PLADEW: A Tool for Teachers Awareness of School Building Sustainability the Case of Carmel School, Mathews, North Carolina

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Abstract

Recent Studies on sustainability suggest a strong correlation between the physical environment of school building and students' performance and behavior. An argument is developed to support this premise based on a structured content analysis procedure. The typical approach for addressing sustainability in learning environments is analytically discussed. This approach—through guidance documents—emphasizes top-down policies that successfully address the professional community. However, school building users are rarely addressed through bottom-up strategies. PLADEW, a tool to sensitize school teachers toward understanding the key issues underlying sustainability was developed.

This is based on the assumption that "if the learning environment has an impact on students' performance, productivity, and behavior, then teachers need to be aware of the physical elements of the school building that influence their students." It is regarded as an awareness tool that involves a checklist and a rating system. The tool was implemented in Carmel School, Mathews, North Carolina where teachers conducted self guided tours and became familiar with sustainability, and were able to comprehend and realize what features positively impact the teaching/learning process while enhancing their students performance. A brief set of recommendations was developed to emphasize bottom up strategies in the current efforts undertaking by school districts and government agencies.

Introduction

A growing body of green knowledge is emerging in support the worldwide surge in the construction of learning environments. This is coupled with a growing support from school districts, administrations, and government agencies for funding the construction of new schools and extension, addition, renovation, and upgrading of existing schools. There is a strong rational behind these efforts: 1) students need a healthy and safe environment that supports the achievement of pedagogical goals, and 2) schools need to be cost-effective in terms of construction, operation, and maintenance so that public funds are not wasted.

In parallel to the development of sustainable design knowledge and to the growing public and government support, sustainable planning and design is emerging as a top priority for all schools in different parts of the world. It means staying within the capacity of the natural environment while improving the quality of life and offering our children opportunities at least as good as those available to us. According to the American Institute of Architects Handbook (1999), sustainability refers to "*the ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future*." It is firmly believed that sustainable school buildings are the responsibility of architects to create learning environments that offer delight when entered, harmony when occupied, and regret when departed.

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When looking at the current efforts for addressing sustainability one can find that there have been a heavy reliance on policy and guidance documents that direct the professional community including architects, planners, designers, and engineers to develop responsive learning environments. Despite the good intentions of these efforts -- that primarily aim at improving the environment in which teaching and learning processes take place -- guidance documents are top down and authoritative in nature and therefore oversimplify other bottom-up initiatives led by the users or the community.

Throughout the second half of the 20th century schools have been designed and built as learning environments that focused primarily on creating spaces that meet basic functional and educational needs. Post occupancy evaluation literature accentuates that there have been varying degrees of successes and failures in terms of function, aesthetics, cost, and comfort. For years however, there was a missed opportunity; that is to create buildings that teach sustainability; buildings that can be utilized as open textbooks where users, community members, and the public can learn.

This paper argues for the need for efficient bottom up strategies and tools that address school building users. In this respect, the rational behind this argument is that the learning environment has a tremendous impact on students' performance, behavior and productivity. Thus, teachers need to be aware of what aspects (direct and indirect) in this environment produce this impact. They need to be sensitized toward understanding building sustainability then transfer their experience to their students, and thereby imbibing sustainability values in future generations by utilizing the school building, its site, and its context as a teaching tool.

Methodology

The methodology and structure of the paper are based on reviewing the literature on sustainable learning environments and content analysis of the recent post occupancy evaluation literature that establishes relationships between the physical environment of a school building and students' performance, behavior, and productivity. The content analysis is based on the work of Sheila Bosch who classified several studies in terms of research hypotheses, subjects of study, physical and classroom variables, performance and behavioral impacts, and major findings. Approaches to addressing sustainability in buildings and in design delivery processes have been discussed and analytically compared. This resulted in defining the need for tools that involve teachers in order to help them comprehend and understand their building sustainability and therefore provide their students with enlightening experiences by utilizing their building as a teaching tool. In essence, creating conditions under which learning takes place is equally important to the knowledge content conveyed to students.

In order to introduce a bottom up strategy that addresses sustainability, a walking tour tool was devised by the author in 2003, encompassing four sets of questions that examine key issues of sustainable planning and design for learning environments. Each set of questions pertains to one of the crucial factors: planning and zoning, landscaping, designing, and energy and waste. The tool is regarded as an awareness mechanism that Carmel School teachers have used. By conducting self guided tours, teachers' responses indicated the validity and efficiency of the tool. However, responses indicated the need to incorporate observable features in the building where teachers can utilize in the teaching/learning process. The paper concludes by a brief set of strategies that act as directions on how to utilize the building features as a teaching tool, thereby developing positive attitudes toward the environment.

