

Investigating the Impact of Lighting Educational Spaces on Learning and Academic Achievement of Elementary Students

*Abdolreza Gilavand¹, Mohammadreza Gilavand², Sakineh Gilavand³

¹Employed Expert on Faculty Appointments, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

²MA in Educational Planning, Islamic Azad University of, Dezful Branch, Dezful, Iran.

³Bachelor of Nursing, Department of Dr Ganjavian Hospital, Dezful University of Medical Sciences, Dezful, Iran.

Abstract

Background

In modern education, physical space is considered as a dynamic factor in students' educational activities. This study was conducted to investigating the impact of lighting educational spaces on learning and academic achievement of elementary students.

Materials and Methods

At a cross-sectional study (2015-2016), a total of 210 students were selected randomly as sample of study. Cluster sampling was done by appropriate allocation and questionnaires were randomly divided among students. Data collection tools included Hermance's achievement motivation questionnaire and researcher-constructed questionnaire (observation checklist to examine the physical parameters of learning environment lighting) and interviews with students. Data of study were analyzed using SPSS- 21 software.

Results

Results of this study showed that lighting educational spaces has a significant impact on learning and academic achievement of elementary school students in Ahvaz, Iran ($P<0.05$).

Conclusion

Since light is most available factor in life, attention to it at schools, best use of it to increase the quality of educational space is a necessary work. Therefore, it is recommended that lightning of class to be provided through natural light (windows, valves, etc) or artificial light (lamps or various kinds of lights) in designing and equipping educational spaces.

Key Words: Educational achievement, Impact, Lighting educational spaces, Learning, Students.

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*Corresponding Author:

Abdolreza Gilavand , Employed Expert on Faculty Appointments, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Email: gilavanda@gmail.com

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1- INTRODUCTION

Light has always been sacred in the major monotheistic religions of the world. In Zoroastrianism, the interpretation of the universe, the essence of angels, and holiness of fire are all based on light. In Judaism, the first creation of God is light and in Christianity, Jesus Christ, is the God's word and light or the father of lights. Light is also emphasized in Islam so much that there is a surah in holy Quran called Light. In holy Quran, the words light and darkness have been repeated 43 and 23 times respectively (1). These two words are used eleven times together. The word light has always been used in singular form while the plural form of the word darkness has been used, and their meanings are different in different contexts. For example, sometimes light is used equivalent to the Torah and the Gospel and justice equal to guidance but light and darkness have been used to refer to the sense of vision and blindness. At times, light is equal to the Prophet Muhammad (PBUH), the religion of truth, the right way, and the Quran. Sometimes it is also used to mean reward but at other times it is related to visible light. In some verses it refers to faith and leader and guiding light and darkness is associated with kufr, falsehood and error (2). The importance of lighting for performance in human adults is well established. However, evidence on the extent to which lighting affects the school performance of young children is sparse (3). The world of children involves their home, school, and the neighborhood around them. These locations must satisfy the children's every single needs be it physical, mental or social. In modern education, physical space is considered as a dynamic factor in students' educational activities (4). The learning environment dramatically affects the learning outcomes of students. Lighting, noise, educational spaces coloring, inappropriate temperature,

insufficient light, overcrowded classes, misplaced boards and inappropriate classroom layout make up factors that could be confounding variables distracting students in class (5-8). Generally, 83 percent of learning takes place by the sense of sight in the learning process. Therefore, if seeing action faces with problem, learning will reduce. The purpose of school lighting is to create an environment in which the act of seeing is done in best way with minimal discomfort and effort so that energy of students to be spent on information and learning process, rather than to combat with seeing problems (9). Studies have also shown that there is a relationship between academic achievement and mental health (10, 11). There is a power problem in more than six thousand schools in Latin America. The plan of lighting for learning is implemented since 2012 (by the governments of Ibero-America). They bring solar energy to the schools. This plan was carried out in 500 rural training center and these schools are now equipped with solar panels and computer and they have access to the internet. More than a thousand teachers and 20 thousand students have benefited from this plan. In countries where the project of "lighting for learning" has been implemented in rural school, dropout rate has declined considerably. Accordingly, this plan plays an important role in the economic growth of the rural communities by encouraging students to complete their education (12). The quality and quantity of light (illumination) undoubtedly influences the perception of comfort in a particular space. Illumination has strong and well-documented effects, but less obvious is the case of light quality (13) undertook a study evaluating how different types of lighting (warm white, cool white, and full-spectrum fluorescent) affect various dependent variables, including: cognitive performance, room attractiveness, judged room size, and pleasure of room. They

