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Analysis of Ergonomic Parameters in Architectural Design Studios: A Case Study of Bursa Technical University

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Abstract

Ergonomics encompasses physical, psychological, and environmental factors, with a crucial role in educational settings. Design studios, integral to architecture, interior architecture, and urban planning education, must ensure optimal spatial, visual, auditory, and thermal comfort to foster creativity and technical skills. This study evaluates the design studios at Bursa Technical University's Faculty of Architecture and Design, assessing ergonomic conditions through technical measurements and user satisfaction surveys. Findings reveal that repurposed spaces used as design studios fail to meet essential ergonomic standards, impacting students' learning experiences. The study highlights deficiencies in spatial organization, lighting, acoustics, and thermal conditions, emphasizing the need for improvements. By addressing these shortcomings, the research aims to guide the optimization of design studios as dynamic educational environments supporting technical drawing, group critiques, model-making, and workshop activities. The study is expected to serve as a guiding reference for the organization of design studios in accordance with ergonomic standards.

Keywords: *Ergonomics, design studios, visual comfort, auditory comfort, thermal comfort.*

Mimari Tasarım Stüdyolarında Ergonomi Ölçütlerinin Analizi: Bursa Teknik Üniversitesi Örneği

Öz

Ergonomi, fiziksel, psikolojik ve çevresel faktörleri kapsayarak eğitim ortamlarında önemli bir rol oynar. Mimarlık, iç mimarlık ve şehir-planlama eğitiminde kritik bir yere sahip olan tasarım stüdyoları, yaratıcılığı ve teknik becerileri desteklemek için mekânsal, görsel, işitsel ve termal konfor açısından optimal koşullara sahip olmalıdır. Bu çalışma, Bursa Teknik Üniversitesi Mimarlık ve Tasarım Fakültesi'ndeki tasarım stüdyolarını ergonomik koşullar açısından değerlendirmiştir. Teknik ölçümler ve kullanıcı memnuniyeti anketleri aracılığıyla yapılan analizler, stüdyo olarak kullanılan dönüştürülmüş alanların temel ergonomik standartları karşılayamadığını ortaya koymuştur. Çalışma, mekânsal düzenleme, aydınlatma, akustik ve termal konfor eksikliklerini vurgulayarak bu alanların iyileştirilmesi gerektiğini göstermektedir. Araştırma, teknik çizim, grup değerlendirmeleri, model yapımı ve atölye çalışmalarına uygun, dinamik eğitim ortamlarının oluşturulmasına yönelik rehber niteliği taşımaktadır. Bu doğrultuda çalışmanın tasarım stüdyolarının ergonomik standartlara uygun şekilde düzenlenmesine yönelik yol gösterici bir kaynak oluşturacağı düşünülmektedir.

Anahtar kelimeler: *Ergonomi, tasarım stüdyoları, görsel konfor, işitsel konfor, termal konfor.*

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1. Introduction

Ergonomics, as defined by Laville (1976), is an interdisciplinary science that examines the relationship between humans and their working environment, aiming to establish the fundamental principles of human, technical, and environmental harmony (Dinçer, 1978; Yapıcı & Baş, 2015). The term itself originates from the Greek words *ergos* (meaning "work") and *nomos* (meaning "law") (Dinçer, 1978; Yapıcı & Baş, 2015). An alternative definition describes ergonomics as an applied science that seeks to maximize productivity and efficiency in various work environments by aligning spatial, technical, and operational systems with the psychophysiological and sociocultural capacities and limitations of human beings (Toka, 1978; Yapıcı & Baş, 2015).

Design studios serve as multifunctional spaces in design education, accommodating a range of activities, including technical drawing, jury assessments, workshops, group projects, and model-making exercises. As the most frequently utilized spaces within architecture and design faculties, design studios function not only as educational environments but also as dynamic, interactive spaces that remain in use throughout the day. Given the intensive nature of design education, it is evident that the spatial, visual, thermal, and auditory comfort conditions of design studios play a critical role in influencing the productivity and overall well-being of students and academic staff. The nature of design courses conducted in these studios demands high levels of creativity, prolonged focus, and sustained cognitive effort, all of which are strongly influenced by spatial conditions. Consequently, it is essential for design educators to evaluate design studios in terms of ergonomic suitability and to plan their spatial organization in accordance with ergonomic principles. By integrating ergonomic considerations into studio design, educators can create optimized learning environments that enhance student creativity, facilitate engagement, and improve overall academic performance.

