

Effect of daylighting on student health and performance

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Abstract: Daylighting is an efficient method for providing better learning conditions and health in schools. Poor daylighting causes discomfort, which reduces learning and it is detrimental to the physical and mental health of students. This study focuses on the effects of daylighting on the physical health, psychological well-being, and performance of students in schools. The paper aims to provide architects, building designers, and researchers with additional information and a better understanding of the effects of daylight on student health and performance.

Keywords: Daylighting, health, psychological, learning, student, school

1 Introduction

Daylighting uses light sources that create pleasant and comfortable indoor environment [1]. Daylight is a free natural resource. Allowing natural light into buildings improves health and psychological reactions, and daylight is an inexhaustible resource [2]. Good daylighting has also been proven to provide healthier environments [3].

Daylighting in school buildings significantly affect students. The majority of schools generally do not provide adequate lighting to encourage the circadian system. Therefore, incorporating sufficient daylight into school buildings will improved circadian stimulation and entrainment [4]. Buildings occupants prefer to utilize the outside view and natural light instead of electrical light. In well-designed interior zones, daylight increases visual quality and mental health benefits, which are costly and hard to reproduce through artificial lighting [5]. Several negative effects are linked with the use of artificial light. Baker and Steemers (2002) states that using artificial light causes strain, fatigue, and circadian dysfunction in building occupants [6].

Switching off artificial light in the classrooms is a good daylighting strategy [7]. Daylighting is one of the main considerations in “sustainable” building design. Researchers have found that daylighting and views improve comfort and health in working environments [8]. The designers are usually tasked to identify the routines of occupants to provide sufficient levels of natural light [9]. Numerous researchers have described and calculated the

quality and quantity of daylighting in architecture [2]. The use of daylight in buildings considerably improves the atmosphere and economy. Natural lighting also has the potential to improve mood, health, presentation, and productivity [10, 11].

Natural school environments have an important role in improving the psychological health of students [12]. Lighting is one of the most important factors for a positive learning environment [13]. The relationship between functional area and lighting should be under optimal conditions to provide a background for high-quality learning in classrooms [14]. Daylighting affects the performance of students and the psychology of students in classrooms [15] (Fig. 1).

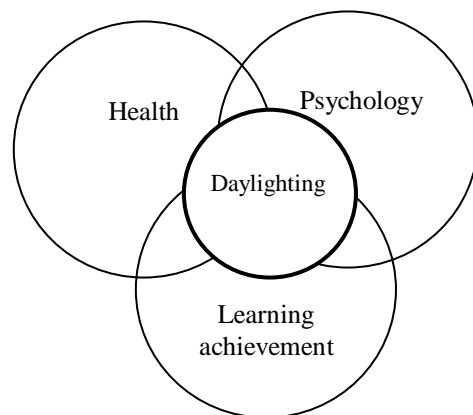


Fig. 1 Effects of daylighting on student achievement

Current studies indicate that natural lighting significantly improves the test scores of students

and develop physical and mental health (Fig. 1). Day-lit spaces have been demonstrated to enhance occupant contentment and develop increased productivity [16].

2 Daylighting and Health

Daylighting promotes a healthy teaching environment, specifically through vitamin D generation and circadian regulation. The level of daylight is important for the student's vision and it limits the effect of harmful electrical light. Daylight has both positive and negative effects on health. The use of artificial light has been linked to several negative effects. Baker and Steemers stated that artificial light can cause strain, fatigue, and circadian dysfunction among building occupants [6].

Outdoor daylight exposure has the strongest effect. Ultraviolet (UV) overexposure has harmful effects on students such as skin cancer. Nevertheless, daylight and sunlight that penetrate through glass windows contain much less short-wavelength ultraviolet radiation than the same outdoor radiation [17]. Windows reduce the number of health problems [11]. However, Baker and Steemers stated that UVA is less efficient than UVB [6]. Sunlight is the primary source of vitamin D, which is good for the body's internal system. Vitamin D is correlated with calcium absorption [17, 18]. Lucas and Pousonby indicated that less UV exposure causes vitamin D deficiency [17]. In the seventeenth century, the first researcher explained that rickets is caused by vitamin D deficiency [19]. Between 1910 and 1930, researchers determined that inadequate vitamin D causes abnormal bone formation, which results in insufficient calcium in bones [19].

Researchers at the University of California in Berkeley proposed that light sources with richer spectra provide more efficient lighting for vision. Daylight generates the richest spectrum, thereby reducing the stress on the eyes [17]. Daylighting provides the required light for easy recognition, which decreases eyestrain [11]. UV exposure also kills microbes [17].

