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A Comparative Analysis on Ergonomics of University Libraries: A Case Study

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ABSTRACT
Libraries provide learning, study, and research environments for their users. For libraries, the issue of suitability for the physical, anatomical, and psychosocial needs of users is crucial. Through on-site investigations and surveys, we investigated library units at two universities in the context of ergonomics to see to what extent they are suitable for the user's physical and psycho-social needs. Library A is a library building on a campus and Library B is a library unit is in a multi-purpose campus building. On-site investigations and survey results showed that both university libraries could not provide the optimum library conditions for the users. Regression model for Library A showed improvement on equipment and space can increase satisfaction by 35%. Regression model for Library B showed improvement on space can increase satisfaction by 44%. Library A, achieved more successful results in terms of user satisfaction compared to Library B. This paper discusses the importance of taking user expectations into account in libraries, regardless of the type of library or concepts used. Attention should be paid to the concept of ergonomics in library units in order to meet user needs, increase efficiency in research and learning activities, and create a healthy and safe environment.
Keywords: Ergonomics in Architecture, Library, Mixed Methods, Study Environment, User Satisfaction.

1. INTRODUCTION

University libraries are the most effective units for students and researchers to make their studies and to achieve their goals. The universities acquire publications, announce them, and deliver them to researchers by their libraries (Akkaya, 2013). According to the American Library Association's Glossary of Library and Information Science: "A library or system of libraries, that is established, supported, administered by a university, provides the information needed by the students and academic staff of the universities which they are affiliated. Also, they support the teaching, research, and service programs of the universities" (Aykan, 2019).

Library units are one of the places where students spend the most time on campus. Therefore, the library units should meet the requirements for the user to easily access the information, as well as the resource needs of the user. These requirements consist of factors such as the adequacy of information boards, computer-aided catalog scanning facilities, a comfortable working environment, and the flexibility of the building in order to easily access the desired resource. In other words, user needs are a priority for a university library (Çağlar, 2006, p.56). The thoughts, wishes, and suggestions of the users should be determined carefully and the university library should be developed and renewed in line with these ideas and thoughts.

This study aims to make a comparative analysis of university library units in the context of ergonomics and to reveal the similarities/differences of two library units that were designed as a library unit and converted into a library. In this context, the library units of

two universities in Istanbul were examined. The library units are named Library A (designed as a library unit) and Library B (converted into a library unit due to the need for it). As a method in the study, on-site investigations and measurements were made. Also, the opinions of library users were consulted via surveys.

In the study, first, the definitions of the concept of ergonomics put forward by different researchers are included. In the third section, the concept of ergonomics is handled in the context of university library units and its importance is emphasized. In the fourth section, the methodology used in the study is explained. In the fifth section, general information about the fields of study is given. In the sixth section, as a result of the findings obtained in the study, the two library units were analyzed in terms of ergonomics comparatively. In the seventh section, a general evaluation and discussion are made. The last section includes the inferences reached in the study.

2. THE CONCEPT OF ERGONOMICS

Ergonomics and *Human Factors* are both globally accepted terms, both in theory and in the practice of learning about human characteristics and abilities. It also explains the later use of this information to improve people's interactions with what they use and the environments in which they do it. While Ergonomics tends to be used more in Europe, Human Factors tend to be used in North America, but these distinctions are gradually blurred (Wilson, 2005).

Ergonomics / Human Factors tries to define itself periodically. Although they overlap, there are many different definitions of ergonomics and human factors; Wogalter et. al. (1998) evaluated; most definitions emphasize Ergonomics / Human Factors as "a joint science, a technology that provides a basic knowledge and applies that knowledge to design problems in the broadest sense" (eg, Shackel, 1996). Within the scope of this view, the Ergonomics / Human Factor field includes all elements of the human-environment system, which includes the interaction of people with hardware, software, firmware, and other people ("live software") both individually and as social groups. Clark and Corlett (1984, p. 2) defined ergonomics as the study of human abilities and characteristics that affect the design of equipment, systems, and jobs that aim to increase efficiency, safety, and well-being, while Wickens (1984, p.3) stated that it is about designing machines that accommodate the user's limits.

The International Standards Organization, in its various committees on ergonomics standards, has been using as a working definition that: "Ergonomics produces and integrates knowledge from the human sciences to match jobs, systems, products, and environments to the physical and mental abilities and limitations of people. In doing so it seeks to safeguard the safety, health, and well-being whilst optimizing efficiency and performance"

Similarly, the International Ergonomics Association has defined: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well-being and overall system performance" (International Ergonomics Association, 2020).

