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THE EVALUATION OF PHYSICAL SPACE QUALITY IN EDUCATION BUILDINGS IN REGARD TO USER SATISFACTION

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Abstract: In this study, physical space quality of two different engineering department buildings in Uludag University Gorukle Campus, Bursa, Turkey are analyzed in regard to user evaluations about the physical space quality. In the analysis of these evaluations, criteria about physical space quality are predetermined by the authors. In the method of the study, the below phases are implemented. In first, the literature review about the physical space quality is done and then a questionnaire is prepared with regard to the key themes in literature review in order to evaluate the user satisfaction. The key themes in user satisfaction questionnaire is accessibility, ergonomics, thermal comfort, audible comfort, visual comfort, inner space air quality, service spaces, socialization. The aim of this study is first to understand which criteria are important for the students and then to improve the physical space quality in regard to the dissatisfaction.

Key Words: Education Buildings, Post Occupancy Evaluation, Environmental Control, Accessibility

Eğitim Yapılarında Fiziksel Çevre Kalitesinin Kullanıcı Memnuniyeti Açısından Değerlendirilmesi

Öz: Bu çalışmada Uludag Üniversitesi Gorukle Yerleşkesi'nde yer alan 2 ayrı mühendislik bölümüne ait binalardaki iç mekân fiziksel çevre kalitesi kullanıcı görüşleri alınarak değerlendirilmiştir. Bu değerlendirmenin yapılabilmesi için fiziksel çevre kalitesini oluşturan unsurlar çalışma yazarları tarafından belirlenmiştir. Çalışmanın yöntemi aşağıdaki aşamalarda gerçekleşmiştir: ilk aşamada fiziksel çevre kalitesine ile ilgili literatür analizi yapılmıştır. Literatür analizinde öne çıkan anahtar kavramlardan yola çıkarak bu kavramların sorgulanmasına ilişkin kullanıcı görüşlerini almaya yönelik olarak anket hazırlanmıştır. Literatür analizi sonrasında ortaya konulan anahtar kavramlar Ulaşılabilirlik, Erişilebilirlik, Ergonomi, Isıl Konfor, İşitsel Konfor, Görsel Konfor, İç Hava Kalitesi, Hizmet Mekânları, Sosyalleşmedir. Bu değerlendirmenin amacı, mekân kullanımında öğrenciler için önemli olan kriterleri tespit etmek ve binanın ihtiyaç duyulan performans koşullarını yerine getirmesine olanak sağlamaktır.

Anahtar Kelimeler: Eğitim Binası, Kullanım Sürecinde Değerlendirme, Fiziksel Çevre Kontrolü, Erişilebilirlik

1. INTRODUCTION

Institutions of higher education are places where information is produced and shared. Not only the academic environment but also the physical and social environment plays a role in carrying out high quality studies and giving comprehensive education services. Institutions of higher education are places where information is produced and shared. Not only the academic

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environment but also the physical and social environment plays a role in carrying out high quality studies and giving comprehensive education services. When evaluated from this point of view, ensuring that higher education institutions' buildings are designed in a way to provide comfort, and have social interaction possibilities will support a higher quality education environment.

Based on this point of view, a study was carried out to understand the expectations of users related to physical and social environment in the education buildings at Uludag University and how much such expectations were met.

In the scope of this study two engineering departments were selected at Uludag University Gorukle Campus. These two departments are located side by side at the same region of the campus and face the same direction. Also the buildings are similar in size, both have courtyards and have similar organization principles. The distinct difference of these buildings are the relation between the inner courtyard and indoor spaces, transparent façades and window sizes, clearance heights, indoor construction and material choices. The goal of the study was to evaluate similar and different features of these two buildings to understand spatial factors that influence user satisfaction.

2. LITERATURE ANALYSIS; USER SATISFACTION AND COMFORT CONDITIONS IN BUILT ENVIRONMENTS

In this chapter studies related to user satisfaction in built environments were examined and classified systematically to contribute to this current study. This was done to identify performance requirements of built environments that create the user satisfaction.

When the literature on the subject is examined it has been seen that a part of international studies focused on thermal comfort conditions. Conceição and dLúcio have studied thermal comfort and indoor air quality in schools in Portugal, whereas Filippín made a similar study in schools in Argentina. Kwok and Chun, focusing on ASHRAE 55, ISO 7730 standards, evaluated students' satisfaction levels related to thermal comfort and air movements in schools in Japan (Conceição ve dLúcio, 2008, Filippín, 2005, Kwok and Chun, 2003). While focusing on thermal comfort, energy efficiency and energy consumption were also examined. Baker, Cooper, Hernandez et al. in British schools; Erhorn et al. in preschool, primary school and university school buildings; Santamouris et al. at 320 schoold in Greece; Arena and deRosa in Argentina; Desideri and Proietti in Italy; Harris et al in England worked on thermal comfort and energy efficiency. Nicolas and Poncelet aimed to reduce energy consumption by using solar energy in Belgium schools (Baker 1982, Cooper, 1983, Hernandez et al. 2008, Erhorn et al. 2008, Santamouris et al. 2007, Santamouris et al. 1994, Arena and Rosa, 2003, de Rosa et al. 2000, Desideri and Proietti 2002a, Desideri and Proietti 2002b, Harris et al. 1991, Nicolas and Poncelet, 1988).

