The Correlation Between The Air Quality, Ventilation And Temperature, And Students' Achievement

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Abstract: This study deals with the relevant factors that were considered as determining factors of comfort in interior space, especially in learning environments. What's more, they imply a psychological trace on a student which affects students' performance and achievement. Regarding the environment, this trace is defined by lighting, the presence of daylight, the acoustic performance, the visual appearance, the selection of building material, air quality, etc. All these appearances form one ambiance that can be adequate or inadequate. The purpose of the study was to investigate the correlation between one of the environmental factors - air quality and students' academic achievement; and find the difference between students' perception of air quality in regards to the high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period. To get data on students' perception, the questionnaire including 20 questions was constructed and delivered to 208 participants. The significant correlation between the air quality and students' achievement was observed, as well as the difference between students' perception in regards to the air quality from faculties from all three periods. This study is significant for the reason it defines to what extends environmental factors affect human comfort, in order to improve the high educational institutions in Bosnia and Herzegovina.

Index Terms: air quality, ventilation, temperature, environmental psychology, students' achievement, classroom setting, high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period.

1 INTRODUCTION

It is believed that the environment shapes our lives. It should not only be observed as a place where the human gets born, reproduces and die (Skinner, 1953). Skinner (1953) stands that the environment always impacts human life in every sphere of its part. Regarding the impact of a physical environment on the behavior of a man, Prochansky (1975) pointed: "The physical environment refers to the complexity that constitutes any physical setting in which human life, interact, and engage in activities for either brief or extended periods. It is the system of instrumental objects and life-supporting conditions organized in space and time to support and mediate the behavior and experience of the individual alone and in relation to other individuals" (p. 16). According to the famous environmental psychologist, Dr. Judith H. Heerwagen (2003), many factors, such as exposure to nature and daylight, air quality, temperature, odors, noise, ergonomics, and opportunities for social gathering, relaxation, and exercise, affect occupants' performance and well-being. The environment has an impact on human behavior, thinking, feeling and attitude. The study of how these changes in different environments are called environmental psychology (Chan, 1996). The research on this topic was constructed in the 20th century. Meanwhile, the reaction of space users was given a lot of importance in the study. Environmental psychology considers all the factors affecting the environment such as air quality, ventilation, temperature, lighting, colors, acoustics, etc. as the message that is given to the space users. The environmental psychology aims to arrange the space for particular purposes. That is why, regarding environmental psychology, the architects and space planners need to know the final users' characteristics and needs to meet most of the needs. Also, environmental psychology deals with space consumers in a sense of culture and origin. So, it could be said that environmental psychology is a combination of the space environment and human psychology. Our study observes the space environment and students' achievement, the way it is correlated. Physical environment, schools, and buildings have symbolic value for space consumers, students. They represent particular values, qualities, and aspirations. Thus, it is believed that for some individuals, a school setting can be a trigger for achievement, success, hope, and future. On the other hand, a particular building may represent failure, insecure and disgusting areas. This was a rationale for many researchers to examine if and to what extends the school environment affects people's behavior. The term education, for centuries, stands for interaction among people – teachers and students. The attention was not focused on "the things of education" to improve the environment of educational buildings. The building and environment were in the second plan of the teaching process (Castaldi, 1977). As Castaldi (1977) stated: "The new instructional tools have had a profound effect on modem educational thinking about the 'things of education.' They have made school buildings more sophisticated in design and function. Presently, the school building is much more than a shelter for its occupants. It is a complete educational tool" (p. 3). The classroom environment is related to the factors that each one separately impacts the learning processes. These factors are lighting, acoustics, thermal condition, air ventilation etc. The environment with high quality will make students concentrate more and encourage them to improve their logical thinking. A good classroom environment automatically represents the high results of the students' performance. In opposite to that, a bad classroom atmosphere will result in physical difficulties, disinterest and low achievement in general. When it comes to a student, they react to every kind of learning environment. When they show a positive reaction to the classroom environment, the motivation will be increased and their productiveness will be better. In the contrary, if students show a negative attitude towards the classroom environment, disinterest will occur and the performance will be low. In order to show a better performance, why a student needs to be placed in a comfortable classroom? Recent studies show that if physical comfort is increased, the stress is decreased in a comfortable classroom. The comfort of the students also represents better performance. Despite weak classroom conditions, students will achieve better results. Since the classroom environment is one of the factors influencing the students' achievement, it is on people in charge to work on its improvement. Having in mind that the classroom environment

influences the performance of students and improving it, all factors affecting the environment can be put under control by new and modern technologies. It implies that quality lighting the visual fatigue is decreased, and concentration is affected by acoustics while the air quality, ventilation and temperature provide physical pleasure. For decades, many studies were conducted to show the effect of the physical environment on students' achievement. However, it is also important to mention that the factors observed in the school buildings were limited, such as noise and lightening. Other variables were not considered. Some studies focused on the condition of school buildings, where others paid attention to the individual classrooms. The significance of this study is that it extends the framework and considers ventilation, air quality and temperature as variables that significantly correlate with the students' achievement.

