The Effect of Environmental Conditions of Schools on Student Success and Absenteeism

Okulların Çevresel Koşullarının Öğrenci Başarısı ve Devamsızlığı Üzerine Etkisi

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ABSTRACT

Objective: The purpose of this study is to reveal the characteristics of indoor physical environments of schools by means of measuring electromagnetic radiation, lighting, noise, temperature, and humidity and to evaluate the relationship between the physical characteristics with the success of students and absence.

Material and Methods: All schools in the Derince region of the city of Kocaeli (n=42) have been included in the survey without selection of a sample and the cross-sectional type of research technique has been employed. For the analysis of the data, correlation analysis (Spearman and Pearson), Mann-Whitney U, and Kruskal Wallis tests have been used.

Results: In schools, the electromagnetic field level was measured as 0.53±0.27 mG, the noise level was 57.43±7.77 dB (schoolyard), and the lighting level was 370.11±95.15 luxury. There has been a statistically significant difference detected between the grade point averages of the sixth grades of the schools that comply with the standards of classroom noise level and those that do not (p=0.039). A negatively significant correlation between the classroom lighting level and grade point averages has been detected (respectively; r -0.498 p 0.011; r -0.548 p 0.021; r -0.563 p 0.004). A negatively significant correlation between the building standards points of the schools and the rate of absence of the students has been detected (r -0.371 p 0.011).

Conclusion: A significant relationship between the indoor physical environment characteristics in schools and the school success has been found.

Key Words: Electromagnetic Fields, Noise, Lighting, School

ÖZ

Amaç: Bu çalışmanın amacı, elektromanyetik radyasyon, aydınlatma, gürültü, sıcaklık ve nemi ölçerek okulların kapalı fiziksel ortamlarının özellikleriyle öğrencilerin başarısı ve devamsızlığı ilişkiyi değerlendirmektir.

Gereç ve Yöntemler: Kocaeli ili Derince bölgesindeki tüm okullar (n = 42) örneklem seçilmeden dahil edilmiş ve kesitsel araştırma tekniği uygulanmıştır. Verilerin analizi için korelasyon analizi (Spearman ve Pearson), Mann-Whitney U ve Kruskal Wallis testleri kullanılmıştır.

Bulgular: Okullarda elektromanyetik alan seviyesi 0.53±0.27 mG, gürültü seviyesi 57.43±7.77 dB (okul bahçesi) ve aydınlatma seviyesi 370.11±95.15 lüks olarak ölçülmüştür. Sınıf gürültü düzeyi standartlarına uyan okulların altıncı sınıflarının not ortalamaları ile uymayanlar arasında istatistiksel olarak anlamlı farklılık tespit edilmiştir (p = 0.039). Sınıf

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aydınlatma düzeyi ile not ortalamaları arasında negatif yönde anlamlı bir ilişki tespit edilmiştir (sırasıyla; r -0.498 p 0,011; r -0.548 p 0.021; r -0.563 p 0.004). Okulların bina standartları puanları ile öğrencilerin devamsızlık oranları arasında negatif yönde anlamlı bir ilişki tespit edilmiştir (r -0.371 p 0.011).

Sonuç: Okullardaki kapalı mekan fiziksel çevre özellikleri ile okul başarısı arasında anlamlı bir ilişki bulunmuştur.

Anahtar Sözcükler: Elektromanyetik alanlar, Gürültü, Aydınlatma, Okul

INTRODUCTION

Children spend approximately 9 months of the year and one third of their days at school. In this respect; among the environments the child spends time in, school is an important establishment that gets involved in his life for a long time and that influences his behaviours (1,2). School health services have an important function in protecting and improving children's health. WHO has defined "the school which promotes health"; as a school that constitutes a healthy environment for living, learning, and studying and maintains this capacity (3). American Academy of Paediatrics has emphasized "the healthy school environment" as a school environment which protects the students and the employees from injuries, illnesses, and disabilities, and in which behaviours and activities for preventing environmental risk factors are embraced (4). In fact, school environmental health practices involve everything at school and its surroundings; they are practices to prevent all sorts of pollution that may occur at the location of the school, in its building, indoor atmosphere, water and sanitation safety, lighting, the noise levels, the school yard and the school buses (1).

The biological risk factors resulting from the school and its surroundings consist of moulds, unsafe foods, diseases that are infected through vectors; the chemical risk factors consist of air and water pollution, pesticides, hazardous wastes, asbestos, paint, cleaning supplies; and the physical risk factors consist of transportation, violence, injuries, extreme hot and cold, and radiation (3).