There are also many studies related to indoor air quality and ventilation. Celements et al. evaluated the impact of indoor air quality on the performance of students in 20 schools. Butala and Novak in Slovenia; Tippayawong et al. in Thailand; Sohn et al. in Korea studies indoor air quality in schools. Becker et al. with Khedari et al. also studied the importance of natural ventilation for indoor air quality and the impact of thermal comfort. Lappalanien et al. examined indoor air quality and the impact of humidity in schools. (Butala and Novak, 1999, Clements-Croome et al. 2008, Tippayawong et al. 2009, Sohn et al. 2009, Clay 1903, Becker et al. 2007, Khedari et al. 2000, Lappalainen et al. 2001, Meklin et al. 2002).Avşar and Gönüllü, and Elmallawany studied audial comfort, acoustics and noise in schools (Avsar and Gonullu, 2005, Elmallawany, 1983, Elmallawany, 1980).

There are also studies that examine user satisfaction of environmental comfort conditions. Collet da Graça et al. carried out a study in Sao Paulo Brazil that examined thermal, acoustic and natural illumination views of users in 39 education buildings. A similar study was also

carried out by Boneh in Israeli schools (Collet da Graça et al. , 2007, Boneh, 1982). The importance of daylight and natural lighting for creating optimum comfort conditions were also examined. Carter, in a school in Englan; Kruger and Dorigo in schools in Brazil examined the impact of natural lighting on visual comfort (Carter 1984, Krüger and Dorigo 2008).
There are also studies that use specific examples to research planning and academic achievement in education buildings. Maitreya has carried out a study related to indoor physical environmental conditions, which can be defined as a guide for designers. Narucki, examined the impact of architectural planning, environmental and social factors on academic achievement in 955 schools in New York. Chan, examined the impact of social environment on schools in Hong Kong. Cooper examined the importance of building design in schools in England (Maitreya, 1979, Narucki, 2008, Chan, 2001, Sleegers et al. 2000, Cooper,1982, Ghaswala, 1968, Agraa and Whitehead, 1968, Hawkins, 1886).

3. FIELD STUDY

The area selected for the field study is composed of the Mechanical Engineering and Industrial Engineering Buildings of the Engineering Faculty in the Gorukle Campus of Uludag University, which is the largest campus of Bursa, the 4th largest city in Turkey (Figure 1). The goal of the study is to examine these two buildings, which are side by side in the same campus and have similar characteristics, to show the architectural expectations of users in educational buildings and how much these expectations are met.

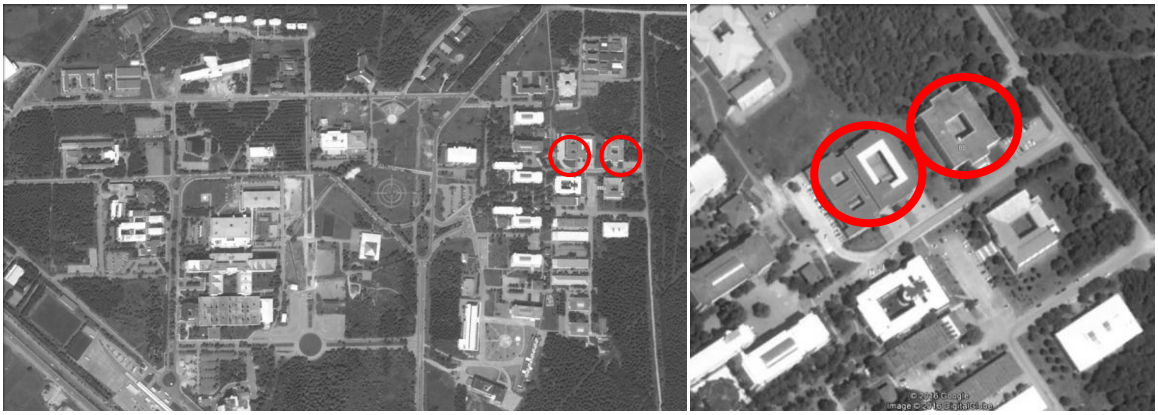
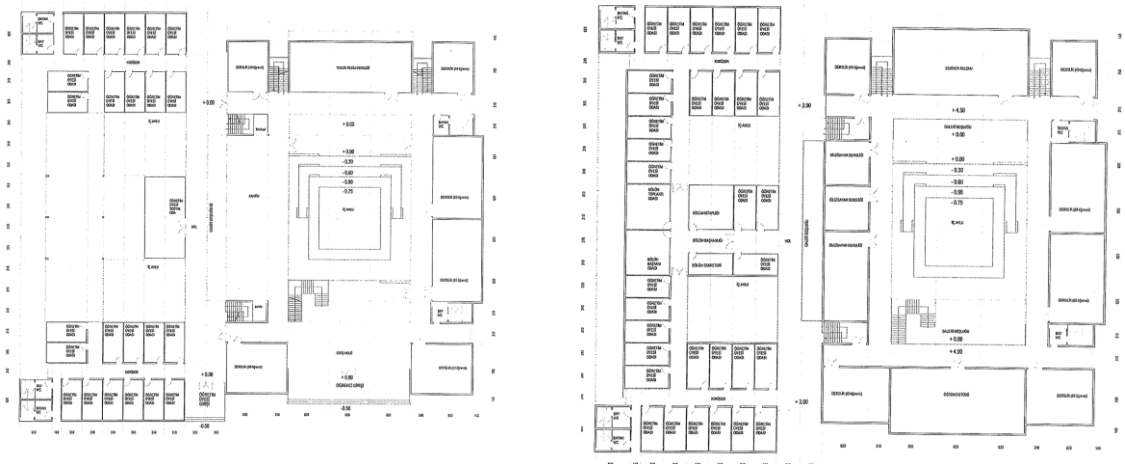