1.2. Background of the study

1.2.1 Air quality

The ventilation and the temperature of the room are interconnected terms that are directly related to terms of air quality. The air is the mixture of nitrogen, oxygen, carbon dioxide, and some other internal gases. Also, one of the components is some water vapors in various amounts. The air contains dust, volcanic ash and other polluting materials. People think that clear air is crucial for human health. It is correct. In most cases, more attention is paid to outdoor air pollution, than to interior air conditions. Materials and activities that can pollute the air of interior space are different kinds of cleansers, paints, thinners, perfumes and cosmetics, various chemicals and different types of fabrics, as well as construction materials having emissions and unwanted effects. The interior air quality condition is a very complex combination of many physical factors, which are influencing human well-being. Besides influencing human health, it also influences the effectiveness, productivity and work achievements. The bad interior air quality negatively impacts the quality of our life and health. The odors will produce discomfort and stale air will cause a headache, respiratory problems, chronic fatigue and asthma. All these mentioned will affect the abilities of people and their concentration.

1.2.2. The Heating and Ventilation in the Last Century

The ventilation in the educational buildings and classrooms is recognized as an essential segment, but the first serious requirements in sense of ventilation were in the last years of the 19th century. The value representing the fresh air required in the classroom varied during the time. There were some questions to be answered during the time, such as; is the natural ventilation solution for all climate zones? What temperature and humidity are the best for health and performance for certain activities? (Gray, 1951). Research conducted in the period after World War II stated that the changing of standards was influenced by the development of technology much more than human needs. Lectures in the classroom occur during the day, and natural heating was used in combination with developed mechanical heating systems. When ventilation standards were made for the teaching environment, the amount of fresh air was decreased from 30 (in the 1920s) cubic feet per minute (cfm) to 10. Researchers in the first half of the 20th century claimed that airflow below 10 cfm was not recommended in the classroom environment (Janssen, 1999). In the period of the 6th and 7th decade of the 20th century, scholars concluded that the decreased value of fresh air to 10 cfm since the classrooms were over-ventilated and that 10 cfm is enough to eliminate the unwanted substances from the air (Castaldi, 1969). But facing the energy crisis, the standards released in 1981 decreased the amount of needed fresh air from 10cfm to 5cfm for every space, not only for classrooms. The reason was the energy savings (Janssen, 1999). Different types of ventilation configurations were required since the open-plan designed classrooms started to be used. Also in this period, there was an idea to decrease the openings area, since the mechanical system started heating and ventilation. The reason was that the work and productivity and effectiveness of mechanical systems was increased by glass area being reduced on walls. All these ideas were the product of the energy crisis and the mechanical systems were preferred because of bigger reliability, even though the natural lighting and air ventilation would be diminished. The idea that cooling is equal to heating in the design of new educational buildings, was a little bit surprising since the educational buildings were generally not in use during the summertime (Castaldi, 1969). In the time of 1970s, there was a striving to controlled temperature and humidity, so the effect of windows was neglected to save energy. In the last couple of decades, a good ambient in the classrooms was established regarding heating, air quality and ventilation. The students show better performance at managed humidity levels and the managed classroom temperature (Azar, C & Schneider, S.H. 2002). Also, the amount of CO2 should be below a certain level.

1.2.3. Ventilation

The purpose of ventilation is to provide healthy and fresh air to the interior environment. Ventilating provides an exchange of stale and clean air. In a modern ventilation system, most attention is paid to energy and reducing energy costs. Also, attention is paid to systems that provide energy recovery. There are two types of ventilation; the natural one and the artificial one. In natural ventilation, the air inside the building rises and goes through the air channels creating pressure in the building. The created pressure makes the exterior air enter inside the building through the gaps in the structure. The more inside temperature differs the temperature of outside, the biggest air exchange occurs. Although natural ventilation sometimes may be satisfactory, some adverse effects occur. In order to provide clear and fresh air into interior space, stronger airflow is needed; energy is wasted because the heated air goes directly outside. Decreasing airflow, energy consumption also decreases. However, this situation negatively impacts the ambiance and makes the air to be stale. The second problem of natural ventilation is that it cannot be controlled and regulated. And in the end, the air is not cleaned, because it is not possible to put filters in every gap towards outside.

