Sixth International Conference on Construction in the 21st Century (CITC-VI)
"Construction Challenges in the New Decade"
July 5-7 2011, Kuala Lumpur, Malaysia

Green Building Policy, School Performance, and Educational Leaders' Perspectives in USA

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Abstract

The movement to construct high performance "green" buildings has had unprecedented market growth and continues to become mainstream practice for constructing schools in the United States. Green schools have economic, environmental and health benefits. Research provides information on the use of increased student performance found in green schools to justify building schools to a higher standard of indoor environment quality. There is clear and compelling evidence that schools currently built to specific green standards of indoor environmental quality, (e.g. thermal comfort, indoor air quality, acoustics and lighting,) result in healthier and more productive students and teachers. Current green building policies for schools in the U.S. provide educational decision makers with many choices in their selection of green building strategies. Educational leaders have perceptions of how green building strategies should be prioritized based on initial cost, long-term cost benefits, and governmental policy that requires building greener schools. This paper addresses the school construction industry, green building policy, research about indoor environmental quality and its affect on students along with educational leaders' perceptions of how they would implement new policies, which may assist with building a framework for the adoption of green building guidelines for schools internationally.

Keywords

Green Building, High Performing Schools, Policy, Indoor Environmental Quality

1. Introduction

The United States Green Building Council (USGBC), a widely recognized green building certification organization, categorizes the three primary benefits of green building as: economic, environmental and social. "The economic benefits are: reduced operating costs, enhanced asset value and profits, improved employee productivity and satisfaction, and optimized life-cycle economic performance. The environmental benefits are: protected ecosystems, improved air and water quality, reduced solid waste, and to conserve natural resources. Health benefits are: Improved air, thermal, and acoustic environments, enhanced occupant comfort and health, and minimized strain on local infrastructure" (USGBC, 2009).

The majority of both the building industry participants and environmental agencies in the U.S. have endorsed public green building policy for schools. Green schools have reduced operating costs for school owners and administrators and have improved the health and performance of students and teachers. The current ease of state adoption of green building requirements for projects defies the conventional idea of environmental policymaking being difficult due to industry opposing environmental interests (Ingram and Mann, 1989). This dichotomy and grass-root support have allowed legislative debates to take place out of the media's attention with enactment by overwhelming majorities.

Public school budgets in the U.S. have been drastically cut as a direct result of the current global economic problems. It has been estimated that the U.S. school infrastructure has a need of $254.6 billion, yet educational leaders have to decide whether to spend funding for facilities or to maintain staffing of school classrooms (Cash & Twinford, 2010). The 21st Century Green High-Performing Public Schools Facilities Act was passed Thursday, May 14, 2009 by the U .S. House of Representatives. This bill authorizes more than $6.4 billion in grant funds to support school repair, renovations and modernization projects in school districts nationwide.

The United States has been recognized as a leader in their acceptance and use of green building guidelines (Korkmaz, et al., 2009). At the *Fifth International Conference on Construction in the 21st Century*, Korkmaz et al. (2009) recommended next steps of developing a framework for other countries adoption of green building guidelines. They recommended examining construction industries, governments and academia within four different countries, including the U.S. Their vision was to build a framework for developing countries to adopt green building guidelines. This paper follows their recommendation by examining school construction, green building policy, research about indoor environmental quality and its affect on students along with educational leaders perceptions of how they would implement new policies. This paper will utilize policy theory as a framework to examine the use of green building in U.S. schools.

2. Green Building Policy

Many school facilities have poor indoor environmental conditions that may result in increased health risks for students, as well as inhibited learning and student performance. The initial research about how building occupants are affected by the building's lighting began in the 1960's. Soon after, advocacy coalitions for improving facilities design began what has now turned into the movement for green schools.