According to Chapanis (1996), ergonomics is "the research and application of information about human behavior, abilities, limitations and other characteristics to design appropriate environments to ensure safe, efficient, effective and comfortable use of human factors". According to Bridger (2003), systems can be developed as follows to get better results in terms of ergonomics:

● designing the user interface to make it more compatible with the task and the user. (This makes it easier to use and more resistant to known mistakes people make).

● changing the work environment to make it safer and fit for the task.
● changing the task to make it more compatible with useful features.
● Changing the way work is organized to meet the psychological and social needs of people (Bridger, 2003).

The tools and equipment used by people, the places where they work and the psycho-social aspects of the working situation, the safety and suitability of the working places, the seating units, the features of the lighting, acoustics, heating, and ventilation are all within the scope of ergonomics (Pheasant, 2003; Erbuğ, 1987). According to Bridger (2011), the focus here is on the interaction between person and equipment/machine and the design of the interface between the two (Figure 1).

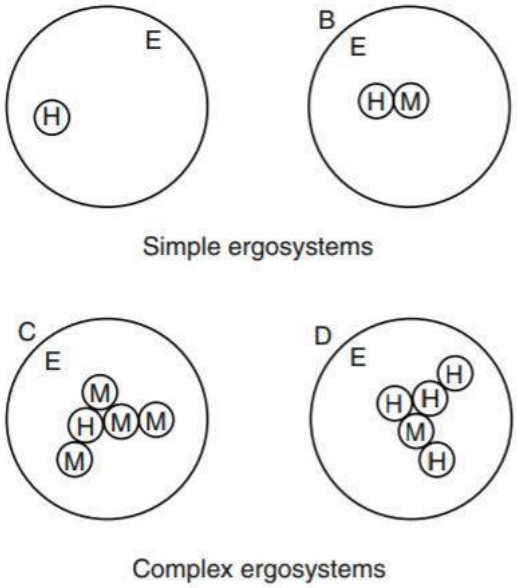

Figure 1. Structural ergonomic view of the working system showing the components (E = Environment, H = Human, M = Machine) (Bridger, 2011, p. 3).

Wilson (2005; 2014) classifies ergonomics in the light of her research as follows:
● *Physical ergonomics:* fit, clearance, reach, access, tolerance, workload, manual handling, health and safety, workplace layout, displays and controls, product and equipment design, environment, tools
● *Cognitive ergonomics:* information processing, sensing, perception, decision making, problem-solving, reaction, mental workload, fatigue, stress, interface design, reliability, communication, fault diagnosis
● *Organizational (social) ergonomics:* attitudes, motivation, satisfaction, job, and team design, hours and patterns of work, pacing, implementation of change
● *Systems ergonomics:* most successful ergonomics analysis, design, and evaluation integrates the physical, cognitive, and social.

Ergonomics / Human Factors make use of anatomy, physiology, and psychology. It also has close links with applied medicine and engineering disciplines. Chapanis (1996) broadly defines it as a multidisciplinary field contributed by psychology (primarily experimental psychology), anthropometry, applied physiology, environmental medicine, architecture, engineering, statistics, and industrial design. On the other hand, Wickens et. al. (1998) states that the field of human factors initially emerged from a rather narrow concern for human interaction with physical devices but has expanded substantially over the past few decades with its various subfields. In this view, it is believed that human factors intersect

with specific disciplines within psychology, engineering, and architecture and that many disciplines overlap with some aspects of human factors.

3. ERGONOMICS IN UNIVERSITY LIBRARIES

Libraries are an important part of the education system. They can generally be defined as an important part that facilitates the learning and research of an institution. Libraries serve an academic setting, so the convenience of library users is paramount. Library conditions are crucial in providing quality information services to library users. Consequently, poor study conditions can affect users' physical well-being (Labajo, 2017).

The library units, which are an important tool in the advancement of the university they serve, are one of the areas that students use intensively on the campus. For this reason, libraries should offer spaces to their users in a way that supports learning, study, and research there. In terms of increasing productivity in research and learning activities, the issue of suitability for the physical, anatomical, and psycho-social needs of the users of these areas is of great importance. At this point, the concept of ergonomics, which deals with human activities and the human factor in all aspects, comes into play. Ergonomics is an important aspect of the design and development of libraries. On the other hand, ergonomics is a scientific discipline that works on improving productivity, health, safety, and comfort, and helping people and technology work together. Every institution should consider ergonomics due to the importance of observing the optimum outcomes of users such as increasing the academic performance of students, encouraging effective study, and research (Narkhede & Sarode, 2018). According to Atkins (2005), achieving an ergonomic study environment requires controlling and changing the layout of the study area, using ergonomic equipment and tools, and implementing education and training programs to encourage safe study practices to ensure healthy conditions.

