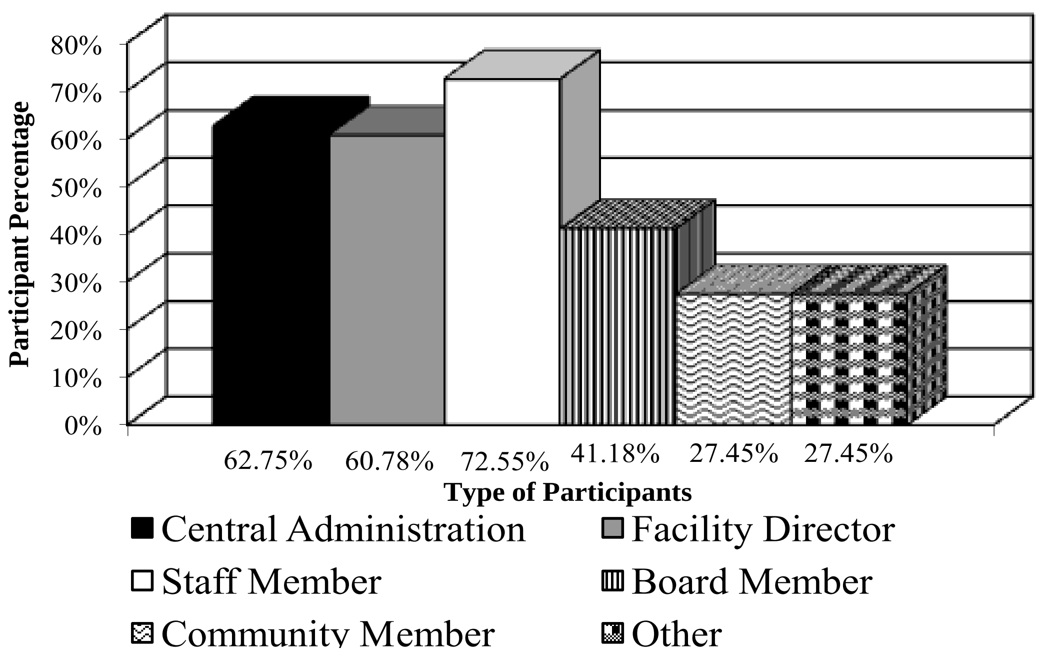

Figure 3. Planning team for Energy Star facilities

Survey Question 3. What was the length of time used for planning the project?

In the planning and development of LEED and Energy Star school facilities, the most common time spent for planning was 6 to 9 months: 47.73% for LEED facilities and 32.65% for Energy Star facilities (see Figures 4 and 5). The least common planning time was 12 to 18 months, 6.82% for LEED facilities and 14.29% for Energy Star facilities. Between 20% and 27% of the time both LEED and Energy Star facilities were planned in 3 to 6 months or 9 to 12 months.

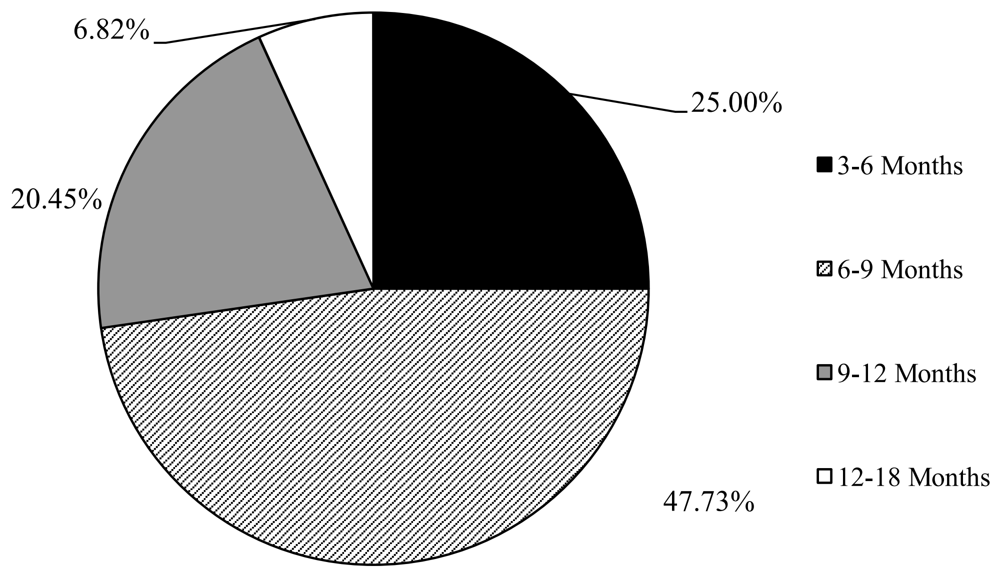

Figure 4. Project planning time for LEED facilities.

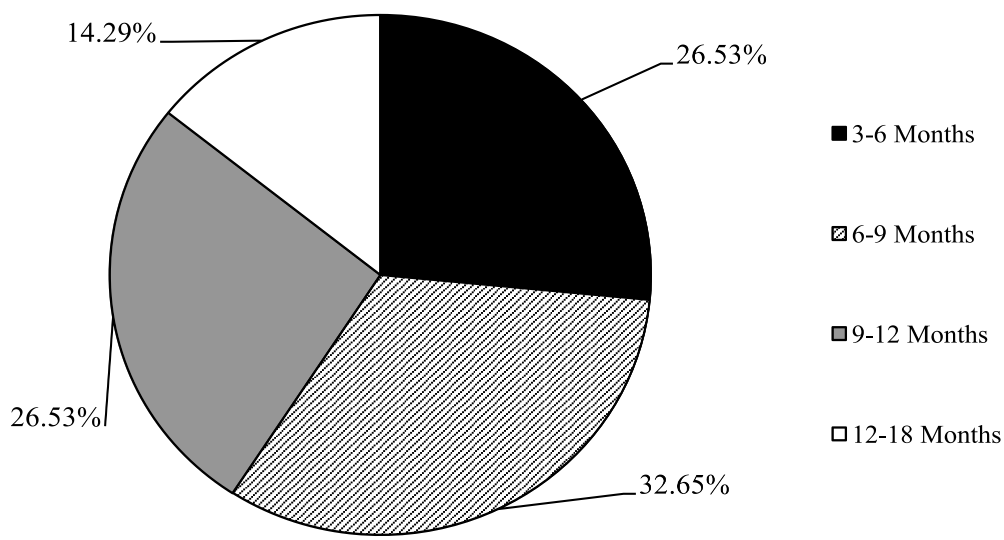

Figure 5. Project planning time for Energy Star facilities.

Survey Question 4. What type of facility was constructed or renovated?

The most common facility constructed or renovated of the schools surveyed were LEED (47.73%) and Energy Star (49.02%) elementary schools (see Figure 6). The least common facilities constructed or renovated were LEED (9.09%) and Energy Star (5.88%) primary school. Of the remaining LEED schools surveyed, 31.82% were secondary schools and 11.36% were combined elementary and secondary facilities. Of the remaining Energy Star schools surveyed, 35.29% were secondary and 9.80% were combined elementary and secondary facilities.

