



IMPACT OF DAYLIGHTING ON STUDENT AND TEACHER PERFORMANCE

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Abstract

In this study, It was aimed to determine the factors of daylighting, which is one of the significant dimensions of green schools, affecting student and teacher performance. For this aim in mind, the literature was reviewed and the existing situation was put forward as it is. It is a descriptive research. When compared to traditional schools, “green schools” present a healthier environment and have the lowest operation costs and negative effect on environment. A green school should have a great access to daylight, high indoor air quality, good acoustics and comfortable temperature. Light affects people’s performance and health through visual and circadian systems. Students who attend daylight green schools demonstrate higher achievement, and higher attendance rates than students who attend traditional schools using electricity for lighting. It was found that daylighting has positive effects on teacher’s motivation, job satisfaction and absenteeism.

Key Words: Green School, Daylighting, Artificial Lighting, Student Achievement, Teacher Performance.

INTRODUCTION

There is no greater challenge facing us today than the issues of global warming, climate change and the depletion of energy and material resources. It is now known that buildings are far and away the greatest consumer of energy and materials and are direct contributors to greenhouse gas emissions through the combustion of natural gas and oil in heating and cooling (Kaplan, 2009: 85). Green buildings have become integrated into the architecture and development professions and are a dominant focus of research and practice in those fields. There are many reasons for the recent popularity of the concept of green buildings. The environmental benefits are perhaps the most commonly cited reason for green buildings. Green buildings are one solution to environmental problems such as water use and pollution, energy consumption, and materials use (Retzlaff, 2009:4) Because the school buildings are the largest building sector in the non-residential construction industry changing the way we design schools will have a profound effect on the environment (Kaplan, 2009: 85). Both in educational aspects and environmental concerns schools should be examined more closely.

Schools are entrusted with the care of the children of a community. It is an enormous responsibility. The school has a special status in the community. It forms the basis of the social life of the children, friendships that teach children how to have friendships, and often extends a web of connectivity into the whole family. Schools cannot be successful without the support of the families, friends, and neighbours who make up the school community (Gelfand, 2010: 7). School buildings are special places. They are the locus of education, the places where children come together to learn about civics and develop basic skills to be productive members of society. Schools are also used for adult education classes, voting, community events, and other activities, and may symbolize the community itself (National research Council, 2007:2). As the schools are the places where the ideas born and grow, they are the right places to discuss the necessities and benefits of green building designs. Green facilities provide occupants of the building with a healthy environment and have minimum



negative effect on nature. In addition to these physically visible benefits integrating environmental awareness into school curriculum will enable the students to be in close relationship with the environment.

According to Schachter (2009) "For many schools, 'Going Green' once meant turning out the lights after leaving the classroom, filling the recycle bins, and celebrating Earth Day". Although these activities are good practice, Kennedy (2008) states that "Countless ways exist for schools and universities to incorporate sustainable strategies into their decisions and operations" (Canaan, 2010: 29). It is needed—in both young people and adults—to cultivate the qualities of optimism, critical thinking and competence, and capacity for 'making a difference' that are identified with resilience. While not the complete answer, education and learning must play a significant part in developing resilient, activist citizens (Davis, 2007: 346). Zhongguo (2004) argues that the environmental education and "green school" establishment at schools is an important means and basic tool to enhance students' environmental awareness. It is also one important aspect of the quality-oriented education at schools and the construction of spiritual aspect of civilization.

Green or sustainable schools are energy, material, and resource efficient and optimize student health and productivity. Additionally, they can provide a unique educational opportunity to link building design to environmental issues and their solutions. Several studies have already shown that students perform at a higher level when they have natural light in their classrooms (Kaplan, 2009:85). According to Sack-Min (2007) green has been the top trend in school design for several years, and most new schools and additions now have at least a few elements that not only make the buildings more environmentally friendly but save money as well. Green school design aims to open buildings to daylight and views, with the general goal of saving on lighting energy costs and reducing energy loads for HVAC systems (Taylor, 2009:126). Light is a metaphor for learning (enlightenment) and a way of creating sacred space. This less tangible benefit should not be neglected as we quantify the importance of daylight while the benefits of higher test scores and lower energy bills can help justify the specific cost of adding daylight windows. Daylighting is one of the best investments you can make in the design of a learning environment (Gelfand, 2010: 83). As one of the most important aspect of green school design benefits of natural lighting cannot be ignored. Designing a useful lighting system certainly will have positive effect on students' academic scores, faculty's teaching performance, occupants' health and mood, saving energy and saving in utility costs.