The design studios of the Faculty of Architecture and Design at Bursa Technical University, selected for this study, are situated within Block A of the Yıldırım Campus in a building originally designed for educational purposes. The studios utilized by the Departments of Architecture and Urban Planning have been established through the transformation of pre-existing spaces within this building. The reason for choosing this specific area is its representation of repurposed educational spaces, which are increasingly common in universities. Researching these spaces is crucial as they often face challenges in terms of adapting to the new functional requirements of design studios, particularly regarding comfort conditions. This research makes a significant contribution to the literature by systematically evaluating the critical factors that must be considered to ensure optimal comfort conditions in spaces intended for conversion into design studios. Unlike traditional classroom designs, design studios need to support not only technical drawing and creative thinking activities but also ensure adequate comfort conditions to accommodate the intense and creative nature of the design environment.In repurposed spaces, the spatial comfort conditions of design studios should be analyzed and improved to ensure the effective delivery of architectural education. Therefore, the design studios within Block A of Bursa Technical University, which were subsequently repurposed as design studios, have been selected as the focus of this study. By analyzing the comfort conditions within these spaces, this research aims to enhance the quality of architectural education environments. is essential for enhancing the quality of architectural education environments. The spatial, visual, auditory, and thermal comfort conditions will be analyzed and evaluated through face-to-face surveys conducted in the field study and technical measurements. The study found that functional and ergonomic deficiencies were identified during the examinations in the studios. These deficiencies may hinder the efficient use of learning environments and negatively affect the overall comfort of the users.

1.1. Literature Review

In his seminal 1980 publication, Edholm posited that the scientific study of human interaction with work environments necessitates an in-depth examination of the psychological, physiological, and anatomical factors influencing human behavior and performance. Similarly, Grandjean (1967) emphasized that human behavior and responses in the workplace are shaped by a complex interplay of these physiological, anatomical, and psychological dimensions. This perspective underscores the notion that humans are intricate entities composed of interrelated components. A purely natural sciences-based approach to understanding human behavior and reactions is therefore insufficient. This recognition has led to the emergence of ergonomics as a distinct scientific discipline. As outlined by Edholm (1980), the primary objective of ergonomics is to analyze the relationship between humans and their work environments by integrating psychological, physiological, and anatomical considerations.

The spatial organization of built environments, particularly from a physical and anthropometric perspective, necessitates the consideration of multiple criteria, including user data, the intended function of the space, the nature of activities performed within it, and volumetric requirements (Temel & Canbay Türkyılmaz, 2018). In defining the dimensional characteristics of a given space, two key factors are particularly significant: the spatial requirements of work-related actions and the manner in which these actions are executed. The dimensions of these work areas are further influenced by the extent of movement required, the dimensions of functional areas, and the psychological space needs of users.

Barnes and Squires have established fundamental dimensional requirements for horizontal work surfaces such as desks, benches, and workstations where physical tasks are performed. Their findings indicate that the maximum reach of an individual's arm in a random movement extends to 79–80 cm. Additionally, the minimum shoulder width for a standing individual is 120 cm for women and 130 cm for men. In seated positions, shoulder height measurements were recorded as 54 cm for the shortest male subject and 49 cm for the shortest female subject. Ergonomic principles further establish that the optimal height for a standing work surface ranges between 95–100 cm for men and 88–93 cm for women. Similarly, the ideal height for reading and writing activities is set between 70–74 cm for women and 74–78 cm for men, while the recommended desk height for seated work is 70 cm. The spatial design of educational buildings, classrooms, offices, and other specialized environments is determined by a combination of these parameters.

The field of anthropometry plays a crucial role in the assessment of equipment dimensions within educational settings. For instance, Mehrparvar et al. (2015) conducted a large-scale study involving 9,476 individuals, revealing significant variations in anthropometric measurements based on gender and race. Similarly, a study by İşeri and Arslan (2009) involving 4,205 students in Türkiye demonstrated that anthropometric differences also correlate with geographical factors. Savanur et al. (2007), in their analysis of students in India, concluded that classroom furniture was often incompatible with students' anthropometric measurements, highlighting the importance of aligning educational environments with user-specific ergonomic requirements.

Effective utilization of natural daylight is essential for optimizing façade efficiency and enhancing visual comfort in architectural design (Kızılörenli & Tokuç, 2022). The concept of visual comfort encompasses various interrelated factors, including the type, intensity, distribution, and direction of lighting, as well as the quality of shadows. The quantitative aspect of lighting is measured in terms of illumination levels, whereas qualitative aspects are defined by the color of light (e.g., warm white, normal white, daylight) and its ability to render colors accurately. The distribution of illumination and shadow quality further contribute to visual comfort. Lighting types are generally classified into direct, semi-direct, mixed, semi-indirect, and indirect lighting. Among these, the illuminance level is a key determinant in achieving optimal visual comfort, particularly in work environments where prolonged exposure to low contrast conditions necessitates an increase in lighting levels (Arpacıoğlu, 2012).

Natural lighting also plays a critical role in visual comfort, with window depth being a primary factor influencing the amount of light that enters an interior space. Grandjean (1967) observed that highly transparent windows permit greater light penetration compared to wider window openings. In workplace environments, window sill heights should be aligned with the height of desks to ensure adequate daylight exposure. The glazed exterior surface should constitute at least one-fifth of the total floor area, and materials used in glazing should facilitate light transmission. Notably, the light transmittance rates of glass bricks and sandblasted glass range between 30–70%, whereas clear glass allows approximately 90% of light to pass through. To maximize natural light intake, the use of glazed inclined surfaces and glass roofs is recommended.