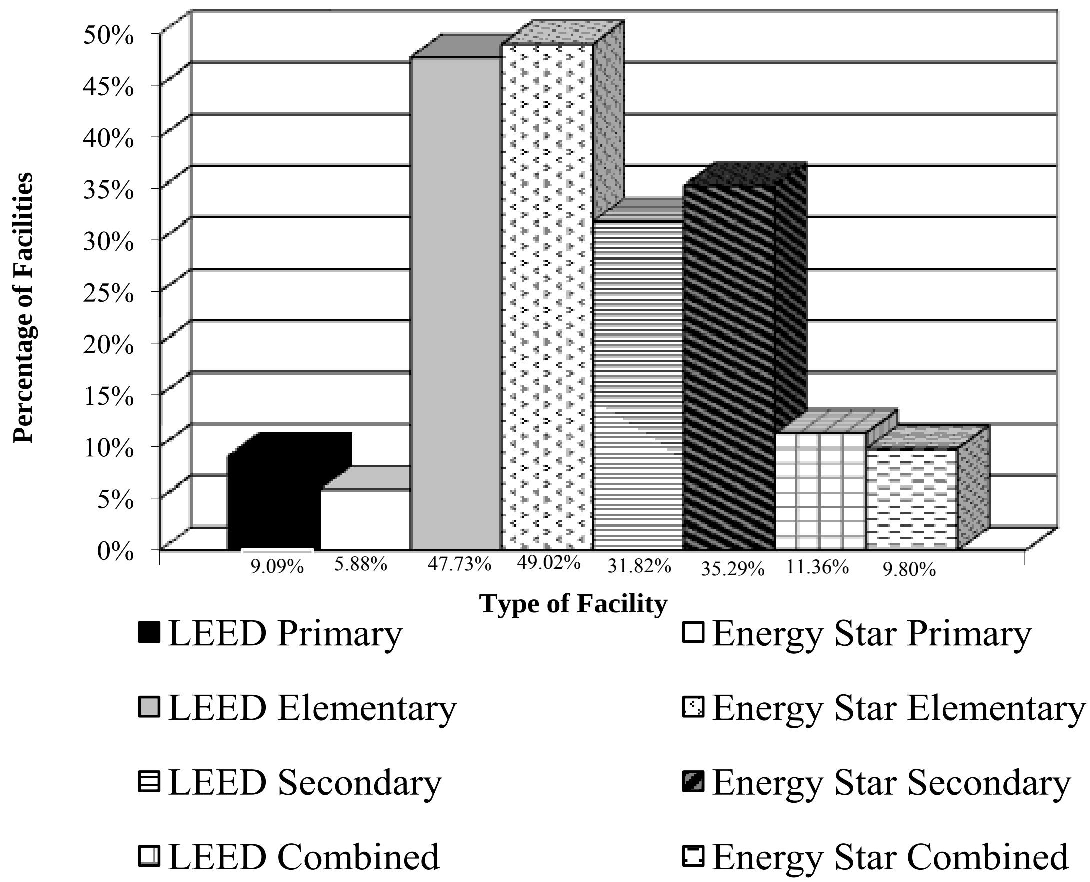

Figure 6. Facility type.

Survey Question 5. What is the approximate total cost of project?

Construction or renovation costs ranged from less than $500,000 to more than $20,000,000. Within this range, there were no LEED facilities constructed for less than $1,000,000. The majority, or 36.36% of LEED facilities constructed ranged from $5,000,000 to $10,000,000, followed by 31.82% in the range of $10,000,000 to $20,000,000. Facilities that cost in excess of $20,000,000 made up 18.18% and those ranging from $1,000,000 to $5,000,000 made up 13.64% of all LEED schools surveyed. The majority, or 41.48% of Energy Star facilities constructed ranged from $1,000,000 to $5,000,000, followed by 21.57% in the range of $5,000,000 to $10,000,000. There were 17.65% of the facilities that cost between $500,000 and $1,000,000. Facilities that cost in excess of $20,000,000 and facilities that ranged from $0 to $500,000 each made up 7.84%. Facilities that ranged from $10,000,000 to $20,000,000 consisted of 3.92% of all Energy Star schools surveyed (see Figure 7).

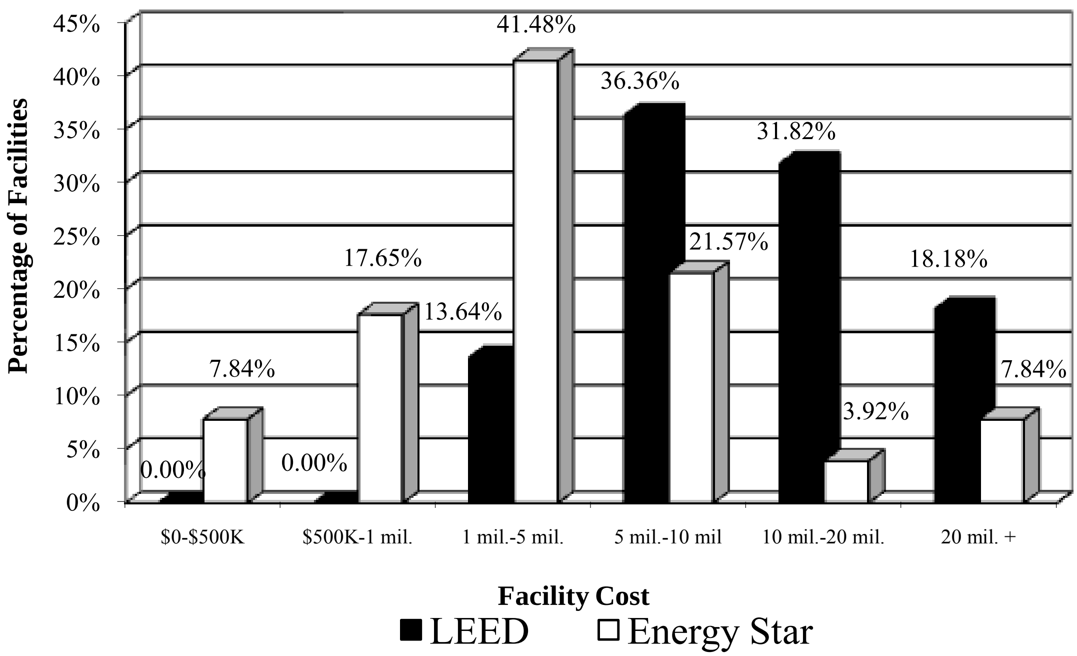

Figure 7. Facility cost.

Survey Question 6. What is the facility square footage size?

The majority, or 27.45% of LEED certified facilities constructed ranged in size from 30,000 to 50,000 square feet. Facilities ranging in size of 50,000 to 70,000 square feet consisted of 23.53% of schools surveyed. 15.69% of LEED facilities were between 70,000-100,000 square feet. Small facilities up to 30,000 square feet totaled 13.71% and those from 100,000 to 150,000 square feet and those in excess of 150,000 each made up 9.8% of LEED school facilities surveyed. The majority, 68.2% of Energy Star facilities renovated or constructed ranged in size from 100,000 to 150,000 square feet. facilities from 50,000 to 70,000 square feet totaled 38.64% followed by facilities from 70,000 to 100,000 square feet at 25%. Energy Star facilities ranging from 30,000 to 50,000 square feet consisted of 18.18%, and those in excess of 150,000 square feet made up 11.36% of Energy Star school facilities surveyed. There were no Energy Star schools surveyed less then 30,000 square feet in size.