Light levels in school buildings are strongly influenced by the expected visual performance requirements for a given task. In general, higher illuminance levels are recommended for specialized tasks such as reading and writing than for less demanding visual tasks such as eating or walking. Lower illuminance levels are also recommended for public spaces where reading and visual inspection are only occasionally performed or where there is no time pressure to complete the task. For these reasons, lighting should be designed not just with respect to the source of illumination or the individual components needed to create the entire lighting system but should instead be designed with respect to the integrated system of enclosure design and controls, space configurations and surface finishes, and fixture components, all of them in relation to the task requirements: In schools, it is inappropriate to require specific types of luminaires and lamps without consideration of the space layout. This is true for new construction, significant renovation, or retrofit of school buildings (National Research Institute, 2007:88). Contemporary schools are composed of many different rooms serving different functions. These schools include classrooms, science labs, cafeterias, gyms, libraries, music rehearsal spaces, conference room etc. all these rooms serves for a different function and needs special lighting designs.

Openings are also a major element in the composition of building facades for harvesting daylight. Gelfand (2010) states that apertures of daylighting include skylights, clerestory windows, windows borrowed light from the other spaces. Both skylights (through roof) and clerestory windows (high on walls above vision windows) allow light into a space from above the occupied area. Windows also view outside. Borrowed lights are windows or clerestories into other spaces – for example the window on a private office that brings light from an open office area. Windows with sills 7.5 feet or more above the floor are optimized for daylighting. They help light penetrate deeply into the classroom because of the angle of the light.

Windows are an important part of a school's design as they relate to lighting. They allow for high light levels and, when properly located, ideal lighting configurations for visual tasks not involving self-luminous displays,

such as computer screens, or audiovisual presentations. Windows are also the largest sources of glare in a classroom. However, glare can be controlled with fixed overhangs and blinds or window treatments that can be manually operated. Methods to control light from skylights and clerestories are also needed because the distribution and level of light changes as the day progresses. A key difference between electric light and daylight is that electric light is almost always static, whereas daylight is ever-changing over the course of a day, with weather conditions, and with season. Daylight will also be different from one school to another, depending on building orientation and site, climate, and latitude, so that a cookie-cutter building design will rarely provide ideal lighting. The dynamic nature of daylight, together with the wide range of intensities and distributions, demands a sophisticated understanding of its interactions with a building and the building's spaces: A much more sophisticated understanding is required for using daylight effectively than for using electric lighting effectively in school design. In some circumstances it may be desirable to conduct detailed lighting, heating, and cooling simulations in order to gain such an understanding. (National Research Institute, 2007:87) Siting location of windows, transparency throughout a school and diffusion of light remains issues important to light quality (Taylor, 2009:130). Although at first it seems to be an easy task, designing the buildings which use daylighting at higher levels requires a deep consideration.

We postulated that by including schools with skylights rather than daylighting from windows, we could better isolate the effect of daylight. Skylights generally provide a simple illumination function, whereas windows may have a far more complex effect on people. Windows typically offer a view, which may provide relaxation, inspiration or distraction (Heschong, 2002: 102). Well designed natural lighting systems can easily eliminate distraction factors resulted from the windows.

According to Molinski (2009) daylighting is the practice of using natural light to illuminate interior building spaces (Oetinger, 2010:36). 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. Light shelves, which are a horizontal reflective surface at or above eye level, are used to channel daylight into an occupied room. According to Glead (2009) daylighting affects the comfort, productivity, performance, health and wellbeing of occupants. Daylighting has a significant influence on energy efficiency (Oetinger, 2010, 37).