Advocacy policy change is a temporal process that focuses on policy subsystems, intergovernmental aspects, and public policies. (Jenkins-Smith and Sabatier, 1994). The temporal change process typically takes at least a decade and has successes and failures dependent on the advocacy and on external factors. Advocacy coalitions have both a top-down and a bottom-up perspective. The policy subsystem focuses on multiple levels and not a single institution but is found in various arenas. The intergovernmental aspect is typically broad, stemming from the local grass-roots level up to the federal level. The public policies aspect typically corresponds to belief systems by being theory based, prioritizing values and incorporating perceptions.In the early 2000's there was a spike in oil prices to nearly $80 a barrel, heating and energy costs soared and there was seemingly no end in sight for these increases (Rothenberg, 2006). This created a large punctuation which stimulated quick decisions toward implementing green building policies. Scholars have employed the punctuated-equilibrium theory to understand a variety of policymaking situations (Baumgartner, & Jones, 2009). Practitioners have cited punctuated-equilibrium theory as a policy theory that can quickly change in the face of accumulating factual evidence (Speth, 2004). The convergences of the advocacy coalition and the external factor of punctuated-equilibrium have created a "policy window". This policy window has been explained as the multiple streams theory developed by Kingdon (1984). Theoretically, this window is currently open and the 21st Century Green High-Performing Public Schools Facilities Act will likely have a positive impact on the health and performance of students and assist with keeping the policy window open longer.

The 21st Century Green High-Performing Public School Facilities Act provides funding for schools to incorporate more sustainable practices in their facilities, and is broad in design allowing educational leaders flexibility in their decisions about the sustainable design strategies they decide to incorporate as part of the grant. The 21st Century Green High-Performing Public School Facilities Act "Directs local education agencies (LEAs) grantees to use a percentage of their grant, rising in 10% increments from

50% in FY2010 to 100% in FY2015, for public school modernization, renovation, repairs, or construction that meet Leadership in Energy and Environmental Design (LEED) green building rating standards, Energy Star standards, Collaborative for High Performance Schools (CHPS) criteria, Green Building Initiative environmental design and rating standards (Green Globes), or equivalent standards adopted by the entities that have jurisdiction over such LEAs. Requires the Secretary to provide outreach and technical assistance to states and LEAs concerning the best practices in school modernization, renovation, repair, and construction" (govtrack.us, Section 309, 2009). Some of these standards are associations that have been formed due to years of advocacy coalitions for green building and are specifically associated with schools and student performance. This bill encourages energy efficiency and the use of renewable resources, but does not delineate a detailed plan for indoor environmental quality, nor does it use student performance as a justification.

3. Indoor Environmental Quality and Student Performance

Historically, educational decision makers have perceived indoor environmental qualities such as thermal comfort, indoor air quality, acoustics and lighting to be the top four physical variables of educational facility designs that have the largest impact on learning (Bosch, 2006 p.335-336).

3.1 Thermal Comfort

Thermal comfort relates to the temperature of a room at which people are comfortable in their tasks. The general agreement between researchers is that thermal comfort is defined by the satisfaction of a percentage of the people in a particular environment (Hoof, Mazej, & Hensen, 2010). There is a strong relationship between student achievement and thermal factors in the learning environments (Earthman & Lemasters, 1998). There is a string of studies relating thermal comfort and student performance that all tie back to the early studies conducted in 1931 by the New York Commission of Ventilation (Earthman, 2002). With the goal of healthy students in mind, the commission studied city and rural classrooms, as well as an experimental classroom at a local college, to determine the best air temperatures in classrooms. The experiment subjected students to different temperatures and correlated them to the illnesses that occurred. Results found temperatures between 67 and 73 degrees Fahrenheit with a humidity level at 50% reduced illnesses (Earthman, 2002). McGuffey (1982) was one of the first to research the impacts of heating and air conditioning on learning, and her work is still widely cited (Schneider, 2002). Harner (1974) concluded the ideal temperature range for learning reading and math was between 68 and 74 degrees Fahrenheit (as cited by Earthman, 2002 and Schneider, 2002).