Artificial or mechanical ventilation is a forced airflow using fans. The advantages of mechanical ventilation are that it does not depend on weather conditions. There is a very big selection of equipment and there is a possibility to control and regulate. There are some disadvantages such as very big costs, high energy consumption, re-circulation of air, and the noise that is produced. Ventilation, as one of the most important factors of the indoor environment of a classroom, determines the air quality and the importance of air quality cannot be neglected. The reason why a classroom is being

ventilated is that various types of contaminants are growing up inside, human breath, clothes, perfumes, sanitary preparations, different building materials etc. Ventilation in educational buildings must be appropriate because of the number of space users (Crawford, 1998). Natural ventilation, which in many things differs from artificial or mechanical ventilation, is in correlation with the way of daylight presence in the classroom. The efficient system of natural ventilation is transversely air flowing in double-sided illuminated classrooms. In the single-sided illuminated classrooms, the efficient system of natural ventilation is limited and the optimum quality of air cannot be fully reached. As a solution, the additional aerators can be installed on the walls across the windows. The ventilation of the classrooms over the corridor is not allowed. As a supplement to natural ventilation, mechanical ventilation is recommended. The area where more research is needed is the lack of proper ventilation inside the classrooms despite the mechanical HVAC industry grow. (Godwin & Batterman, 2007). Plenty of classrooms today, in terms of ventilation, depend on windows and doors. As mentioned above, there were some standards for the ventilation of classrooms during the time, but we face that many classrooms have the amount of fresh air below 5 cfm (Turk et al,1989). The ventilation, besides getting the fresh air inside the room, also removes some harmful chemical and biological substances. Regarding that, mechanical systems for ventilation or used materials can have a positive influence on the overall air condition inside the classroom by putting the filtered air, in the contrary, the building systems can decrease the quality of air in the classroom having the toxic substances in the system. It could be also due to various materials that are not healthy for humans. Classrooms, where the education process is held, should have permanent, flexible and slight ventilation. But, too much airflow can cause a cold because of the sensitivity of mucous membranes in the nose, and too slow airflow can cause stale air. The students with weak ventilation in their classroom will not function normally, having difficulties with their capacities. Poor outdoor quality of air affects students' health and performance, as it is affected by inside air quality (Frumkin et al, 2007). The indicators of poor indoor air quality are the pain of eyes, respiratory tract, annoyance, headaches and fatigue (EPA, 2000). The major influence of students' performance is sleepiness. One of the signs that classroom ventilation is poor is the presence of increased CO2 that is produced while humans breathe. When the level of CO2 is increased above the level that is normally found in the atmosphere, it causes headaches and decreased concentration. The carbon dioxide in the room can have variable concentrations. The permitted concentration of carbon dioxide is in the function of intensification (mental or physical) activity.

1.2.4. Temperature

The task of heating is to provide an environment in interior space where the balance between the temperature of the human body and his/her environment will be achieved in order to have a feeling of well-being. The factors that impact the feel of thermal comfort are the physical activity, temperature of the space, temperature of the walls, humidity, airflow velocity and its quality. Heating the room can only impact two of the above mentioned, these are the temperature of the space and the temperature of the walls. The other factors will be affected by ventilation systems.