School Building Sustainability and Students Performance and Behavior

There are many factors that affect the abilities of students to learn and succeed. Among these factors is the condition of the facilities in which learning occurs, including interior environmental conditions. This has been shown to contribute to or hinder learning (Bowers and Burkett, 1987; Cash, 1993; Chan, 1980; Christie and Glickman, 1980; Edwards, 1991; Evans and Maxwell, 1997; Heschong Mahone Group, 1999; Wollin and Montagne, 1981). Those who make decisions about school facilities – which schools to renovate, where to build new schools, what school designs to use and how to maintain the facilities – therefore play an important role in student education.

It has been reported --in many government documents either in the developed or the developing world-- that the condition of many schools is less than desirable. Many schools throughout the world operate in very poor physical conditions and need major renovations. In the United States, approximately $127 billion is needed to bring schools up to good overall condition (Lewis et al., 2000). According to Lewis, when surveyed about satisfaction with environmental conditions, including lighting, heating, ventilation, indoor air quality, acoustics or noise control, and physical security of buildings, 43% of the schools responding reported at least one environmental factor as being unsatisfactory. Nearly one third of schools surveyed reported inadequate condition of heating, ventilation and air conditioning systems. Increasing enrollment and a push for smaller class sizes is creating a greater need for school construction and renovation.

By conducting a content analysis procedure to the literature that has been developed over the last two decades striking results are revealed. Several studies have shown correlations between physical environmental conditions (e.g., lighting, humidity, acoustics) and student performance and/or behavior. The poor conditions that exist may hinder student achievement. In a study involving 47 small, rural high schools in Virginia, student achievement was shown to be higher in schools with better physical conditions (Cash, 1993). Socioeconomic status was controlled. Higher science scores were associated with schools with better science laboratory facilities, and structural conditions had less of an impact on student achievement than cosmetic conditions. In another study involving 280 fourth and sixth grade students, those attending a newer school had higher achievement in math, reading, listening and language than those enrolled in an older, "less desirable" facility (Bowers and Burkett, 1987). Bowers also found that fewer major health problems were reported, fewer disciplinary actions were taken, and attendance was higher in the new school. The actual extent to which physical features impact the learning process remains unclear, but occupants in school buildings perceive that features such as physical comfort and health and classroom adaptability affect educational outcomes (Lackney, 1996).

Realizing that school conditions impact student learning and behavior, many school districts are seeking to create sustainable learning environments. One particular lighting study has received a great deal of attention. The Heschong Mahone Group (1999) studied the effects of daylighting on student performance. Test scores in math and reading were compared for 21,000 students from 3 school districts, including Orange Co., CA, Seattle, WA, and Fort Collins, CO to measure achievement. These scores were evaluated against lighting variables such as window size, tint, presence and type of skylights, and the amount of anticipated daylight. Multivariate linear regression was used to control other factors such as demographics and participation in special programs. Students with more daylighting progressed 20% faster on math tests and 26% on reading tests in one year (data for the entire sample on 'progress' were not available). Those with the greater window area progressed

15% faster in math and 23% faster in reading than those with the least, and well designed skylights that diffuse light effectively were also related to more rapid progress on test scores. Additionally, students in classrooms in which the windows are operable also progressed more quickly than those with inoperable windows.

Student behavior was the focus of a study that compared white walls and cool-white fluorescent lighting, common in school facilities, with blue walls and full-spectrum lighting (Grandgaard, 1995). Off-task behavior and mean blood pressure were measured for five 6-year old boys and six 6-year old girls in a public school during 3 phases of the study (before modification, during and after the classroom was returned to its original condition). A decrease of 22% in off-task behaviors was observed in the room with the blue walls and full-spectrum lighting and student mean blood pressure was 9% lower.

Christie and Glickman (1980) evaluated 156 students who were asked to perform 60 visually presented tasks from the Standard Progressive Matrices (a type of intelligence test), 1938 version, in either a noisy environment (70 dbA) or a quiet environment (40 dbA). The findings indicate that boys perform complicated problems better in a noisy environment, while girls perform higher in a quiet environment.

