Evaluation of environmental factors affecting student stress in educational spaces based on Shannon entropy

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Abstract: **Stress is one of the important issues in modern societies and in fact an inevitable part of people's lives. Educational environment are among the environments where people experience stress. Therefore, identification and extraction of environmental stressors to reduce them and increase spatial relaxation is the main objective of the present study. In this research, survey methodology and Delphi technique have been used to answer the research questions. This study has focused on the attitude of experts and professors in the fields of psychology, psychiatry, and architecture. In this regard, library resources were first studied and reviewed, and then open-ended interviews were conducted with twelve psychiatrists, psychologists, and professors in these areas in Shiraz, Iran. Then, Shannon's content analysis method was used to analyze the information and extract the effective components of stress in educational environment according to the weight coefficients for their importance and acceptability. In the next step, the grouping of the contributing factors into four distinct categories was done by five professors in the field of architecture. The results indicate that independent variables have different degrees of impact on the dependent variable. Noise and inappropriate lighting were identified as the most important environmental components increasing the stress level. Congestion was determined as the most important psycho-social variable while inadequate availability of space and colors were suggested as significant physical and spatial components of stress. The conclusion of this study is some design strategies that are suggested to help in reducing stressors such as educational space location, arrangement, neighboring, shape, noise, heating, and cooling, ….**

Key words: **Stress, Educational Environment, Shannon Entropy, noise, lighting.**

I. INTRODUCTION

Architecture is an interdisciplinary field that benefits from findings in social sciences. Therefore, in creating an architectural work, it is important to have a proper understanding of the users and their needs (1), which enables the designer in gaining a better and deeper understanding of the subject. Designing an efficient and valuable architectural work can be the result of such an understanding (2).

Physical environment has always been an interesting subject for psychologists and sometimes it is compared to a vessel in which human interactions take place (3). It can facilitate the fulfillment of physical and psychological needs of the users (4). Lack of attention to this issue can result in spaces that harm people physiologically as well as psychologically (3).

Daily stressors significantly influence physical and psychological health of people and may result in numerous psychological and social pathologies. Interestingly, families are more capable in overcoming unexpected stressful situations, but they are less capable when dealing with usual daily stress. Stress is an important consideration in educational spaces. Dr. Richard L. Hall has said that in his 31 years of teaching he had never experienced more stress than what he witnessed during his school years. Considering the importance of high school period and its significance for higher education and job market requirements, investigating and determining stress factors in high schools is of special importance. Many physical, social, and psychological factors distinguish this period from the others.

Studies show that lack of a sense of belonging as well as lack of inviting factors and spatial attractiveness tend to reduce the effective participation of students in educational environments. On the other hand, in most cases people are not relaxed and focused in the classroom. Therefore, if the environment and architectural spaces are not properly designed, it will cause stress in humans, as the users of the environment, and will naturally lead to a reduction in efficiency of these spaces.

Identifying stress factors in students is the basis for creating various preventive programs (5,6). Meanwhile, schools are of great importance because teenagers spend a lot of their time in them. Since students spend a lot of time at school, the quality of this physical space directly influences the quality of teaching and the learning process (7). Therefore, educational activities should be carried out in appropriate environments (8).

In this study, by educational spaces we mean areas that are more often used by students including classrooms and the courtyard and the relationship between the two. Moreover, it is tried to examine all design-related factors from the viewpoint of experts and to extract the most important factors

to determine the necessary qualities of these two spaces to reduce stress.

II. BACKGROUNDS

Stress

Stress is derived from the Latin word "stringer" meaning "to draw tight". The word "stress" is used in psychological context to mean "force", "pressure", and "compulsion". The word stress has different meanings for different specialists. Prior to 1936, the word stress in the English Oxford Dictionary had various meanings including pressure, tension, difficulty, and misery, but it was only after the research by the Austrian Hans Selye that this concept was precisely defined. He believed that stress could easily be interpreted as the degree of wear and fatigue in human body. He later offered a more precise definition of stress. He considered the goal of nonspecific responses to be the creation of balance and physiological compatibility. Stress related theories are mainly inspired by the works of Bandura (1986-1992) (9), Habfol (1988-1989), and Lazarus (1966-1991) (10).

Dictionaries consider stress as mental strain. According to Davis and New storm (1970) (11), mental strain is a situation where human emotions, thought processes, and physical conditions are put under pressure. When mental strain is above the acceptable threshold, then human ability to adapt will be jeopardized. Mental strain is the result of physical or mental forces that cause wear and fatigue. Mental strain is a general term that may include any type of pressure that people experience in their lives.