In order to have thermal equilibrium, the human body needs to give the produced heat to the environment. In the period when the human body has no activity, the heat flow is around 70 W, and the secreted humidity in the shape of water steam in value of 30 g/h. This transfer occurs by convection, radiation, respiration and transpiration over the skin. In the period when the human body has high activity, these values increase up to 500W and 250 g/h of water. The temperature loss will occur when outdoor air gets into the interior through the gaps. Ventilation contributes to temperature loss. Thermal comfort is not managing the temperature by cooling and heating. The temperature comfort depends on many factors such as the velocity of the air (airflow), control of the user, materials radiant, the activity of the students, and how the students are clothed. The human body tries to manage its temperature at 36.6 C degrees. According to Sleeman and Rockwell, four factors are influencing the temperature of the body; air temperature, radiant temperature, humidity and air movement (Sleeman&Rockwell, 1981). The most proper temperature for learning would be 20-24 C degrees, most proper humidity 40-60% and airflow velocity of 0.1-0.2 m/s (Sleeman&Rockwell, 1981). Harmon suggested that the best temperature for students, in order to have the best effectiveness, in value of 20-24 C degree. He also stands that the classroom environment must have airflow and appropriate humidity (Harmon, 1953). Earlier, Harner stated that the students' best performance would be at the humidity of 40 to 70% and the managed temperature from 20 to 24 C degrees (Harner, 1974). Research showed that temperature inside of the classroom surely affects the students' performance. If the temperature and humidity are increased, the attention will be decreased and when the temperature of the classroom is decreased, the productivity and speed of the students are increased (Wyon&Wargocki, 2007). The temperature and humidity cannot fit every student, because the report to comfort differs individually (McGuffey, 1982). The airflow is a very important segment of the inner climate. Airflow contributes a feeling of freshness and the ventilation can be considered as continuous air exchange in the room so that air quality of inner space should strive towards the clean, outdoor air. The optimum airflow velocity should be from 0.07 m/s (according to Russian standards) up to 0.10-0.15 m/s (according to English standards) (Hadrovic, 1996). But, some standards allow the airflow velocity up to 0.3 m/s (Auf-Franic, 2004). Creating a static thermal ambiance became quite challenging, especially in high-performance educational buildings. It is important to explore the impact of new systems, new ways of air distribution to students, their health and their performance, having in mind that energy saves in such buildings is the main concern. But, more important is to explore the ventilation and heating level in order to have comfort and energy savings at the same time. Thermal comfort and temperature environment are in direct correlation with air quality. Kennedy states that the quality of the interior environment, impacts the students' and teachers' health, and as such is reflected in absenteeism (Kennedy, 2005). Humidity and temperature levels impact the phenomenon of mold. The high amount of humidity results in the mold on ceilings. Wyon states that when the humidity was increased from 22 to 35%, the performance of the students also changed (Wyon&Wargocki, 2007). The temperature of the classroom also affects the lecturer, it influences their ability to teach and their concentration. Lecturers have expectations to manage

the classroom conditions in terms of sunlight, acoustics, temperature etc. Lecturers themselves think that thermal comfort influences their work and the effectiveness of their students (Lackney, 1999). Many studies claim that decreased job satisfaction, decreased effort and effectiveness, low morale and motivation are some of the results of bad thermal comfort. Researchers Manning and Olsen (1964) state that the air-conditioning. It is the most important factor in making a good thermal environment for learning (Manning&Olsen, 1964). Also, while examining typical classrooms, they claim that the removal of overage temperature is much more important than adding heat during the year. By improving the air condition in the classroom, the annoyance, visual display flexibility and comfort is also improved in general (McDonald, 1960) as stated in (Chan, 1996). Peccolo (1962) tried to determine how students are successful in a good or a poor classroom environment, regarding ventilation, heating, humidity. The experimental group was placed in a modeled classroom with the best effects of ventilation, heating and humidity. That experimental group was more successful and resulted in better achievement. Peccolo states that the thermal environment impacts mental efficiency (Peccolo, 1962). Almost the same research was done by McCardle (1966). He made an experimental classroom for the experimental group with ideal thermal ambiance and made a comparison of effectiveness with the students from regular classrooms. The results showed that despite having small mistakes as a result of a task, the task given to the experimental group was finished with more quality and in less time. The controlled thermal environment provides better achievement for students. Regarding that, Stuart and Curtis (1964) made a comparison between students having almost the same teaching content and teaching staff, but in different classrooms, one of them was thermal controlled and non-controlled one. The results after two years of examination showed that the achievement of the students in a thermally controlled classroom was superior in comparison with the performance of the students in a non-controlled classroom.

1.3. Literature review

Plenty of studies have been made on the importance of the air quality, temperature and ventilation inside the classroom in a sense of effectiveness and performance of the students. Researches confirmed the mentioned factors impact students, which automatically represents the better performance of the students. The study by the New York Commission on ventilation (1931) investigated the impact of temperature and humidity on students' productivity. The commission tried to define the most appropriate temperature for the classroom environment and the condition that will increase the students' performance. The result of the research made in the early years of the 20th century was a recommendation to manage the classroom temperature from 20 to 21.1 C degrees and to manage the humidity to 50 percent. The research also resulted that the temperature which is more than 24 C degrees increases the body temperature of the students, which disturbs the pulse. The performance among the examined students was decreased 15 percent at the temperature above 24 degrees. Also, the results presented the physiological harm from a very high temperature. As mentioned, the research was made in the first decades of the 20th century, but some of the recommendations can be still used in school design.