Figure 1: Light shelf bouncing direct light (LPA Architects,2009:28)

Another way to light the sailing is to bounce direct light from a light shelf. This can turn south facing walls into a great source of indirect light. (Gelfand, 2010: 100). Relating to the orientation of the rooms the “window’s direction” is determined and resulting, effect of direct sunlight and daylight are different. Shading systems should be designed according to the occupation time and function of rooms. To obstruct direct sun beam, recently developed systems can lead daylight into the room and transmit it to the further distant parts of the room while simultaneously providing sun control (Kesten, 2006: 22). Further simple and sensible solutions like blinds or window treatments will also enable occupants of the building to control the negative effects of direct sunlight.

Benefits of Daylighting

Economic benefits of using natural lighting should not be ignored. More recently, daylighting has been advocated as a way to reduce lighting energy use in schools and other non-residential buildings. Turning off electric lights when sufficient daylight is available can save a significant amount of lighting energy costs. Because daylight introduces less heat into a building than the equivalent amount of electric light, cooling costs can also be reduced with appropriate daylight design (Heschong, 2002: 101). Decreasing the 40% to 60% of power going to electric lighting is the first cost saving. Daylighting, with less waste heat from lights, can also contribute up to 20% to energy savings due to decreased cooling loads in schools with air conditioning. Nearly 60% of electricity production comes from the burning of coal and its attendant emission of carbon. Every watt of energy saved reduces the amount of carbon emissions released into atmosphere. Daylight provides its benefits during daytime, when the demand for electricity is at its peak. Reducing energy usage during the day reduces the strain on the electricity grid infrastructure (Gelfand, 2010:83). Saving on the costs of energy arise interest of school administrators. This way the costs of energy can be saved and used for educational purposes. There is a growing body of literature indicating that the effect of light on circadian rhythms can affect productivity as well as health. Seasonal affective disorder (SAD), or the “winter blues,” is recognized by the medical community as a psychiatric disorder. According to Rosenthal (1998), apparently, seasonal reductions in the amount of daylight available in the winter at extreme northern and southern latitudes can induce depression. Light treatment, typically provided as bright light from electric lighting systems, is recognized by the medical community as the preferred method of treating SAD (National Research Institute, 2007:86). Although it may seem an unimportant daily mood SAD affects people’s mood and makes them unhappy resulting a decrease in productivity and attendance.

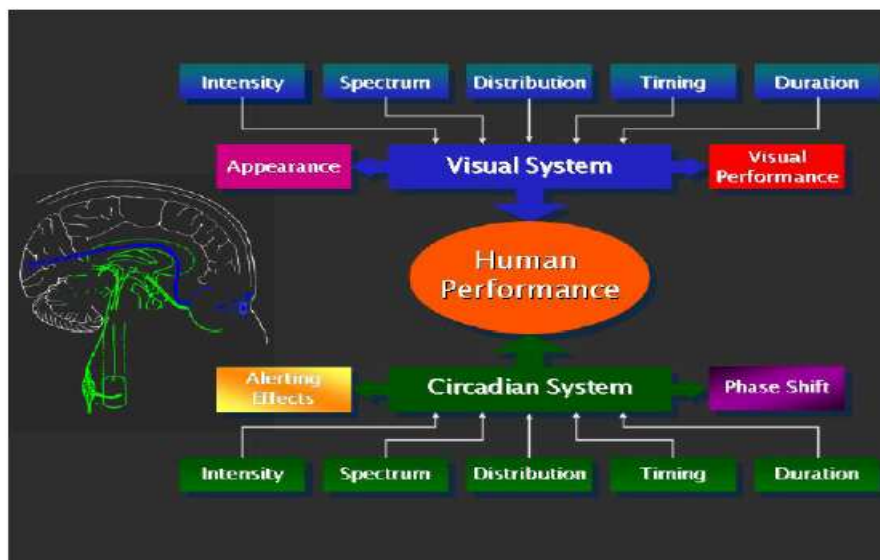


Figure 2: Light as it affects human performance and health through the visual and circadian systems. (National Research Institute, 2007:85).