Researchers in this area have often focused on the structure of stress while it is an important and complicated task to identify the contributing factors and processes. More precisely, stress assessment processes need to identify environmental and personal variables, as well as coping strategies and long-term effects of stress. As a process, it is emphasized that there are three stages between the confrontation with a potential stressor and the final reactions of the person to it. The first stage is anticipation when one must prepare for stress and think about similar circumstances and what the consequences may be. When stressors occur, the person tries to cope with it. This is the waiting stage in which the person waits for feedbacks to see if the coping responses were adequate. Outcome is the final stage in which a person has to cope with the success or failure of the initial reactions. Throughout these three stages, two concepts are emphasized: cognitive assessment and coping responses.

Cognitive assessment is the thought process in which people assess the relevance of the stressors to their wellbeing. In this regard, stressors may be helpful or harmful. Coping is a specific cognitive, emotional, and behavioral effort to control specific internal and external circumstances that threaten or challenge a person. In other words, coping is the person's efforts to deal with the stressor. Coping may include any healthy or unhealthy and conscious or unconscious efforts to eliminate or weaken the stressors or tolerate their effects with

the least possible cost (12).

Physical environment and its everyday impact on people have been extensively studies in recent years. Designers and architects have used interdisciplinary methods to try and eliminate the shortcomings and identify these environmental factors (13). Students are among the most susceptible groups to mental strain. Sometimes these pressures may originate from external sources such as family problems, death of loved ones, etc. and sometimes these pressures may result from internal factors related to teachers, supervisors, examinations, higher education entrance exams, mental conditions, personal issues, educational content, and other factors that may cause stress in students.

III. OBJECTIVES

The main goal of this research is to identify and extract the factors affecting stress in educational spaces and to pay attention to these factors to reduce stress and enhance spatial relaxation, and this is achieved by measuring the attitude of experts in the fields of psychology, psychiatry, and architecture. The main hypothesis of this research is based on the effect of environmental factors on creating stress and tries to find those components whose control reduces stress more effectively and consequently creates a more comfortable and relaxed environment. For this purpose, the following questions were examined:

a. Which elements play a more important role in reducing the stress level in educational spaces?
b. How can we reduce stress in educational settings by adjusting environmental variables?

IV. METHODS

The present study is conducted using a survey methodology and Delphi technique. Delphi, a method for acquiring group knowledge that is used in deciding on qualitative issues. This technique can be used in qualitative research with exploratory aspects where the researcher tries to identify the fundamental nature of a phenomenon. The Delphi technique is a structured process for collecting information through sequential rounds and finally reaching a group consensus. The basis of the Delphi method or technique is that the opinion of experts in each scientific domain is of most value in predicting the future. Therefore, unlike survey research methods, the validity of the Delphi method is based on the scientific credibility of the participating practitioners rather than the number of participants in the research (14). Delphi method is based on dialectic approach in which the idea or thesis (creation of opinion or belief), anti-thesis (opposing opinion or belief), and finally, the synthesis (new agreement and consensus) is formed to create a new theory. Baldwin believes that in situations of inadequate knowledge, decision- makers are bound to make decisions based on their direct perceptions or the experts' opinions.

This research seeks to identify and prioritize the environmental factors affecting student stress at school.

Considering the lack of evidence in this regard, the Delphi technique was employed to make use of the expertise and attitudes of specialists and professors in the fields of psychology, psychiatry, and architecture. Then using Shannon's content analysis method, the collected data was analyzed. This was started by gathering information through the study of library resources and then open-ended interviews were used to collect opinions expressed by twelve psychiatrists, psychologists, and professors in these areas. Afterwards, the content of these interviews was analyzed and effective components of stress in educational spaces were extracted with weighted coefficients indicating their relative importance and acceptability.

In this study content analysis method was used to analyze the data collected through the interviews. Content analysis is a technique that seeks to obtain the perceptual and emotional aspects of messages or implicit implications that can be extracted from statements. Based on this technique, attempts are made to extract information from the text of a message to analyze the research hypotheses (15).

For this purpose, data analysis was performed using Shannon entropy, which is one of the content analysis methods, and insignificant components were removed based on the viewpoints of the experts. Then five experts in the fields of architecture and environmental psychology were consulted to sort these components into four categories of physical and spatial, environmental, psychosocial, and perceptual

components. In the next step, the grouping of the components into four distinct categories was carried out by five professors in the field of architecture.

Data analysis was done descriptively and analytically by Shannon entropy content analysis method in three stages.

Stage 1: Obtaining the normalized data table
Stage 2: Calculating the information load of each category and placing it in the corresponding columns
Stage 3: Calculating the coefficient of importance for each category based on its information load

Finally, the factors were extracted based on the values of their information load and coefficients of importance.

V. RESULTS

The findings of this study are based on content analysis. Content analysis takes several steps. Among them, we can mention the following three major steps:

1- Pre-analysis stage (preparation and organization) 2- Content review (message) 3- Processing of the results

In order to process the data collected from the message, after categorizing it, the obtained information should be analyzed. In this research, the content of the message was divided into four distinct categories by five university professors specialized in architecture. The results are outlined in Table 1.