Lighting impacts on student behavior was the focus of a study by Ott (1976). The behaviors of first-grade children in 4 windowless classrooms were observed. Standard cool-white fluorescent lighting with solid plastic diffusers provided illumination in two of the classrooms; while the others used full-spectrum fluorescent tubes with lead foil to shield the ends of the tubes to reduce X radiation exposure. Children in the room with standard lighting were more fidgety and were observed “leaping from their seats, flailing their arms, and paying little attention to their teachers”, while those with full-spectrum lighting were less nervous and paid more attention to the teacher.

Sustainable School Design: Between Guidelines and User Awareness

When investigating the recent literature on sustainability (Rees, 1991; Lyle, 1993; Meek, 1995; ECE, 1996; Rosenbaum, 1999; CEEDS, 2000; SBIC, 2001), one can find that there are two major approaches, Top-Down and Bottom-Up. The Top-Down approach is a term used to refer to initiatives led by the authorities or decision makers. It aims at developing policies, strategies, and standards. However, this approach has been heavily accused of being more evaluative than informative, and that it relies on forcing the professional community to be aware of an issue then responds to it. The Bottom-Up approach is a term used to refer to initiatives led by the community and facilitated by professionals. It aims at building public and professional awareness, while providing feedback mechanisms. It is more informative than evaluative and relies heavily on developing a common understanding, a common language, and develops a sense of responsibility toward the environment.

The examination of several guidance documents for creating sustainable schools (Bosch, 2002, Bosch and Pearce, 2003; Salama and Adams, 2003) reveals that emphasis is placed on the top-down approach, while the bottom-up approach is over simplified (Salama, 2002 & 2003). The question that can be raised here is "Have the policies, strategies, and guidelines been transformed into real practices?" Simply, the answer is that very few examples exist, and many in the professional community agree on that. Again, the question here is “why we do not find as many examples as we find this accumulation of green knowledge, developed in the last few years?” The answer lies in the following argument against “Guidelines.”

Typically, guidelines introduce critical technical measures and recommendations. They encapsulate the best building practices that address the professional community. However, they are always rough, "not-illustrated", mainly address quantitative aspects, and more importantly, they do not leave enough room, or give enough direction for the creativity of the architect, the planner, or the facility manager. Guidelines are always generic and do not address a specific building type and also do not deal with the building occupants. Only recently the professional community started to realize the need for guidelines that address specific environments including schools (Salama, 2002). Some scholars believe that by developing guidelines socially and environmentally responsive learning environments can be realized. In this respect, one can assert that no guidelines are ever final; they evolve over time according to the changing circumstances. Therefore, they have to be strategically developed to respond to emerging needs and to the nature of the users. In fact, they do not provide blue prints on how sustainability can be achieved; only an expectation about the good pretty picture of what the future might be.

The bottom-up approach that emphasizes users' awareness and involvement has also been criticized in terms of time consumption. Some argue that time invested in training programs, and awareness campaigns, is excessive. Although the results are far reaching, the process consumes considerable time while developing positive attitudes toward the environment, and reconfiguring the culture of sustainable building management and operation.

The preceding argument suggests that while emphasis has been placed on the top-down approach to achieve sustainability the bottom-up approach has been oversimplified or ignored. In this regard, it is believed that both approaches are needed and none of them can replace the other.

PLADEW: Awareness Tool for Carmel School Teachers

In order to address an effective bottom-up strategy that involves building users, an instrument was devised as an awareness-raising tool where teachers can take a walking tour through their building. It allows them to explore, think, comprehend, develop impressions, and deeper insights into the understanding of their environment from sustainability perspective, then transforming this understanding to their students. The tool is named PLADEW and encompasses four sets of questions that examine the key issues of sustainable planning and design. Each set of questions concerns itself with one of the crucial factors: 1) Planning and Zoning, 2) landscaping, 3) Designing, and 4) Energy and Waste.

Key questions and issues underlying planning and zoning category include building orientation, relation between activities and natural settings, and to what extent has the planning of the site produced impacts on the environment. Landscaping issues include existing vegetation, water provision and treatment, materials and pavements, and vehicular and pedestrian paths around and within the site. Key issues underlying designing include natural lighting in classrooms, indoor environment qualities and the careful selection of building materials and detailing. Energy and waste issues include maximum utilization of renewable energy, where and how building materials are produced, transported, manufactured, and assembled, and waste collection and recycling.