The problems resulting from the school environment affect the learning capacity of children significantly as much as they affect their health. The studies carried out determined that bad school environment conditions cause a decrease in the general well-being and the learning capacity of children while causing an increase in the rates of absence (5,6). Moreover, it has been determined that exposure to noise within the school decreases the long-term memory, reading skills, and motivation of students; and the inconvenience of the lighting level cause a decrease of success in classes and a state of discomfort (7-9). As for temperature and humidity values, they have been accepted as a mixer in learning processes and it has been determined in the studies that the convenient temperature levels improve the cognitive performance; and that a relationship between exposure to electromagnetic field and childhood leukaemia has been found (10,11). Therefore, the school success rate is accepted as an indicator showing the health effects of the school environment (12).

Studies conducted in Turkey have shown that schools have significant deficiencies in compliance with environmental health standards (13-16). In this study, it was aimed to evaluate the effects of physical environment characteristics of schools on students' success and absenteeism.

MATERIAL and METHOD

Population and sample

The population of this cross-sectional study consists of total of 42 primary and secondary level schools located within the borders of the province of Derince in the city of Kocaeli in the school year of 2014-2015. A sample has not been selected for the research and all schools have been included in the research. The total number of classrooms in schools is 624, and in our study, measurements were made in 203 (32.5%) classrooms. The classroom selection criteria in schools has been made by investigating two classrooms from the right and left sides of each hall from each floor, starting from the top floor, for schools that have a single building; and for schools that have two separate buildings, by investigating one classroom that is closest to the end of the staircases from each hall in each floor, starting from the top floor, separately from each building (13). The study was obtained from the Kocaeli University Clinical Research Ethics Committee with the decision number 4/18, dated 27.11.2015.

Variables of the research

The dependent variables of the research are the school success rates. School success rates are calculated by dividing the total of success points of the students in each school to the number of students in the school. This data has been obtained from the records of Derince District Directorate of National Education.

Independent variables of the research consist of 2 different groups of variables.

1) School indoor environment physical characteristics: Electromagnetic field level in schoolyard (mG), noise level in schoolyard (dB), temperature in schoolyard (°C), and humidity levels (%), measurement parameters related to the electromagnetic field, lighting, noise, temperature, and humidity levels of the determined classrooms. In schools that had a library, the lighting level of the library was also measured.

1) Class properties: It consists of variables such as the hygiene of the classroom, type of the board, distance of the board from the desks, position of the windows, width of the door, space

of the classroom, capacity of the classroom. The data has been collected by means of questions and measurements composed based on TS 12014 School Environmental Health, TS 9518 General Physical Settlement Rules for Elementary Schools, developed by the Turkish Standards Institution for schools, and the literature information (17,18). It has been calculated by giving 1 point to the question and values in the data form that were compliant with the standards and adding them up. The maximum standard point that a school can obtain according to this scoring is 14 and more points show compliance with the standards.

Measurements

Electromagnetic field measurement; It has been performed in the form of 5 measurements in total as from 4 corners and from the middle with Traxial Elf Magnetic Field Meter Model 4190 device in the determined classrooms; as for the schoolyard, four corners of the yard and the entrance of the school building, 5 measurements in total. The limit value of ≤2 mG for electromagnetic radiation level, which is recommended by USA National Council of Radiation Protection and Measurements (NCRP) for schools and children playgrounds, has been accepted as the limit values in our research (19).

Noise measurement; Measurements that lasted 10 minutes were performed with a RION NL-31 brand noise measurement device, in classrooms as 1 meter away from the surface, 1.5 m away from significant sound permeation elements such as windows and with the conditions of having at least 0.7 m long distance between the 3 spots measured. The measurement in the schoolyard has been performed as 3.5 away from the school building, 3 m away from the road from where the traffic flows, and 1.5 m above the ground. The values of 35 dB when the class windows are open and 45 dB when the class windows are closed, which are in the Regulation of Evaluation and Management of Environmental Noise have been accepted as the limits (20). For the outdoor schoolyard noise level, 55 dB, determined by WHO, has been accepted as the limit value (21).

Lighting measurement; has been performed with a TES 1335A Digital Light –Meter luxmeter as 80 cm above the ground, 9 measurements from the front, middle, and back seats and 1 from the middle spot attached to the board, 10 measurement in total by pulling 1 m away from the device. The limit values in classrooms for lighting was based on at least 200 lux light intensity, which is in TS 9518/ General Physical Settlement Rules for Elementary Schools, maximum 500 lux (in the literature), and as for the libraries, it is based on 500 lux (17,18,21-23).