Table 1: Classification of environmental stressors from the perspective of specialists

Physical and spatial components	Environmental components	Psycho-social components	Perceptual components
Dimensions and proportions of space, shape and geometry of space, aesthetics and age of the building, color and texture of space, amount of vegetation and landscape, materials, facilities and equipment available in space, legibility and lack of complexity, space layout and space hierarchy	Inappropriate visual sight, noise, humidity, heat, cold, light, unpleasant smell, security	Proper communication and interaction with others in space, congestion, privacy and exposure, lack of sense of privacy and territory	Sense of location, perceptual conditions of the environment, spatial location, immobility and movement, shortage or excessive abundance of information in space

The frequency of each category (with its subsets) is given in the following table (Table 2).

Table 2: Average physical and spatial factors affecting stress

	Measures	Average
Physical and spatial components	Dimensions and proportions of space (dimensions of the openings, height)	5.6
	Space form and geometry	4.0
	Aesthetics and age of the building	1.6
	Color and texture of space	5.6
	Vegetation and landscape	4.0
	Materials used in the design and construction of space	2.4
	Facilities and equipment available in space	2.4
	Legibility and lack of complexity	3.2
	space layout and hierarchy	4.0
Environment	Visual sight / closed spaces	1.6

al components	Noise	8.0
	Humidity	6.4
	Heat	6.4
	Cold	4.0
	Light	7.2
	Unpleasant smells (ventilation)	5.6
	Security	4.0
Psycho-social components	Proper communication and interaction with others	2.4
	Number of people in space, congestion	7.2
	Privacy and exposure	3.2
	Lack of sense of privacy and territory	2.4
Perceptual components	Sense of location	1.6
	perceptual conditions of the environment	3.2
	spatial location	0.8
	immobility and movement	0.8

Using the above table, the amount of information load and coefficient of importance for each category were obtained using the Shannon entropy method. Content analysis based on the Shannon entropy technique provides an importance factor for each component. Based on the W vector, the categories

derived from the message were ranked according to the Tables 3 to 6.

shortage or excessive abundance of information in space	1.6

Table 3: The weight of physical and spatial components based on Significance coefficient

	Physical and spatial components								
indicators	Dimensions and proportion s of space	Space form and geometry	Aesthetics and age of the building	Color and texture of space	Vegetation and landscape	Materials used in the design and construction of space	Facilities and equipment available in space	Legibility and lack of complexity	space layout and hierarchy
The amount of information load Ej	0.716	0.604	0.279	0.716	0.604	0.418	0.418	0.558	0.604
Significance coefficient Wj	0.051	0.043	0.02	0.051	0.043	0.03	0.03	0.04	0.043

This analysis shows that among physical and spatial components, dimensions and proportions of space as well as color and space texture have the most effect with a coefficient

of 0.051 and the aesthetics and the age of the building has the lowest ranking among physical and spatial components with a coefficient of 0.02.

Table 4: The weight of environmental components based on Significance coefficient

	Environmental components							
indicators	Visual sight / closed spaces	Noise	Humidity	Heat	Cold	Light	Unpleasant smells (ventilation)	Security
The amount of information load Ej	0.279	0.93	0.818	0.818	0.604	0.837	0.716	0.604
Significance factor Wj	0.02	0.067	0.058	0.058	0.043	0.06	0.051	0.043

Analysis of the environmental components' weight table based on coefficients of importance shows that the noise component with a coefficient of 0.067 is the most important component among environmental factors. Visual sight/ closed spaces have the lowest significance rank with a coefficient of 0.02.

social components, the congestion component is the most effective one with a coefficient of 0.06, and the components of proper communication and interaction with others and lack of sense of privacy and territory have the lowest rank among psycho-social components, both with coefficients equal to 0.03.

Table 5: The weight of psycho-social components based on Significance coefficient

	Psycho-social components			
indicators	Proper communication and interaction with others	Number of people in space, congestion	Privacy and exposure	Lack of sense of privacy and territory
The amount of information load Ej	0.418	0.837	0.558	0.418
Significance factor Wj	0.03	0.06	0.04	0.03

Table 6: The weight of perceptual components based on Significance coefficient

	Perceptual components				
indicators	Sense of location	perceptual conditions of the environment	spatial location	immobility and movement	shortage or excessive abundance of information in space
The amount of information load Ej	0.279	0.558	0	0	0.279
Significance factor Wj	0.02	0.04	0	0	0.02

Analysis of the above table shows that among the psycho-

This analysis shows that among the perceptual components, perceptual conditions of the environment is identified as the most important with a coefficient of 0.04, and the spatial location and immobility and movement components are the least important ones with importance coefficients of 0.