The following procedures outline how the tool was implemented:

- Conducting a self-guided tour, starting by the site and the surrounding context then interior spaces (teachers may inquire about some technical aspects and get feedback from personnel in charge of the utility system and maintenance)

- Numerical scores from 1 to 7 are assigned to each question underlying the factors
- (1= highly appropriate, 7= very inappropriate)
- Responding to each question underlying each factor
- Analyzing the numerical ratings by computation of average scores for each factor, then computation for the overall scores of the building
- Developing concluding comments based on the overall appraisal, while highlighting positive and negative aspects

Validating PLADEW required testing it. The tool was examined by a number of architects and elementary school teachers. They were asked to provide their feedback concerning any ambiguity of the questions or the terminology used, and also to add any questions they feel they are critical to be addressed. 15 teachers responded and few of them noted that they had difficulty understanding some of the terms. As a result, a glossary was added to the tool and included definitions of terms such as buffer zone, site topography, gray water system, building shell.

Carmel school was selected to implement the tool. Its campus has been designed in 1992 and includes kindergarten and elementary wings. It houses several after school programs where the south Charlotte community is involved (figure 1).

Figure 1: Carmel School Site Plan and Entrance to the Administration Building.

The tool was delivered to all the teachers of the school based on the approval of the principal. Teachers were asked to conduct a self-guided walking tour and assess their school building according to the questions underlying the four factors. They were not requested to follow a specific route within the school. They were informed to structure their tour and to start by the site and the outdoor environment then tour the interior of the building. The overall time frame for conducting the tour was one hour, so that the process would not consume their time. Teachers have been actively involved in the awareness process. A number of teachers have conducted the tour in groups. However, each has his/her own response sheet.

Walking Tour Results

One should note that for the specific purpose of this study the objective was clearly to sensitize schoolteachers toward understanding the meaning of sustainable learning environments. The intention was not to reach a comprehensive conclusion about Carmel school building sustainability. However, the analysis of teachers' reactions reveals striking results on how teachers perceive the building. 40 teachers received the tool and 22 responses were received. The following tables and figures illustrate the questions and issues underlying each category and the analysis of teachers' responses.

The total averages of the four categories were 4.29 for planning and zoning, 4.55 for landscaping, 4.88 for designing, and 4.84 for energy and waste. Since these averages are around neutral scale (4.00), they indicate that there is an overall satisfaction with the four factors. However, a number of teachers have indicated dissatisfaction with issues underlying designing, and energy and waste categories. In their notes, they expressed concerns for the indoor environmental quality including color, noise levels, and views and access to the outdoors. They also expressed concern for energy conservation strategies including the use of photovoltaic cells, daylighting, and natural ventilation. Under planning and zoning, and landscaping categories teachers were satisfied with most of the issues. However, few of them have expressed concern for the amount of paved parking areas that create heat islands and increase temperatures around the building.

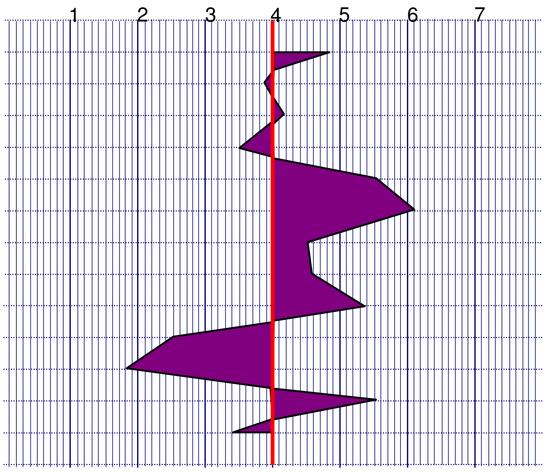
A considerable number of teachers expressed concerns for the lack of evergreen trees and the need for continuous maintenance and irrigation of green spaces, thereby increasing water use. Teachers commented in generic terms that they had to refer to school maintenance and facilities staff. While this may seem negative as the tool can be regarded as not explanatory enough, it has a real positive impact where some questions encouraged teachers to inquire about technical issues thereby increasing the educational value of the process. By and large, the analysis reveals that teachers became familiar with sustainability issues in their building, and started to question the impact of these issues on their students' performance, behavior, attitudes, and overall productivity.

Figure 2: Table Illustrates the Checklist and the Rating System underlying Planning and Zoning and Landscaping.