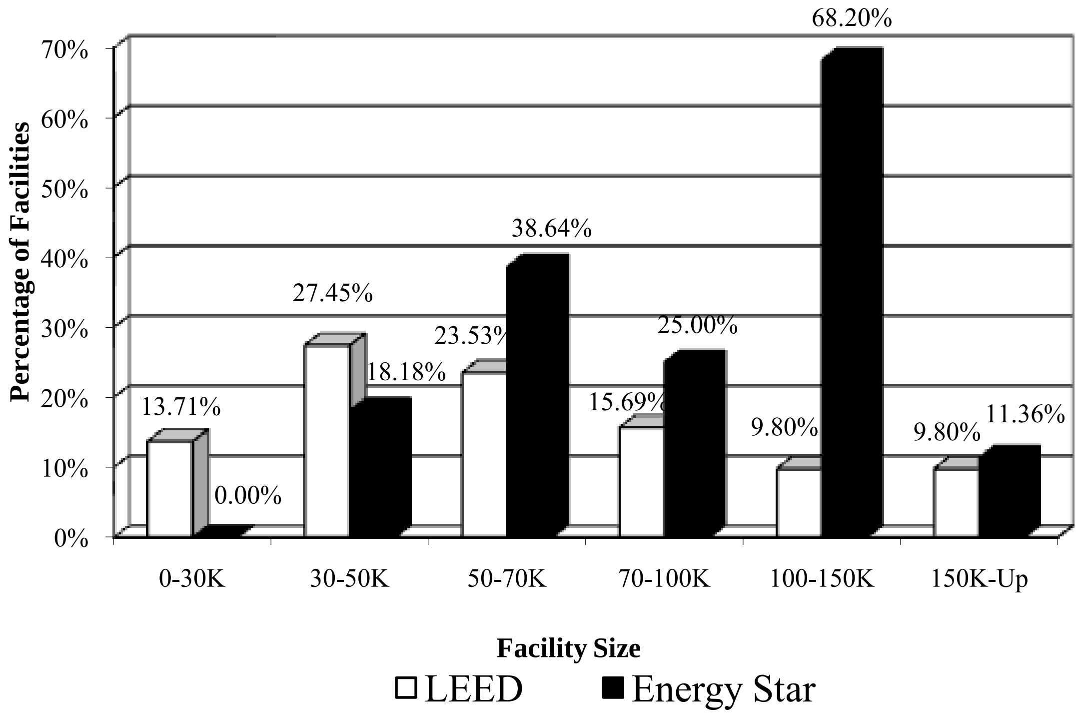

Figure 8. Facility size.

Survey Question 7. What is the student population housed in the facility?

The most common, at 61.36%, LEED certified facility housed a student population ranging between 500 and 750. Facilities with student populations up to 300, and those from 300 to 500 each made up 9.09% of all facilities surveyed. Facilities from 1,000 to 1,500, and those in excess of 1,500 students each made up 6.82% of LEED school facilities surveyed. The most common, at 25.49%, Energy Star certified facility housed a student population ranging between 300 and 500 students. Facilities with student populations between 750 and 1,000 students' totaled 23.53%, and 21.57% of the Energy Star facilities reported a student population between 500 to 750. Facilities between 1,000 and 1,500 in student population consisted of 11.76% while those with a population up to 300 made up 9.8%. Energy Star facilities with a student population in excess of 1,500 students totaled 7.84% (see Figure 9).

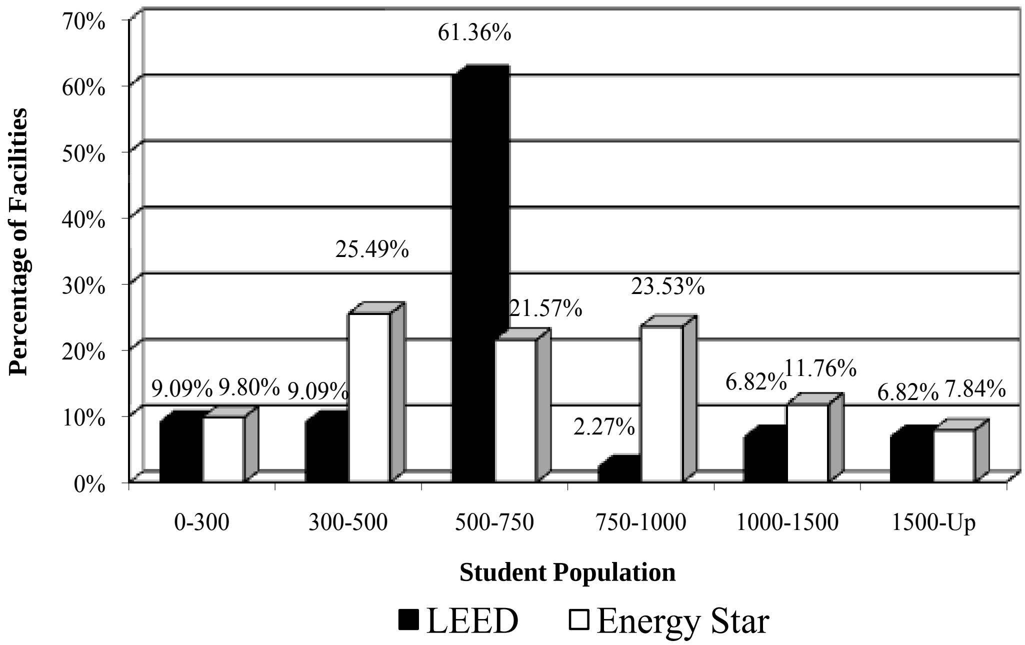

Figure 9. Facility student population.

Survey Question 8. Please enter the total utility cost for the facility the year prior to construction/renovation and the utility cost the year after construction/renovation.

Figure 10 represents the average utility cost decrease. Katz (2006) conducted a study in which he observed "green schools use an average of 33% less energy than conventionally designed schools" (p. 4). Districts utilizing sustainable construction realized financial benefits by using reduced amounts of resources to operate the facility (SOSI, 2008). School facility administrators from LEED schools reported utility costs decreased by an average of 19.41% the first year of occupying the newly constructed or renovated facility. School facility administrators from Energy Star schools reported utility costs decreased by an average of 20.62% the first year of occupying the newly constructed or renovated facility.

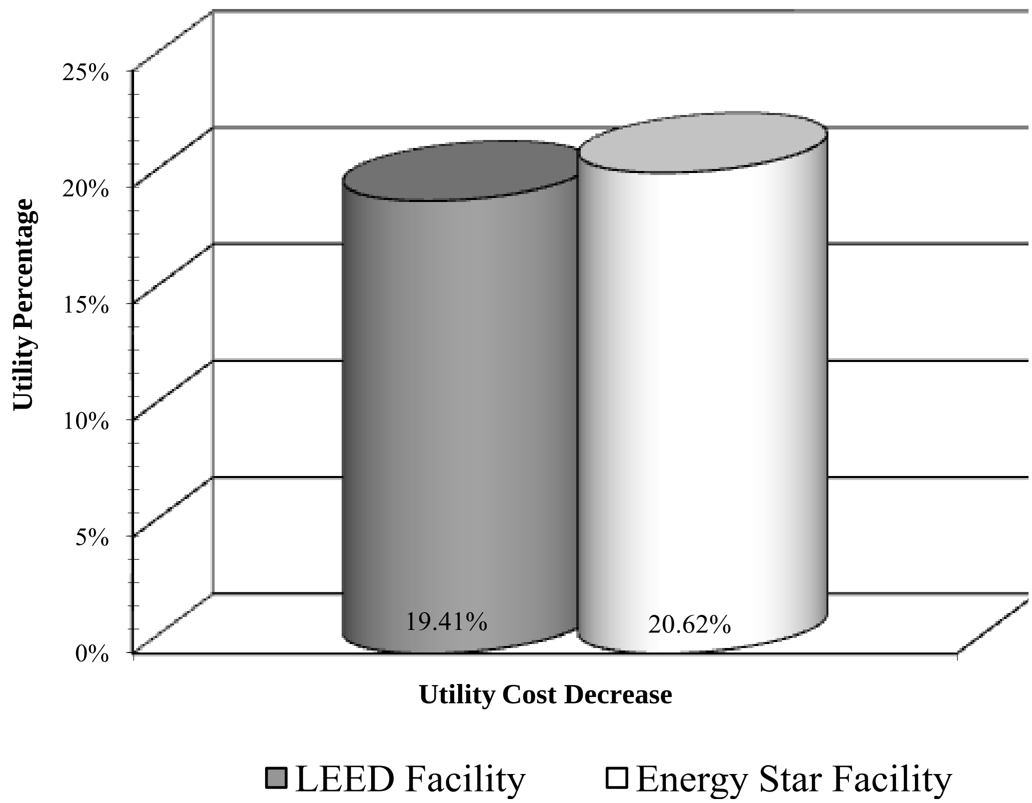

Figure 10. Utility cost.