Considering the basic principles, which will be applied during the spatial organization of the library buildings, it is seen that ergonomics appear in almost every stage. It is important to have spaces that will create the library, contain all kinds of materials that make up the collection, increase the productivity of the staff, increase the frequency of use and desire of the users. And also interior equipments that will give meaning to these spaces are significant (Onat Öz, 1992). According to Galvin (1963), an institution, that does not have a place where staff can serve comfortably and does not have suitable and comfortable reading halls and does not have the necessary spaces according to the type and purpose of the library, is certainly not considered as a library.

It is necessary to determine the spatial dimensions in libraries, thus ensuring spaciousness. The dimensional needs of individuals consist of the dimensions required to be able to act alone or collectively and psychological dimensions. To exemplify this; for a reader in the reading room, size of space other than the space occupied by the necessary tables, chairs, bookcases, is required. These limits can only be determined with ergonomic data. Besides, the determination of layout alternatives and dimensional criteria in library units are directly based on anthropometric data. Entrance and service areas, benches, reading areas, furniture, bookcases and determination of their sizes, necessary arrangements according to the open and closed shelf system, lighting, indoor air conditions, noise control, measures required by systems such as computers, communication, special study cells (carrel) and all future measures will be able to create adequate and comfortable library spaces in the light of ergonomic data and regulations (Onat Öz, 1992).

4. MATERIAL AND METHOD

In this paper, we studied two university libraries with different architectural features. We referred to them as Library A (Lib A) and Library B (Lib B) in further sections. The main difference between libraries is Library A is a library building on a university campus and Library B is a library unit in a campus building with several other services. Both libraries

are analyzed in terms of ergonomics, and user comfort. Evaluation criteria/factors were created as a result of examining the indicators/criteria in the main studies on the subject in the literature: Bridger, 2003; Burke, 1991; Dul and Weerdmeester, 2001; Grandjean, 1987; Labajo, 2017; Macleod, 2000; Marras and Karwowski, 2006; Narkhede and Sarode, 2018; National Safety Council, 1993; Noro and Imada, 1991; Oborne, 1993; Oborne, 1995; Rajan Pillai and Jayalatha, 2016; Rooney, 1994; Roughton, 1996; Salvendy , 1997; Stanton et al., 2014; Trumble, 1997; Wilson, 2014. The scope of the investigations consists of visual comfort, noise, thermal comfort, spatial features, security, and information. For these analyses, we conducted two-part investigations. Table 1 shows detailed factors and which part of the study it was analyzed. For the first part, we conducted on-site inspections of the libraries whether they are fit the ergonomic and comfort standards.

Table 1. Factors and method

Factor		Method
Visual Comfort	Natural Lighting	On-site and Survey
	Artificial Lighting	On-site and Survey
	Daylight Control	On-site
	Reflection/glare	Survey
Noise	Noise Level	On-site and Survey
Thermal Comfort	Air quality	Survey
	Winter temperatures	Survey
	Summer Temperatures	Survey
Spatial Features	Spatial Adequacy	On-site and Survey
	Floor plan	On-site
	Furniture dimensions	On-site
	Easy navigation	Survey
	Color choice	Survey
Security	Warning signs	On-site
	Smoke alarms and fire equipments	On-site
	Emergency exits	On-site
Information	Navigation Signs	On-site and Survey
	Bookcases Navigation signs	On-site and Survey
	Information Boards	On-site

For the second part, we conducted a survey for the users to understand their perception of the libraries. Survey includes demographic questions and 15 questions about the library. There are 6 questions on physical conditions, 4 questions on space, and 5 questions on equipment. We used a 5 point Likert scale for the surveys which is a reliable scale that was used as an attitude and trend measurement technique (Turan et al., 2015). The Likert format used is ranging between "1-Strongly Disagree" and "5-Strongly Agree". In each library, we reached 50 users, a total of 100 user responses.

To investigate the association between key variables, different analyses were conducted using the SPSS 23 package. First, descriptive statistics produced to summarize respondents' socio-economic attributes and to determine the mean and standard deviation

of variables. Then a correlation analysis was conducted to understand the differences between both libraries. To test to what extent group variables (Physical Conditions, Equipment, and Space) influence satisfaction, hierarchical regression models are estimated for both libraries. Physical condition, space, and equipment variables were added stepwise. Therefore, only significant variables remained. This analysis provided data about which kind of improvements will increase user satisfaction.

4.1. Library A

Figure 2 presents photographs of Library A, which is located on the campus of a university that was established in 1911. Library A is designed as a university library building. It has two floors for books with study areas for 80 people, one floor for group studies, and one floor for computers and management.

