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RESEARCH PAPER

Examining the Direct Influence of Classroom Lighting Quality on Students' Learning Abilities and Academic Achievement

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ABSTRACT

This study examined the impact of quality of light in classroom on student's learning abilities and academic achievements, with primary objectives to know about quality of light in classrooms, and, to determine and evaluate its importance. Sixty students of grade XI from one government girls' higher secondary school were selected as judgemental sample. Sample students were divided into two (experimental and control) groups, housed in two separate spaces, and taught for three weeks. To set a baseline about the academic level of students, a pre-test in the subject of English was developed. After three weeks treatment, the academic achievements of students were evaluated through post-test. Data obtained through pre-test and post-test was analysed and interpreted. Findings revealed a considerable impact of the quality of light on students' academic achievement. The study suggests improving lighting conditions to create more supportive learning environments and enhance educational outcomes.

KEYWORDS Quality of Light, School Buildings, Students' Academic Achievement

Introduction

Educational environments play a crucial role in shaping students' academic performance and overall learning experience. Among various environmental factors, classroom lighting has been identified as a potentially significant yet often overlooked aspect that influences students' concentration, motivation, and academic outcomes (Muzaffar & Javaid, 2018; Choudhry, et. al., 2016). Optimal lighting conditions have been associated with enhanced visual comfort, reduced eye strain, and improved cognitive functioning, all of which contribute to a more effective learning environment. However, while substantial research has explored the role of lighting in workplaces and other settings, the impact of lighting quality in educational spaces, particularly in developing regions, remains under-investigated.

This study seeks to address this gap by examining the effect of classroom lighting quality on students' academic achievement, focusing on female higher secondary students in Dera Ismail Khan, khybarpakhtunkha, Pakistan. It investigates how different lighting conditions may influence learning outcomes, specifically in the subject of English. Using an experimental research design, the study compares the academic performance of two groups of students under varying lighting conditions to determine whether improvements in classroom lighting could serve as a feasible strategy to enhance educational attainment. The results offer valuable insights into how classroom

environment modifications, particularly in under-resourced educational settings, can support better academic performance, guiding policymakers, educators, and school administrators in creating more conducive learning spaces for students.

Researchers have defined daylighting as the indoor illumination achieved by the penetration of natural light in a space through some type of fenestration resulting in the net reduction of necessary electrical lighting for ambient, accent, emergency, or task lighting (Deru et al., 2005).

Some researchers (Dudek, 2008) have also established a strong relationship between the daylight and the human beings in the form of circadian rhythm. Cycle of day and night causes chemical and physiological changes in human body to control its functions accordingly. Many researchers hold that the daylighting not only has a direct impact on the efficiency of the occupants of a space but it has other implications as well (Phillips, 2004; Boubekri, 2008).

Creation of shadows by the light penetrating through windows increases the aesthetic quality of an indoor environment. Psychologically, it creates a sense of connection with the outdoor environment. It helps in the improvement of resistance to infections, the skin disorders and helps in the prevention of cardiovascular impairment. Last but not the least; it helps in the considerable reduction of energy uses within the buildings (Dalay, (2020).

Lighting and daylighting inside enclosed spaces has been an area of interest for many researchers throughout the world since 1920s. A significant amount of research has been conducted in this regard proving that daylight has a direct impact on the health and efficiency of the occupants (Phillips, 2004; Boubekri, 2008; Çakir, 2009). Absence of daylight or even the lack of daylight may culminate in Seasonal Affective Disorder (SAD) or other kinds of depression (Dudek, 2008).

Building orientation, especially alongated along the east and west axis, allows the maximum daylight in the interior spaces (Johnsen et al., 2006; Dudek, 2008). To allow sufficient daylight inside a room, several design solutions are adopted in the buildings including a variety of window openings – roof windows, dormer windows and simple vertical windows – roof lights or sky lights, atria and glazing (Phillips, 2004). Similarly, to avoid excessive lighting and glare inside the buildings, permanent and removable sun-shading devices are also used to either cover the windows or to direct the sunlight to the spot where the direct light is required (Johnsen et al., 2006).