Survey Question 9. Please enter the total student attendance percentage of the facility for the year prior to construction/renovation and the year after construction/renovation.

The attendance rates for LEED primary facilities increased 1.5%, elementary increased 2.45%, secondary increased 1.43% and combined elementary and secondary facilities increased 2.34%. The average student attendance increase for LEED constructed or renovated facilities was 2.22%. The attendance rates for Energy Star primary facilities increased 2.0%, elementary increased 1.35%, secondary increased 1.46% and combined elementary and secondary facilities increased 0.25%. The average student attendance increase for Energy Star constructed or renovated facilities was 1.44% (see Figure 11).

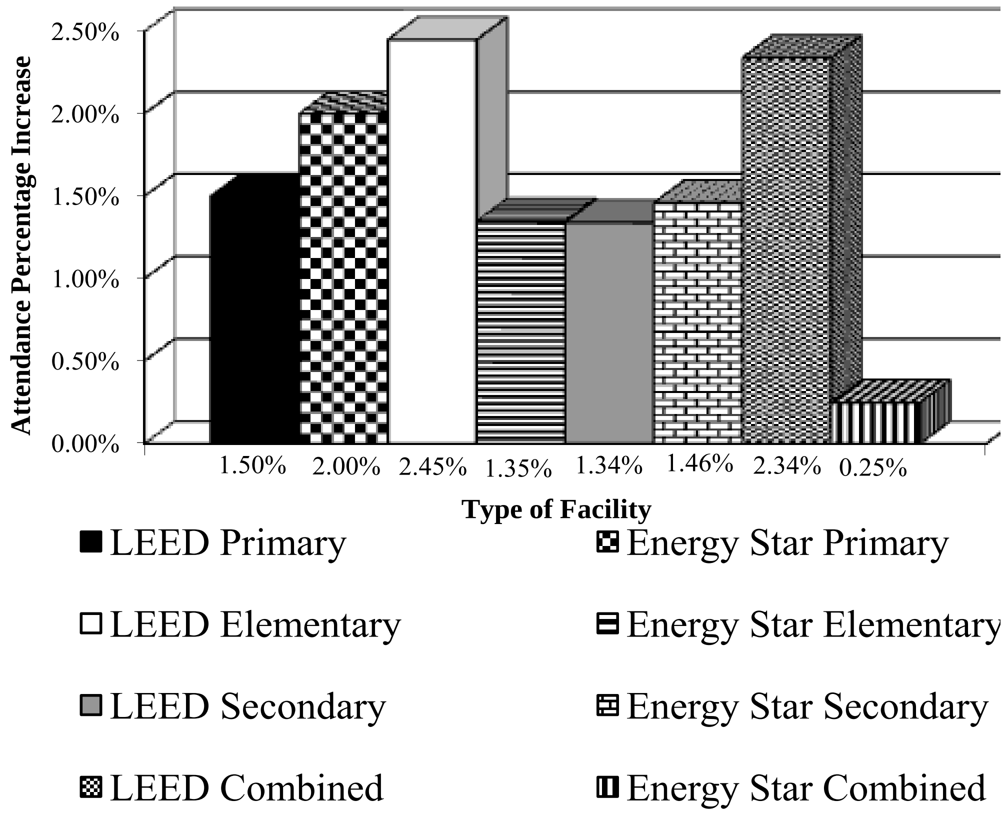

Figure 11. Student attendance.

Survey Question 10. Please enter the staff attendance percentage the year prior to construction/renovation and the year after construction/renovation.

The USGBC (2008) reported, "Green schools commonly report reductions in teacher absenteeism and teacher turnover." (p. 3) With the exception of LEED primary school facilities, all categories of LEED and Energy Star facilities reported an increase in staff attendance. The overall average of staff attendance in the newly constructed or renovated LEED facility increased 1.82%. LEED combined facilities increased 3.5% followed by elementary (1.83%), and secondary (1.5%). The overall average of staff attendance in the newly constructed or renovated Energy Star facility increased .89%. Energy Star primary facilities increased 2.5% followed by elementary (0.89%), secondary (0.71%), and combined (0.5%) facilities (see Figure 12).

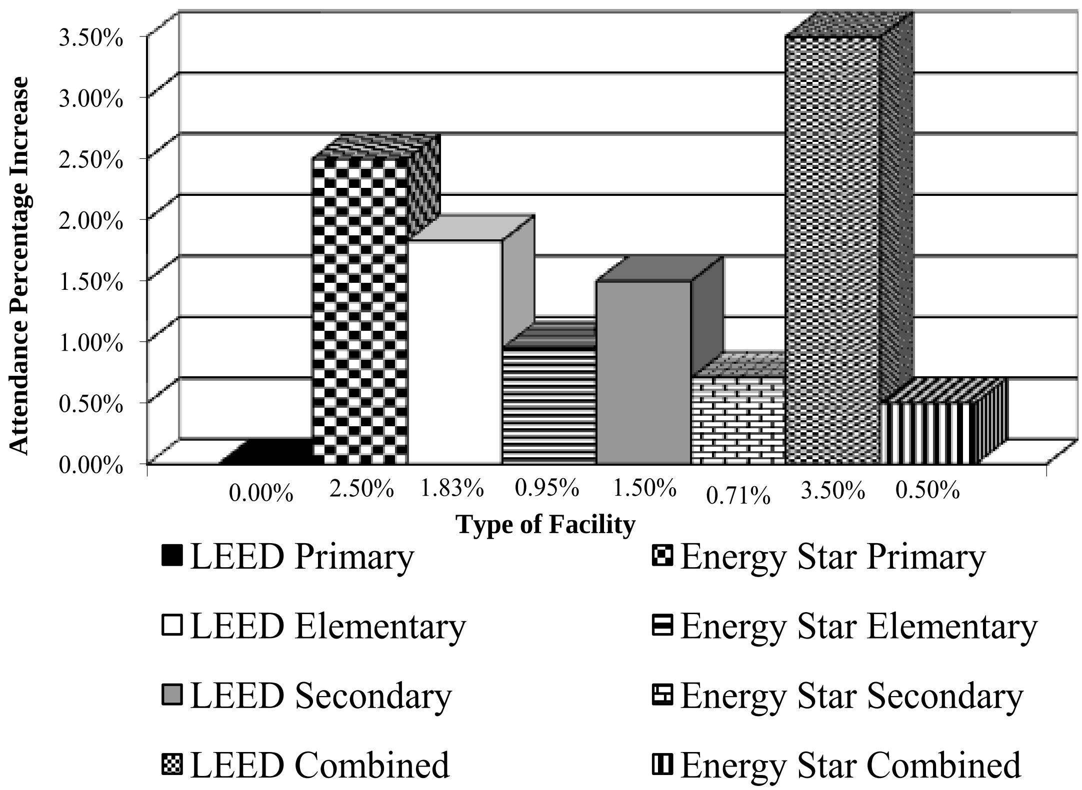

Figure 12. Staff attendance.