VI. DISCUSSION

The results indicate that the coefficients of importance and acceptability in the extracted components are not the same, and noise was identified as the main factor affecting the increase of environmental stress. Noise refers to unwanted sounds. It is a stressful and distressing factor (16). High noise level is not only likely to cause hearing loss, but is often referred to as an important source of stress. Matson and Ivanovich (1980) introduced intense (around 80 dB) and repetitive and persistent noise as a factor that could cause stress (17). There are different views regarding the acceptable noise levels and working hours in noisy environments. Stress level of the individual depends on the expectation of noise in addition to the noise level. In expectably noisy situations people experience less stress compared to noisy situations that are unexpected. Those who used to work in environments with unpredictable and uncontrollable noise, had a weaker performance in editing texts, and showed less stability and perseverance in tasks that measured their tolerance to failure (18).

Factors such as light (dark or overly bright) and congestion are in the next rank followed by factors like humidity and heat. Given the widespread association between what the eyes see, and the nervous system perceives, light seems to have a significant effect on the regulation of human vital rhythms. These rhythms depend on night and day, lunar, and seasonal cycles which are the three main geophysical rhythms in nature. These cycles can affect the human physiology, mood, and capabilities (19). Sufficient light is a requirement in proper work environments. Reduction or excessive increase in light can negatively influence the performance and accuracy of the individual (20).

Congestion is another stress factor that sometimes occurs in densely populated environments (21). There can be two types of congestion (22): 1- Crowds made by the presence of individuals - functional density (23), 2 - Space congestion - spatial density (24). Functional and spatial densities are both due to inappropriate distribution of users and audiences in activity, inappropriate location of people considering their activity and behavior, inappropriate interior design, use of materials that reflect noise (in the event of overcrowding, lack of sound absorbing materials can amplify the noise by several times), or the result of inadequate space available in the building. Congestion is accompanied by a feeling of lack of control over the environment and is influenced by the individual's perception of the degree of control over the environment (25). Of course, congestion is a mental notion and the reaction of various people to these situations may differ.

Although the physiological response to temperature variations differs between individuals and even in one person from a set of conditions to another, overly hot or cold environments, unpleasant smell, or overly dry environments can cause mental and physical problems. Heat, depending on its severity, can cause stress (5, 6).

Humidity, especially in hot conditions, makes it difficult to function. Humidity reduces people's efficiency for two reasons: first by reducing free oxygen in the air through replacement and second by saturating the air with water vapor (21).

Factors such as dimensions and proportions, color and texture, and lack of proper ventilation are among other extracted factors affecting the increase of environmental stress (26).

Similarly, other factors such as the form and geometry of space, vegetation, space layout and hierarchy, temperature, security, complexity, privacy, ventilation, exposure, and perceptual conditions of the environment are among the stressors (27). Materials used in buildings, available facilities and equipment, proper communication and interaction with others, lack of sense of territory and privacy as well as aesthetics and age of building, lack of attention to sight, sense of location, shortage or excessive abundance of information, locating, immobility and movement are considered as other environmental stressors (28).

VII. LIMITATIONS AND SUGGESTIONS

There are limitations in all research studies. One of the limitations in this research pertains to the size of the sample selected by the researcher using the Delphi method. It is obvious that an increase in sample size can improve the study's accuracy. However, this accuracy would come at a cost, i.e. financial and time-related limitations. The purpose of the present study depends on the researcher's selected sample size in the Delphi method. This research suggests an increase in the number of Delphi technicians. However, extending the Delphi technique courses can also be one of the suggestions for future research.

VIII. CONCLUSION

Considering the most important stressors as suggested by the experts, the following measures can be taken to reduce stress levels in educational settings:

Locating educational spaces by considering neighboring areas as well as arranging the space in such a way that noise is minimized. This can be achieved by observing the right distance from neighboring facilities, considering the purpose and circumstances of the neighboring buildings as well as their height, and creating independent access routes.

To provide appropriate lighting in educational spaces, proper orientation of the building and the dimensions of the openings in proportion to the area of space should be taken into account.

It is important for the students not to feel congestion which helps in creating psychological balance. Therefore, it is recommended that in addition to reducing the density of students in classes, in order to reduce the volume density of classrooms, effective measures (e.g. higher ceilings) should be taken to reduce unwanted outcomes such as reduced oxygen levels and feeling of congestion followed by fatigue, in case the number of students exceeds the desired level.

To regulate heat and humidity, air conditioners should be used in accordance with the educational environment standards.

Dimensions and proportions, as well as the shape and geometry of space are other factors that should be tailored to the age group that uses the educational environment. Moreover, considering the importance of vegetation in reducing stress in educational spaces, it is suggested that non-allergenic plants should be used inside classrooms and in the courtyards. Also, it is important to provide courtyard view from the classrooms and study spaces.

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