Figure 2. Location and photographs of the Library A

4.2 Library B

Figure 3 presents photographs of the Library B which is located on the campus of a university that was established in 2010. It is a unit in a campus building with many services such as conference rooms, classrooms, and cafeterias. The Library has two different rooms on different floors. Books are in a room on the ground floor and a study room on the first floor.

Figure 3. Location and photographs of the Library B

5. RESULTS

5.1 On-site Investigations

As given in Table 1, we conducted on-site analyzes for some of the ergonomic criteria. In the context of the specified ergonomic criteria, the results of on-site investigations of the libraries are given in this section.

5.1.1. Visual Comfort

Good visibility and an adequate amount of light prevent visual stress and risk of visual discomfort (Carlucci et a., 2015). Visual comfort and sufficient daylight quantity are important factors in educational buildings since they could affect productivity and wellbeing (Heschong Mahone Group, 2003). Figure 4 presents the windows and lighting elements of both libraries. In Library A, study areas get direct sunlight through large windows, and the sunlight is controlled by white screens and coated windows. The group study area on the ground floor gets less light than the other floors. Also, the group study area has different lighting arrangements than the other floors. We observed that all the floors have some shadowed areas that could affect comfort. Library B gets daylight only in east and south directions. Sunlight is controlled by white screens and coated windows. We observed that although library B has smaller windows and a lower ceiling, it has less shadowed areas.

5.1.2. Noise

Our on-site observation revealed some noise sources that could affect user comfort. Library A located close to a motorway, which is a major noise source. We observed that when the windows opened motorway noise can cause discomfort. But when the windows closed, motorway noise is not an issue. According to our observation windows often closed and motorway noise rarely audible. On the other hand, student chatting is more of an issue than a motorway, especially on the group study floor. We observed that the materials and design of the group study reflect noise and increase discomfort.

Library B is also located near a motorway, and it is a major intercity highway. Façades of the Library do not face the highway, but it is still a major noise source. Even though the windows closed, noise is still audible. We observed that people's talking is not a problem, but some of the students told that it is a problem during exam weeks.

Figure 4. Day light and lighting arrangements

5.1.3. Thermal Comfort

Figure 5 shows the heating and cooling systems in both libraries. Library A does not have any centralized HVAC system. There are separate heating systems and cooling systems. Cooling is provided by air conditioners. Library B has a centralized HVAC system and is controlled by staff. Both libraries can ventilate through windows. Library temperatures should be between 20-22°C (Sezgen,1992). The temperature in Library A was 26°C, in Library B was 22°C at the time of our investigations. It was May and Library A's air conditioners were not working. According to our observations, it was hot for staying long periods of time.

Figure 5. Heating and cooling systems

5.1.4. Spatial Features

We analyzed spatial features in terms of space adequacy, interior design, colors, accessibility, desk, and chairs. Figure 6 presents photography to demonstrate space adequacy. According to our observations, both libraries do not have enough space for students. Even though Library A has 3 floors with plenty of desks, it is still crowded. Library A has more working areas and desks than Library B and it does not meet students' needs. Library A has carpet floorings, except the group study floor which is tiled. Also, light colors are used on the walls and circulation areas. Library B has carpet flooring and light colors on walls, too. We observed that it is easier to access restrooms, cafes, etc. from Library B than Library A. Both Libraries have elevators for accessibility. Only Library B has disabled WC.

Figure 6. Library spaces

Library furniture comparisons are given in Figure 7. Each library's desks, chairs, bookcases, and their arrangements are compared to standard from Neufert (2008). In Library A, desks sizes which are 61x53cm, are not enough for a student. Each student has a 0,32 m2 desk area. The height of the desks (75cm), the distance between desks (130cm) conforms to the standard. Also, chair size and its relation between desk conform the standard. Library B has a 60x80 desk area, which is below standard. Each student has a 0,48 m2 deck area, larger than Library A. The height of the desks (75cm), the distance between desks (124cm) conforms to the standard. Also, chair size and its relation between desk conform to the standard (Figure 7). Library A's bookcases have 5 shelves with a height of 181 cm. The distance between bookcases is 166 cm. These shows Library A bookcases conform to standards. Library B's bookcases have 6 shelves with a height of 207 cm. The distance between bookcases is 107 cm which does not conform to standards.