Importance and impact of light becomes more significant and far reaching when it comes the discussion of learning environments. Consistant yet controlled indoor lighting is one of the major design factors of contemporary learning environments. Quality of light inside classrooms directly affects the learning abilities of the occupants and hence is reflected in their academic achievements.

Literature Review

The Importance of Classroom Environment in Learning

Research underscores the influence of classroom environment on students' academic performance, emphasizing that well-structured spaces contribute to better learning outcomes. Environmental factors, including noise levels, temperature, ventilation, and lighting, significantly affect students' concentration and cognitive

engagement (Gustafsson et al., 2012). Among these, classroom lighting stands out for its impact on students' visual comfort and cognitive responses. Studies indicate that inadequate lighting can lead to eye strain and fatigue, detracting from attention and focus, while optimal lighting improves concentration and learning efficiency (Figueiro et al., 2017).

The Impact of Lighting on Academic Achievement

Lighting quality has been directly correlated with academic performance, as good lighting enhances visibility, allowing for comfortable reading and writing—essential skills for subjects requiring detailed attention, such as English (Winterbottom & Wilkins, 2019). Research by Barrett et al. (2015) suggests that lighting quality can affect academic outcomes by up to 20%, with the optimal environment comprising a mix of natural and adjustable artificial lighting.

Lighting in Educational Settings: Global and Local Perspectives

In developed countries, educational lighting standards have shown positive effects on student performance (Küller & Lindsten, 2018). However, developing countries, including Pakistan, face challenges such as outdated infrastructure and poorly lit classrooms in public schools due to budget constraints (Shwind, 2014)). Addressing these deficiencies could improve students' academic outcomes and overall well-being.

Psychological and Physiological Effects of Lighting

Lighting impacts more than just visibility; it influences psychological and physiological well-being. Studies show that lighting that mimics natural daylight can help regulate circadian rhythms, improving mood and cognitive function. Conversely, poor lighting can increase stress and reduce learning efficiency (Figueiro et al., 2017; Winterbottom et al., 2019). These findings highlight the importance of well-designed lighting in classrooms to enhance both academic and emotional outcomes for students.

Work and Learning Environment

A conducive indoor environment supports the productivity of its occupants. Similar factors affect both work and learning spaces, as both are intended to enhance productivity (Muzaffar, 2016; Bell et al., 2000; Croome, 2000; Hepner et al., 2006). Studies show that factors like noise, temperature, and efficient ventilation play a critical role in the overall well-being and productivity of occupants.

Work Environment

The work environment, or workspace, is characterized by factors such as noise control, temperature regulation, and proper ventilation, which all contribute to productivity and job satisfaction (Bell et al., 2000). Researchers note that factors like building occupancy, ventilation efficiency, and facilities management can impact productivity and even contribute to "sick building syndrome" if inadequately managed (Croome, 2000).

Learning Environment

A learning environment should be designed to engage students actively, offering resources, tools, and support structures (Virginia Tech, 2010; Muzaffar, et. al., 2020). Key principles for an effective learning space include visibility of visual aids, clarity of audio

presentations, and comfort in terms of air quality, temperature, and ergonomic furniture (Allen et al., 1996). Flexibility in classroom design, including adjustable layouts, contributes to better instructional settings and facilitates different teaching and learning activities (Zunde & Bougdah, 2006; Chiara & Crosbie, 2001).

Considerations in Learning Environment
Daylighting and Indoor Light in Classrooms

Daylighting and artificial lighting in classrooms significantly affect illumination quality. Standards for surface finishes and light reflectance levels are recommended to achieve optimal light distribution:

Ceiling reflectance: 80-90%
Floor reflectance: 30-50%
Wall reflectance: 50-60% (Allen et al., 1996).

The lighting at desk level should not fall below 50 foot candles for adequate illumination (Offermann, 2005). The arrangement and control of both natural and artificial lighting should be optimized to prevent unnecessary energy consumption while maintaining effective lighting for learning (Chiara & Crosbie, 2001).