3.2 Indoor air quality

Poor indoor air quality (IAQ) has the potential to affect students, staff and faculty's comfort and health, which may affect attendance, concentration and performance. Poor indoor air quality problems in schools are attributed to environmental tobacco smoke, formaldehyde, volatile organic compounds, nitrogen oxides, carbon monoxide, carbon dioxide, allergen, radon, pesticides, lead, mold and dust (Sundersingh & Bearg, 2003, p.2). The main reason for poor indoor air quality is inadequate ventilation with outside air (Daisey et al., 2003). The American Society for Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) has recommendations for minimum ventilation rates for acceptable indoor air quality. Indoor air quality can be monitored in buildings by monitoring the carbon dioxide levels in the classroom air. Studies indicate that the indoor air pollutants range from two to one hundred times higher than the outdoors (U.S. EPA, 2000), which is considered "sick building syndrome". Over 43 percent of U.S. schools have reported problems associated with indoor air quality (NCES, 2000). These school facilities are classified as facilities with sick building syndrome. People exposed to indoor environments of sick buildings complain about symptoms such as upper respiratory problems, skin irritation, headache and fatigue (Kreiss, 1989).

One of the major health risks to students is asthma which is related to poor indoor air quality. Data on asthma, asthmatic symptoms and allergies was gathered over a two-year period for 1,476 students in 39 randomly selected schools (Smedje & Norback, 2000). 12 percent of the classrooms had new ventilation and were compared to classrooms with older ventilation systems. The research concluded that asthmatic symptoms were less common among the students who attended schools with new, more effective ventilation systems. A more recent study found that indoor chemical air pollutants, such as formaldehyde from new school furniture and building materials, asthmatic symptoms such as wheezing and daytime attacks of breathlessness for children (Zhao et al., 2008). The off-gassing of chemicals from carpeting in schools has been considered to be a primary cause for poor indoor air quality. Twenty-three different studies were also analyzed on carpet and indoor air quality, the results of which concluded that carpet does not increase asthma and allergies (Sauerhoff, 2008).

There is still debate that the quality of indoor air directly correlates with the comfort and performance of students, faculty and staff in today's schools. The majority of research found linked poor indoor air quality to sick teachers and students which resulted in a lack of performance due to illnesses and led to absenteeism (Kennedy, 2001). These illnesses, such as asthma, resulting from students being exposed to sick building syndrome may also result in learning deficits while students are in class (Mendell et al., 1996).

The Environmental Protection Agency (EPA) has an Indoor Air Quality Tools for Schools (IAQ IFS) Kit. This kit can be used to assist existing schools to improve their indoor air quality. Since the kit was issued in 1996, there are over 13 million students, staff and faculty in 25,000 schools experiencing improved indoor air quality based on the EPA's standards. In 2006, a questionnaire about schools IAQ management program was sent out to selected school regionally across the nation (Moglia, Smith, MacIntosh, & Somers, 2006). Out of the 890 respondents, 40 percent of them had an active IAQ management program. The study concluded that an IAQ management program that is continuously supported by the administration is a valuable factor in improving the learning environment.

3.3 Acoustics

Another classroom factor that contributes to indoor environmental quality is acoustics. Research correlates the link between acoustics and educational outcomes. Good acoustics have been recognized as a fundamental aspect to good academic performance (Schneider, 2002, p. 6). Outside noise has been found to result in students' dissatisfaction with their classroom, stress and lower achievement (Earthman and Lemaster,1998). Unwanted noise inside the classroom has also been recognized as having an impact on student learning (Earthman and Lemaster,1998).

In order to prevent noise interfering with student learning, effective acoustical measures should be implemented during the design and construction phases (Glass, 1985). When designing a learning environment the acoustical elements that potentially impact learning and need to be addressed include: limiting outside noise, background noise from heating ventilation and air conditioning (HVAC) systems, and reducing distracting indoor sounds (Stewart, 2009). Outside noise can be described as interfering with the learning environment due to sound transmission (Stewart, 2009). Examples of outside noises are motor vehicle noise, conversations from outside, athletic activities, and noise from classrooms next door or above. Stewart recommends designing the exterior walls of the room to follow American National Standards Institute's (ANSI) Sound Transmission Class (STC) Ratings to minimize the noise from outside the classroom (Stewart's, 2009).