Yurdakul (2018) asserts that the illumination levels on documents should be maintained at a minimum of 500 lux, in accordance with the standards established by the Turkish Standards Institution (2011). These standards, which define the fundamental principles of lighting in Türkiye, align with the European Regulation on Workplace Lighting, which stipulates a minimum lighting intensity of 500 lux in workspaces. Furthermore, Yurdakul's comparative study of lighting standards across different countries indicates that the minimum and maximum illumination levels in classrooms range between 200 and 750 lux (Table 1).

Table 1. Lighting design values in educational buildings (Yurdakul, 2018).

Educational Building	İllumination provided in the working area (lux)	Measurement height(m)
Classrooms	500	0,8
Auditoriums	500	0,8
Technical drawing rooms	750	0,7
Fine arts drawing classes	750	0,7

In educational buildings and classrooms where active learning is conducted, auditory factors play a critical role in the efficiency of both learning and practical application activities. In the context of architectural education, which integrates both practical and theoretical coursework, acoustic comfort significantly influences the overall quality of education within architectural faculties (Bilmez et al., 2022). To facilitate effective communication within these spaces, it is imperative to calibrate ideal reverberation times in accordance with the intended function of the environment and to determine the internal sound levels to ensure that verbal interactions can be perceived with clarity.

Beyond physical variables such as the volume and dimensions of the spaces, noise levels also impact auditory comfort. Under typical conditions, the acceptable noise level ranges between 40 and 60 decibels. The maximum allowable noise level within indoor educational environments varies between 35 and 55 dBA, depending on the specific characteristics of the indoor setting during daytime hours, in compliance with national noise regulations. According to the prEN 15251-2006 standard established by the European Union, the recommended noise levels are set at 35 dBA for classrooms, 40 dBA for corridors, 35 dBA for conference halls, and between 35 and 40 dBA for office environments (Table 2).

Table 2. Indoor noise limit values according to different standards (Yurdakul, 2018)

	Turkish standard TS- Regulation on the assessment and management of environmental noise		European Union prEN 15251-2006	UK, Acoustic design of schools: performance standards (2015)		WHO 1996 (indoor, dB)
	Closed window (dBA)	Open window (dBA)		New building	renewed building	
	Values when there are no activities in the usage areas					
Classrooms in Schools	35	45	35-40 typical value 35	35	40	-
Special Education Facilities	35	45	35-40 typical value 45	-	-	-
Offices	45	55	35-40 typical value 35	-	-	-
Educational Buildings	-	-	-	-	-	35

Thermal comfort is influenced by a combination of subjective and objective factors. Subjective parameters include individual characteristics such as age, gender, and health status, while objective parameters encompass environmental conditions such as seasonal variations, air temperature, relative humidity, air circulation, and climate. The Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) thermal comfort indices, as defined by the ASHRAE-55 (2010) and TS EN ISO 7730 (2005) standards, serve as critical benchmarks for assessing thermal comfort levels.

According to the ASHRAE-55 (2010) Standard for Thermal Environmental Conditions in Workplaces, the acceptable indoor temperature range is specified as 17.5 to 24.5 ºC during winter and 24.5 to 31.5 ºC in summer, with the precise limits being contingent upon outdoor temperature variations. Similarly, in accordance with the TS EN ISO 7730 (2005) Thermal Environment Ergonomics Standards, the permissible range of relative humidity is established between 30% and 70%, ensuring optimal indoor thermal conditions.

2. Material and Method

The study employs a two-phase research methodology. In the first phase, an analysis was conducted on five design studios (337, 436A, 418C, 418B, and 432H) located within the same building. This analysis was carried out in accordance with established criteria for spatial, visual, auditory, and thermal comfort. In the second phase, user satisfaction was assessed through structured questionnaires administered to students and academic staff, who represent the primary users of these design studios.

This section provides a comprehensive evaluation of the design studios within the Faculty of Architecture and Design at Bursa Technical University, integrating spatial, visual, auditory, and thermal comfort measurements. Spatial and visual parameters were assessed through surveys, photographic documentation, and measurements obtained via the "Lightmeter" light measurement application. Additionally, auditory and thermal comfort levels were determined through data collected using the "Decibel X" sound measurement application and thermometer readings.

2.1. Spatial Comfort Measurements

2.1.1. Architectural design studio 1: studio 337

Studio 337, located on the third floor of Block A, was repurposed into a design studio through the conversion of a corridor area into a classroom. As a result of this transformation, remnants of the original corridor layout, including invisible traces and the pre-existing speaker system, have been retained within the studio. The studio measures 8.50 x 20 meters, encompassing a total area of 174 m². The classroom is characterized by large windows that face the corridor, while the glass door, equipped with transom windows, provides access to the terrace. The arrangement of drawing tables maintains a spacing of 60 cm between each unit. In addition to the primary entrance connecting to the corridor, the studio also features a secondary access point leading to the meeting room and corridor; however, it is important to note that these doors are not actively in use (Figure 1).