Figure 1.
Uludag University Campus (Google Earth, 2016)

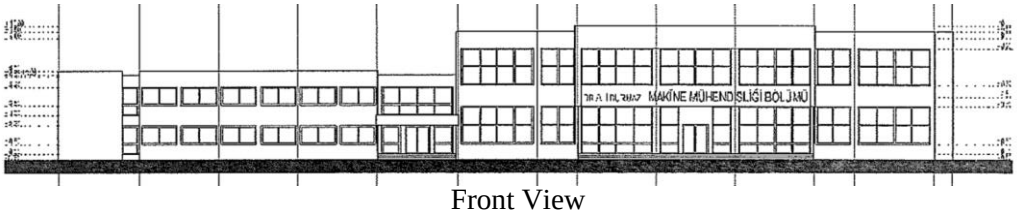
Introduction of the field study areas:

Mechanical Engineering Department building was inaugurated in 2010. The concrete building has a ground and first floor. The classrooms in the building face north, south, east and west. There is an open courtyard in the middle of the building. . There are no cafeterias in the building. There is an elevator in the building. There are no fire escapes and ramps in the building (Figure 2). Plans and views of the building are given in Figure 3.

Figure 2.
Mechanical Engineering Department Building



Ground Floor First Floor

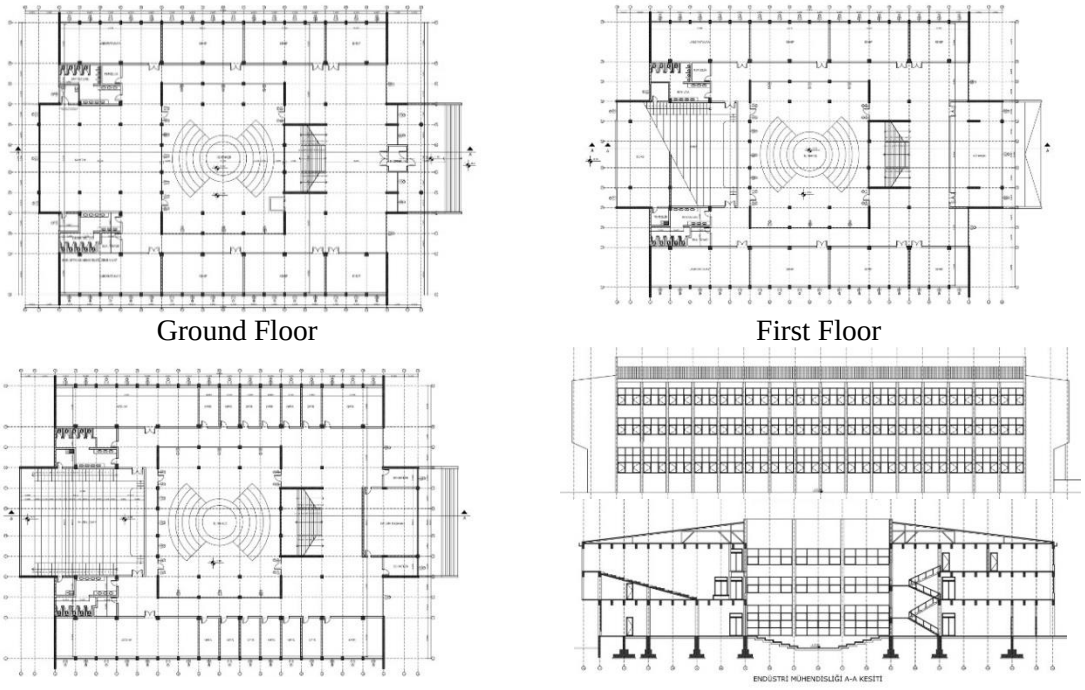


Front View

Figure 3.
Mechanical Engineering Department view and plans

Industrial Engineering Department building was inaugurated in 2006. The concrete building has a ground, first and second floors. Similar to the other building the classrooms in this building also face north, south, east and west. There is an open courtyard in the middle of the building. There are no cafeterias, elevators, fire escapes and ramps in the building (Figure 4). Plans and views of the building are given in Figure 5.