Factor 1: PLANNING AND ZONING **Highly Appropriate 1 2 3 4 5 6 7 Very Inappropriate**	**Score**	**Factor 2: LANDSCAPING** **Highly Appropriate 1 2 3 4 5 6 7 Very Inappropriate**	**Score**
1. How does the building suit the most appropriate use of the surrounding area?	____	**1.** How effectively are the site features kept? *(consider leveling, excavations, and land filling).*	____
2. How does the building encourage teachers, students, and visitors to respect the surrounding natural environment?	____	**2.** Does the landscape design integrate the site with the surrounding environment? (is the site surrounded by fences, if so, consider the materials used for fence treatments).	____
3. How does the building encourage fostering and enhancing environmental education and awareness?	____	**3.** How effectively does the design of landscape items avoid the use of synthetic materials*? (consider the materials used for walkways, and the asphalt pavements of the parking area)*	____
4. How does the project alter or change the site topography?	____	**4.** Does the project introduce soft-scape elements (natural plants and shrubs)? If so, how effective? *(consider their harmony with the existing natural environment, and correspondence to climatic conditions).*	____
5. How does the orientation of the building and its components fit well with the orientation of the site and the climatic constraints? *(consider the sun path and north-south orientation, day lighting).*	____	**5.** How effectively is the site furniture items (seats, pergolas, garbage boxes) installed in and distributed within the site? *(Consider their location, materials, and manufacturing).*	____
6. Is there a buffer zone around the site, and if so, is it suitable for protecting any surrounding significant natural features?	____	**6.** How well are the routes around and within the site marked? Are the markings clear and easily understood? *(consider directional signs, their location, content, and material).*	____
7. Does the access to the site fit well with the existing natural landscape?	____	**7.** Are there any signs for environmental education purposes? If so, how effectively they convey messages about appropriate behavior?	____
8. Do the pedestrian paths and their angles of vision correspond to the natural scenes (if any) around the site?	____	**8.** Are the pedestrian paths and other hard-scape elements made of natural or recycled materials?	____
9. Are the entry points sufficient, easily accessible, and suitable for building size, no. of students and teachers, site area, and dimensions?	____	**9.** Does the site have a re-used water system (gray water)? If so, How effective? *(Consider capturing rain water and re-using it for plants, or any other purposes)*	____
10. Are the entry points appropriate for minimizing any negative impacts on the surrounding natural environment?	____	**10.** How effectively does the project introduce native plants that require least amount of watering?	____
11. Are the motorways around the site suitable for and respecting the surrounding environment; natural and built*? (Consider width of motorways and speed limits, safety aspects,…etc.,).*	____		
12. How does the project introduce any damaging, polluting, or waste generating activities?	____		
Average = Sum of Scores/12		**Average = Sum of Scores/10**	

Figure (3)

A) Average of Teachers Responses- Planning and Zoning "4.29"



B) Average of Teachers Responses Landscaping "4.55

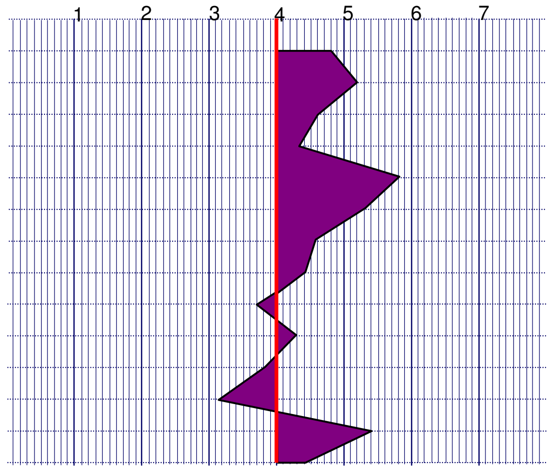


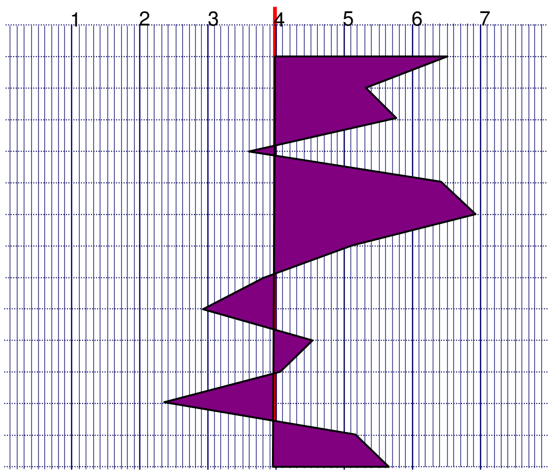
Figure 4: Table Illustrates the Checklist and the Rating System underlying Designing and Energy and Waste.