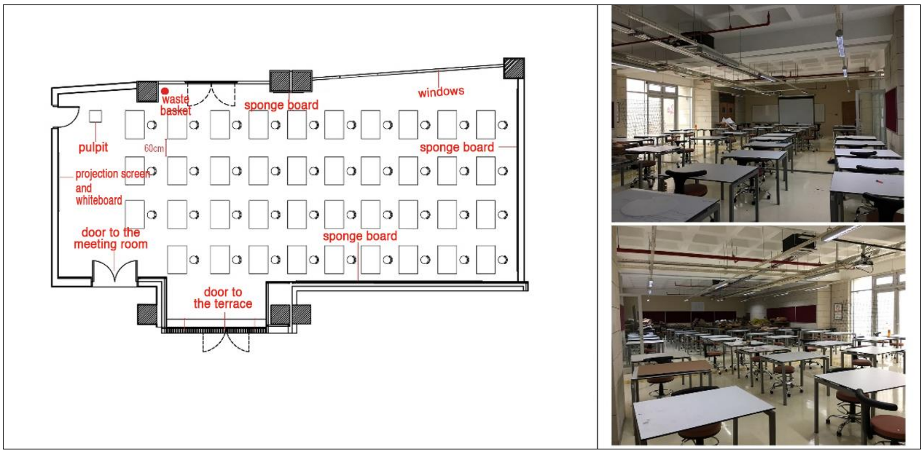

Figure 1. Design studio 337 plan diagram and images (Created by authors)

The spatial equipment within Studio 337 consists of a whiteboard, a projection system, three chairs, a desk, and a lectern. The classroom is furnished with drawing tables measuring 80 x 100 cm, facilitating design-related activities. The projection screen within the studio measures 2.40 x 2 m, while the blackboard dimensions are 203 cm in length and 500 cm in width, with its base positioned at a height of 81 cm from the floor. The lectern within the classroom has dimensions of 55 cm by 45 cm. The ceiling lighting switches are installed at a height of 125 cm, and the air conditioning control panel is affixed to the wall at 125.5 cm above the floor. The studio door is a double-leaf glass door with a width of 180 cm, ensuring accessibility. Additionally, eight red sponge boards are mounted on the classroom walls to support educational activities. For project lessons and juries, steel grids have been installed within the classroom. However, due to insufficient structural stability, these grids are supported by desks to maintain their upright position. The layout and spatial distribution of the lighting elements within the classroom are illustrated in the accompanying diagram.

2.1.2. Architectural design studio 2: studio 436A

Studio 436A, the largest design studio within Block A, was specifically designed to facilitate design-related activities and continues to serve this purpose. The studio measures 9.4 x 21 meters, encompassing a total area of 197 square meters. The walls are lined with foam boards, contributing to both acoustic performance and visual presentation. To enhance storage capacity, two rows of shelves are positioned on either side of the glass panel on the rear wall, providing students with designated areas for storing models and project materials. Although the studio features four entrance doors, only one is actively in use, while the remaining three remain unused. The drawing tables measure 70 cm by 100 cm, and the spacing between them is 120 cm, ensuring adequate workspace for design activities. The spatial arrangement and dimensions are considered appropriate for the functional requirements of the studio (Figure 2).

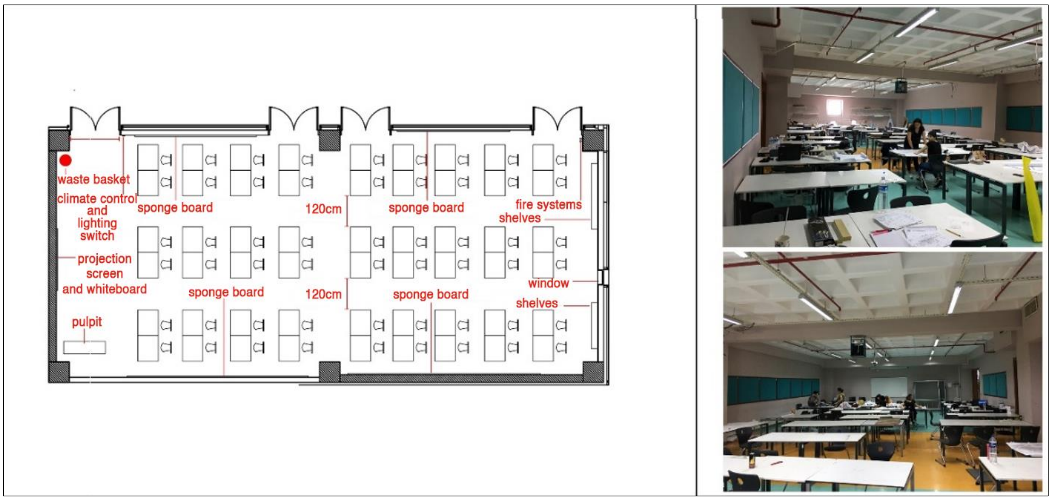

Figure 2. Design studio 436-A plan diagram and images (Created by authors)

The spatial equipment within Studio 436A consists of drawing tables, chairs, shelves, sponge boards, movable boards with legs, and whiteboards. The board measures 240 cm in length and 130 cm in width, while the projection screen dimensions are 240 cm by 200 cm, providing a sufficient surface area for the effective projection of visual materials.In-class presentations are facilitated through the use of movable boards and sponge boards affixed to the walls, which serve as display surfaces for student work. Additionally, fixed boards mounted on the walls are utilized for jury evaluations and critiques. The plan below illustrates the spatial arrangement and distances of the lighting elements within the classroom, ensuring optimal illumination for design activities.