Sustainable or green building design demonstrated a positive relationship between the improved environment and higher student achievement (Iffrig, 2009). According to the USGBC (2008), benefits of sustainable construction can include improved student test scores. In comparing results from student test scores the year prior to learning in a sustainable school and the first year learning in a sustainable school (see Figure 13), LEED school facilities averaged an increase of 2.31% in the number of students who performed at or above proficient in reading. Energy Star school facilities averaged an increase of 2.16% in the number of students who performed at or above proficient in reading.

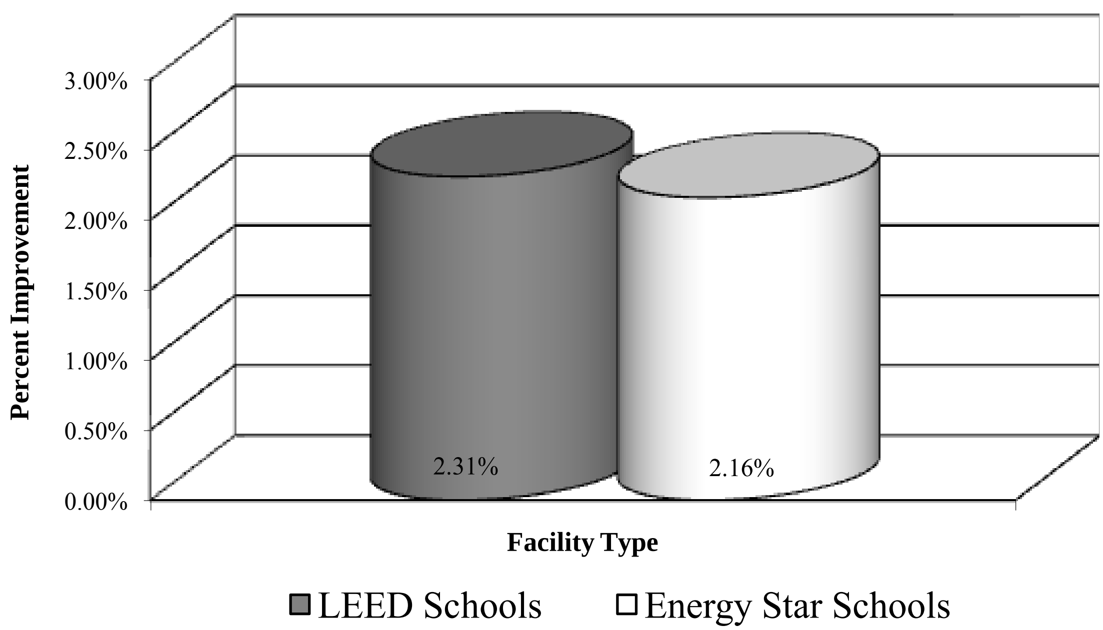

Figure 13. Students proficient and above

Analysis of Qualitative Data

Two licensed architects, referred to as Architect 1 (A1) and Architect 2 (A2) for the purpose of this study, were interviewed in the spring, 2010, to gather supporting information for this study. A series of questions were used to obtain their specific perceptions and experiences in sustainable construction. The responses were transcribed to assure accuracy, than coded to identify common themes.

Interview Question 1. Have you had specific training or education for designing and developing LEED certified or energy efficient school facilities?

Licensed architects are required to participate in continuing education courses to keep their license current. A1 and A2 referred to many of the continuing education courses focusing on green building and LEED building concepts in an effort to preserve the environment. A2 currently has LEED certification and A1 is preparing to take the LEED certification testing later this year.

Interview Question 2. What experience do you have in planning, developing, and constructing sustainable school facilities?

Neither architect has developed a LEED certified school facilities; however, both have incorporated sustainability concepts into the development of school facilities. A1 stated "we make every effort to incorporate sustainable and energy efficient elements into every project we participate in" (p. 1, line 11). A1 added that current budget constraints have caused school districts to scrutinize building budgets and not consider additional front-end project costs.

A2 pointed out that schools must consider the concept of sustainability district wide to understand the value. Furthermore, A2 (2010) stated, "We have developed and implemented green policies for school districts to focus on lessening their footprint and saving resources" (p. 1, line 28). A2 continued to add that for school personnel to build a sustainable facility, they must understand the thought process of sustainability.

Interview Question 3. What knowledge base do you see from school personnel interested in sustainable school facilities?

The architects acknowledged there are many resources such as conferences, written literature, and consultants for school personnel to access information about sustainable information. Learning sustainability and conserving allows for the understanding of sustainability. According to A2 (2010), "those interested understand and to understand, they must know what a sustainable site looks like, understanding efficiency inside and outside of the building" (p. 2, line 16). Sustainability goes beyond just building a highly efficient facility, the operation of that facility must be understood and allowed to operate as designed to maximize efficiency.

Interview Question 4. In cost estimating, what trends do you see in pricing sustainable products and concepts in school facilities?

The cost gap has narrowed to 2% - 5% from 10% - 20% from ten years ago. When the green movement began, there were only were only a few companies that manufactured sustainable products, driving the cost of them up (A1). The climate for building sustainable facilities is ideal for these concepts because products have been mainstreamed into the regular construction industry resulting in a minimal increase for the premium (A2).

Interview Questions 5. What additional time is needed for design and construction of sustainable products?

The design of a sustainable facility is more intensive because education of a facility and its operation must be understood by those involved in operating the facility (A2). The quality in the planning of sustainable facilities is critical. If facilities are planned to meet LEED standards, the time needed for completion will take longer as it is more involved, however, if just incorporating sustainable features, once the facility operation is understood, the design and construction follows similar timelines as non-sustainable projects (A1).

Interview Question 6. What long-term cost savings have you seen in facilities you have designed and constructed?

A2 (2010) stated, "The most important thing to focus on is what is best for the students and what will improve their educational atmosphere, the secondary focus is how the building is good for everyone else" (p. 3, line 25). There are many sustainable components that can be easily identified to show cost savings (A1). Once design criterion is completed, items such as HVAC can be monitored to show savings in performance (A1).

The final source of data gathered to show how sustainable facilities improve education, was looking at state standardized testing scores. The following information represents the average increase in test scores for students at proficient or above minimum testing standards.

Summary

Data for the analysis were gathered from LEED and Energy Star certified schools constructed from 2001 through 2008 across the United States. School facility administrators were sent a survey to determine cost benefits and potential educational value of a sustainable school facility. The majority of facilities surveyed were elementary and secondary schools costing between $1,000,000 and 10,000,000 dollars. For both LEED and Energy Star certified construction and renovation projects, utility costs decreased by over 19%. In reference to attendance, the attendance for students and staff members improved for LEED and Energy Star schools surveyed.

The architects interviewed supported the survey data with specific examples of how operating sustainable facilities saves money. These interviews provided historical information about the recent evolution of incorporating sustainable building materials, explaining these materials are more readily available in the competitive market.

The final component for data analysis was the comparison of standardized testing scores for each facility in the study. Student proficiency scores improved from the previous non-sustainable facility to scores for the first year in the new sustainable facility. This was based on the percentage of students meeting or exceeding proficiency levels. The findings, conclusions, and suggestions were presented in Chapter Five.

Chapter Five – Findings, Conclusions, and Suggestions

The purpose of this study was to determine the value of implementing Leadership in Energy and Environmental Design (LEED) certified, energy efficient, and sustainable design features in constructing new and renovating existing school facilities. A summary of this includes results of the study, conclusions based on the results, suggestions of additional components for the study, and offer recommendations for continued study.