found no significant differences among all dependent variables with respect to the type of lighting used. The researchers could only conclude that management prefers warm white or cool white over full-spectrum light, chiefly because the first two are less costly to buy and maintain. A natural assumption might be that more light always creates a better, more positive impression of a classroom's qualities. However, one study clearly shows an upper limit to classroom lighting, above which the lighting has negative effects (14) conducted a study in Brazil comparing luminance in classrooms throughout the course of several days in August 2000. One room was equipped with windows with light shelves; another was not. Classrooms were on the same side of the building, and all other variables were held constant. Interestingly, these studies showed that rooms with light shelves and without light shelves condition had advantages and disadvantages. In late afternoon, windows with light shelves produced light below prescribed luminance, whereas windows without light shelves created high luminance values throughout the day, which can lead to gradual furniture and fixture damage—and distract students and teachers—as well as increase thermal discomfort. This research showed that even such feature like light shelves might have some drawbacks.

In recent years, the curriculum and textbooks has been considered, but this principle, the physical characteristics of educational environment and its impact on students' performance and spirit have not been investigated so much and only a few of studies have been carried out at this regard. Theoretically, paying attention to environmental factors affecting the educational environments and foresight on supplying facilities and needs of educational spaces not only help managers and planners in adopting right and realistic decisions, but also they are necessity of

any kind of educational planning (6-8). On the other hand, in applied area, understanding environmental factors affecting the educational process and considering them in planning increases mental health of students and reduces their stress, resulting in enhanced educational performance. In Iran's old architecture, it can see the dependent of building and light in the role of body and spirit; one for physical presence and one for spiritual presence. This is the same thinking and insight that makes everlasting our old architecture. Since light is most available factor in life, attention to it at schools, best use of it to increase the quality of educational space is a necessary work. The aim of this study was to investigate the effect of lighting educational spaces on learning and academic achievement of elementary students of Ahvaz, Iran.

2-MATERIALS AND METHODS

2-1. Study design and population

At a cross-sectional study in 2015-to 2016, the population of the study included all male elementary school students in Ahvaz, (South-west of Iran), of whom 210 students were selected randomly as the sample of the study. Questionnaires were randomly distributed among students. Also, in this research, the sample data were selected from the different educational areas including educational area no. 1: 50 students, No. 2: 41 students, No.3: 59 students and No. 4: 60 students.

2-2. Ethical considerations

The ethical considerations necessary to satisfy the respondents were observed and they were ensured that their views will be kept confidential. Also, participation in the study was voluntary.

2-3. Measuring tools

2-3-1. Construction Observation checklist

Observation checklist to examine physical variables of lighting the learning environment: due to there is no standard questionnaire related to subject of study, after interviews with a number of teachers and experts organization development, equipping and modernization of schools, environmental health and collect their views and taking into account the scientific principles, a questionnaire was developed. Then, by conducting pre-test (among 30 students), reliability and validity of questionnaire was calculated. Their validity was confirmed by content and construct validity was confirmed by a number of experts and their reliability was calculated and confirmed by Cronbach's alpha (87%).

2-3-2. Academic Achievement Motivation Questionnaire of Hermance(14)

It is one of the most common paper and pencil questionnaire to assess the need for achievement. Hermance (1977) constructed this questionnaire based on experimental and theoretical knowledge about the need for achievement and studying the related literature related. The initial questionnaire included 29 questions developed based on ten characteristics that distinguish people who have high achievement motivation with those who have low achievement motivation. To prepare materials of questionnaires, Hermance considered ten characteristics of people as based in selecting questions:

- High level of desire;
- Strong motivation for upward mobility;
- Long resistance facing with assignments or moderate difficulty level;
- Willingness to reattempt in doing assignments;
- Dynamic perception of time, the feeling that things happen quickly;

- Foresight;
- Paying attention to merit criterion in selecting friends, colleagues and model;
- Recognition through good performance at work;
- Doing job well;
- Low risk behavior.

Hermance found these ten characteristics was acquired on the base of previous research and he selected them as guide for selecting the questions. After trial implementation and analyzing the questions and calculating the correlation of individual questions with total test, 29 questions were selected as final questionnaire of achievement motivation.

It should be noted that after analyzing the questions, no significant question about the tenth characteristics was included in the final questionnaire. Therefore, the final questionnaire was constructed only on the basis of nine characteristics. The questions of questionnaire were stated as incomplete sentences and multiple options were given for each of the. To equalize the value of questions, four options were written for all 29 questions. The options were given score in terms of intensity of motivation of achievement from high to low or low to high. Scoring the questionnaire was conducted based on nine characteristics that questions were developed based on them. Some of the questions were written positively, while other groups of them were written negatively.