Factor 3: DESIGNING **Highly Appropriate 1 2 3 4 5 6 7 Very Inappropriate**	**Score**
1. How effectively does the architectural program consider the appropriate activities and space requirements and standards required for accommodating these activities? *(consider the nature of the curriculum and students and teachers' needs, classroom shapes, integrating indoor learning and outdoor activities…etc.)*	____
2. Is the architectural form designed in harmony with the natural landscape and the surrounding physical setting?	____
3. Does the design of outdoor elements allow for interaction of students and teachers with nature *(consider roof garden design, terraces, and verandahs, semi-covered outdoor areas).*	____
4. How effectively does the design provide visually appealing interior environment? *(consider classroom paintings, expression of materials, interior plantations, and day lighting).*	____
5. How effectively does the interior design consider aspects associated with human comfort? *(consider the degree of natural lighting in classrooms, the design of teachers' work areas, students absenteeism…etc.).*	____
6. How effectively does the design of the building allow for achieving acoustical quality and hearing privacy? *(consider noise around classrooms, separation between learning and recreational activities…etc).*	____
7. How effectively does the design of the building consider aspects that pertain to indoor air quality? *(consider naturally ventilated areas vs. artificially ventilated areas where AC is used)*	____
8. How does the design of the building employ ecological design techniques? *(consider orientation and aspects that pertain to solar energy, natural ventilation, lattices and shades on windows, natural lighting).*	____
9. How does the design of the building allow for maximum natural lighting for interior space? *(consider this only in classrooms)*	____
10. Are the building components placed apart (but integrated) so as to allow for natural growth of vegetation and wild life movement?	____
11. How does the capacity of the building correspond to site features and the surrounding natural context? *(consider built up area, density, number of students, teachers and cars).*	____
12. Does the design allow for the ease of maintenance, cleaning, and repairing? If so, how effective?	____
Average = Sum of Scores/12	

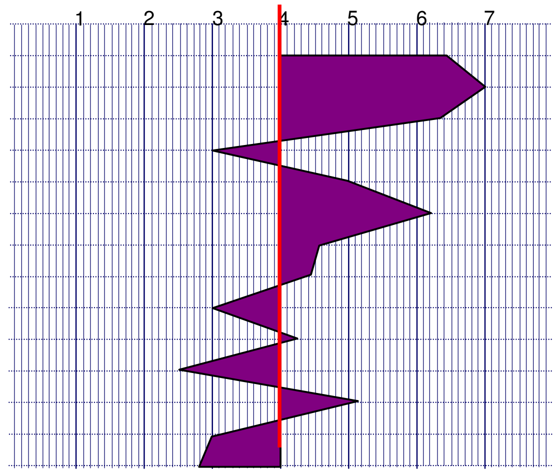
Factor 4: ENERGY AND WASTE **Highly Appropriate 1 2 3 4 5 6 7 Very Inappropriate**	**Score**
1. Was the building designed in a manner that saves energy embodied during the construction process? *(consider the materials used in the building, Are they locally produced, if not, from where they were transported).*	____
2. Does the design consider the use of photovoltaic system to generate electricity as primary, secondary, or integrated with the regular power source? *(Photovoltaic systems are units that utilize the renewable energy (sun radiation) in lighting or in other electrical and mechanical systems in the building).*	____
3. To what extent does the design of the building shell avoid exposing the exterior walls to direct heat gain *(consider north- south orientation, wall thickness, wall material, and insulation).*	____
4. Is modern technology employed for energy and water savings? *(consider the use of light sensors, solar tanks, and taps that work automatically).*	____
5. To what extent does the design of the building avoid high-energy consumption and the use of hazardous materials?	____
6. Is waste recycling system working well? *(consider drainage system, and separation of waste, paper, glass, aluminum cans, cardboard…etc.,).*	____
7. How effectively is the water recycled via different uses in the operation process? *(consider water source, recycling process, and the use of gray water for irrigation).*	____
Average = Sum of Scores/7	

Figure 5:

A) Average of Teachers Responses Designing "4.88"



B) Average of Teachers Responses Energy and Waste "4.84"



Conclusion: Schools and Schooling for Tomorrow

This paper has presented review of the literature that emphasizes the impact of the school environment on students' performance and behavior. Approaches to address sustainability in learning environments were explored and critically analyzed. PLADEW was developed and implemented as a tool that increases teachers' awareness while utilizing the building as an open textbook.