2.1.3. Architectural design studio 3: studio 418B

Studio 418-B was specifically designed as a design studio and continues to serve this function. The positioning of window openings within the studio, allowing for natural lighting from multiple directions, has been identified as a beneficial feature in terms of overall design efficiency and illumination quality. The studio measures 9 x 16 meters, encompassing a total area of 144 square meters. The distance between rows of workstations is 90 cm, ensuring sufficient spatial arrangement for user movement and interaction. The studio is equipped with essential design workspace elements, including a movable board, a fixed whiteboard, a lectern, a desk, and chairs. Additionally, it contains 42 drawing tables, each featuring an adjustable height with dimensions of 70 x 90 cm. The rear wall is fitted with four cork boards, each measuring 103 x 100 cm, to facilitate the display of student work and project sheets. Furthermore, wheeled whiteboards are provided, allowing for flexible presentation and display arrangements. The height-adjustable wheelchairs used within the studio incorporate seating and reclining components constructed from plastic, ensuring uniformity in material selection (Figure 3).

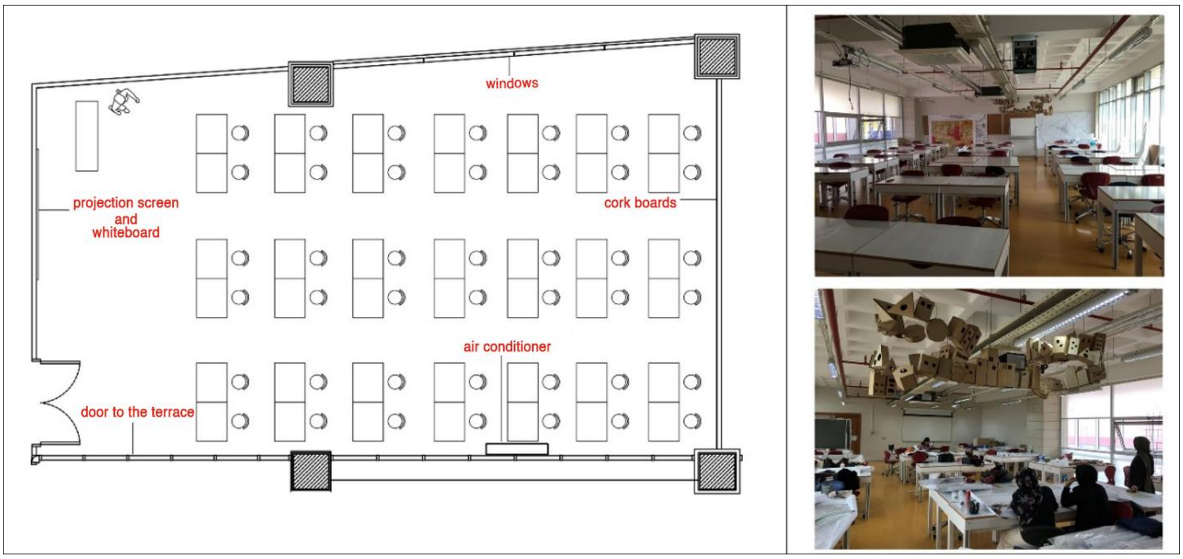

Figure 3. Design studio 418- B plan diagram and images (Created by authors)

The whiteboard in Studio 418B measures 240 cm in length and 255 cm in width, providing a sufficient writing and display surface for instructional purposes. The projection apparatus is securely affixed to the ceiling, ensuring optimal visibility for presentations. Unlike the design configurations of other studios, the drawing tables in 418B are equipped with a retractable mechanism, allowing for greater flexibility in use. These tables have been designed in accordance with ergonomic principles, featuring adjustable height and angle settings to enhance user comfort and efficiency. The electrical infrastructure of the studio includes five electrical outlets, with socket heights positioned 28 cm above the floor. The lighting switch is conveniently located at the entrance at a height of 103 cm from the floor, facilitating easy access. Additionally, the studio is equipped with two ceiling ventilation units, a floor-mounted air conditioner, a ventilation control box, and sixteen fluorescent lighting elements, contributing to the overall thermal and visual comfort of the space. The lighting and air conditioning components are mounted onto metal rods suspended from the cassette ceiling, which also serve as structural hangers. Moreover, all installation systems, including those related to the sprinkler system, remain fully visible on the ceiling, ensuring accessibility for maintenance and inspection.

2.1.4. Architectural design studio 4: studio 418C

Studio 418-C was specifically designed as a design studio and continues to serve this function. The studio measures 9 x 16 meters, encompassing an approximate area of 145 square meters. To accommodate student needs, shelving units are installed at the rear of the classroom, providing storage space for student work and materials. The studio is furnished with four distinct types of seating, ensuring adaptability to various learning activities. Additionally, it is equipped with eight drawing tables, each measuring 80 cm x 100 cm, facilitating design and drafting exercises. Movable boards are utilized to display student work and project sheets, enhancing the functionality of the workspace. The projection screen within the classroom measures 170 cm in width, which has been determined to be insufficient for its intended purpose. This limitation negatively affects visual comfort, potentially hindering the effectiveness of visual presentations and instructional activities (Figure 4).