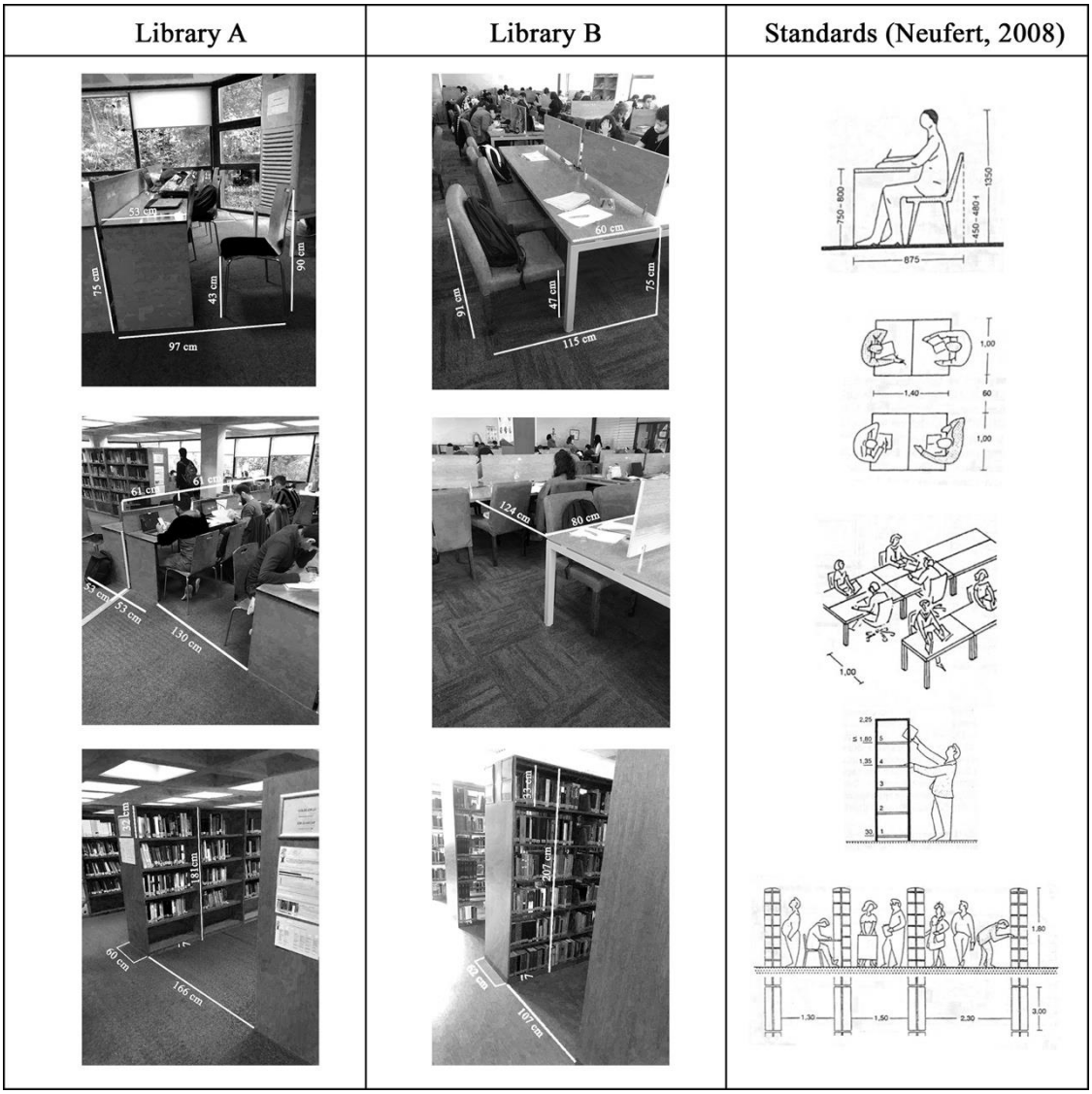

Figure 7. Library Furnitures

5.1.5. Security and Information

Libraries were examined in terms of safety signs, warning signs, fire sensors, fire extinguishers, and emergency exits. In Library A, there are fire extinguishers and informative boards on every floor. Fire alarms are located on the walls in every unit. There are signs on all floors to guide the emergency exit. Lack of sprinklers is a problem in Library A. Library B has fire detectors and sprinklers on the suspended ceiling. There is a board containing fire extinguishers and fire extinguisher's instructions. There is an emergency exit direction at the library door.

In the libraries, ergonomics in terms of informatics, we examined the presence of direction signs, the convenience of shelves guidance, and information boards. Library A has information boards and a borrowed book device at the entrance of the library. In the library section, direction boards in each library make it easy to find books. Besides, there are computers for searching for books. We observed that the entrance door of the library is used as board announcements and notifications in Library B. Also, no direction signs have been found in the borrowing section.