Figure 4.
Industrial Engineering Department Building



Ground Floor First Floor

Second Floor View and Section

Figure 5.
Industrial Engineering Department view, section and plans

There are classrooms, lecture halls, computer labs, studying areas, a conference hall and various laboratory rooms in the education buildings in the scope of the field study. There are also rooms for academicians and administrators, wet areas for common usage, staircases and circulation areas.

Method:

The research part of this study has employed the following phases:

- Literature research for the subject to be analyzed, and review of information regarding indoor requirements,
- Determining issues that users complain and/or feel uncomfortable in the sample areas of the pilot study,
- Creation of a questionnaire for receiving feedback related to the user experience in the designed environment,
- Evaluating defined performance requirements together with the results of the questionnaires to understand the level of user satisfaction.

Using the data gathered, various performance criteria (building performance requirements) were developed in order to determine the criteria that are important for students in using the buildings and to help creating the needed performance requirements in those buildings. For defining these criteria the parameters in the literature that are used to measure user satisfaction in education buildings were examined. It has been seen that 3 issues come to forward. These are Design, Planning (Dinç, Onat, 2002; Agraa and Whitehead, 1968); Physical Environmental Control (Boneh, 1982; Collect et al. 2007; Hassanain, 2007) and Social Environment (Chan, 2001; DeClercq, et al. 2014). Evaluation criteria are respectively;

- Design – Planning: Transportability, Accessibility, Ergonomics,

Physical Environmental Control: Thermal comfort, audial comfort, visual comfort, indoor air quality,

- Social Environment: Service Areas, Socializing.

Practical Implications of the Study:

Reviewing satisfaction levels of users from buildings is a common approach for increasing the efficiency of existing buildings and for guiding future design activities. In this regard, the Post Occupancy Evaluation - POE system has the following benefits as explained in "Post-Occupancy Indoor Environmental Quality Evaluation of Student Housing Facilities";

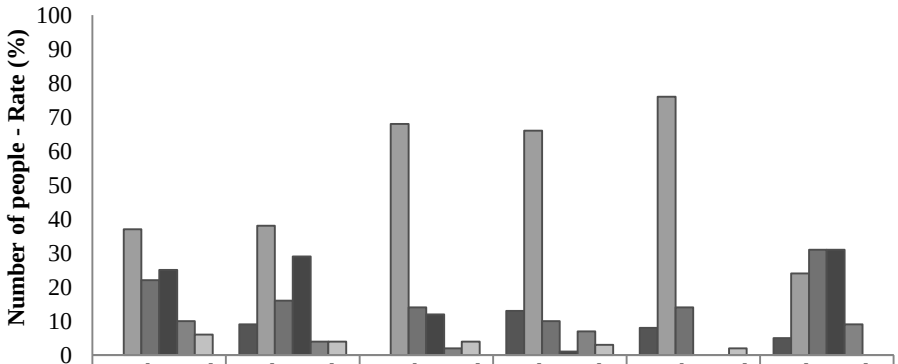
- Determining building problems and solutions in a short period of time,
- Enhancing building performance and feedback related to usage,
- Creating important costs savings during construction and the building lifecycle
- Creating long term improvements in building performance
- Creating a knowledge base for improving databases, standards, and criteria (Hassanain, M. A. 2007). The data collected in this study is believed to assist the design of news buildings in the campus and will also assist new arrangements for current buildings.

A "user satisfaction survey" was prepared to evaluate the experiences of students related to their usage of indoor space. To define the level of satisfaction of the students the results obtained from the survey was analyzed. During the 2014-2015 education year there were 672 and 366 students enrolled in the Mechanical Engineering and Electronics Engineering departments respectively. In order to simplify understanding student numbers and percentages the survey was conducted on 100 students in each department and reached a total of 200 students. The survey was conducted during the day between 12.00 and 16.00. Students, who participated in the survey, were aged 18-24.

4. RESEARCH FINDINGS

According to the demographic findings of the survey 74% of the participants of the survey from the Mechanical Engineering Department were male and 26% were female; 59% of the participants from the Industrial Engineering Department were male and 41%% were female.
After the key concepts to measure the physical environmental quality were defined in the scope of the literature analysis and before the study interviews were make in the scope of a pilot study with a total of 50 students at various locations in the campus. The goal of this pilot study was to understand the main factors that influence the satisfaction levels of students from education environments in Uludag University. In the scope the findings some of the concepts that were defined in the literature analysis were eliminated and it has been seen that 4 basic concepts came forward. These parameters are design-planning, accessibility, ergonomics and physical environmental. To define sub-parameters a questionnaire was prepared composed of questions regarding each of the parameters. In the questionnaire the questions were prepared as following: a total of 9 questions related to Design-Planning (3 questions each for transportability, accessibility, ergonomics); a total of 12 questions related to Physical Environmental Control (3 questions each for thermal comfort, audial comfort, visual comfort, indoor air quality); a total of 6 questions related to Social Environment that covered services areas and socializing; there were a total of 27 questions in the questionnaire. Questions were evaluated with a liker type scale of five.