The preliminary testing of PLADEW revealed that elementary school teachers were not able to comprehend some of the issues underlying each factor. However, adding a glossary of technical terms and definitions helped them recognize sustainable design features and make judgments about their school building sustainability. At the same time, they were able to think of the building features that allow them to adopt the concept of *"utilizing the building as a teaching tool."*

In order to take full advantage of PLADEW and other awareness mechanisms and to benefit from the idea of the school building as a teaching tool, teachers should be involved early in the design process to better explain to the design team their current curriculum objectives and teaching procedures. Their involvement will help designers explore how sustainable design features can best be incorporated to maximize the learning experience. Exploratory creative thinking by teachers and designers during the initial stages of design fosters the production of educational opportunities once the building is completed and occupied. The following is a set of simple strategies that represent issues that need to be integrated into current guidance documents on sustainable design of learning environments. By incorporating these strategies into school specific guideline documents bottom up strategies can be effectively addressed and tools like PLADEW become catalysts for raising teachers' awareness of building sustainability and thus allow them to utilize the building as a teaching tool.

Site Design

- Incorporate outdoor teaching courtyards
- Develop spaces to grow vegetables
- Protect areas for viewing natural habitats

		▪ Maximize pedestrian pathways from residential areas to the school ▪ Use explanatory signage for different plants and trees
Daylight and Windows		▪ Make daylighting strategies and treatments obvious ▪ Establish deliberate connections to the outdoor environment so that changes in weather are apparent and become stimulating to students ▪ Incorporate sundials as educational tools on solar arrangements ▪ Utilize prisms in focal areas to celebrate sunlight while educating students about light
Lighting, Electrical and mechanical Systems		▪ Incorporate photovoltaic lighting for parking lots, walkways, and signal and caution lights ▪ Expose parts of the mechanical system so that heating and cooling processes can be explained.

References

Bosch, S. (2002) Characterization of Guidance Documents for Creating High Performance Schools. Internal Paper. Center for Sustainable Facilities and Infrastructure. Atlanta, Georgia: Georgia Institute of Technology.

Bosch, S. and Pearce, A. (2003) Sustainability in Public Facilities: Analysis of Guidance Documents. Journal of Performance of Constructed Facilities. February (03), 3-9.

Bowers, J. H. and C. W. Burkett (1987) Relationship of Student Achievement and Characteristics in Two Selected School Facility Environmental Settings. Alberta, Canada: 64th Council of Educational Facility Planners, International Conference in Edmonton.

Cash, C. S. (1993) Building Condition and Student Achievement and Behavior. Ph.D. Thesis, Educational Administration., Blacksburg, VA: Virginia Polytechnic Institute and State University.

CEEDS, Center for Environment, Education and Design (2000) http://ceeds.caup.washington.edu

Christie, D. J. and C. D. Glickman (1980) The Effects of Classroom Noise on Children: Evidence for Sex Differences. *Psychology in the Schools* 17(3), 405-408.

City of New York (1999) High Performance Building Guidelines. New York, NY: Department of Design and Construction.

Collaborative for High Performance Schools (2001) Best Practices Manual, Collaborative for High Performance Schools. San Francisco, CA: Eley Associates.

Davies, J. et al (Eds.) (1994) Sustainable Urban Projects: Principles of Implementation. Torino, Italy: European Academy for the Urban Environment.

Duke, D. L. (1998) Challenges of Designing the Next Generation of America's Schools. Phi Delta Kappa.

ECE, Economic Commission for Europe (1996) Guidelines on Sustainable Human Settlements Planning and Management. New York/Geneva: United Nations Publications

Evans, G. W. and L. Maxwell (1997) Chronic Noise Exposure and Reading Deficits: The Mediating Effects of Language Acquisition. *Environment and Behavior* 29(5), 638-657.

Gelder, J. (1998) Teaching Environmentally Sustainable Design in Schools. *PEB Exchange*, Issue 35, 14-16. <http://www.oecd.org/els/education/newsletters.htm>.