To each question of this questionnaire (Observation checklist to examine physical variables of Schools' open space the learning environment), the minimum score (0) and maximum score (2) were assigned, in the other hand:

(0): If the school has not met the standard principles at all in the studied component (non-standard);

(1): If the school has met the standard principles relatively in the studied component (semi-standard);

(2): If the school has met the standard principles fully in the studied component (standard).

Given the number of questions in observation checklist (5), the minimum score obtained by each school (completely non-standard), and the maximum obtained score by in terms of studied components, researcher marks each item in terms of meeting the standards according to three standard option of standard, semi-standard and non-standard. According to the observation checklist, standard schools were those schools which required the min score based on confirmation of modernization, development and equipping of schools organization.

2-4. Data analyses

The data of the study were analyzed using descriptive statistics (frequency, percentage, mean, standard deviation) and inferential statistics (factor analysis, t-test, Kolmogorov - Smirnov test and one-way ANOVA analysis) using SPSS-21. In this section, the descriptive statistics related to observation, a checklist to examine the impact of physical variables of lighting on learning and achievement questionnaire of students was provided. Then, statistical hypotheses were examined in the data analysis section. To examine the normal distribution of data, Kolmogorov-Smirnov test was used. Then, to examine the hypothesis of study, structural equation and Pearson correlation coefficient were used, while single-sample t-test, independent two-sample t-test and ANOVA were used to examine the sub-hypotheses of study.

3-RESULTS

For investigating students' amount of learning and academic achievement (including 29 questions of 4 options), the

Hermans' standard questionnaire was used as a research tool and for studying physical variables of lighting educational spaces (including 6-question of the standard, semi-standard and non-standard of 3-option) a researcher-made questionnaire; given the age of the respondents, the method of interview was used in completing questionnaires. By completing questionnaires and interview, some parents or teachers of students were also present. Based on (Table.1) in which the demographic characteristics of the students have been specifically mentioned, from between 210 elementary students samples under study, 11(5%) students were from elementary second grade, 25(12%) students were from elementary third grade 38(18%) students from third grade, 63(30%) students from fifth grade and 73(35%) students from sixth grade. Also in terms of age characteristics of the students under question, 15(7%) students were 7-year old, 21 (10%) students 8-year old, 38 (18%) students 9-year old, 63 (30%) students 10-year old, and 73 (35%) students 11-year old. For investigating the normality of the distribution of data related to the lighting educational spaces, amount of learning and academic achievement, in (Table.2) the Kolmogorov-Smirnov test (by accepting the null hypothesis at the error level of 5%) has been used. Results showed that the lighting in educational institutions was equal to 1.16 ± 0.135 , learning 0.34 ± 1.04 and academic achievement 0.42 ± 1.09 . In (Table.3), regarding 6 questions related to the checklist of variables of lighting educational institutions with three options standard, medium and non-standard, the amount of point and score of students has been stated.

The first question was about Natural source of light in class, so that it does not cause eye dazing in students; 32(13.5%) students have selected the standard option, 53(22.4%) students the medium option and 72(30.4%) students non-standard option.

The mean and standard deviation (SD) of this question have been 2.95 ± 1.20 .

The second question asked Class natural light can be adjusted by curtain; 19(8.0%) individuals have selected the option standard, 55(23.2%) individuals the option medium and 93(39.2%) individuals the option non-standard. The mean and standard deviation of this question have been also 2.97 ± 1.03 .

The third question asked Artificial light source in class, so that it does not cause eye dazing in students; 34(14.3%) individuals have selected the option standard, 64(27.0%) individuals the option medium and 94(39.7%) individuals the option non-standard. The mean and standard deviation of this question have been also 2.67 ± 1.03 .

The fourth question asked was about the Classroom artificial light can be provided by fluorescent lamps; 38(16.0%) individuals have selected the option standard, 51(21.5%) individuals the option medium and 98(41.4%) individuals the option non-standard. The mean and standard deviation of this question have been also 2.71 ± 1.05 .

The fifth question asked was about the Ceiling lams of class are attached to ceiling or they are placed in high altitude (near to main street, highway); 24(10.1%) individuals have selected the option standard, 33(13.9%) individuals the option medium and 85(35.9%) individuals the option non-standard. The mean and standard deviation of this question have been also 3.13 ± 1.08 .