The correlation between temperature and the students' performance, especially the word recognition was the subject of research of Murrain (1983). The same procedure of the examination was implemented in the cold and warm classrooms. The result showed that students reached better results and performance in warm classrooms. The researcher McGuffey (1982), based on the analysis of the previous research on this topic, claims that there is a relationship between temperature and students' performance and behavior. But in the research made earlier, Peccolo (1962) investigated the correlation of the temperature and student achievement and got the result that the correlation surely exists. The students in this research were examined under the ideal temperature of 21- 24 C degrees. The same result confirmed McCardle (1966) telling that students showed great achievement in the temperature of 21-24 C, and their performance was decreased by increased temperature above 24 C degrees. The concentration of the CO2 in school buildings was examined in the work of Myhrvold, Olsen and Lauridsen (1996). They stated that the concentration of the CO2 is related to the ventilation system. It is concluded that a good HVAC system can improve the learning environment. They also claim that poor ventilation can affect humans' health especially the respiratory system. Different ranges of temperatures were used in the research regarding the effect of temperature. Kahl (2005) examined the effect of low and high temperature on the academic performance, arousal and comfort through different tasks given to students. Although room temperature affected subjective physical comfort, there was not a big difference in the performance in certain tasks, but Kahl recommends further studies regarding the influence of temperature based on gender. Bako-Biro, Clements-Croome, Kochhar, Awbi and Williams (2011) tried to find the effect of ventilation on students' performance in England. A portable mechanical ventilation system was made in order to improve the concentration of CO2 for examination. 200 students were included in the research. By increasing the air quality in the classrooms, the students' achievement was also improved. They had a better choice reaction, picture memory, word recognition at the improved ventilation conditions. The main findings of these researchers are that the ventilation of the classroom significantly impacts students' attention and concentration. The literature on air-conditioning implies that there is an impact of the air quality on the students' performance in the school building. And the importance of the well-being in sense of thermal comfort of the students is observed. The work of Myhrvold et al (1996) represents the issue of carbon dioxide in the classrooms. The research was done among eight different educational institutions all around Europe. The increased amount of carbon dioxide decreased the performance of the students. The presence of CO2 caused certain health problems among students that they complained about. In 2013 researchers Cui, Cao, Park, Ouyang and Zhu, measured the impact of inside air temperature on human comfort, performance and motivation. The examination was made in five different chambers having different values of temperature (22, 24, 26, 29, 32 C degree). The results showed that the productivity of students was decreased in the cold and hot discomfort, and also in the condition where the temperature was frequently changed. The motivation was increased by increased comfort condition, stimulating the performance of the students. Also, the results implied that the most appropriate temperature for education was between 22

and 26 C degrees. The environment with high temperatures had a bad influence on performance and motivation.

2 MATERIALS AND METHODS

The study aimed to investigate the correlation between the air quality, ventilation and temperature and students' academic achievement; and find the difference between students' perception of air quality, ventilation and temperature in regards to the high educational buildings from Austro-Hungarian Empire, Socialist period and After-war period. In this study, 208 students participated. The study was conducted among students in Bosnia and Herzegovina from five faculties that were built in three historical periods: Austro-Hungarian Empire (Faculty of Law and Faculty of Islamic Studies, University of Sarajevo, Sarajevo), Socialist period (Faculty of Philosophy and Faculty of Political Science, University of Sarajevo, Sarajevo) and After-war period (The Faculty of Business and Administration, International University of Sarajevo, Sarajevo and The Faculty of Engineering and Natural Sciences, International University of Sarajevo, Sarajevo). In order to gather data for the study, we designed a questionnaire based on the literature review. The questions were in terms of temperature, thermal comfort, ventilation and air content. The questionnaire included 20 questions with a rating scale from one to five for each one of them, Likert scale. The questions were composed clearly without ambiguity. Besides, the survey included several lines where students could provide their answers and make suggestions. The researcher consulted the experts in the field of architecture in order to verify the survey. As an integral part of designing a questionnaire, field testing was conducted. In another word, piloting the questionnaire itself, we chose a group of 15 people (N=15). After gathering the data from the participants, it was decided that the questionnaire does focus on the information of the research interest right after examining and confirming the reliability and validity of the data. The reliability of the questionnaire was measured by the reliability analysis. We used Cronbach's Alpha, a method to measure the consistency of the questionnaire. The SPSS measured it. The Cronbach's Alpha wss .836 implies a very high level of consistency. Cronbach alpha coefficients calculated for air quality, ventilation and temperature were above the recommended value of 0.7, thus it indicated reliable measures. We implemented the survey method and questioned students' perceptions of air quality, ventilation and temperature at their universities. It provided the data for correlation research. For analyzing the obtained data the researchers used Statistical Package for the Social Sciences (SPSS21).