Temperature and humidity measurement; has been performed from 5 different spots, 10 minutes after entering the determined classrooms, as 1 m above the ground. The in-class and schoolyard measurements were made with a ROHS Model AR 714 type XG6608 thermometer – hygrometer. Outdoor temperature and humidity values have been recorded by measuring once in the schoolyard, regardless of a particular place. The temperature values recommended by ASHRAE as 22.77°C.-26.66°C for summer; and humidity between 30-60% were accepted (24).

The in-class measurements from the determined classrooms (space of the classroom, window, door, distance of the board to the first desk, etc.) have been made with a 5 meter long tape measure.

Statistical Analysis

Data entry and analysis have been made by using the package software SPSS 20.0. The compliance of the continuous variables to the normal distribution has been tested via Kolmogorov-Smirnov test. For the data could not meet the parametric test estimates in the comparison of the average between groups, Mann-Whitney U test, Kruskal Wallis test and Spearman correlation analysis were employed.

RESULTS

The average of the score of conformity, 203 classrooms examined in the research have obtained with regards to their classroom physical properties is 9.56±1.02 (min:7.75-max:12.00). It has been determined that in 30.1% of the classrooms, the air volume per student is 6 m^3 and above, thus conforming with the standards, and the average air volume per students is 3.21±0.96 m^3. It has been determined that, in 99.5% of the classroom, it is 1.2 m^2 and above per student, thus conforming with the standards. It has been determined that the space per student in the classrooms is minimum 1,12 m^2 maximum 3.20 m^2 per student and the average space per

Table I: Distribution of the Classroom Properties of the Schools, (n=203).

Classroom Properties of the Schools	Number(n)	Pct. (%)
Space per student ≥1.2 m^2 (conforming)	202	99.5
Air volume per student ≥6 m^3 (conforming)	61	30.1
Height of classroom from floor to ceiling ≥3.5 m (conforming)	0	0.0
Total	203	100

Table II: Distribution of Schools According to Their State of Conformity with the Standards of Electromagnetic Field, Noise, Lighting, Temperature, and Humidity Levels.

	Number (n)	Pct. (%)
Conformance of School Electromagnetic Field Level to the Standards		
Schoolyard		
≤ 2 mG (conforming)	42	100
Classroom		
≤ 2 mG (conforming)	203	100
Conformance of School Noise Levels to the Standards		
schoolyard		
≤ 55 dB (conforming)	20	47.6
Classroom with windows open		
≤ 45 dB (conforming)	30	71.4
Classroom with windows closed		
≤ 35 dB (conforming)	25	59.5
Conformance of School Lighting Levels to the Standards		
Classroom with Lights on windows closed		
200 ≤ and ≤ 500 lux (conforming)	37	88.1
Classroom with lights off windows open		
200 ≤ and ≤ 500 lux (conforming)	27	64.3
Library (n=23)		
≥500 lux (conforming)	15	65.2
Conformance of School Temperature and Humidity Levels to the Standards		
Classroom Temperature		
22.77 ≤ and ≤ 26.6 ºC (conforming)	18	42.9
Classroom Humidity		
%30≤ and ≤%60 (conforming)	41	97.6
Total	42	100

student is 1.81±0.32 m^2. It has been determined that the height of none of the classrooms, from floor to ceiling, is 3.5 m and above. It has been determined that the height of the classrooms is minimum 2.80 m maximum 3.20 m and the average classroom height is 3.01±0.08 m. The classroom properties of schools are given in table I. The measurement results of the indoor physical characteristics of the schools within the scope of our research are given in table II.

The average of the electromagnetic field measurement while the electronic devices were on in the classrooms measured in our research, has been determined as 0.53±0.27 mG (minimum 0.20 mG-maximum1.20 mG). The average of the electromagnetic field measurement while the electronic devices were off has been determined as 0.47±0.26 mG (minimum 0.17 mG - maximum 1.12 mG). The electromagnetic field level measured in the administrative units of schools has been determined as 0.74 mG±0.40 mG in average. The electromagnetic field level of schoolyard has been determined as 0.63±0.26 mG (minimum 0.34 mG - maximum 1.50 mG) in average. The electromagnetic field level in all of the schools in our research is conforming with the recommended limit values.