The sixth question asked was about the Light distribution in class appropriately and uniformly spread; 33(13.9%) individuals have selected the option standard, 48(20.3%) individuals the option medium and 88(37.1%) individuals the option non-standard. The mean and standard deviation of this question have been also 2.84 ± 1.06 .

Table.3, shown that, there was a significant relationship between the impact of lighting educational spaces, and educational achievement of elementary students ($P < 0.05$). Also in this research there was not observed any relationship between amount of learning and academic achievement and the demographic variables under investigation such as age, education level, education district of education place etc. ($P > 0.05$).

Table 1: Examination of normal distribution of data

Variables	Z Kolmogorov – Smirnov statistic	P- value
Educational Spaces lighting	0.677	0.749
Degree of learning	1.04	0.34
Educational achievement	1.09	0.42

Table 2: The perspective of students about Impact of Educational Spaces lighting

Questions	Response			Mean \pm SD	P-value
	Standard n (%)	Moderate n (%)	Non-standard n (%)		
Natural source of light in class is so that it does not cause eye dazing in students	32(13.5)	53(22.4)	72(30.4)	2.95 ± 1.20	0.597
Class natural light can be adjusted by curtain.	19(8.0)	55(23.2)	93(39.2)	2.97 ± 1.03	0.586
Artificial source of light in class is so that it does not cause eye dazing in students	34(14.3)	64(27.0)	94(39.7)	2.67 ± 1.03	0.564

Classroom artificial light can be provided by fluorescent lamps.	38(16.0)	51(21.5)	98(41.4)	2.71±1.05	0.552
Ceiling lams of class are attached to ceiling or they are placed in high altitude.	24(10.1)	33(13.9)	85(35.9)	3.13±1.08	0.544
Light distribution in class appropriately and uniformly spread	33(13.9)	48(20.3)	88(37.1)	2.84±1.06	0.540

Table 3: The relationship between the impact of lighting of educational spaces on learning and academic achievement

Variables		Observed frequency	Expected frequency	Remaining	P-value
Students' perspective	Standard	82	79	3.0	0.001
	Moderate	83	79	31.0	
	Non-standard	45	79	-34.0	
	Total	210			

4- DISCUSSION

Results of this study showed that lighting educational spaces has a significant impact on learning and academic achievement of elementary school students in Ahvaz. Therefore, we can say that the results of this study are in line with those of other studies conducted by Lewinski (5), Boray et al. (13), Kruger et al.(14), Barrett (16), Mot et al.(17), Ahmadpoor Samani et al.(18), Safak Yacan (19)and Bellia(20).

Barrett et al. (2015) assessment the153 classrooms in 27 schools in order to identify the impact of the physical classroom features on the academic progress of the 3,766 pupils who occupied each of those specific spaces. This study confirms the utility of the naturalness, individuality and stimulation conceptual model as a vehicle to organise and study the full range of sensory impacts experienced by an individual occupying a given space. In this particular case the naturalness design principle accounts for around 50% of the impact on learning, with the other two accounting for roughly a quarter each. Within this structure, seven key design parameters have been identified that together explain 16% of the variation in pupils' academic progress achieved.

These are Light, Temperature, Air Quality, Ownership, Flexibility, Complexity and Color. The muted impact of the whole-building level of analysis provides some support for the importance of "inside-out design". The identification of the impact of the built environment factors on learning progress is a major new finding for schools' research, but also suggests that the scale of the impact of building design on human performance and wellbeing in general can be isolated and that it is non-trivial. It is argued that it makes sense to capitalise on this promising progress and to further develop these concepts and techniques (15).

Mot et al. (2012) showed that light is universally understood as essential to the human condition. Yet light quality varies substantially in nature and in controlled environments leading to questions of which artificial light characteristics facilitate maximum learning. Recent research has examined lighting variables of color temperature, and illumination for affecting sleep, mood, focus, motivation, concentration, and work and school performance. This has resulted in artificial light systems intended to support human beings in their actualization through dynamic lighting technology allowing for different lighting conditions per task. A

total of 84 third graders were exposed to either focus or normal lighting. Focus lighting led to a higher percentage increase in oral reading fluency performance (36%) than did control lighting (17%). No lighting effects were found for motivation or concentration, possibly attributable to the younger age level of respondents as compared with European studies.