Reverberation time inside the classroom is the technical phrase that describes indoor sounds that distract from learning (Stewart, 2009, p. 30). The HVAC system in a classroom can generate enough noise that it makes it difficult for the classroom participants to hear and communicate. Reducing the noise of the

HVAC system includes distributing the sound in the learning environment and maximizing the distance between the fan and first diffuser (Stewart, 2009). ANSI and The Collaborative for High Performance Schools (CHPS) have collaborated to create a standard for the HVAC reverberation. Having the proper amount of sound absorptive materials in the space to mitigate the reverberation and errant sound transmission and achieve building standards is recommended to reduce a potential impact on learning (Stewart, 2009). Two specific recommended materials to reduce noise are carpet and ceiling tile (Stewart, 2009). Student achievement was reported to be higher in schools with carpet, and the carpeting improved the acoustics of the learning environment. The study concluded that overall student achievement is higher in classrooms with lower reverberation times (Tanner and Langford, p. 42).

3.4 Lighting and Student Performance

Lighting is one of the primary design elements considered in common green building practices. Lighting is commonly used as a justification for building greener schools because of its documented positive impact on energy use and student performance. Lighting has been determined to be a fundamental contributing factor to a school building's overall indoor environmental quality.

Many of the classrooms built in the 1960's were built with very few windows. The architectural thought process was that this type of design would make conditioning the indoor air more efficient, be more secure, quieter and reduce maintenance costs. The lack of windows led to controlled experiments involving school children and fluorescent lighting with UV lamps (Zamkova & Krivitskaya, 1966). Students who were exposed to the UV light showed resistance to fatigue, improved academic performance, improved stability of clear vision, and increased weight and growth. Another study examined elementary school students' dental health, growth and development, attendance, and academic achievement when subjected to four different types of lights (Hathway, 1992). These lights were full-spectrum fluorescent lamps, full-spectrum fluorescent lamps with ultraviolet light supplements, cool white fluorescent lamps, and high-pressure sodium vapor lamps. A study was also designed to replicate the findings of studies by Wohlfarth (1986) and Hargreaves and Thompson (1989). 327 students located in 5 schools were studied for a 2 year period. The results of this research indicated student improvement in the areas of dental histories, growth and development, scholastic achievement, and attendance over a two year period increased when subjected to full-spectrum fluorescent lamps (Hathway, 1992).

The 1990's had many studies relating lighting to student performance (Hathaway, 1992; Nicklas & Bailey, 1996). Some of these studies results were controversial and have been labeled as "fads" that affect school lighting decisions. For example in the 1970's, full spectrum lighting manufacturers made claims that their fluorescent lamps provided health benefits (Benya, 2001). In 1985, the United States Food and Drug Administration (FDA) ruled that the full spectrum lamps provided no health benefits. The strong claims about UV enhanced "full-spectrum" lamps have been based on poor research that does not meet the basic standards of scientific research (Gifford's, 1994). This information led to studies about daylighting. Earthman and Lemasters (1998) reported that there were no significant relationships between student performance and windowless facilities. They found that light with ultra-violet content seemed to improve student health, but daylight appeared to improve student achievement.

The Heschong Mahone Group (1999) prepared one of the most detailed studies investigating the relationship between natural daylighting and student performance for Pacific Gas & Electric and the California Board for Energy Efficiency. Their data set included over 21,000 students in more than over 100-schools. The three U.S. school districts in the study were located in Orange County, CA, Seattle, WA, and Fort Collins, CO. The results found a positive and significant correlation between the presence of daylighting and student performance (Heschnog Mahone Group, 1999). In a 1 year study at Orange County's Capistrano school district, students with the most daylight in their classrooms progressed twenty percent faster in math, and twenty-six percent faster in reading than students with the least amount of natural daylight in their classrooms. The results additionally indicated that views out of windows increased performance by five to ten percent. The results appeared to be valid because the three school districts analyzed had different teaching styles and curricula, different facility designs. Yet, there was not a peer review on the study. The Heschong Mahone Group published a re-analysis of the report in 2001 to address any concerns in the validity of the study. Some of these concerns related to better teachers being assigned to daylight classrooms and the aggregation of data across four grade levels. The peer review panel was satisfied with the methodology and rigor of the statistical analysis. They concluded: a) Students in classrooms with the most daylight had 21 percent higher learning rate performance compared to least amount of daylight. b) No teacher assignment bias to classrooms. c) Daylighting effect does not vary by grade. d) Physical classroom characteristics such as daylighting, operable windows, air conditioning, and portable classrooms are not associated with absenteeism (Heschong Mahone Group, 2001).