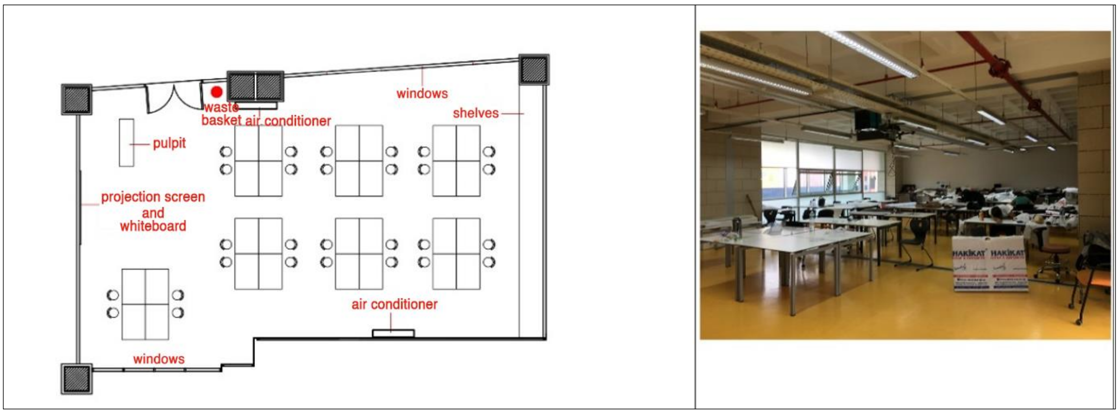

Figure 4. Design studio 418- C plan diagram and images (Created by authors)

2.1.5. Architectural design studio 4: studio 432H

This section, located as an extension of the corridor on the top floor of the building, has been repurposed into a studio in accordance with spatial requirements. The narrow and elongated configuration of the classroom impacts the overall level of visual comfort. Additionally, the centrally positioned column disrupts visual continuity with the blackboard, creating an obstruction within the instructional space. As a result, the section of the classroom extending from the column to the door is designated for model and material storage, while the space preceding the column is allocated for active use. The studio measures 23 x 6.5 meters, with a total approximate area of 150 square meters (Figure 5).

The classroom is equipped with a movable blackboard measuring 127 x 300 cm. The projection screen is positioned on the west side of the building, along the longer side of the classroom. However, during high student attendance, the effectiveness of the projection process is compromised, leading to a decline in visual comfort levels. The seating elements within the studio consist of wheeled stools, offering flexibility in arrangement. The drawing tables, measuring 70 x 90 cm, incorporate shelf compartments designed for storing drawing materials. A significant proportion of the classroom surfaces consist of glass partitions, which have a detrimental impact on visual comfort, potentially affecting concentration and instructional effectiveness.

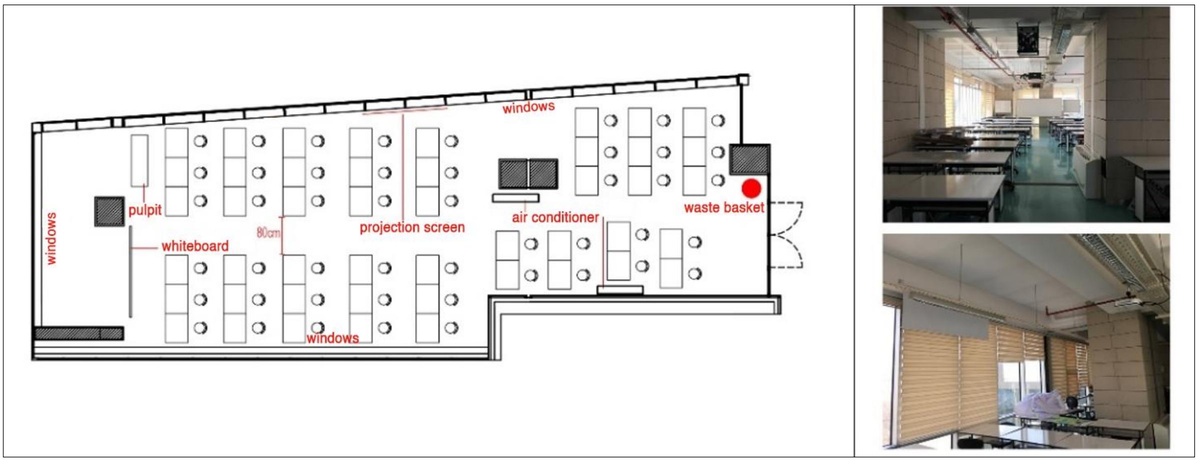

Figure 5. Design studio 432-H plan diagram and images (Created by authors)

2.2. Visual Comfort Measurements

In Studio 337, a total of 11 fluorescent lighting units were installed. Measurements conducted at two distinct locations within the classroom revealed lux values of 3,272 near the glass door and 810 in front of the board. In Studio 436A, 18 fluorescent light sources were utilized. The studio receives natural light through a 60 cm x 60 cm window, which is insufficient given the overall dimensions of the space. Measurements taken from two separate points within the classroom yielded lux values of 267 and

1,749, respectively. Notably, desks positioned toward the rear of the classroom would benefit from increased exposure to natural light.