The students were delivered the questionnaire in the hard copy.

3 RESULTS

The first research question investigated if there is ‘’a correlation between students’ achievement (GPA) and air quality, ventilation and temperature’’. There is a significant correlation between Grade Point Average (GPA) and air quality, ventilation and temperature (Sig=-,143*).

TABLE 1*.THE CORRELATION OF GPA AND AIR QUALITY, VENTILATION AND TEMPERATURE*

		GPA
Air quality, ventilation and temperature	Pearson Correlation	-,143*
	Sig. (2-tailed)	,049
	N	189

*. The mean difference is significant at the 0.05 level

The second research question investigated "the difference between students' perception of air quality, ventilation and temperature in regards to the high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period". It can be observed that there is a significant difference .000 (Sig=0.000) between students' perception of air quality, ventilation and temperature at faculties from three periods. The ANOVA test represents only the presence of difference among treated periods in terms of air quality, ventilation and temperature. (Table 2)

TABLE 2. *THE DIFFERENCE BETWEEN STUDENTS’ PERCEPTION OF AIR QUALITY, VENTILATION AND TEMPERATURE IN REGARDS TO FACULTIES FROM ALL PERIODS*

		Sum of Squares	df	Mean Square	F	Sig.
Air quality, ventilation and temperature	Between Groups	118,766	2	59,383	11,991	,000
	Within Groups	906,266	183	4,952		
	Total	1025,032	185			

However, the one-way ANOVA test does not imply which group means are different. In order to learn which group means are different, we applied post-hoc test. The Scheffe Multiple Comparison Test shows which Period means are different in terms of air quality, ventilation and temperature. In the table below (Table 3), multiple comparisons among different periods are presented. The result show among which periods the difference in attitudes towards air quality, ventilation and temperature exist and in which volume. The difference between Period I and III is significant (Sig=0.000), the difference between Period II and III is also significant (Sig=0.003) but in a smaller volume. The difference between Periods I and II has a minor significance (Sig=0.055), since the mean difference is significant at the 0.05 level.

TABLE 3. *THE MULTIPLE COMPARISONS AMONG PERIODS IN TERMS OF AIR QUALITY, VENTILATON AND TEMPERATURE*

Scheffe

Faculty	Faculty	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Period I	Period II	-1,036	,427	,055	-2,09	,02
	Period III	-2,487*	,514	,000	-3,76	-1,22
Period II	Period I	1,036	,427	,055	-,02	2,09
	Period III	-1,451*	,414	,003	-2,47	-,43
Period III	Period I	2,487*	,514	,000	1,22	3,76
	Period II	1,451*	,414	,003	,43	2,47

Table 3. indicates the significant difference among faculties from Period III and faculties from the other two periods. In other words, faculties from Period III (M=15.15), considering air quality, ventilation and temperature at their faculty is better comparing to faculties from periods II (M=13.70) and I (M=12.67). (Table 3)

As a conclusion, the difference between periods in terms of air quality, ventilation and thermal comfort surely exists, but in different values. The largest difference is between periods of I and III. The large difference is noticed also between Period II and III, while the difference between periods I and II is minor. (Table 4)

TABLE 4. *THE REPORT ON AIR QUALITU, VENTILATION AND TEMPERATURE*

Faculty	Mean	N	Std. Deviation
Period I	12,67	36	1,621
Period II	13,70	111	2,263
Period III	15,15	39	2,570
Total	13,81	186	2,354

Socialist period and the After-war period and students' academic achievement, we applied correlation analysis. A significant correlation was observed.

We already defined human comfort as a satisfaction of all human needs, psychological and biological ones, in order to have undisturbed work, functioning and living, to have the best performance. Students, as a space consumer in the classroom environment, will react to every kind of environment condition. When students react positively to conditions in ambiance, motivation and productivity will be increased. On the other hand, if the reaction towards environment conditions is negative, the performance and activity will be low. Castaldi (1977) explains that if the environmental conditions are bad, the focus will not be on the lesson topic, it will be on struggling with conditions that are not fit to the human body's need. That actually explains that human comfort equals better performance.

Our aim was also to investigate the difference between students' perception on air quality, ventilation and temperature in regards to the high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period.