Summary of the Study

The cost of operating school facilities has continued to increase as goods, services, and energy expenses have increased (King, 2006). Some schools have seen expenditures exceed the additional revenue many schools receive (Dekovic, 2006). During this same time, schools across the United States try to identify ways to improve education without large additional expenditures (King, 2006). The overarching question becomes, then, what impact does the environment have on constructing and operating school facilities, and, at the same time, what relationship exists between the learning environment and constructing and operating school facilities? King (2006) reported, "Green schools cost a little more to build, generally 1% to 2% extra, than conventional schools but promise payback through lower utility bills and, some studies suggest, better student achievement" (para. 1). The reduction on building utility usage decreases the needed fossil fuels (Katz, 2006). For the purpose of this study, data collected included, (a) survey information from LEED certified and Energy Star certified schools (b) interviews of two experienced architects, and (c) student proficiency data. The following research questions were posed for this study:

1. What commonalities exist between sustainable school facility construction and renovation of LEED certified and Energy Star certified facilities?

2. What cost savings result from constructing or renovating a school facility with energy efficient and sustainable concepts?

3. How have trends in sustainable school facility construction and renovation changed since 2001?

4. What educational benefits were realized from constructing or renovating school facilities with energy efficient and sustainable concepts?

5. What changes have those assisting schools in sustainable construction and renovation of school facilities experienced?

Literature related to this study included, historical information about sustainability principles, guidelines for the development of LEED certified and Energy Star certified facilities, the benefits of constructing and renovating sustainable school facilities, and various concepts that could be included in the construction or renovation process.

The population sample for this study included 98 LEED certified and 98 Energy Star certified school facilities that have been constructed or renovated from 2001 to 2008. The sampling number was determined by the total number of LEED certified schools facility projects completed during this time. The response rate from the survey sent to all ninety-eight LEED schools was 45%. The response rate from the survey sent to all ninety-eight Energy Star certified schools was 52%.

Results

Survey results showed that LEED certified school facilities constructed or renovated during the timeframe from 2001 to 2008 increased 2,900% and 1,400% for

Energy Star certified facilities over the same timeframe. These facilities included various stakeholders as part of the planning team and the majority of these stakeholders planned their respective projects between six and nine months. Nearly 50% of all LEED and Energy Star projects were elementary schools with a cost ranging between one and ten million dollars. The majority of LEED projects ranged from thirty thousand to seventy thousand square feet with a population of three hundred to five hundred students. The majority of Energy Star certified projects ranged from one hundred thousand to one hundred and fifty thousand square feet with a population of five hundred to seven hundred and fifty students. Utility costs for both certified classification facilities decreased in excess of 19%. The student attendance percentage increased over all by 1.91% for LEED certified facilities and 1.27%. The staff attendance percentage increased over all by 1.71% for LEED certified facilities and 1.16%. Student performing at proficient or above increased by 2.25% in LEED certified facilities and 2.16% in Energy Star certified facilities.

Conclusions

Research Question 1. What commonalities exist between sustainable school facility construction and renovation of LEED certified and Energy Star certified facilities?

In both groupings, central office personnel and district staff members were the majority voice on facility planning teams. The planning time of new or renovated facility took six to nine months, a majority of the time. LEED (47.73%) and Energy Star (49.02%) elementary facilities were the most common constructed or renovated facility. The student population affected by sustainable school facilities ranged from three hundred to one thousand in 72.85% of LEED certified facilities and 60.59% of Energy Star certified facilities.

Research Question 2. What cost savings result from constructing or renovating a school facility with energy efficient and sustainability concepts?

Sustainability in design has become the norm in the design industry taking no additional time yet leading to long-term operating cost saving (A1, 2010). LEED schools surveyed reported utility costs decreased by 19.41% the first year of occupying the newly constructed or renovated facility. Energy Star schools surveyed reported utility costs decreased by 20.62% the first year of occupying the newly constructed or renovated facility.

Research Question 3. How have trends in sustainable school facility construction and renovation changed since 2001?

In recent years, sustainability has become the focus for consultants, facility publications, and continuing education (A1, 2010). In 2001, of the 196 schools surveyed, there was one reported LEED construction or renovation and two reported meeting Energy Star certification. In 2008, 29 reported construction or renovation meeting LEED certification and 28 reported construction or renovation meeting Energy Star certification. This represented an increase of 2,900% more LEED certified facilities and 1,400% more Energy Star certified facilities.

Research Question 4. What educational benefits were realized from constructing or renovating school facilities with energy efficient and sustainable concepts?

LEED school facilities averaged an increase of 2.25% in the number of students who performed at or above proficient in reading. Energy Star school facilities averaged an increase of 2.16% in the number of students who performed at or above proficient in reading. Student attendance increased in all subgroups for LEED facilities ranging form and increase of 1.34% in secondary facilities to an increase of 2.45% in elementary facilities. Staff attendance in newly constructed or renovated LEED facilities increased as well ranging from an increase of 1.50% in secondary facilities to 3.50% in K-12 facilities. Increases were seen in all subgroups of students and staff attendance of Energy Star facilities as well. Student attendance increased from 0.25% in K-12 facilities to 2.00% in primary facilities. Staff attendance ranged from an increase of 1.50% in secondary facilities and 3.50% in K-12 facilities.

> Some schools have realized the educational value in design and incorporating teaching features of sustainable designs. Schools have constructed sustainable facilities that show occupants how the systems work as well as design components of their curriculum to educate students as to how the facilities operated efficiently (A1, p. 2, line 13, 2010).

A2 (2010) added, "we have developed and implemented green policies for school districts to focus on lessening their footprint and saving resources." (p. 1, line 28)

Research Question 5. What changes have those assisting schools in sustainable construction and renovation of school facilities experienced?

Licensed architects are required to take 18 learning credits per year to maintain certification (A1, 2010). Many offerings center around sustainability and energy efficient design (A1, 2010). A2 (2010) has completed the design accreditation LEED and have been incorporating sustainability in designs since the late 1980's. Neither architects interviewed have designed a LEED certified school facility, however both continually incorporate energy efficiency and sustainability in their designs.

Suggestions

1. In an effort to increase validity of results, expanding student achievement data could be expanding to include other subject areas and the results of this information, comparing scores in the final year of the old facility and scores in the first year of the new facility.
2. In obtaining a true cost benefit of sustainable measures, doing this study by regions of the country. This study reached across the country for all LEED certified schools constructed and renovated between 2001-2008 and an equal number of Energy Star certified schools completed during the same time-period. By breaking it down by regions, the study could focus on specific energy efficient measures and determine benefits to those measures. This being done by regions because different regions of the country cater to different operations of efficiency.

Recommendations

Based on the results of this study, the following recommendations are offered:

1. The study should be furthered to include schools building to sustainability from 2008 to the present. Research showed this concept is gaining in

popularity, educational benefits are present, and materials for construction are more streamlined. Continued study to include schools constructed and renovated from 2008 through 2010 will continue to clarify results of constructing sustainable school facilities.

2. Comparing this study to the future study including LEED and Energy Star facilities from 2008 through 2010 to show validation.
3. Continued research to include other concepts (solar or wind) of sustainability and what benefits could result from those concepts.
4. Expanding statistical data collection to include other core areas of educational study. While scores improved in the area of reading at or above proficiency, validity could be added by incorporating Mathematics and science testing results.