Ahmadpoor Samani et al (2012), aimed to identify the influence of indoor lighting on students' learning performance within learning environments from knowledge internalization perspective. This study was a comprehensive review of literatures base on the influence of indoor lighting on people's productivity and performance especially students' learning performance. The result showed that it is essential to improve lighting in learning environments to enhance students' learning performance and also motivate them to learn more. This study found significant impact between lighting quality and students' learning performance (17).

Safak Yacan (2014) assessed infants' social and cognitive developments, and daylight in preschool classrooms. Results revealed that there was a crucial correlation between preschool students' social behavior and cognitive skills and daylight in preschool classrooms. Also, the results showed that there was a significant correlation between students' social behaviors and preschools' classrooms daylight conditions. Furthermore, students' cognitive skills were also crucially correlated with classrooms' daylight conditions in preschools. (18).

If seeing action faces with problem, learning will reduce. The purpose of school lighting is to create an environment in which the act of seeing is done in best way with minimal discomfort and effort so that energy of students to be spent on information and learning process, rather than to combat with seeing problems. It

should be reminded that in doing any activity, the required amount of light is different. Class lighting is provided through natural light (windows, valves) or artificial light (lamps and lights). In any case, the amount, direction and quality of light must be considered. Numerous experiments have shown that the area of the glassy windows must be at least one-fifth of room surface so that minimum lightening to be provided for reading and writing. On the other hand, any action that would equalize lightening for all students should not be ignored. The light must be desirable in terms of distribution and it should be distributed uniformly so that does not cause eye discomfort. In addition, amount of light should be sufficient and annoying shadows should be avoided. In this regard, Noifert states: "The direct and bubbled fluorescent light is very normal producing proper for blackboard". In America, the artificial lighting is automatically controlled by photoelectric cells (4).

5-1. Recommendations

Finally, 4 recommendations were provided as follows:

1. Due to relationship between components of lighting of educational spaces and increased behavioral disorder among students, it is recommended that educational managers of country pay attention to psychological advices on colors, lighting and sounds.
2. It is recommended that particular attention should be paid to educational space of schools in terms of designing and building. The physical environment spaces should be designed and built so that they can be compatible with inherent tendency and nature of students. In addition, solutions should be found for educational spaces requiring major repairs.
3. As standards and criteria determine the desired level, and since the desired level of one region might be different from other

region, it is recommended that a committee to be established to assess the internal situation of schools in Ahvaz so that it can determine the desired standards and criteria and schools to be assessed accordingly.

4. It is required that higher attention to be paid on ergonomic relationship with behavioral disorders in students since the beginning of pre-school education and conduct the assessment plan to detect children who have particular needs and attempt to organize children with behavioral disorder (7,8).

6- CONCLUSION

The use of performance indicators and fundamentals of aesthetics in designing the educational physical space will cause to develop students' talents and creativity, besides satisfying their psychological and physical needs. Recognized the advantages of natural light, using optimally artificial lighting in educational spaces alongside with the architectural design recommendations that are effective in providing proper lighting of educational spaces, are considered helpful for designers and planners of these spaces. Having spaces with good physical quality at disposal of learning centers' teachers and students is one of the effective ways of greater productivity of human and material capitals. The spaces with good physical quality are the spaces that in designing them the standard indicators such as clean air, suitable temperature, adequate moisture, light, sound, proper perspective, energy efficiency, access and communication are observed. Proper lighting includes both natural and artificial lights which should be considered together, so that we achieve its highest standard by their right combination; these are activities that are directly related to light and a variety of lighting systems in the educational and research environments. Natural light is one of the important

factors in designing the education spaces with good quality and has a considerable influence on individuals' conscious and non-conscious memory. Also, due to its ultraviolet rays, day light is one of the factors that cause the normal rhythm in body's biological systems. Studies have shown that students, who are in an environment of natural lighting, have clearly a better performance. The use of natural lighting is significantly effective in saving electric energy and has a direct impact on the quantity and quality of other space standard factors such as temperature and humidity amount.

7-CONFLICT OF INTEREST

1. Impossibility of generalizability of the research results to schools in other cities, due to geographical and climatic conditions of metropolis Ahvaz.
2. The dispersion of research population and non-equality of facilities in schools in metropolis Ahvaz.
3. The use restriction of questionnaire as the only means of data collection and the impossibility of doing quality works in this regard, including interview with managers, parents and experts in ergonomics
4. The absence of standards according to which the quality of available possibilities and resources can be evaluated.
5. Given the age of the students and the lack of understanding of some of the questions, which can be considered as one of the limitations of the present research, the teachers were asked to distribute the questionnaires and read the questions one by one in plain language to students so that they can have an understanding of appropriate response to the questions.

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