Evaluation of Built Environment for Lighting and Daylighting

Evaluating a space for lighting and daylighting involves analyzing factors such as room geometry, window properties, and building orientation. Conditions such as overcast, intermediate, and sunny skies influence lighting needs, requiring careful consideration (Johnsen et al., 2006). Methods like scale models and computer simulations are employed to assess lighting levels, though quick evaluations can be done using simple walkthroughs and assessments of durability, control, and maintenance (HEFCE, 2006; Thanachareonkit et al., 2005).

In summary, a well-designed classroom environment, especially with appropriate lighting, enhances students' academic performance, physiological comfort, and psychological well-being. Both natural and artificial lighting must be carefully planned and managed to provide optimal learning conditions.

Material and Methods

Population

Students of intermediate part-I of all Government Higher Secondary Schools of DIKhan district of Khyber Pakhtunkhwa comprised the population of the study.

Sample

In this one of its own kind experimental study every possible care was taken during sampling of the components formulating the entire study design. Verifiable appropriate procedures were followed for the sampling of students, subject and teachers.

Sampling of the Students

Sixty students of intermediate part-I of Government Girls Higher Secondary School Paharpur, DIKhan were selected as a judgemental sample for the study.

Sampling of the Subject Matter

To ensure the accuracy of study and authentication of resultant findings dependent upon the selection of the sample (Kumar 2000, p. 19), the possibility of students' prior familiarity with the selected subject was carefully ruled out. The subject of English was selected for the commencement of this study after consultation with a team of experts.

Sampling the Teachers

All other possible variables associated with teachers' own qualification, experience, age, training, exposure, socio-economic background and the methodology of teaching were tried to be ruled out by selecting only one teacher to teach both the groups.

Research Instruments

Instruments used for the study included two achievement tests (one pre- and one post-test) in the subject of English at intermediate level, contents of the subject matter and instructions for the teacher.

Achievement Test

For the assessment of students' acquaintance as well as achievement, two achievement tests were prepared in the subject of English at XI level. These were used as pre-test and post-test in the study. For a thorough assessment and evaluation of the perception level of students in the subject, and to encompass the maximum possible portion of the material taught during the study, tests was based on Multiple Choice Questions. Pre-test and Post-test were judged by the team of experts and were served on ten students of the same level for the sake of pilot testing. Advices of the experts and outcomes of the pilot testing were incorporated into the tests and these were finalized.

Contents of the Subject Matter

Six lessons from the textbook of English for class XI were decided to be taught to the students in three weeks.

Instructions for the Teachers

Comprehensive and unambiguous set of guidelines regarding various aspects pertinent to the successful conduction of this study were delivered to the selected teacher in both written and oral format.

Written instructions

The set of written instructions provided to the teacher was similar to comprehensive lesson plans containing guidelines on teaching methodology, distribution of the time into various teaching-learning activities such as lecture delivery/ presentation, discussions and question-answer sessions. It also contained exclusive guidelines on controlling light in the classroom and its expected impacts on students' efficiency.

Oral instructions

Teacher was further clarified on the set of written guidelines regarding the daylight and ambient light control within the classroom. Oral instructions were on:

- Controlling the adjustable lighting components of the classrooms including quantity of daylight entering the room, control of available artificial lighting fixtures when and where applicable, and following the suitable seating arrangement.

- The administration and scoring of achievement test (pre-test and post-test) at the beginning and culmination of the study.

Design of the Study

In this experimental study, the Pre-test – Post-test equivalent group design was used. This design may be represented as (Best and Kohn, 1986, p. 127):

RT_1 E T_2 E gain = $T_2 - T_1$

RT_3 C T_4 C gain = $T_4 - T_3$

Where

R = Random assignment of subjects to groups.

E = Exposure of a group to an experimental (Treatment) variable.

C = Exposure of a group to the control condition

.T_1, T_3 = Pre-tests

T_2, T_4 = Post-tests

In this design, Pre-tests are administered before the application of the experimental and control treatments and Post-tests at the end of the treatment period. A test of the significance of the difference between means (t-test for this particular case) may be used to reach the findings. The design was selected due to its capability of minimizing the threats to the validity.