Summary

The purpose of this study is to determine the value and benefits of implementing energy efficient and sustainable design features in constructing new and renovating existing school facilities. Survey results showed that LEED certified school facilities constructed or renovated during the timeframe from 2001 to 2008 increased 2,900% and 1,400% for Energy Star certified facilities over the same timeframe. While this type of school facility construction and renovation increased in popularity, the financial benefits were realized in the streamlining in costs and the energy savings, in excess of 19% realized in the first year of operation. Educational benefits were realized through increases in student and staff attendance rates and an increase in students performing at or above proficient levels in the area of reading.

Appendix A

USGBC Program Requirements

1. The project building or space, all other real property within the project boundary, and all project registrations must comply with all applicable federal, state, and local building-related environmental laws and regulations in place where the project is located.
2. The entire project must be designed for, constructed on, and operated on a permanent location on already existing land.
3. The project boundary must include all contiguous land that is associated with and supports normal building operations for the project building, including all land that was or will be disturbed for the purpose of the project.
4. The project must include a minimum of 1,000 square feet (93 square meters) of gross floor area.
5. The project must serve one or more full time equivalent (FTE) occupant(s).
6. All certified projects must commit to sharing with USGBC all available actual whole-project energy and water usage data for a period of at least 5 years.
7. The gross floor area of the project building must be no less than 2% of the gross land area within the project boundary. (USGBC, 2009, p. 2)

Appendix B

Energy Star Recommendations for Energy Savings

1. A retrofit commissioning study to identify facility equipment that is not operating at maximum efficiency.
2. Lighting represents about 26 percent of electricity consumption in a typical school, not including its impact on cooling loads. Lighting retrofits can save as much as 30 to 50 percent of lighting energy, plus 10 to 20 percent of cooling energy.
3. Load reduction measures that reduce the operational time or intensity of HVAC (heating, ventilation, and air conditioning) equipment while still maintaining a comfortable work environment can offer substantial savings. Plug loads from equipment such as computers and copiers represent about 20 percent of electricity used in education buildings. Cooking equipment represents a much smaller portion of total energy used by schools, but equipment purchases and operational measures for school kitchens can be very cost-effective. When purchasing these types of items, look for Energy Star qualified products, which use 10 to 50 percent less energy than conventional models without compromising quality or performance. Not only do they offer significant return on investment because of these savings, many also feature longer operating lifetimes and lower maintenance requirements.
4. On average, ventilation systems consume seven percent of the electricity used in education buildings. Savings can be found by installing efficient fan motors and sizing the system to match the load (which may now be lower due to other measures that have already adopted). Even more savings are possible by using energy-recovery equipment and variable speed drives.

5. Together, heating and cooling represent over half of the energy used by schools. In most climates, the boiler is typically the largest single piece of energy-using equipment in a school. Energy Star qualified boilers use about 10 percent less energy than standard equipment. Alternative heating and cooling technologies offer as much as 50 percent energy savings. (Energy Star, 2009, pg. 2)

Appendix C

President's Council on Sustainable Development Goals

1. Establishing a common set of goals which define the terms of sustainability and indicators for monitoring progress toward achieving goals.
2. Reforming the environmental management system and building a new framework based on performance, flexibility, and responsibility.
3. Providing formal and informal education, increasing awareness and ability to make environmentally conscious decisions.
4. Developing community driven strategic planning to improve community and building design.
5. Serving as stewards of natural resources. Developing collaborative approaches for coexistence of humans and natural resources.
6. Developing a plan for future population growth and sustainability of natural resources as the United States expands, requiring the use of additional natural resources.
7. Serving as international leaders with policies, procedures, and practices for creating and maintaining a sustainable environment. (President's Council on Sustainable Development, 1996)

Appendix D

Institute for Research and Innovation in Sustainability Principles

1. Principle One determines a vision of sustainable development, establishing clear goals and definition of the vision.
2. Principal Two envisions considerations being made for the well-being of social, ecological, and economic systems and the interaction of systems with consideration of positive and negative consequences of human activity.
3. Principle Three considers the current and potential future populations and development, along with the resource usage and access to necessary resources for sustainability.
4. Principal Four determines adequate scope with consideration to timeline and impact, assessing space and ecosystems of area being considered.
5. Principal Five organizes the frameworks that link vision to goals.
6. Principle Six creates accessibility of all data and materials to every stakeholder by allowing all assumptions, uncertainties, and interpretations of data collected available.
7. Principle Seven incorporates stakeholders and open communication ensuring the facility is designed to address the needs of those who use it.
8. Principle Eight involves participation of interested parties to include, but not limited to, professional, technical, and social groups ensuring recognition of a diverse and ever-changing population.
9. Principle Nine requires continuous assessment throughout the project allowing for change and uncertainty. This accommodates needed adjustments for users and the environment.

10. Principle Ten concludes the aforementioned assessment with continuous support in decision making, providing data collection, maintenance, and documentation; supporting the assessment (Institute for Research and Innovation in Sustainability, 2004).

Appendix E

USGBC Checklist

LEED for Schools 2007
Registered Project Checklist

Project Name: ______________________

Project Address: ______________________

Yes	?	No			
			Project Totals (Pre-Certification Estimates)		79 Points
			Certified: 29-36 points **Silver**: 37-43 points **Gold**: 44-57 points **Platinum**: 58-79 points		

Yes	?	No			
			Sustainable Sites		16 Points
Yes			Prereq 1	**Construction Activity Pollution Prevention**	Required
Yes			Prereq 2	**Environmental Site Assessment**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Development Density & Community Connectivity**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation	1
			Credit 4.2	**Alternative Transportation**, Bicycle Use	1
			Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel Efficient Vehicles	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
			Credit 5.1	**Site Development**, Protect or Restore Habitat	1
			Credit 5.2	**Site Development**, Maximize Open Space	1
			Credit 6.1	**Stormwater Design**, Quantity Control	1
			Credit 6.2	**Stormwater Design**, Quality Control	1
			Credit 7.1	**Heat Island Effect**, Non-Roof	1
			Credit 7.2	**Heat Island Effect**, Roof	1
			Credit 8	**Light Pollution Reduction**	1
			Credit 9	**Site Master Plan**	1
			Credit 10	**Joint Use of Facilities**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No	Water Efficiency		7 Points
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
			Credit 2	**Innovative Wastewater Technologies**	1
			Credit 3	**Water Use Reduction**	1 to 3
			Credit 3.1	20% Reduction	1
			Credit 3.2	30% Reduction	2
			Credit 3.3	40% Reduction	3
			Credit 4	**Process Water Use Reduction**, 20% Reduction	1

Yes	?	No	Energy & Atmosphere		17 Points
Yes			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 2	**Minimum Energy Performance**	Required
Yes			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1:** All LEED for Schools projects registered after June 26, 2007 are required to achieve at least two (2) points.