5.2 Survey Results

Survey results for both libraries analyzed using the SPSS 23 package. Reliability results for Library A α= .859 and Library B is α= .851. That means both are above α= .05 and information is credible. We used an alpha level of .05 for all statistical tests. Table 2 shows the demographic data of the participants for both surveys. Library A's survey results show there is 30% female and 70 % male. Library B's survey results show there are 64% female and 36% male. Both surveys present the majority of the participants' age group is 19-24 (Lib A 90%, Lib B 74%). Moreover, the majority of the participants' education is bachelor's level (Lib A 88%, Lib B 76%) and occupation is the student (Lib A 96%, Lib B 90%).

Table 2. Demographic results

		Library A		Library B	
Parameter	**Categories**	**N**	**Frequency (%)**	**N**	**Frequency (%)**
Gender	Female	15	30	32	64
	Male	35	70	18	36
Age group	15-18	1	2	2	4
	19-24	45	90	37	74
	25-29	3	6	8	16
	30-34	2	2	1	2
	35 and above	0	0	2	4
Education	High school	1	2	3	6
	Bachelor's	44	88	38	76
	Master's	3	6	9	18
	PhD	2	4	0	0
Occupation	Student	48	96	45	90
	Non-Student	2	4	5	10

Survey consists of physical condition, space and equipment groups and one single question of satisfaction. Results presents both individual and group scores in Table 3. All of the group results for both libraries score slightly above average. In Lib A Physical Condition group results P3(Winter temperature) scores *(M = 4.2, SD = .72)* highest and P1 (Air Quality) scores lowest *(M = 3.04, SD = 1.06).* In Lib B physical condition group results P4 (Summer Temperature) scores *(M = 4.12, SD = .93)* highest and P2 (Lighting) scores lowest *(M = 2.82, SD = 1,10).* In Lib A Space group results S2 (Easy Navigation) scores *(M = 3.66, SD = .84)* highest and S3 (Space) scores lowest *(M = 2.92, SD = 1.35).* In Lib B Space group results S1 (Accessibility to services) scores *(M = 3.08, SD = 1.20)* highest and S2 (Easy Navigation) scores lowest *(M = 1.98, SD = 1.37).* In Lib A Equipment group results E1 (Screen reflection) scores *(M = 3.48, SD = .84)* highest and E4 (Color) scores lowest *(M = 3.18, SD = 1.06).* In Lib B, Equipment group results E4 scores *(M = 4.28, SD = .88)* highest and E3 (Chair) scores lowest *(M = 3.16, SD = 1.16).* For total satisfaction (Q1) Lib A score *(M = 3.68, SD = 1.05)* slightly better than Lib B *(M = 3.34, SD = 1.11).*

Table 3. Descriptive Statistics

	Library A			Library B		
	N	**Mean**	**Std. Deviation**	**N**	**Mean**	**Std. Deviation**
Physical Conditions	50	3.6700	.63128	50	3.4933	.77807
P1. Air Quality	50	3.0400	1.06828	50	3.3200	1.21957
P2. Lighting	50	3.7200	.88156	50	2.8200	1.10083
P3. Winter Temperature	50	4.2800	.72955	50	3.7000	1.12938
P4. Summer Temperature	50	3.1400	1.22907	50	4.1600	.93372
P5. Daylight	50	3.9200	.89989	50	3.4800	1.16479
P6. Noise	50	3.9200	.85332	50	3.8200	1.04374
Space	50	3.2750	.86933	50	3.1500	.79379
S1. Accessibility to Services	50	3.1200	1.40901	50	3.0800	1.20949
S2. Easy Navigation	50	3.6600	.84781	50	1.9800	1.37752
S3. Space	50	2.9200	1.35285	50	2.9800	1.36262
S4. Interior Design	50	3.4000	1.16058	50	3.0200	1.15157
Equipment	50	3.3250	.89820	50	3.2500	.81910
E1. Screen Reflection	50	3.4800	1.11098	50	3.4800	1.01499
E2. Tables	50	3.2800	1.26233	50	3.2800	1.10730
E3. Chairs	50	3.3600	1.19112	50	3.1600	1.16689
E4. Colors	50	3.1800	1.06311	50	4.2800	.88156
Q1. Satisfaction	50	3.6800	1.05830	50	3.3400	1.11776

Bivariate correlations were computed using listwise deletion to examine relationships between Q1-Satisfaction and all of the other variables. The results for both libraries are given in Table 4. In Lib A results, there is a positive significance between Satisfaction and other factors, $p < .01$, except P2-Lighting, S2-Space, and E1-Screen Reflection, $p > .01$. In Lib B, P3-WinterTemperature, P4-SummerTemperature, P5-Daylight and E1-Screen Reflection are not significant, $p > .01$.