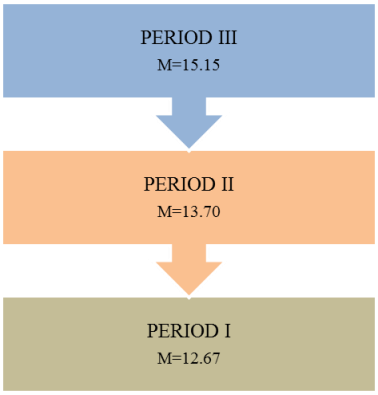

Fig 1. *The Mean Scores of Air Quality, Ventilation and Temperature in Different Periods*

The significant difference was noticed in students' perception on air quality, ventilation and temperature from Period III. It means that air quality, ventilation and temperature in the institutions from period III is much higher than the institutions from period II and I. Period III (M=15.15), Period II (M=13.70), and Period I (M=12.67). The result implies that the educational buildings from recent history provide better air quality, ventilation and temperature in comparison with the educational buildings constructed in the period of Socialism and the Austro-Hungarian period. The ventilation used in all periods is natural ventilation in classrooms, and the system of heating is central heating in all periods. We want would like to present data for several questions in the questionnaire: For the question, 'There is always fresh air in the classroom', the students from the faculties from the Period III are more sure about the air quality, ventilation and temperature (M=2.85), comparing to the students from Period II (M=2.41) and I (M=2.08) faculties. It shows that the students' attitudes towards fresh air presence are much better in buildings from recent history. The fresh air is related to ventilation quality and the presence of CO2 in air. The stale air in older buildings can be a result of energy savings during the wintertime. The biggest air pollutants in faculties are building consumers. In comparison with office or residential buildings, the number of space users in educational institutions is much higher. The bigger attention to ventilation should be paid in educational

buildings because of the number of space users (Crawford, 1998). Fresh air is being provided naturally in all periods. According to students' perception, the institutions from the Period II are very warm inside (M=3.73) due to the answers to the statement: 'It is very hot in the classroom during the summer'. Similar answers were offered by the students from the Period I (M=3.67), whereas the students from Period III (M=3.46) faculties' students have a more positive perception towards this question. The overheating of the room during summer gets in a collision with ventilation and air quality, and the energy use increases. Properly designed light will not include glare and overheating. The struggle with sunlight in the summer period is very challenging. The almost approximate values of means from all periods are a result of the fact that there is a very small amount of lessons in the summer period, which resulted that the efforts on sunlight diffuse are at the minimum. 'The heating system is good' at the faculties from Period III (M=3.92), Period II (M=2.78) and Period I (M=2.50). This means that the heating system from the students' point of view is much more effective in buildings from recent history. It also explains the satisfaction of students; how their body reacts to the temperature in the classroom during wintertime. It is very hard to manage the temperature in the rooms with high ceilings and big volume, such having the educational institutions from Period I. The construction materials also contributed to heating dissatisfaction of students from buildings Period I. The materials generally used in Austro-Hungarian period, despite heating efforts, emit the cold, such as stone, terrazzo flooring, etc. For the question 'The air is clear even in the winter', the students' attitudes were positive in Period III (M=2.85), comparing to other periods, Period II (M=2.73) and Period I (M=2.33). These results represent the ability to build to provide the fresh air in wintertime, despite having heat loss during ventilation. As mentioned, a very big difficulty is to manage the temperature in the wintertime, especially in the institutions built in Period I. In order to have energy savings, the ventilation is surely decreased to the minimum, which results in stale air. As mentioned before, the stale will produce discomfort and headache, respiratory problems, fatigue and asthma in the worst case. All the mentioned problems will affect the performance and ability to concentrate. Regarding the question 'I cannot smell chemical and biochemical in the classroom', the students form the Faculties form Period I and III share the same opinion (M=2.08). Students from Period II (M=2.05) faculties are more likely to smell chemical and biochemical in the classroom. There are not notable differences among faculties from different periods when talked about chemical and biochemical odors. The results of biochemical and chemical odors could be different types of perfumes, cleaners and the use of harmful materials for humans. This result confirms the claims of Kahl (2005) who examined the effect of temperature and air quality on the performance of the students. He stated that temperature affected the subjective physical comfort, but the temperature did not affect the achievement of the students in large volumes.