According to the Green School Initiative (Global Green USA, 2005) daylight provides biological stimulation that regulates body systems and mood, saves costs, and offers the benefits of natural ventilation (Taylor, 2009:130). Moore (1997) states that the circadian system involves biological rhythms those repeat at approximately 24-hour intervals. The behaviour of all terrestrial species, including humans, is driven by an internal clock synchronized to the solar light-dark cycle. Indeed, light is the primary stimulus for the internal clock. The circadian system regulates not only overt patterns of behaviour such as activity and rest, but also bodily function at the cellular level, such as the cell cycle (National Research Institute, 2007:85).

The design professional must provide extraordinary design leadership through the use of natural daylighting and daylight modelling. Use of research for health and productivity benefits of natural daylighting and daylight modelling to forecast environmental consequences are mandatory. Higher productivity comes from the occupants having better views and daylight access, more precise temperature control, and the psychological benefit of a higher volume space (Johnson, 2006:59).

Daylighting changes with weather and time and is the spectrum human beings are biologically adapted to perceive. Daylighting can enhance a connection to nature and directly improve the mood of the students and faculty (Gelfand, 2010: 83). 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 (Johnson, 2006:59). Schools are important settings in which to promote children's and young people's physical and emotional health. An evaluation of the National Healthy School Standard in England showed that education and health professionals have implemented a range of projects and activities to improve pupils' health (Warwick, 2005:697). Even if it may be in an indirect way, role of natural lighting on the health of human being is accepted for a long time. It should not be ignored that schools are the most crowded buildings most of the year and hosts young people. Applying green building principles to schools contributes the occupants' physical and emotional health.

Learning requires visual tasks (writing reading observing) for both students and teachers. For young children learning to read the faces and the bodies around them is as important as learning to read text. Successful daylighting engages the entire space of the classroom, not just in work surface (Gelfand, 2010: 83). Heschong et al. (2002) argues that the addition of natural daylight has been shown to improve student test scores by up to 20%. In the United States, a North Carolina architectural firm has received attention for reporting that student test score performance improved in their daylit schools compared to neighbouring non-daylit schools. While these studies all have methodological limitations, they have suggested a consistently positive effect for the presence of daylight on student performance.

Kuller and Lindsten (1992) studied children's health and behaviour in classrooms with and without windows for an entire academic year. They concluded that work in classrooms without windows affected the basic pattern of the hormone cortisol, which is associated with stress, and could therefore have a negative effect on children's health and concentration. This finding is strictly suggestive, however, because no direct relationship between cortisol levels and student performance and health was established (National Research Institute, 2007:84).

Heschong et al. (2002) give place to another study in Sweden found that observed behaviour and circadian hormone levels of elementary students in classrooms with daylight stayed closer to expected norms than those in classrooms with only fluorescent sources. The Swedish researchers concluded that windowless classrooms should be avoided.

Another study by the California Board of Energy Efficiency shows test scores improve by as much as 26 percent in daylit schools. Typically built along an east-west access, with windows on the south and north walls, these schools usually have fingers or wings with "flag baffles" that cut down glare. Classrooms line sunny outer walls and closets, and other nonessential rooms are in the middle. Daylighting reduces the need for both electrical lighting and cooling, because sunlight provides a higher ratio of light to heat than electrical sources do (Shorr, 2004:23). Taylor (2009) argues that a commonly cited daylighting study found that students in classrooms with



the most daylighting progressed 20 percent faster in one year in maths tests and 26 percent faster in one year in reading tests than their counterparts with the least amount of natural light.

METHOD

The literature was reviewed and the existing situation was put forward as it is. It is a descriptive research.

FINDINGS

When compared to traditional schools, “green schools” provides a healthier environment and have the lowest operation costs and negative effect on environment. Green schools provides a healthy environment for the occupants enabling them to reach natural lighting, indoor air quality, acoustics, comfort and clean air. As one of the most important part of green school daylighting has positive effects on people. When compared to artificial lighting natural light increases performance and health through visual and circadian systems. Some researches on daylighting and performance suggests that Students who attend daylit green schools demonstrate higher achievement, and higher attendance rates than students who attend traditional schools using electricity for lighting. In addition to that it was found that day lighting has positive effects on teacher’s motivation, job satisfaction and absenteeism.