Grandgaard, E. M. (1995) Color and Light Effects on Learning. Washington, DC: Association for Childhood Education International Study Conference and Exhibition.

Hayduke, L. (1983) Personal Space: Where We Now Stand. *Psychological Bulletin.* 94(2)13-17.

Heschong Mahone Group (1999) Daylighting in Schools: An Investigation Into the Relationship between Daylighting and Human Performance. Fair Oaks, CA: The Pacific Gas

and Electric Company on behalf of the California Board for Energy Efficiency Third Party Program.
Innovative Design (2001) Sustainable Schools Guidelines. Raleigh, North Carolina: Innovative Design Consulting.
Lackney, J. (1999) The Relationship between Environmental Quality of School Facilities and Students Performance. Washignton, DC: Congressional Briefing Report to the U.S. House of Representatives.
Lewis, L., Snow, K., Farris E., Smerdon, B., Cronen, S. and Kaplan, J. (2000) Condition of America's Public School Facilities. Washington, DC: National Center for Education Statistics.
Lyle, J. T. (1993) Regenerative Design for Sustainable Development. New York, NY: John Wiley and Sons.
Meek, A. (Ed.) (1995) Designing Places for Learning. Alexandria, VA: Association for Supervision and Curriculum Development.
Ohrenshall, M. (1999) Better Learning in Better Buildings: Sustainable Design of School Facilities. Pacific Northwest Energy Conservation and Renewable Energy Newsletter. http://www.newsdata.com/enernet/conweb/conweb43.html#cw43-4.
Ott, J. N. (1976) Influence of Fluorescent Lights on Hyperactivity and Learning Disabilities. *Journal of Learning Disabilities* 9(7), 22-27.
PNWPPRC, Pacific Northwest Pollution Prevention Resource Center (1999) Topical Reports: Sustainable Design for Schools. Seattle, WA: PNWPPRC Publications
Rees, W. (Ed.) (1990) Planning for Sustainable Development: A Resource Book. Vancouver: University of British Columbia Center for Human Settlements.
Rosenbaum, M. (1999) Whole Systems Analysis as a Basis for Decision Making in Green Buildings Environmental Building News. http://www.buildinggreen.com/features/mr/systems.html.
Salama, A. (2002) A Critical Thought on Sustainability. IAPS-Bulletin of People Environment Studies. Netherlands: Technical University of Eindhoven and IAPS.
Salama, A. (2003) Toward a Transformative Thinking for Re-Addressing Sustainability In Learning Environments. Minneapolis, Minnesota: Proceedings of the Environmental Design Research Association – EDRA 33.
Salama, A. and Adams, G. (2003) Designing Sustainable Learning Environments: Rethinking the Missing Dimensions. Cairo – Egypt: Proceedings of Al Azhar Engineering International Conference. Al Azhar University.
SBIC, Sustainable Building Industry Council (2001) High Performance School Buildings: Resource and Strategy Guide. Washington, DC: SBIC Publications.
Triangle J Council of Governments (2001) High Performance Guidelines: Triangle Region Public Facilities. Research Triangle Park, NC: Triangle J Council of Governments.
University of Minnesota (2000) Minnesota Sustainable Design Guide. Twin Cities, MN: Uniersity of Minnesota, College of Architecture and Landscape Architecture.
U.S. Green Building Council (2000) LEED Green Building Rating System™, Version 2.0, U.S. Washington, DC: Green Building Council.
U.S. Green Building Council (2001) LEED™ Reference Guide. Washington, DC: Green Building Council.
Unger, D., K. A. Forrest, et al. (2000) Poudre School District Sustainable Design Guidelines. Poudre, Colorado: Poudre School District, Facility Services & Planning, Design and Construction Services.
Vanegas, J. A., M. Hastak, et al. (1998) A Framework and Practices for Cost-effective Engineering in Capital Projects in the A/E/C Industry. Austin, TX: Construction Industry Institute.
Weiss, J. (2000). Sustainable Schools. CEFPI Issue Track: 4. http://www.neetf.org/pubs/NEETF8400.pdf .

Acknowledgement

Thanks to Dr. Sheila Bosch of the Center for Sustainable Facilities and Infrastructure at Georgia Institute of Technology for providing valuable and thoughtful insights toward the development of this paper. Thanks to Mr. Van Wade, Principal of Carmel Christian School, for facilitating the implementation of PLADEW with his teaching faculty.