In Studio 418B, 16 fluorescent lighting elements were installed, with an average spacing of 140 cm between fixtures. The studio benefits from ample natural light, facilitated by two surfaces clad in transparent materials featuring a combination of openings and fixed glass modules. Lux measurements taken at two points within the classroom were recorded at 1,911 and 648 respectively. Studio 418C is equipped with 16 fluorescent lighting units. The illuminance levels recorded within the classroom were 427 lux near the entrance door and 9,250 lux in front of the glass, highlighting significant variations in light distribution. The Studio 432H facility features 12 fluorescent lighting elements. Due to the prevalence of openings and fixed windows along the length of the classroom, the lux values were considerably high. Measurements conducted at three different locations within the classroom yielded illuminance levels of 1,012, 7,711, and 8,650 lux, respectively. To regulate light intensity, the studio is equipped with roller blinds on three sides, ensuring adjustability of natural light exposure.

2.3. Auditory Comfort Measurements

The noise level in Studio 337 was recorded at 52.9 decibels. In Studio 436A, the cassette flooring acts as an acoustic barrier, limiting sound transmission toward the rear of the room. Additionally, due to the restricted dimensions of the window opening, external noise sources have minimal impact on the classroom environment. The measured noise level within this studio was 51.2 dB.

Similarly, in Studio 418B, the noise level was determined to be 51.2 dB. The studio is equipped with a floor-mounted air conditioning system, and the ventilation system contributes to the overall sound levels within the space. The presence of cassette flooring on the ceiling further influences the acoustic properties of the studio. Additionally, the considerable depth of the classroom negatively impacts sound distribution, particularly in the rear rows. To enhance acoustic comfort and optimize sound transmission, modifications to the existing setup are recommended. The noise levels recorded in Studios 418C and 432H were found to be identical, measured at 53.1 dB.

2.4. Thermal Comfort Measurements

Studio 337 is naturally ventilated through a glass door on the east elevation, which opens to the terrace, along with transom windows and windows facing the hallway. However, the transom windows are difficult to operate due to their placement. The studio is heated and cooled by three ceiling-mounted air conditioning units. The measured indoor temperature was 24°C.

In Studio 436A, natural ventilation is provided by a single window, while artificial air conditioning is facilitated by grilles installed at six points within the classroom. However, when the artificial air conditioning system is operational, the noise level increases, leading to a negative impact on auditory comfort. The measured indoor temperature was 26°C.

Studio 418B is naturally ventilated via a glass door opening to the terrace, transom windows, and hallway-facing windows. The rear section of the classroom, where the windows face each other, plays a crucial role in air circulation. The temperature in the studio was recorded at 27°C, exceeding the recommended range for thermal comfort. Studio 418C is equipped with one ceiling-mounted air conditioning unit and two floor-mounted units. However, the air conditioning controls are located at the rear of the classroom, making access ergonomically challenging. Natural ventilation is provided by transom windows on the east side and windows facing the hallway. The measured indoor temperature was 26°C. Studio 432H is naturally ventilated through transom windows on the east side and operable windows on the west side of the building. The studio is also equipped with two ceiling-mounted air conditioning units and two floor-mounted air conditioners. The measured indoor temperature was 26°C. Notably, due to the studio's west-facing façade being entirely composed of glass, thermal comfort is negatively affected, particularly during the summer months.

According to Building Bulletin 101 (2006) in the United Kingdom, classroom temperatures should remain between 23°C and 26°C during the summer. In the thermal comfort assessment, Studios 436A, 418C, and 432H fall within the recommended range, while Studio 418B exceeds the specified limits.

3. Findings and Discussion

Among the students who participated in the questionnaire, 10 were enrolled in the Interior Architecture program, while 32 were studying Architecture or City and Regional Planning. The distribution of students by academic year included 32 first-year students, 17 second-year students, 6 third-year students, and 2 fourth-year students. The majority of students reported frequent campus usage, typically attending every day of the week. Regarding the academic staff respondents, 11 were affiliated with the Department of Architecture, while 5 were from the Department of City and Regional Planning. Most academic staff members indicated that they utilize the campus for more than three days per week. The surveyed academic staff, comprising faculty members, research assistants, and lecturers, reported an average campus experience ranging from one to three years (Figure 6).