Procedure of the Study

Administration of the Pre-test

The study began with the administration of the pre-test to the students of both the groups to make sure that the both, experimental and control, groups were equivalent at the time of starting the experiment.

Pre-treatment Conditions

All the factors like time of the day and the length of the treatment were kept equal in both the group by carefully adjusting the time table for both experimental and control groups.

Treatment

The students of the two selected groups were taught by the same teacher in the same time slots on alternative days. All the other aspects related to teaching-learning activity except the quality of light in classrooms were ensured to be kept similar throughout the experiment.

The experimental group was accommodated in a purposefully designed classroom wherein the qulity of light was controlled. Windows were covered with blinds to control the intensity of incoming natural light. Light fixtures were properly arranged to directly throw light on chalkboard and students' writing area. Walls and ceiling were painted with light colour in such a way that no glare could be produced through direct reflection.

The control group was accommodated in an ordinary classroom of the school building of Government Girls Higher Secondary School Paharpur, Dera Ismail Khan. Duration of teaching was three weeks with a period of approximately fifty minutes six days a week.

Administration and Scoring of the Post-Test

After teaching for three weeks, the relevant post-test were taken to the students of both the groups, and scored by the teacher who taught them.

Scoring Criteria

Pre-Test: It was designed to evaluate and estimate students' previous knowledge about the subject. It contained multiple choice questions encompassing vocabulary, grammar and sentence structure.

Post-Test: The post-test also consisted of multiple choice questions (MCQs) but it hovered over the lessons taught during the period of study. It also covered grammar, composition and sentences structure as well as types of narrations and voices.

Data Analysis Techniques

Paired sample t-test was used for data analysis.

Results and Discussion

Table 1
Difference of Pre-Test between Control Group And Experimental Group

Pre-Test	Paired Differences					t	df	Significance (2-tailed)
	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Experimental	18.6316(a)	4.77473	1.0793	-	-	-	-	-
Control	18.6316(a)	4.77473	1.0793					

Table 1 indicates that Mean, standard deviation and standard error mean are 18.6316, 4.77473 and 1.0793 respectively for both groups. The corelation and t value can not be computed because the standard error of the difference is zero. This indicates that the experimental and control groups at the time of starting experiment were equivalent.

Table 2
Difference of both pre-test and post-test between Control Group and Experimental Group

F	Paired Differences					t	df	Significance (2-tailed)
	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Experimental	-3.26316	2.15618	0.49466	-4.30240	-2.22391	-6.597	18	0.000
control	-1.31579	2.33459	0.53559	-2.44102	-.19055	-2.457	18	0.024

The table above indicates the paired differences between the pre-test and post-test of experimental as well as control groups. Mean, standard deviation and standard error mean for both the groups are -3.26316, -1.31579, 2.15618 and 2.33459, 0.49466,.53559 respectively. The lower and upper limits of the 95% of confidence interval of the difference for both the groups are -4.302402, -2.44101 and -2.22391, -.19055 respectively. Value of t is -6.597, -2.457, degree of freedom is 18, 18 and the 2-tailed significance is 0.000, 0.024 for both the groups respectively. This indicates that there is no significance development in the achievement of the students in control group, whereas a note worthy development is present in the achievement of students in the experimental group.

Table 3
Difference of Post test between Controlled Group and Experimental Group

Test	Paired Differences					t	Df	Significance (2-tailed)
	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Post-Test	1.94757	12.61351	,59958	.68770	3.20705	3.248,	18	0.004

Table 3 indicates the paired differences between the post-test of control and experimental groups. Mean, standard deviation and standard error mean are 1.94737, 2.61351 and .59958 respectively. The lower and upper limits of the 95% of confidence interval of the difference are .68770and 3.20705 respectively. Value of t is 3.248, degree of freedom is 18 and the 2-tailed significance is 0.004. This indicates a noteworthy difference between the academic achievement of control and experimental groups after the experiment.

Discussions

Bowers and Burkett (1987) were among the first researchers who conducted studies on the impact of classroom lighting on students' performance. They argue that classroom lighting plays a particularly critical role because of the direct relationship between good lighting and students' performance they discovered in their study. They concluded that the improper maintenance of lighting fixtures caused misinterpretation of the written words in students whether on a handout or at the chalkboard.