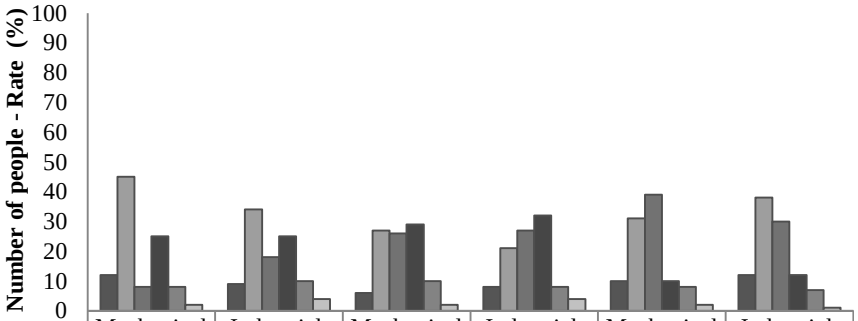
The first part of the questionnaire evaluated criteria of pedestrian access in the campus, perception of building entrances, and the location of education buildings under the title "Transportability" (Figure 6).



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Pedestrian access to the campus		Perception of building entrance		Position of education areas	
very satisfied	0	9	0	13	8	5
satisfied	37	38	68	66	76	24
neither satisfied nor dissatisfied	22	16	14	10	14	31
unsatisfied	25	29	12	1	0	31
very unsatisfied	10	4	2	7	0	9
can't choose	6	4	4	3	2	0

Figure 6.
User opinions related to transportability

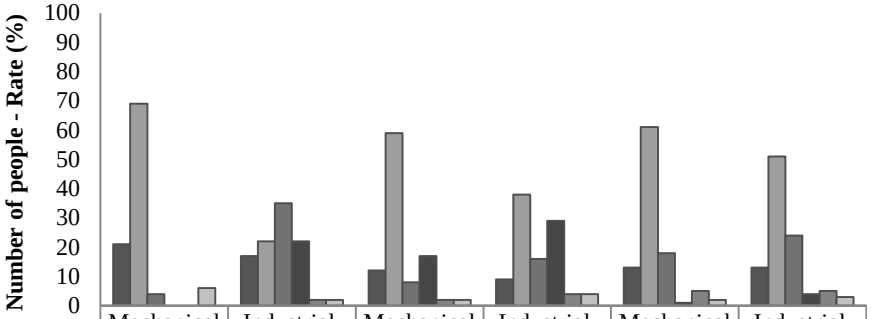
Ease of access between storeys's taking into consideration obstacles, circulation areas, ease of access between corridors and building spaces and ease of access between units were evaluated as "Accessibility" criteria (Figure 7).



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Accessibility between storeys's		Circulation areas		Ease of access to units	
very satisfied	12	9	6	8	10	12
satisfied	45	34	27	21	31	38
neither satisfied nor dissatisfied	8	18	26	27	39	30
unsatisfied	25	25	29	32	10	12
very unsatisfied	8	10	10	8	8	7
can't choose	2	4	2	4	2	1

Figure 7.
User opinions related to accessibility

Indoor storey height, dimensions of windows in classrooms, width of stairs and riser height were examined as "Ergonomics" criteria (Figure 8).

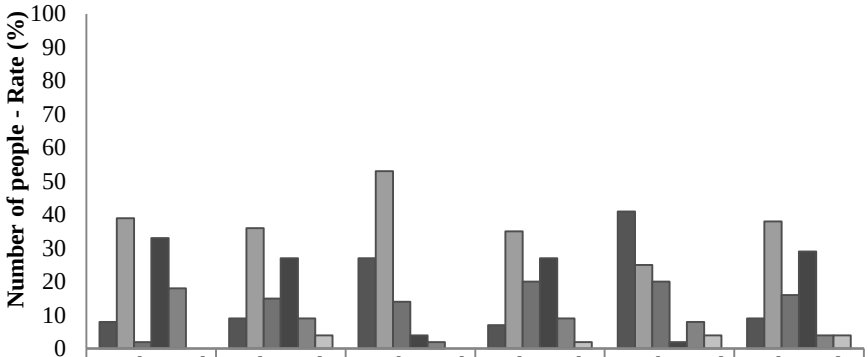


	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Indoor storey height		Size of windows		Width of stairs and height of risers	
very satisfied	21	17	12	9	13	13
satisfied	69	22	59	38	61	51
neither satisfied nor dissatisfied	4	35	8	16	18	24
unsatisfied	0	22	17	29	1	4
very unsatisfied	0	2	2	4	5	5
can't choose	6	2	2	4	2	3

Figure 8.
User opinions related to ergonomics

In the second part of the questionnaire the satisfaction levels from thermal comfort, audial comfort, visual comfort, and indoor air quality were examined in the scope of "Physical Environmental Control".