5 Conclusion

The comfort of the student learning environment has been a prominent area in the field of research. It is our responsibility to create a suitable area for a learning environment. Many studies have dealt with the learning process, however, less attention is paid to the ambiance. Sometimes it is underestimated that interior environmental conditions are closely related to the teaching process. Thus, we focused our study on the physical environmental factors that affect students' academic achievement. There are many factors as acoustics, lighting, air quality, and age of the building, etc. The study was based on the theory of Prochansky, Hadrović, Auf-Ranić and Earthman. For this reason, our study investigates the correlation between one of the factors - air quality, ventilation and temperature and students' achievement. Another significant element is the period in which the higher educational institutions were built: the Austro-Hungarian Empire, the Socialist period and the After-war period. It is for the reason: some buildings are made just for educational purposes, but we observe a lot of ongoing educational processes in buildings that were not built for education. It is also important to find out if the buildings made for purpose of education meet students' needs in order to give maximum performance. The aim of the study was to find found the correlation between the air quality, ventilation and temperature at the high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period and students' academic achievement. The correlation was significant. According to the researches done on this issue, it can be said that the influence of thermal condition on students' achievement surely exists. Even a small change in temperature inside of the classroom may impact the students' performance and effectiveness. The air quality, ventilation and temperature will impact the students' achievement even though they will not be aware of it. Ventilation, temperature and air quality of interior space are interconnected terms that have invisible effects in space. The role of ventilation is to provide healthy and fresh air into the interior environment naturally or artificially due to many contaminants such as humans, perfumes, odors, building materials etc. Heating and cooling are terms related to managing and balancing the interior temperature with the temperature of the human body. Airflow, materials radiant, the activity of space users and the way how they are clothed are the elements of interior thermal comfort. The condition of the air in the classroom environment must have special attention due to the ratio of space users and area of the space. The level of thermal conditions and air quality control is determined by the age of the building, the amount of equipment, volume of the space and by the materials of construction. Researches made on the most proper temperature for students' productivity recommend the temperature from 20 to 24 degrees. (Harmon, 1959; Harner, 1974; Sleeman & Rockwell, 1981). The study also investigated the difference between students' perception of air quality, ventilation and temperature in regards to the high educational buildings from the Austro-Hungarian Empire, the Socialist period and the After-war period. Students' perception of air quality, ventilation and temperature was significant for the students from Period III. The air quality, ventilation and temperature in the institutions from period III is much higher than the institutions from period II and I. Period III (M=15.15), Period II (M=13.70), and Period I (M=12.67). The result implies that the educational buildings from recent history provide better air quality, ventilation and temperature in comparison with the educational buildings constructed in the period of the Socialism and the Austro-Hungarian period. In terms of ventilation and heating, space users are generally not aware of their impact on human comfort and performance. The ventilation still depends on windows and doors in every

educational building in absence of mechanical ventilation. The main considerations of building management are the energy savings in the winter period, which will result in stale air in the classroom. The problem of heating in the Austro-Hungarian period has a result of poor ventilation conditions, where students as space users show the awareness of this problem. "Thermal comfort has been defined as 'that condition of mind which expresses satisfaction with the thermal environment. The emphasis is on the condition of mind. It is therefore a psychological phenomenon and not a physiological state. It will be influenced by individual differences in mood, personality culture and other individuals, organizational and social factors. It is not surprising, therefore, these methods for predicting thermal comfort conditions will never be perfect" (Nicole, Humphreys, Sykes & Roaf, 1995, p.8). The environment of faculty buildings implies a psychological trace on a student which affects his performance and achievement. Regarding the environment, this trace can be defined by lighting, the presence of daylight, the acoustic performance, the visual appearance, the selection of building material, air quality, etc. All these appearances form one ambiance that can be adequate or inadequate. The level of stress, health and feel of well-being, according to Baker and Bernstein (2012), are determined by the daylight, acoustics, air quality and thermal comfort. To sum up, there is plenty of old buildings where education occurs nowadays, the quality of the physical environment is much higher in new buildings. New buildings and technology will positively influence the factors of environmental psychology. All around the world, even in developed countries, students attend schools, which are more than fifty years old. Those schools mostly do not fulfill the modern norms and standards of today's schools. Thus, results gained from such schools, imply that the relationship between students' performance and school environment is significant. Students spend 7-8 hours at school premises, which stands for fifteen percent of their entire life. The transition from old to a new facility is important for the learning gains of students. The new facilities help to maintain the students' health and feel of well-being. The lecturers, staff and administration are also affected by a new building. That is why collaborative work and interaction are allowed only in flexible learning spaces, which are essential for the skills of the 21st century: collaborating, critical thinking, communicating and creativity (Hanover Research, 2011).

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