

The Impact of Day Lighting in Classrooms on Students' Performance

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Abstract-The study examines daylight and other features of indoor environment of classrooms on students' learning over an academic year at selected faculties at King Abdul-Aziz University campus at Jeddah, Saudi Arabia. Correlation analysis is used to compare the performance of 400 students in 20 classrooms at the selected faculties. The classrooms were on different floors of educational buildings. A statistical model was used to investigate the link between Daylight in classrooms and students' performance in their classrooms, despite the fact of existence of traditional descriptive learning variables. Other elements including, thermal comfort, Indoor air quality, acoustics and artificial light are examined to indicate any possible effect to students' performance. Further investigation was made which include interviews with teaching staff to examine the effect on classroom daylight on students' academic performance.

Keywords: Daylight, classrooms, educational buildings, artificial lighting, indoor environment, energy

I. INTRODUCTION

Natural lighting for many centuries was the main source of lighting in buildings until the late nineteenth century, when it was discovered the artificial lighting. During the last quarter of the twentieth century and the first years of the twenty-first century, architects and building designers have considered the important of natural lighting within buildings. Recently, daylight becomes very important in order to reduce energy consumption in buildings, and improve the indoor live quality.

"There is a distinct and proven link between illumination and student achievement, as indicated in the National Clearinghouse for Education (NCEF) study. "Do School Facilities Affect Academic Outcomes?" NCEF's report states that, in terms of lighting, there are seven independent studies indicating that classroom lighting affects student performance. These reports also document that there are optimal lighting levels for learning, that appropriate lighting improves test scores and reduces poor behavior, and that daylight fosters higher student achievement. Clearly, correct illumination is a critical component of teaching and learning" [7]

This research aims to investigate whether the level of student performance is influenced by the availability of daylight in the classrooms. Air quality in indoor, thermal comfort, acoustics, and artificial lighting is also taken into account. Some educational buildings on campus, King Abdul Aziz University in Jeddah, Saudi Arabia, were selected to carry out the research.

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A pre-designed questionnaire and some interviews with some students and faculty members were used to assess the impact of daylighting on student performance the day light.

II. STATEMENT AND OBJECTIVES

Natural lighting and its impact on the performance of students have gotten the attention of researchers for many years. Before the artificial lighting become the dominant, all the classrooms were lighted by the natural light, of course. Recently, more interest has revived the importance of the windows to provide daylight and looking to outside, especially whenever a good exterior landscapes be available.

The primary goal of this study is to examine some classrooms in the educational buildings at King Abdul Aziz University to determine whether daylight can affect student performance. Collect information about the natural lighting conditions in the classroom is the first step to test the impact on student performance. Also other aspects of the internal environment of the classroom affect student performance and interact with the light of day. To achieve the objective of the study, information about the selected classrooms, including, along with natural lighting, HVAC, ventilation, windows and roof coverings, and opinion, and the quality of indoor air, has to be considered. Figure (1) shows examples of the Faculty of Environmental Design classrooms.



Figure (1) Samples of the classrooms at the Faculty of Environmental Design, KAU.

III. DAYLIGHT IN CLASSROOMS

"A school with insufficient light can reduce a student's ability to learn due to the effect lighting has on physiology. Poor spectral light can create eyestrain, leading to decreased information processing and learning ability and causing higher stress levels"[3] Providing the appropriate level of illumination, with uniform distribution of light with ungeared effect are essential for comfortable classroom indoor environment. Lighting of classroom should be in the level that is sufficient for student activities such as writing and reading on the study tables and blackboards or boards on the wall. Glare control is a key consideration in the classroom, particularly in the direct sunlight penetration to classrooms. There is a need for a comprehensive study in a variety factors such as sun shine angles and other modifiers of the building elements. (Figure 2)

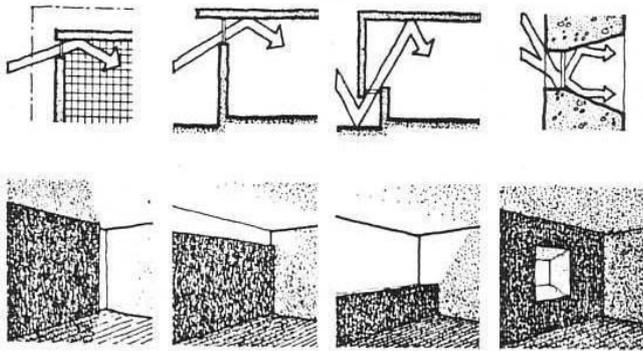


Figure (2) Daylight pattern of side windows and controlling outdoor glare [1].

Achieving good concept for natural lighting and aware of different tasks in the classroom that are affected by natural light is critical because every task requires specific lighting conditions.

Students and faculty members benefit from lighting that supports their activities requires good lighting design to fit their needs, while energy efficiency should not be ignored. The European norm EN 12464-1 provides guidelines for illuminations at schools buildings (Table 1).