The noise level in the classroom has been determined as 37.60±7.09 dB (minimum 24.60 dB - maximum 48.78 dB) in average when measured when the windows were open and as 35.23±6.76 dB (minimum 22.25 dB - maximum 46.42 dB) when measured when the windows were closed. The average noise level of the schoolyards has been determined as 57.43±7.77 dB (minimum 45.00 dB- maximum 69.50 dB). It has been determined in our research that, the schoolyard noise level of 47.6% of the schools, the noise level of 71.4% in the classroom when the windows are open, and the noise level of 59.5% when the windows are closed, comply with the values determined in the standards.

The level of lighting measured in the classrooms when the lights are on and the curtains are closed has been determined as 370.11±95.15 lux (minimum 213.66 lux - maximum 586.25 lux) and the level of lighting measured when the lights are off and the curtains are open as 446.62±164.41 lux (minimum 150.66 lux - maximum 815.66 lux). The level of lighting in the libraries of the schools has been determined as 525.76±113.23 lux (minimum 235.00 lux - maximum 717.00 lux). It has been determined in our research that, the level of lighting of 88.1% of the schools, when the classroom lights are on and the curtains are closed, the level of lighting of 64.3%, when the classroom lights are off and the curtains are open, comply with the standard values. It has been determined that the library lighting level of 65.2% of the schools that have libraries (n=23), complies with the standard values.

The temperature of the classrooms has been calculated as 26.83±2.12 ºC (minimum 23.25 ºC- maximum 33.66 ºC) in average and the humidity level as 50.61±5.73% (minimum %35.00 - maximum %60.33). According to the measurements made in the schoolyard, the temperature of the school environment has been determined as 28.08±3.06 ºC (minimum

Table III: Relationship Between the State of Conformity of the Noise Levels of Schools to the Standards and Grades.

	Grade Average± SS	p
School Environment Noise Level*		
Conforming	79.03±1.24	0.042
Nonconforming	73.79±1.47	
Classroom Noise Level†		
Conforming	80.21±2.15	0.039
Nonconforming	76.62±1.05	

*****7th Grades, † 6th Grades*

Table IV: Relationship Between the Physical Parameter Measurement Values of Schools and The Grade Average of Students.

Correlation	Grade Average
	r (correlation coefficient)
Level of Lighting when lights are on and windows are closed	0.563
Level of Lighting when lights are off and windows are open	0.480
School environment temperature level	0.491
Total class scores of schools	0.528

23.00 ºC- maximum 35.00 ºC) and the school environment humidity level as 59.19±10.41% (minimum %32.00- maximum %74.00). In our research, it has been determined that, the classroom temperature values in 42.9% of the schools, and the classroom humidity values in 97.6% are conforming with the standards.

The student grade point average of elementary schools (n=19) has been determined as 81.26±4.86 (minimum 73.43-maximum 88.59). The student grade point average of middle schools (n=23) has been determined as 77.35±4.90 (minimum 69.39-maximum 86.02).

As for the statistical analyses conducted by means of categorising as schools conforming with the school environment noise level standards and those that do not, a statistically significant difference between the grade averages of the seventh grades of schools conforming with the noise standards and schools that do not (p=0.042) has been determined. Similarly, a statistically significant difference between the grade averages of the sixth grades of schools conforming with the in-class noise level standards and schools that do not has also been determined (p=0.039) (Table III).

A negatively significant correlation between the level of lighting in the classroom when the lights are on and the curtains are close and the grade averages of the fifth, sixth, and seventh grades has been determined (respectively; r -0.498 p 0.011; r-0.548 p 0.021; r -0.563 p 0.004). Similarly, a negatively significant correlation between the level of lighting in the classroom when the lights are off and the curtains are open and the grade average of the fifth, sixth, and seventh grades (respectively; r -0.480 p 0.015; r-0.416 p 0.039; r -0.409 p 0.047).

A negatively significant correlation between the school environment temperature level and the grade average of the 4th grades has been determined (r -0.491 p 0.020).

A positively significant correlation between the classroom scores of the schools and the grade averages of the fifth grades has been determined (r 0.528 p 0.007). A negatively significant correlation between the building scores of the schools and the rate of absence of the students has been determined (r -0.371 p 0.011). The correlation between the physical parameter measurement results of the schools and the grades has been given in Table IV.