Yes	?	No			
			Credit 1	**Optimize Energy Performance**	2 to 10
			Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
			Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
			Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
			Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
			Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
			Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
			Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
			Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
			Credit 2	**On-Site Renewable Energy**	1 to 3
			Credit 2.1	2.5% Renewable Energy	1
			Credit 2.2	7.5% Renewable Energy	2
			Credit 2.3	12.5% Renewable Energy	3
			Credit 3	**Enhanced Commissioning**	1
			Credit 4	**Enhanced Refrigerant Management**	1
			Credit 5	**Measurement & Verification**	1
			Credit 6	**Green Power**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
			Materials & Resources		**13 Points**
Yes			Prereq 1	**Storage & Collection of Recyclables**	Required
			Credit 1.1	**Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof	1
			Credit 1.2	**Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof	1
			Credit 1.3	**Building Reuse,** Maintain 50% of Interior Non-Structural Elements	1
			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
			Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
			Credit 3.1	**Materials Reuse**, 5%	1
			Credit 3.2	**Materials Reuse**, 10%	1
			Credit 4.1	**Recycled Content**, 10% (post-consumer + 1/2 pre-consumer)	1
			Credit 4.2	**Recycled Content**, 20% (post-consumer + 1/2 pre-consumer)	1
			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured	1
			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured	1
			Credit 6	**Rapidly Renewable Materials**	1
			Credit 7	**Certified Wood**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No	Indoor Environmental Quality		20 Points
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
Yes			Prereq 3	**Minimum Acoustical Performance**	Required
			Credit 1	**Outdoor Air Delivery Monitoring**	1
			Credit 2	**Increased Ventilation**	1
			Credit 3.1	**Construction IAQ Management Plan,** During Construction	1
			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
			Credit 4	**Low-Emiiting Materials**	1 to 4
			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
			Credit 6.1	**Controllability of Systems**, Lighting	1
			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
			Credit 7.1	**Thermal Comfort,** Design	1
			Credit 7.2	**Thermal Comfort,** Verification	1
			Credit 8.1	**Daylight & Views,** Daylight 75% of Spaces	1 to 3
				75% of classrooms (Required for either points below)	1
				90% of classrooms	2
				75% of other spaces	3
			Credit 8.2	**Daylight & Views,** Views for 90% of Spaces	1
			Credit 9	**Enhanced Acoustical Performance,** 40 dBA / RC level of 32	1
				Enhanced Acoustical Performance, 35 dBA / RC level of 27	1
			Credit 10	**Mold Prevention**	1

Yes	?	No	Innovation & Design Process		6 Points
			Credit 1.1	**Innovation in Design:** Provide Specific Title	1
			Credit 1.2	**Innovation in Design:** Provide Specific Title	1
			Credit 1.3	**Innovation in Design:** Provide Specific Title	1
			Credit 1.4	**Innovation in Design:** Provide Specific Title	1
			Credit 2	**LEED® Accredited Professional**	1
			Credit 3	**School as a Teaching Tool**	1

(USGBC, 2008)

Appendix F

Implementation of Energy Star

1. Make a Commitment. This commitment includes starting an energy management program, as well as sustaining the program in the future to continue conservation.
2. Assess Performance. Research and understand the past and current energy data and records to identify where improvements need to begin in order to provide the greatest financial gains. The assessment must continue as improvements are implemented to verify research results and reveal what needs continued modification for peek energy performance.
3. Develop Performance Goals. Setting goals for improvement demonstrates a commitment to reducing environmental impacts. Setting clear and measurable goals drive energy management activities and continue to promote future improvements. Goals both acquired and not achieved, guide decisions for continuous modifications and implementations.
4. Create an Action Plan. Using predetermined goals, develop a roadmap to improve facility energy performance. Action plans are updated regularly to reflect achievements. Updated action plans allow the plan to shift priorities as improvement goals are achieved.
5. Implement Action Plan. Implementation is accomplished through the involvement of prominent individuals dedicated to the philosophy designed for energy improvement. By creating awareness of goals and action plans, positive results are inevitable.
6. Evaluate Progress. Formal review of energy use data and activities is continuous. Using original data collected as a baseline, compare new figures to original figures.

Results and information gathered creates a new action plan, identifies most successful measures implemented, and set new performance goals.

7. Recognize Achievements. Recognizing achievement sustains momentum for continuing and building programs. Recognition will enhance awareness of implemented energy efficiency measures. (Energy Star, 2009)

Appendix G

LEED Certified Schools

Please complete the following survey:

1. What was the date of completion of your LEED Certified facility?

   A) 2000

   B) 2001

   C) 2002

   D) 2003

   E) 2004

   F) 2005

   G) 2006

   H) 2007

   I) 2008

   J) 2009

2. Who was included on the project planning team?

   A) Central Office Personnel

   B) Facility Director

   C) Staff member(s)

   D) Board Member(s)

   E) Community Member(s)

3. What was the length of time you used for planning the project?

   A) 0-3 Months

   B) 3-6 Months

C) 6-9 Months

D) 9-12 Months

E) 12-18 Months

4. What type of facility was constructed or renovated?

A) Primary

B) Elementary

C) Secondary

D) Combined Elementary and Secondary

5. What is the approximate total cost of project?

A) $0-$500,000

B) $500,000-$1,000,000

C) $1,000,000-$5,000,000

D) $5,000,000-$10,000,000

E) $10,000,000-$20,000,000

F) $20,000,000 & Up

6. What is the facility square footage size?

A) 0-30,000

B) 30,000-50,000

C) 50,000-70,000

D) 70,000-100,000

E)100,000-150,000

F) 150,000-&Up

7. What is the student population housed in the facility?

   A) 0-300

   B) 300-500

   C) 500-750

   D) 750-1000

   E) 1000-1500

   F) 1500-&Up

8. Please enter the total utility cost for the facility the year prior to construction/renovation and the utility cost the year after construction/renovation.
9. Please enter the total student attendance percentage of the facility for the year prior to construction/renovation and the year after construction/renovation.
10. Please enter the staff attendance percentage the year prior to construction/renovation and the year after construction/renovation.

Appendix H

Energy Star Certified Schools

Please complete the following survey:

1. What was the date of completion of your Energy Star Certified facility?

   A) 2000

   B) 2001

   C) 2002

   D) 2003

   E) 2004

   F) 2005

   G) 2006

   H) 2007

   I) 2008

   J) 2009

2. Who was included on the project planning team?

   A) Central Office Personnel

   B) Facility Director

   C) Staff member(s)

   D) Board Member(s)

   E) Community Member(s)

3. What was the length of time you used for planning the project?

   A) 0-3 Months

   B) 3-6 Months

C) 6-9 Months

D) 9-12 Months

E) 12-18 Months

4. What type of facility was constructed or renovated?

A) Primary

B) Elementary

C) Secondary

D) Combined Elementary and Secondary

5. What is the approximate total cost of project?

A) $0-$500,000

B) $500,000-$1,000,000

C) $1,000,000-$5,000,000

D) $5,000,000-$10,000,000

E) $10,000,000-$20,000,000

F) $20,000,000 & Up

6. What is the facility square footage size?

A) 0-30,000

B) 30,000-50,000

C) 50,000-70,000

D) 70,000-100,000

E) 100,000-150,000

F) 150,000-&Up

7. What is the student population housed in the facility?

   A) 0-300

   B) 300-500

   C) 500-750

   D) 750-1000

   E) 1000-1500

   F) 1500-&Up

8. Please enter the total utility cost for the facility the year prior to construction/renovation and the utility cost the year after construction/renovation.

9. Please enter the total student attendance percentage of the facility for the year prior to construction/renovation and the year after construction/renovation.

10. Please enter the staff attendance percentage the year prior to construction/renovation and the year after construction/renovation.

Appendix I

Architect Interview

1) Have you had specific training or education for designing and developing LEED certified or energy efficient school facilities?
2) What experience do you have in planning, designing, and constructing sustainable school facilities?
3) What knowledge base do you see from school personnel interested in sustainable school facilities?
4) In cost estimating, what trends do you see in pricing sustainable products and concepts in school facility?
5) What additional time is needed for design and construction sustainable projects?
6) What long-term cost savings have you seen in facilities you have designed and constructed?

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Vita

Jonathan Oetinger earned a bachelor degree from Newman University in 1995 in the field of education. He worked in the field of education while attending graduate school, graduating from Missouri State University in 2001 with a Masters Degree in Secondary Administration and in 2004 with a Specialist Degree in Superintendent Administration. Jonathan anticipates graduating from Lindenwood University in 2010 with a Doctoral Degree in Education.