On the other hand, a study conducted by Olson and Kellum (2003) concluded that two elements of sustainable building design, daylighting and indoor air quality, have more legible effects on students' performance. One of the most significant findings of the study revealed that students performed far better in daylit classrooms, whereas their learning abilities were adversely affected when they were uncomfortable or distracted by poor lighting, heating, cooling and ventilation, noise etc.

Reffat and Harkness (2001) while determining the environmental quality of a space, considered lighting comfort, acoustic comfort, thermal comfort and indoor air quality.

A similar study (Earthman, 2002) discovered measureable influence of design features and components of a school building on student learning. Indoor light quality was one among these important design features. Researcher also recorded negative impacts on student learning due to prevailing deficiencies in proper lighting inside classrooms.

Another study (Fisher, 2000) discovered an improvement in students' academic achievement with an improvement in the physical condition of the school building. The researcher also found that lighting levels along with other aspects not only affected the academic outcome but also impacted the behaviour of students. However, on some of the factors mentioned by the researcher, relatively limited quatitative evidence existed.

A significant number of researches (Earthman, 2004; Earthman and Lemasters, 1996; Earthman and Lemasters, 1998; Higgins et al., 2005; Schneider, 2002) establish a strong consistant relationship between building quality and student academic outcomes. Researchers have discovered that design considerations improving factors like daylighting affect students' overall achievement in a demonstrable way.

The provision of basic facilities in school buildings also plays a very important role in the overall performance of students. This was confirmed in a research conducted by Bacolod and Tobias (2006). Researchers place the provision of electricity in the category of most basic facilities a school building must have. All lighting fixtures are operated by the electric current within the classroom.

Conclusions

This study demonstrates the significant impact of classroom lighting quality on students' academic performance. Key conclusions derived from data analysis include:

- **Influence of Lighting on Academic Achievement** Classroom lighting quality directly affects students' academic performance, as evidenced by the differences between baseline and post-test mean scores. Optimal lighting conditions improve focus, reduce eye strain, and enhance students' overall learning experience.
- **Inadequate Design of School Buildings** The majority of school buildings are not designed to support effective teaching and learning. Many buildings lack appropriate fenestration size and placement, which limits natural light penetration, resulting in insufficient daylight within classrooms. This design shortfall hinders the creation of an optimal learning environment.

Recommendations

This research explored the critical role of classroom lighting in learning environments, highlights actionable improvements with both immediate and long-term impacts. These recommendations aim to enhance educational quality and make learning spaces more conducive to academic success.

Immediate Remedial Plan

- **Student-Led Classroom Enhancements** Engaging students in improving classroom lighting can be cost-effective and impactful. Through collaboration with vocational and professional institutes, student-led initiatives can upgrade classroom decor and lighting using minimal resources.
- **School-Level Improvements with Parent-Teacher Committees (PTCs)**PTCs can support small, localized projects that improve lighting in classrooms. By involving parents and teachers, schools can implement affordable and simple modifications, creating better-lit environments that enhance students' visual comfort.

1. **Long-Term Improvement Plan**

- **Training for Teachers and Head Teachers** All secondary school teachers, particularly head teachers, should receive training on evaluating and enhancing classroom lighting. By fostering an environment that encourages innovative, practical solutions, authorities can leverage teachers' insights to improve lighting quality across classrooms effectively.
- **Standards for New School Building Designs** Every new school building should undergo a SWOT analysis tailored to its specific context to develop designs that are both environment- and context-responsive. Priority should be given to incorporating passive solar lighting into classrooms, reducing reliance on artificial lighting and fostering sustainable learning spaces.
- **Emphasis on Adequate Classroom Lighting in Education Policy** cognizing the influence of lighting on academic achievement, it is recommended that policymakers set standards for lighting quality in educational facilities, ensuring all classrooms meet basic illumination requirements to support students' well-being and educational success.

By implementing these recommendations, educational institutions can create learning environments that maximize students' academic potential through improved lighting quality, supporting both immediate and future educational goals.

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