DISCUSSION AND CONCLUSION

Green schools appear to provide an environment which pupils and teachers both value, and this finds expression in a number of external measures. The quality of the classroom environment resulting from green design approaches appears to reduce stress in teachers, leading to lower rates of absenteeism or staff turnover, and this in turn leads to improved productivity. The lower level of pupil absenteeism (approved and unapproved) suggests greater satisfaction with the school as a place for learning, the improvement in performance of pupils appears to be related to the level of daylight in the classroom (and the presence of sunlight). By maximising children’s exposure to daylight green schools offer investment advantages beyond that of reducing the environmental footprint of the school in terms purely of energy consumption. Although schools which consume less of their budget on utility bills have extra money available for computers or classroom assistants, the quality and type of light in the classroom appear most critical in terms of learning (Edwards, 2006:30). The study undertaken suggests that school buildings designed on green principles applying natural lighting offer benefits for the pupil and teacher alike.

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REFERENCES

Canaan, Paul, Greg Lesan, Ryan Nowlin, Garrett Wade Smith (2010) *Public School Districts’ Adherence to Guidelines for Environmentally Sound Practices* Saint Louis University, America.

Davis, Julie M., Sue M. Cooke (2007). “Educating for a Healthy, Sustainable World: An Argument for Integrating Health promoting Schools and Sustainable Schools” *Health Promotion International* Oxford University Press 22 (4) 346–353.

Edwards, Brian W. (2006) “Environmental Design and Educational Performance with particular reference to ‘Green’ Schools in Hampshire and Essex” *Research in Education* 76 14-32 November.

Gelfand, Lisa ve E. C. Freed. (2010) *Sustainable School Architecture: Design for Elementary and Secondary School* John Wiley and Sons Inc.



Heschong, Lisa, Roger L. Wright, Stacia Okura (2002) "Daylighting Impacts on Human Performance in School" *Journal of Illuminating Engineering Society* Summer 101-114.

Johnson, Raymond, Leo J. Bernabei Joseph M. (2006) "Green Building Design for Schools: The Next Time Around" *Strategic Planning for Energy and the Environment* Fall 26 (2) 56-77.

Kaplan, Howard (2009) The Time is Now. In A. Taylor, *Linking Architecture And Education: Sustainable Design For Learning Environments* China: University of New Mexico Press.

Kesten, Dilay (2006) *Investigation of Efficient Lighting System Design in Educational Buildings at the Example "Municipal School of La Tour De Salvagny* (Unpublished Master Thesis), İstanbul: İstanbul Technical University.

LPA Architects (2009). Beaver, Robyn Ed. *Green School Primer: Lessons in Sustainability* Images Publishing, Australia.

National Research Institute (2006) (National Research Council) *Green Schools: Attributes for Health and Learning* Washington: The National Academies Pres.

Oetinger, Jonathan W. (2010) *Green Schools: Constructing and Renovating School Facilities with the Concept of Sustainability* (Dissertation in Partial Fulfilment) America: Lindenwood University.

Retzlaff, Rebecca C. (2009) *Journal of Planning Literature* "Green Buildings and Building Assessment Systems: A New Area of Interest for Planners" 24 (1) 3-21 August.

Sack-Min, Joetta (2007) "Districts Reap Cost Savings by Building 'Green Schools'" *School Board News* 27 (1) 19-21.

Shorr, Pamela Wheaton (2004) "It's so Easy Being Green: Schools Discover the Dollars-and-Sense Value of Energy Efficient, Eco-Friendly Facilities" *American School Board Journal* October.

Taylor, Anne, Katherine Engass (2009) *Linking Architecture and Education: Sustainable Design For Learning Environments* China: University of New Mexico Press.

Warwick, Ian, P. Aggleton, E. Chase, S. Schagen, S. Blenkinsop, I. Schagen, E. Scott, M. Eggers (2005) Evaluating Healthy Schools: Perceptions of Impact Among School-Based Respondents *Theory & Practice* 20 (6) 697-708 Oxford University Press.

Zhongguo, Tang (2004) Establishing "Green Schools" and Enhancing Teachers and Students' Environmental Awareness *Chinese Education and Society* vol. 37 (3) May/June, 94-96.