Thermal comfort is defined by The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) Standard 55 as satisfaction from the thermal conditions. Optimum thermal environments are defined as environments in which 80% or more of their users agree that the environment is acceptable. The factors that influence thermal environment are defined as heat, ventilation, humidity, thermal spread and filtered air quality. Regarding physical environmental control and "Thermal Comfort" the opinions of users regarding indoor temperature, and the usage of air conditioners both in winter and summer were taken (Figure 9).

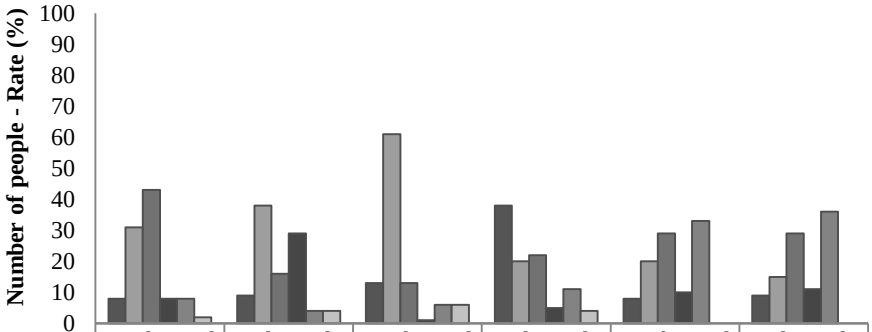


	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Indoor temperature in summers		Indoor temperature in winters		Usage of artificial air conditioners	
very satisfied	8	9	27	7	41	9
satisfied	39	36	53	35	25	38
neither satisfied nor dissatisfied	2	15	14	20	20	16
unsatisfied	33	27	4	27	2	29
very unsatisfied	18	9	2	9	8	4
can't choose	0	4	0	2	4	4

Figure 9.
User opinions related to thermal comfort

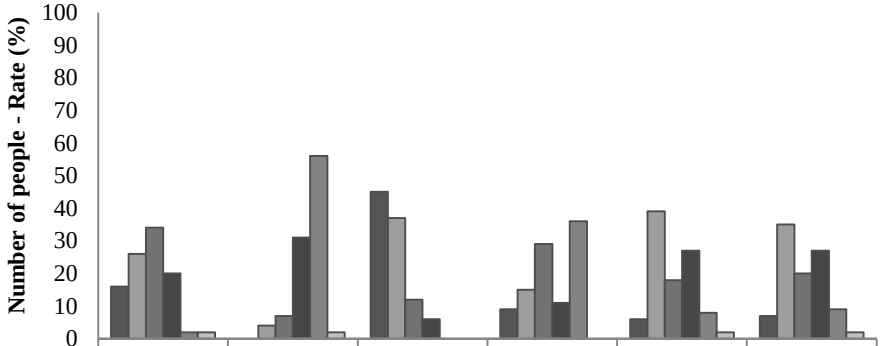
Regarding "Audial Comfort", volume and building acoustics, noise of building installations and noise generated outside were evaluated (Figure 10).

Visual comfort quality is defined as the quality and quantity of the light source and how it brightens its close surroundings. As Baird et al. (1996) indicates, the impact of colors in an environment and light sources, which are positioned at wrong angles creates glares that negatively effects vision and as a result creates inadequate lighting levels. However adequate window sizes and positions enable adequate lighting throughout the day and removes glares (Chiara and Callender, 1980). In the scope of this study, as “Visual Comfort” criteria, adequate or inadequate natural lighting, features of artificial lighting, wall coverings and colors of classrooms were evaluated to see if they were suitable for concentration to lessons.



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Audial comfort		Noise from installations		Outdoor noise problem	
very satisfied	8	9	13	38	8	9
satisfied	31	38	61	20	20	15
neither satisfied nor dissatisfied	43	16	13	22	29	29
unsatisfied	8	29	1	5	10	11
very unsatisfied	8	4	6	11	33	36
can't choose	2	4	6	4	0	0

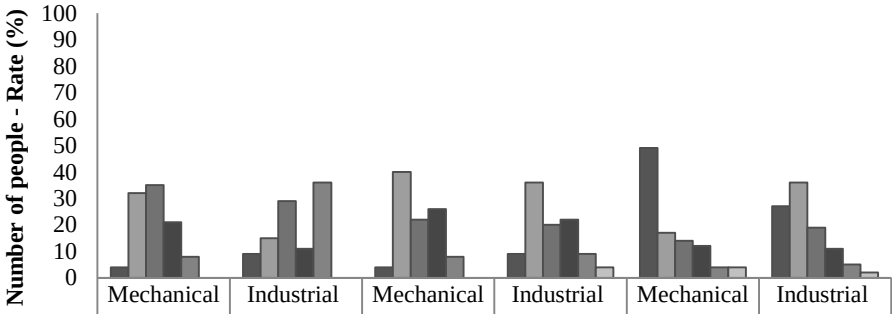
Figure 10.
User opinions related to audial comfort