Table 4.Correlation results

		Lib A	**Lib B**
		Q1.Satisfaction	Q1.Satisfaction
Q1.Satisfaction	Pearson Correlation	1	1
	Sig. (2-tailed)		
	N	50	50
P1.AirQuality	Pearson Correlation	.373**	.432**
	Sig. (2-tailed)	.008	.002

	N	50	50
P2.Lighting	Pearson Correlation	.208	.632**
	Sig. (2-tailed)	.147	.000
	N	50	50
P3.WinterTemperature	Pearson Correlation	.409**	.240
	Sig. (2-tailed)	.003	.093
	N	50	50
P4.SummerTemperature	Pearson Correlation	.286*	.092
	Sig. (2-tailed)	.044	.527
	N	50	50
P5.Daylight	Pearson Correlation	.358*	.228
	Sig. (2-tailed)	.011	.111
	N	50	50
P6.Noise	Pearson Correlation	.355*	.541**
	Sig. (2-tailed)	.011	.000
	N	50	50
S1.AccesibilityToServices	Pearson Correlation	.382**	.357*
	Sig. (2-tailed)	.006	.011
	N	50	50
S2.EasyNavigation	Pearson Correlation	.559**	.487**
	Sig. (2-tailed)	.000	.000
	N	50	50
S3.Space	Pearson Correlation	.238	.389**
	Sig. (2-tailed)	.096	.005
	N	50	50
S4.InteriorDesign	Pearson Correlation	.422**	.581**
	Sig. (2-tailed)	.002	.000
	N	50	50
E1.ScreenReflection	Pearson Correlation	.203	.085
	Sig. (2-tailed)	.158	.557
	N	50	50
E2.Tables	Pearson Correlation	.588**	.465**
	Sig. (2-tailed)	.000	.001
	N	50	50

E3.Chairs	Pearson Correlation	.449**	.367**
	Sig. (2-tailed)	.001	.009
	N	50	50
E4.Colors	Pearson Correlation	.415**	.505**
	Sig. (2-tailed)	.003	.000
	N	50	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Multiple regression analysis conducted as Q1 (Satisfaction) variable is dependent and Physical Condition, Space and Equipment groups are independents for both Lib A and Lib B. Table 5 shows model summary and Table 6 shows ANOVA results for Lib A. Regression model excluded Physical Conditions variable and Physical Conditions and Space together variables, because of the insignificant results (*p > .05).* Regression model 2 for Lib A, taken assets, the predicators Equipment and Space account for 35% of the variance in satisfaction *(R2 = .352)*. ANOVA results for Model 2*: F (2, 47) = 12.76, p < .001.* Therefore, taken together, the predicators Equipment and Space significantly predict satisfaction. Also, Equipment *(Model 1; R2 = .293, F (1, 48) = 19.86, p < .001)* and Space (*R2 Change = .059 F(1,47) = 4.29, p<.05)* predicators separately predict satisfaction but Model 2 has higher significance.

Table 5. Model summary for Library A

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.541[a]	.293	.278	.89926	.293	19.865	1	48	.000
2	.593[b]	.352	.324	.86990	.059	4.294	1	47	.044

a. Predictors: (Constant), Equipment

b. Predictors: (Constant), Equipment, Space

c. Dependent Variable: Q1.Satisfaction

Table 6. ANOVA results for Library A

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.064	1	16.064	19.865	.000[b]
	Residual	38.816	48	.809		
	Total	54.880	49			
2	Regression	19.314	2	9.657	12.761	.000[c]
	Residual	35.566	47	.757		
	Total	54.880	49			

a. Dependent Variable: Q1.Satisfaction

b. Predictors: (Constant), Equipment

c. Predictors: (Constant), Equipment, Space

Table 7 shows model summary and Table 8 shows ANOVA results for the Lib B. Regression model only included Space variable, excluded Physical Conditions variable Equipment variable, and their combination variables because of the insignificant results ($p > .05$). Regression model summary for Lib B presents the Space predictor accounts for 44% of the variance in satisfaction ($R2 = .443$). ANOVA result for the model: $F(1, 48) = 38.23$, $p < .001$. Therefore, the Space predictor significantly predicts satisfaction.

Table 7.Model summary for Library B

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666[a]	.443	.432	.84255

a. Predictors: (Constant), Space

Table 8.ANOVA results for Library B

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27.145	1	27.145	38.238	.000[b]
	Residual	34.075	48	.710		
	Total	61.220	49			

a. Dependent Variable: Q1.Satisfaction

b. Predictors: (Constant), Space

6.DISCUSSION

This paper aims to determine differences in ergonomic factors and satisfaction between two university libraries with different designs. Lib A is a library building that is designed for a university and Lib B is a library unit in a campus building which has many facilities such as classrooms, conference center, etc.