Inadequate daylight reduced the circadian cycle is reduced, which requires resynchronization. Melatonin is secreted at the wrong times of the day [17], causing chronic fatigue, depression, and possibly even cancer [20]. Van Bommel and Van den reported that obtaining sufficient daylight every morning synchronizes the internal body clock to the Earth's 24 h rotational cycle [21]. Exposure to daylight in the early evening with a short-

wavelength (blue) affects the biological clock during spring as with early morning light. Students must receive light that acts on the circadian system in the morning and avoid light with similar wavelength in the evening to maintain a regular sleep cycle and to sleep earlier [22]. Students are usually at school daily in the morning; therefore, windows should be designed to allow sufficient sunlight in classrooms. Students can have difficulty to synchronizing with the circadian 24 h cycle. Therefore, daylighting is an important component in school designs (Fig. 2).

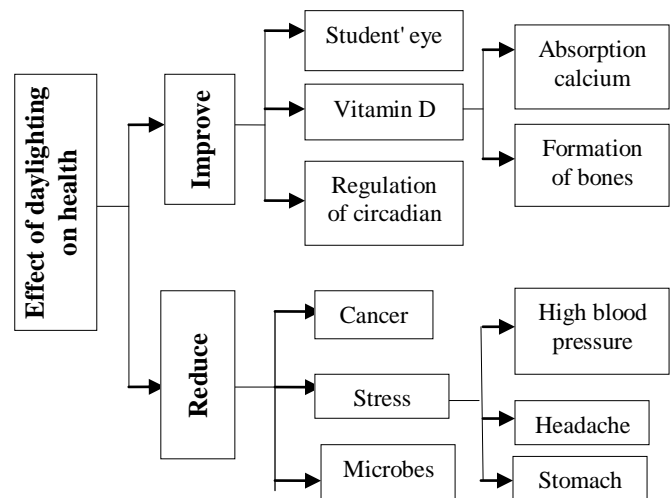


Fig. 2 Effect of daylighting on health

3 Daylighting and Psychology

Various lighting conditions affect the feelings of building occupants. However, guidelines for selecting the type of lighting to maximize the positive mood are lacking. Windows are significantly preferred for daylighting in working environments [11].

Daylight promotes the mental well-being of teachers and students. According to Knez (1990) and Vetich (1997), lighting affects mood and attitude. Heschong et al. (2003) stated that the physical characteristics of the classroom, such as lighting, does not influence student absenteeism; however, Hathaway (1994) found a good correlation between lighting and student attendance [23].

The level of illumination has a special psychological function in schools. Other researchers indicated that daylighting enhances mental performance, decreases violent behaviour, decreases depression, and improves sleep. Exposure to intense light has been used to treat ailments such as seasonal affective disorder [24].

Cakir (1998) studied stress among the occupants in the Federal Republic of Germany and the

Ergonomic Institute in Berlin investigated more than 2000 working population for lighting-associated health defects. More than 50% of health problems in offices are caused by lighting conditions [25]. These studies indicate the significance of daylighting on psychology, as well as personal health and well-being [26]. The absence of windows contributes to the stress on occupants [30]. Maslach and Jackson and Revicki et al. studied depression and stress. The results of their studies indicated that daylight is directly linked with depression and stress. At least 3 h of exposure to daylight is required to decrease stress and depression [19, 27–29].

Stress is characterized by hormonal and physiologic changes that in response to threats and disagreeable events. These events include life events such as unpleasant environmental condition [11, 30]. Furthermore, researchers stated that internal daylight provides students a feeling of security [31]. Daylight affects the function of a space and personal biological and internal clock of humans. Therefore, the positive effects of natural light on humans is one of the most important aspects considered in architectural design [32]. Fig. 3 shows the effect of daylight on psychological function.

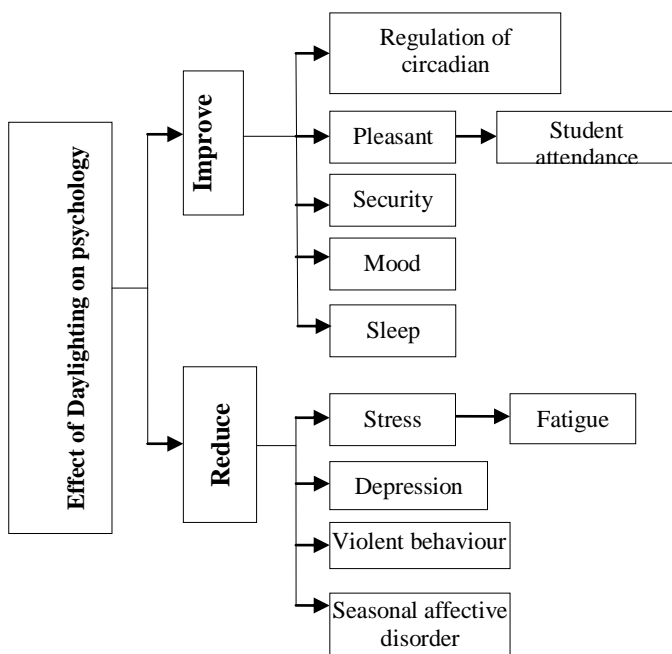


Fig. 3 Effect of daylighting on psychological function

4 Student Performance

Good daylighting can improve classroom conditions promote students learning, and reduce the rate of absenteeism in classrooms [7]. Researchers

indicated that adequate natural lighting promotes student performance. In the United_States of America, a number of studies have investigated the effects of natural lighting on student performance. The results show a strong correlation between daylighting variables, such as window size, sky conditions, tint, and level of anticipated daylight, and students performance [33].