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Natural lighting		Artificial lighting		Color preference	
very satisfied	16	0	45	9	6	7
satisfied	26	4	37	15	39	35
neither satisfied nor dissatisfied	34	7	12	29	18	20
unsatisfied	20	31	6	11	27	27
very unsatisfied	2	56	0	36	8	9
can't choose	2	2	0	0	2	2

Figure 11.
User opinions related to visual comfort

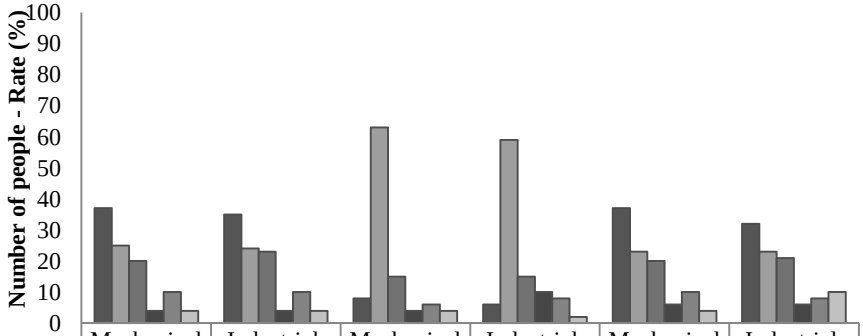
Indoor air quality is defined by ASHRAE (1989) Standard 62 as indoor air that does not contain pollutants and that does not dissatisfy 80% or more of the users. Poor air quality creates various health problems related to “sick building syndrome" that results from indoor air conditions (Gots, 1998). In the scope of this study, natural ventilation, satisfaction from indoor air quality and odors and humidity in wet areas were taken into consideration as criteria of “indoor air quality” (Figure 12).



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Natural ventilation		Indoor air quality		Odor problems in wet areas	
very satisfied	4	9	4	9	49	27
satisfied	32	15	40	36	17	36
neither satisfied nor dissatisfied	35	29	22	20	14	19
unsatisfied	21	11	26	22	12	11
very unsatisfied	8	36	8	9	4	5
can't choose	0	0	0	4	4	2

Figure 12.
User opinion related to indoor air quality

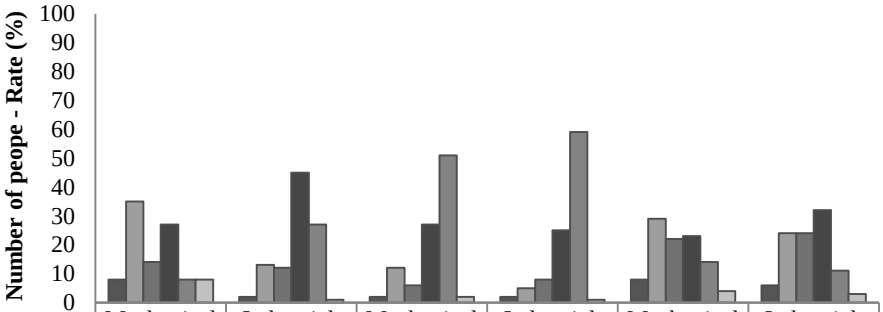
In the third part of the questionnaire satisfaction levels from services areas and social environment was examined. In this regard adequate catering and resting areas, position and suitability of wet areas in the buildings, condition of car parks were examined under the title "Service Areas" (Figure 13). There are 16 toilet cubicles (8 each for man and woman) in the Mechanical Engineering Department building; and in the Industrial Engineering Building there are a total of 27 toilet cubicles, 15 for women and 12 for men. There wasn't any significant negative feedback related to wet areas.



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Catering and resting areas		Wet areas		Car parks	
very satisfied	37	35	8	6	37	32
satisfied	25	24	63	59	23	23
neither satisfied nor dissatisfied	20	23	15	15	20	21
unsatisfied	4	4	4	10	6	6
very unsatisfied	10	10	6	8	10	8
can't choose	4	4	4	2	4	10

Figure 13.
User opinions related to service areas

Common indoor and outdoor areas, courtyards and green areas that enable socializing are evaluated as "Socialization" criteria (Figure 14). 41% of the students in Mechanical Engineering Department and 39% of the students in Industrial Engineering Department are smokers. Even though it is a troubling ratio, students indicate that they have trouble of finding spaces for smoking.