Due to current material and design improvements such as energy-efficient windows and skylights, along with renewed indications for positive psychological and physiological effects of daylight, there has been an increase in interest in daylight in schools (Benya, 2001). The advocacy groups are also pointing out energy efficiency and the associated cost savings as an additional benefit of daylighting.

Indoor environmental quality is not the only reason for lighting strategy design. A recent study of a middle school in North Carolina indicated an energy savings of 50% in lighting and 11% of total building energy reductions through daylighting. About 60% of the building's total square footage is provided with natural daylighting as compared to a code compliant building without daylighting utilization (Eckerlin et al., 2007).

4. Educational Decision Makers

Many decisions are made during the design and construction of green schools. Although the decisions about green building can be complex, in the absence of other considerations, the drivers for decisions are energy efficiency (cost) and indoor environmental quality (functionality and aesthetics).

Kelting and Montoya (2011) presented research about lighting and its' impact on student performance and discussed generally the long-term economic benefits of green building energy efficiency strategies to educational decision makers. They then discussed the green building portion 21st Century Green High-Performing Public Schools Facilities Act. In this research the educational leaders were asked hypothetically, "Given the information on energy efficiency green building methods, and lighting and its' impact on student performance, how would you prioritize your decisions of energy efficiency or lighting strategies if awarded grant funds from the 21st Century Green High-Performing Public Schools Facilities Act.?" They were also asked about what information they would use to guide their decisions.

All of the educational leaders in the research results indicated that perceived energy efficiency strategies outweigh the health and student performance benefits of indoor environmental quality, including lighting. The educational leaders felt the decision to strictly reduce energy consumption and reduce their operating costs took precedence over student performance. The educational leaders seemed very skeptical of the research that correlated daylighting to student performance. One educational leader asked to see a follow up study to see if the findings of the Heshchong Melone study were still similar or if the results could be categorized as a Hawthorn effect. Another educational leader requested that they would like to see a side-by-side comparison of the student performance based on daylighting verses the student performance that would result from more teachers and smaller class sizes, more textbooks and computers. Additionally, the schools evaluated were in affluent areas, raising questions about the lack of socioeconomic considerations in the study's published results. All of the educational leaders interviewed were familiar with the general long-term economic benefits of utilizing energy efficiency strategies when considering investing in greener facilities. Overall, they felt that by spending the money on strategies that increase energy efficiency, such as solar panels, a school could reduce their building's energy costs for the life of the building. The savings could be used for other ways to improve student performance. In fact, one respondent suggested that energy savings from solar panels could lead to class size reduction, the purchase of new instructional technology, or the faculty and staff could be allowed more time for training. All the educational leaders interviewed revealed they would look to the faculty and staff to improve the students' performance and to the building to reduce overhead.

5. Conclusion

Currently, there are a number of green building guidelines from which educational leaders may choose and still be in compliance to receive grant monies. Not all of the green building guidelines incorporate the same prescriptive methods for indoor environmental quality. This demonstrates the vast array of options in green building guidelines that are available for building "green" schools. Educational leaders' perceived energy savings strategies to be more important than indoor environmental quality in the design and construction of new schools (Kelting and Montoya, 2011). Based on the educational leaders' perception, the research base does not have the depth and breadth that is needed to use student performance as a justification for investing in green building strategies that improve indoor environmental quality in lieu of energy efficiency strategies. A potential area for further research would be to study the decisions made about green building strategies during the design and construction of schools that received money from the 21st Century Green High-Performing Public School Facilities Act. The goal for this effort is to provide both the U.S. and other countries information about the guidelines that are most commonly used to assist with their adoption of green building guidelines.

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