DISCUSSION

The problems resulting from the school environment affect the learning capacity of children significantly as it does their health. In a study examining the effects of school environmental health conditions on students and teachers, the characteristics related to natural lighting, ventilation, acoustic design and thermal conditions of the school building are described as the main determinants affecting student health (12). The determinant of the students' health are the performance indicators such as the grades, graduation averages of students. The acquisition of values belonging to the variables of noise, lighting, electromagnetic field, temperature, and humidity, which determine the indoor physical environment of the schools in this research through measuring, is the strength of the research. However, the fact that the students' success was evaluated based on the school and there had been no individual measurement conducted is a constraint of the research.

Our findings support that the physical characteristics of classrooms have effect on the success of the students.

The air quality in the indoor volume of schools, in which children who are more defenceless against environmental risks spend a significant amount of their time, affects the health and success of the students negatively due to natural pollution

source (respiration/CO_2), in case precautions are not taken. Therefore, it is important that enough space and air volume per student, which are indicated also in school environmental health standards, are provided (25,26). In our research, the determination of the conformity of space per student with the standards in nearly all of the classrooms, is positive. However, it has been determined that in only 30.1% of the classrooms, 6 m3 and above air volume per student is provided. In the study carried out by Heath et al, it was determined that the indoor air quality, the absence and the performance of the students result from the effects of the air pollutants on health (27). Bako- Birko et al. has determined in the study they have carried out that, when the speed of the clean air circulation is increased from 0.3-0.5 L/s to 13-16 L/s, the study rate of the students has increased 7% (28). In the study carried out by Shaughnessy similarly, a significant relationship between the increase of the speed of ventilation and the increase of the math scores has been determined (29).

The basis of noise's mechanism of disrupting learning is on the disrupting the student's relationship with pronunciation, reading, and perception during language learning. In the studies carried out, it has been detected that the students receiving education in schools which are exposed to environmental noise, have issues precepting and that their scores on the long-term memory test are low (8). A significant relationship between the school noise level and the grade average of the 6th and 7th grades, has been found. Similarly, in the study carried out by Pujol et al. average school noise level has been determined as 51.5 dB and the students' low scores in math and French classes has been associated with the school noise level (p= 0.02) (p= 0.01) (30). In the study carried out by Papanikolaou et al. the reading performance of the children in schools with low noise level (55-66 dB) has shown a statistically significant difference from the children with middle (67-77 dB) and high levels of noise (72-80 dB) (p <0.001) (31).

As a component of indoor environment, lighting affects the learning processes, memories, and the attention span of student directly (32). A negatively significant correlation between the lighting levels of the classrooms and the grade averages of the fifth, sixth, and seventh grades has been determined in our research. Similarly, it has been determined in the study carried out by Heschong Mahone Group that, high intensity of light affects vision negatively due to flashing and particularly has a negative effect on the success of the students in math class (33). In the study of Samani it has been detected that the improvement of the lighting conditions in classrooms motivates the students and increases their performance (34). Similarly, In the study carried out by Gilavand et al. (35) it has been shown that lighting affects learning and academic success significantly (p <0.05).

Inconvenient temperature and humidity values may disturb the students physically and thus affect their academic success negatively. It has been determined in our research that, the classroom temperature levels of the 42.9% schools, and the classroom humidity levels of the 97.6% conform with the standards. In the study, Teli et al. (36) has carried out in England, it has been determined that the temperature in classrooms rages between 19.2-28.9 °C and that the humidity levels are between 40-60%. In the study carried out by Haverinen-Shaughnessy et al. (37) it has been determined that, students who do not receive education under the conditions of a hot classroom have given 4% more correct answers in the test questions, in comparison to other students, and thus the high level of temperature has been associated with headache, having difficulty concentrating, and the increase of absence.

CONCLUSION

In this study, the effect of the environmental parameters of all schools in the Region of Derince, which has a relatively low socio-economic state, on the success and the absence of the students has been examined. It has been determined that the lighting and noise levels are effective on the success of the students and also the building scores of the schools affect the absence of students. In general, the environmental conditions of the schools may be evaluated as mediocre. The deficiencies of the school buildings located in the area we have worked needs to be eliminated and they need to have child-friendly school environment. For this purpose, solutions such as increasing the awareness of teachers and school administrators, re-evaluation of the in-school architectural services, for example; sound-proof insulation panels, adjustment of the amount of in-class natural and artificial light, may be suggested. Minimising the environmental risks resulting from the school environment, shall provide security for children, thus for the society. Should the studies, which shall be carried out with regards to this matter, get planned as intervention studies and focus on individual success, more in detail results might be obtained.

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