Schneider showed evidence that teachers and students have clear preferences on classroom lighting [34]. For example, Hathaway claimed that teachers prefer natural lighting and Lang found that teachers prefer to have control over lighting levels [35]. Dunn et al. reviewed previous studies on the effect of lighting, including daylighting and electrical lighting on student behaviour and performance [36]. Students tend to achieve better result when tested in classrooms with adequate lighting than those with insufficient lighting [26]. Natural environments are a significant sources of motivation for learning [37]. The study by Liberman showed evidence of the effects of daylighting on students in school buildings [18, 38].

Heschong et al. (2002) investigated daylighting and student performance. They carried out several analyses on the academic performance of around 8000 students in 450 classrooms. Windows with pleasant views positively influence students, whereas direct sunlight, glare, and the inefficient use of windows and shading negatively influence students [39]. Thus, both studies by Heschong et al. concluded that daylight directly influences student performance [17]. Previous research by Heschong et al. (1999) found that student performance improved by 20% in day-lit classrooms compared with non-day-lit classrooms [24].

Students in classrooms with high levels of daylight exhibited 20% to 26% faster learning rates than those with low levels of daylight [24]. Heschong et al. (1999) analyzed the reading and math test scores of more than 21,000 elementary students from CA, Seattle, and Fort Collins for one year [40]. The California students showed approximately 20% to 26% increases in academic performance, whereas those in Fort Collins and Seattle exhibited almost 7% to 18% improvements (Heschong et al. 1999). Classrooms with maximum daylight improved math (20%) and reading tests (26%) of students compared with those under minimum daylight. Classrooms with maximum window areas were correlated with 19% to 20% better reading and math performance [19].

Nicklas and Bailey (1995) compared the result of score tests of students between day-lit and non-day-lit schools in North Carolina Johnston County

schools. The students in the day-lit schools had better grades than those in artificially lit schools. Their scores were between 5% and 14% in reading and math [26, 41].

Heschong et al. compared the effects of several schools in the same country for more than 4 years. The result showed that daylighting positively affects student performance [26] as shown in Fig. 4.

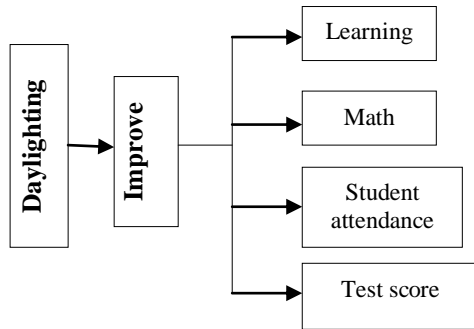


Table 1. Benefit of daylighting on students

| Improved | | | Reduced | |
|--------------------|--------------------|----------------------|---------------------|-----------------------------|
| Health | Psychological | Learning achievement | Health | Psychological |
| Vitamin D | Mood | Learning | Headache | Depression |
| Student’s vision | Cheerful | Math | Cancer | Fatigue |
| Calcium absorption | Student attendance | Student attendance | Stomach ulcers | Seasonal affective disorder |
| Bone formation | Sleep | Test score | High blood pressure | Violent behaviour |
| Biological clock | | | Stress | Stress |
| | | | Microbes | Security |

6 Conclusion

This paper reviews previous studies on the effect of daylight on the physical and psychological health of students and their performance based on test scores. Artificial lighting causes strain, fatigue, and circadian dysfunction among students.

This study provides valuable information for researchers on increasing health and student performance using natural light in schools. Moreover, this review can help designers and architects in designing daylight in schools, which generally provides inadequate natural light. Students who attend schools with good daylighting exhibited enhanced health, well-being, and student performance based on the result of test scores.

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Fig. 4 Effect of daylighting on learning achievement

5 Summary

The research shows the effects of daylighting on the health of students should be considered for school design because natural light considerably influences the health, psychology, and cognitive abilities of students, as shown in Table 1. Liberman claimed that reading is the most visually stressful task for students. Heerwagen et al. (1995) explained that working environments without window contribute to work stress. Stress can disagreeably affect health, such as high blood pressure, headaches, and stomach ulcers [30].

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