	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering	Mechanical Engineering	Industrial Engineering
	Areas that enable social communication		Open areas, courtyards		Green areas that enable socializing	
very satisfied	8	2	2	2	8	6
satisfied	35	13	12	5	29	24
neither satisfied nor dissatisfied	14	12	6	8	22	24
unsatisfied	27	45	27	25	23	32
very unsatisfied	8	27	51	59	14	11
can't choose	8	1	2	1	4	3

Figure 14.
User opinions related to socializing

When evaluated in general the answers of students from both of the faculties to the question: “Our faculty building is designed properly for education” is given in Figure 15. It has been understood that students are satisfied with the education buildings.

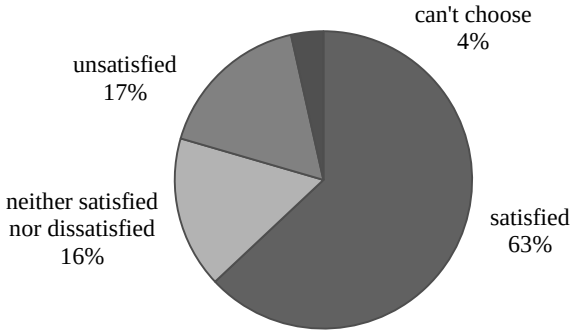


Figure 15.
General opinions of students related to the design principles of the department buildings

5. CONCLUSION

In the scope of the study, it is very important to define the issues that students are discontent with to establish design criteria for buildings to be designed in the future and to establish main goals for the planning of the campus in general. In this regard the results of the study are summarized in the table below (Table 1).

Table 1. Satisfaction of students

Evaluation Criteria:			Mechanical Engineering		Industrial Engineering	
			Satisfied	Dissatisfied	Satisfied	Dissatisfied
Design - Planning	Transportability	Pedestrian access to the campus	x		x	
		Perception of building entrance	x		x	
		Position of education areas	x		x	
	Accessibility	Accessibility between storey's	x		x	
		Circulation areas		**x**		**x**
		Ease of access to units	x		x	
	Ergonomics	Indoor storey height	x		x	
		Size of windows	x		x	
		Width of stairs and height of risers	x		x	
Physical Environmental Control	Thermal comfort	Indoor temperature in summers		**x**		**x**
		Indoor temperature in winters	x		x	
		Usage of artificial air conditioners	x		x	
	Audial comfort	Audial comfort	x		x	
		Noise from installations	x		x	
		Outdoor noise problem		**x**		**x**
	Visual comfort	Natural lighting	**x**			**x**
		Artificial lighting	**x**			**x**
		Color preference	**x**		**x**	
	Indoor air quality	Natural ventilation	**x**			**x**
		Indoor air quality	x		x	
		Odor problems in wet areas	x		x	
Social Environment	Service areas	Catering and resting areas	x		x	
		Wet areas	x		x	
		Car parks	x		x	
	Socializing	Areas that enable social communication	**x**			**x**
		Open areas, courtyards		**x**		**x**
		Green areas that enable socializing		**x**		**x**

The differences in satisfaction levels between two buildings are explained below:

● **In terms of visual comfort:** The difference related to natural illumination in buildings is believed to be caused by the transparent façades that face the internal courtyard in the Mechanical Engineering Department. Also the similarity between the internal courtyard and indoor areas both in terms of usage and visual characteristics increased the level of satisfaction. In the Industrial Engineering Department building the façades that face the internal courtyard has less transparency and visual harmony is not achieved between indoors and the internal courtyard. The difference between artificial lighting is due to the selection of lighting fixtures. While the lighting fixtures in the Mechanical Engineering Department building were selected to ensure visual comfort, standard while florescent lamps were used in the Industrial Engineering Department building.

● **In terms of indoor air quality:** The difference related to natural ventilation in buildings is believed to be caused by the usage of inward opening aluminum transom window frames used in the Mechanical Engineering Department. This enabled air to enter in without causing discomfort for the users. Also the air entering inside indirectly positively effects indoor air circulation. In the Industrial Engineering department plastic casement windows which open

inwards were used. Wind generated between opposing windows makes it impossible to keep windows open for a period of time that would create natural ventilation.

● **In terms of socializing:** The difference related to the usage of areas that enable socialization is evaluated as follows: The transparent façades facing the internal courtyard in the Mechanical Engineering Department building create visual communication between indoors and outdoors. Also because the inner courtyard is at the same level of the ground floor enables users of the building to use this area freely. Also the openings of galleries inside the building strengthens visual communication. The entrance hall that faces the inner courtyard strengthens the unity of the building. However, the situation is the opposite in the Industrial Engineering Department building. The inner courtyard is not perceived from the entrance. The courtyard is at a different height and the steps limit its usage. It has been observed that students do not prefer to use this area.

In summary the negative opinions of the users are related to inadequate accessibility to indoor circulation areas, high temperatures in summers that has a negative influence on thermal comfort, and outside noise that disturb students. The highest dissatisfaction is about socialization; it has been noted that the number of areas that enable social communication is limited, open areas and inner courtyard are ineffective, and green areas are not designed in a way that enable social communication.

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