In terms of visual comfort, survey results show a lack of daylight affects satisfaction in Library A, and lighting arrangements affect satisfaction in Library B. these results are in line with our on-site investigation. Shadowed areas in both libraries decrease visual comfort. Library A and B need improvements in daylight and lighting to create better working areas.

According to descriptive statistics (Table 3), both libraries have above average results in terms of noise (For Library A, $M = 3.9$, $SD = 0.8$, for Library B, $M = 3.8$, $SD = 1.0$). But the satisfaction and noise correlation results are significant for both libraries, $p < .01$ (Table 4). Respondents complained about people talking as a noise source for both libraries. The effects of being near a motorway are inconclusive and need further research.

Thermal comfort is acceptable in both libraries. But control of the heating, cooling systems, and ventilation is important, especially in Library A. Because thermal comfort is a significant factor in satisfaction. Since Library A does not have an HVAC system, staff should carefully operate separate systems.

Our on-site investigation and survey results are in line with that both libraries' spatial features are inadequate. Libray A can supply the students' demand even though it is larger than B. As given in Figure 7 and survey results, tables and chairs are insufficient for Library A and Library B. Interior design of both libraries should be reconsidered and improved. Also, as we informed by the university, there will be a new campus library for Library B, which is promising for users.

In terms of informatics, both units provide partial satisfaction. The Library B library needs navigation signs. In Library B, a more comprehensive fire safety should be provided with fire detectors and sprinklers.

Descriptive statistics (Table 3) for Lib A show slightly above average means for most of the factors. The highest satisfaction is for winter temperature factor and lowest for space factor. Respondents' overall satisfaction mean is slightly above average *(M = 3.68, SD = 1.05)* which proves Lib A needs improvements. The regression model (Table 5, Table 6) presents improvements in the Equipment group and the Space group may improve satisfaction by 35%. Also, the Physical conditions group is insignificant for satisfaction in Lib A. Although the bivariate correlations show an insignificant correlation S3-Space factor, other factors in the group have a strong significance on satisfaction. This proves space adequacy is not the main problem for the Lib A but the other space factors are. Especially, future arrangements on navigation in and around the library (S2-EasyNavigation, $r(48) = .55, p < .001$) can be made the highest impact on satisfaction in the Space group. Moreover, all of the equipment group factors have a strong correlation with satisfaction, but the E2-Tables factor has the highest correlation ($r\ (48) = .558, p < .001$). Future improvements in study tables in Lib A can improve satisfaction.

Descriptive statistics for Lib B also show slightly above average means for most of the factors. But there are more problematic factors than Lib B. Two of the four space group factors are below average, including the S3-Space adequacy factor. Respondents' overall satisfaction mean is slightly above average *(M = 3.34, SD = 1.11)* which proves Lib B also needs improvements. As the bivariate correlations show, there is a strong positive significant correlation between space factors group and satisfaction, all of the group factors p-value is less than .01. Moreover, as the regression model for Lib B presents improvements on the Space group predictor may improve satisfaction by 44% *(R2 = .443)*. These results illustrate Lib B needs a larger and well-designed library space. Besides, there is a strong positive correlation between the Equipment factor group *(E2-Tables, E3-Chair, E4-Color factors* $p < .01$), even though the regression model is insignificant for the Equipment factor group, new arrangements on tables and chair may improve satisfaction.

7. CONCLUSION

Libraries are among the areas most frequently used by students on campus. In terms of increasing productivity in research and learning, the suitability of the users of these areas to the physical, anatomical, and psycho-social needs is of great importance. The concept of ergonomics, which deals with human activities and deals with the human factor in all aspects, has a great and important place.

In this study, the library units of two universities were examined and evaluated in the context of ergonomic, to understand to what extent they are suitable for the user's physical and psycho-social needs. In this context, two library units with different qualities in terms of design and equipment were compared and similar-different situations were revealed through on-site investigations and surveys. Results show that both university libraries could not generally provide optimum values. It has been observed that the users are not satisfied with the situations that are not at optimum values, too. However, it was understood that Library A, which was designed as a university unit, achieved more successful results in terms of user satisfaction compared to Library B.

In conclusion, attention should be paid to the concept of ergonomics in library units to increase efficiency in research and learning activities, to create a healthy and safe environment. Considering the optimum values of the library units in terms of visual comfort, noise, thermal comfort, spatial comfort, security, and informatics will contribute to user satisfaction.

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