Table (1) Overview of tasks in a classroom together with the requirements for the luminance [2]

Task	The Teacher	The Student	Standard - Luminance	
			In the class	In general
1	Writing on blackboard	Reading on blackboard	500 lux (vertical)	200 lux
2	Talking to students	Paying attention to the teacher	300 lux	300 lux
3	Showing a presentation (slides, PowerPoint, television program, etc.)	Looking at the screen	300/10 lux	10 lux
4	Paying attention to working students	Writing, reading, drawing, etc.	300 lux	300 lux
5	Coaching computer activities	Looking to the computer screen and the paper	50 lux	300 lux above the computer
6	Preparing lessons	Not present	300 lux	50 lux

IV. BENEFITS OF DAYLIGHT

“Using natural light or daylight for illumination is one of the hallmarks of a high-performance building. In addition to the benefits of supplying substantial light for free, natural light provides great physical and psychological benefits to the building's occupants” [2]

Daylight can be defined as the combination of all direct and indirect sunlight during the daytime, which is often incorporated as an architectural treatment for building energy savings. Daylight added value range beyond energy and architecture; it is a leading feature of movement in classrooms which could enhance the academic performance of students as well as other aspects such as organizational direct costs reduction and decrease of harmful effects of environment.

In educational buildings, daylight may play an important role in student statues in respect to their mode, health and level of productivity.

"A study of three school systems in Washington,

Colorado, and California found that students in rooms with the most diffuse and glare-free daylight improved their performance on standardized tests by up to 26%. The study analyzed test score results for over 21,000 students" [9].

Recently, many monitoring studies have been conducted to determine the ways in which students are affected by the indoor environment. Beside the daylight effects, many aspects of indoor environments can affect students' performance; these aspects are discussed in the next sections. Because daylight cannot generally meet all of a building's daytime lighting requirements, artificial lighting can be used whenever the amount of daylight is insufficient. Integrating daylight and artificial light is required for the visual indoor environment. The optimal solution combining the daylight and artificial light depends on the type of building, its use, and other local environmental aspects.



Figure (3) Integrating daylight and artificial when the amount of daylight is insufficient

V. METHODOLOGY

This study mainly investigates the effect of daylight addition to features of classrooms indoor environment on students' performance over one academic year at some selected classrooms at King Abdul Aziz University campus at Jeddah, Saudi Arabia. Statistical analysis is used to relate the performance of 400 students in 40 classrooms at the selected buildings. The classrooms were distributed among different floors of the educational buildings.

A statistical model was used to examine the relationship between improvement of students' performance and the presence of daylight in their classrooms compared with the standard requirements for the illuminations in classrooms, while considering some traditional explanatory educational variables. Various other physical elements of classrooms are tested due to their probable effect on students' performance such as thermal comfort, indoor air quality, acoustics, ventilation, outdoor window views, artificial lighting and classroom type. Observations of classrooms and assessments of some professors and assistants were mad in this study to provide additional insight for evaluating the impact of daylight on students' performance.

A. Questionnaire distribution

The questionnaire was distributed by a group of 10 students; each student managed the distribution and collection of 40 questionnaires. The total number of students at the selected group of faculties is shown in Table 2. The targeted study sample represents 5% (188 students) of total students that was distributed to different faculties proportionately. To ensure this percentage would reach the targeted number, the questionnaires were distributed to 10% of the total targeted study sample, equivalent to 382 students.

Table (2) Distribution of students in the selected faculties

Faculties	Number of Students
Faculty of Meteorology,	500
Engineering	2,000
Environmental Design	470
Earth Science	410
Marine Science	380
Total	3,760

B. Data entry and analysis

The data of the collected questionnaire have been entered into the database of the Statistical Package for the Social Sciences (SPSS) software. Each student entered about 40 questionnaires into the database. A statistical model was used to study the connection between students' performance and levels of classrooms daylight compared with the standard requirements for illuminations in classrooms. A light meter was used to measure the illumination levels of the selected classrooms.

Table (3) The measured minimum, maximum and average illumination (lux) of all over one academic year in south- and north oriented classrooms.

Classrooms	Illumination (lux)		
	Min	Max	Average
Oriented North	980	8,200	3,590
Oriented South	1,400	8,000	4,700

C. Results

The results of the measurements are shown in Table (3). Key findings are summarized below.

- The illumination in most of the north and south oriented classrooms during most of the year was above 500 lux.
- The average illuminations in the south oriented classrooms were higher than the north oriented classrooms.
- Some upper floors north and south oriented classrooms were affected by skylight contributions.
- The illumination was almost equals in both south and north oriented classrooms.
- The average illumination for all the year in the south oriented classrooms was 4,700 lux, and in the north oriented classrooms was 3,590 lux.

Correlation is a useful tool for determining whether relationships exist between two variables. A high negative correlation means that when a variable changes, the other variable will often move in the opposite direction. In our statistical analysis, the correlation of daylight in classrooms with students' GPA is negative, which means that the GPA will move to the positive direction. The data in Table 4 show that the Pearson Correlation between students' GPA and daylight in classrooms is (-.202), which is means that the correlation is more significant than other variables. The other correlations of artificial lights, ventilation, and outdoor view are negative, which means that the correlation is

significant except for the noise level, which is positive but small (.003).

Table (4) Correlations analysis output of SPSS software.

		GPA	Daylight	Artificial Light	Noise Level	Ventilation	Outdoor View
GPA	Pearson Correlation	1	-.202*	-.015	.003	-.061	-.042
	Sig. (2-tailed)		.014	.851	.970	.494	.638
	N	172	149	153	151	128	125

*Correlation is significant at the 0.05 level (2-tailed).

VI. DISCUSSION

Daylight in classrooms has an essential effect on the learning environment. The careful introduction of daylight into educational buildings reduces operating costs, improves students' vision and perception, and contributes to students' health, comfort, and productivity. In general, classrooms should get as much daylight as possible, although designers must control the illumination of areas within the students' fields of vision. Effective use of daylight in classrooms can help educational buildings realize significant energy savings, increase students' attendance, demonstrate environmental responsibility, and provide a better environment in which students can learn.

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