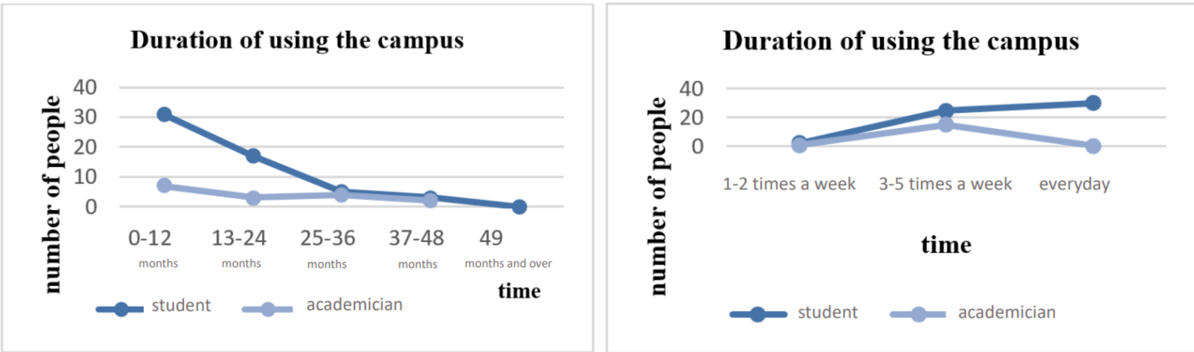

Figure 6. Duration and frequency of use of the campus by students and academics (Created by authors)

The questionnaire assessed the perceptions of both students and academic staff regarding the spatial, audiovisual, and thermal comfort levels within the studios. The questions outlined in the table below were presented separately to academics and students for each studio, with responses recorded on a scale ranging from "very good" to "very poor". Overall, the natural and artificial lighting conditions in the studios were generally rated as fair. However, a more detailed analysis of the survey results revealed that natural lighting levels in Studios 418B, 418C, and 432H received higher ratings, whereas Studios 337 and 436A were rated lower in this regard. Notably, the responses from academics and students exhibited consistency, indicating similar perceptions across both groups (Figures 7, 8).

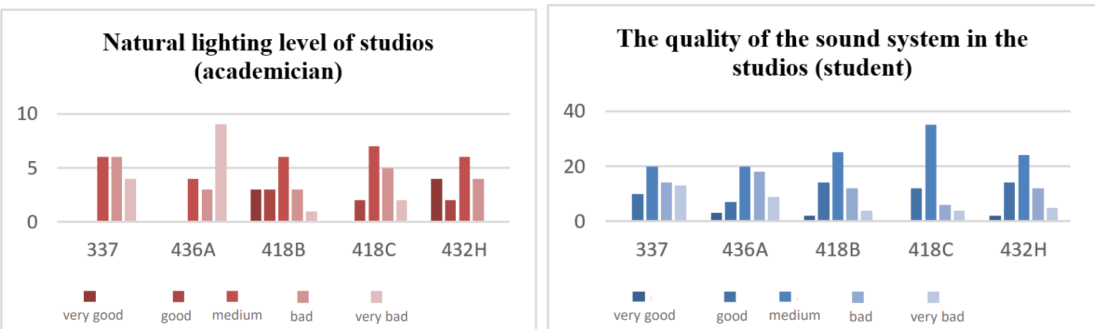

Figure 7. Students' and academicians' responses regarding the level of natural lighting in the studios (Created by authors)

An analysis of the survey results revealed that the artificial lighting levels were rated higher in Studios 418B and 418C, whereas lower satisfaction levels were observed in Studios 436A and 337. The responses from students and academic staff were generally consistent; however, academics provided higher ratings for Studios 418B and 418C compared to students. The auditory comfort levels across the studios were primarily influenced by perceptions of the sound system and ambient noise levels, which were predominantly rated as poor or fair. When analyzed on a class basis, students rated the impact of the sound system on room comfort as high in Studios 418C, 418B, and 432H, whereas lower ratings were recorded in Studios 436A and 337. In contrast, academic staff rated the impact of the sound system on room comfort as high in Studios 337 and 418C, while lower ratings were assigned to Studios 436A, 432H, and 418B (Figure 9).

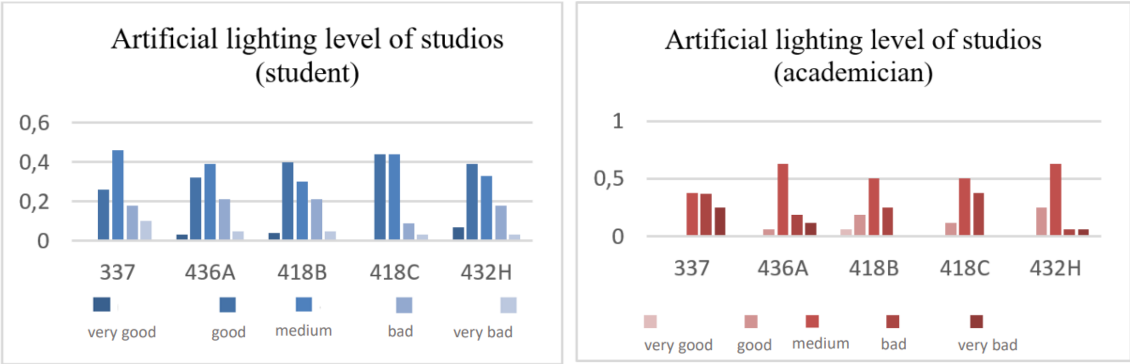

Figure 8. Students' and academicians' responses regarding the level of artifical lighting in the studios (Created by authors)

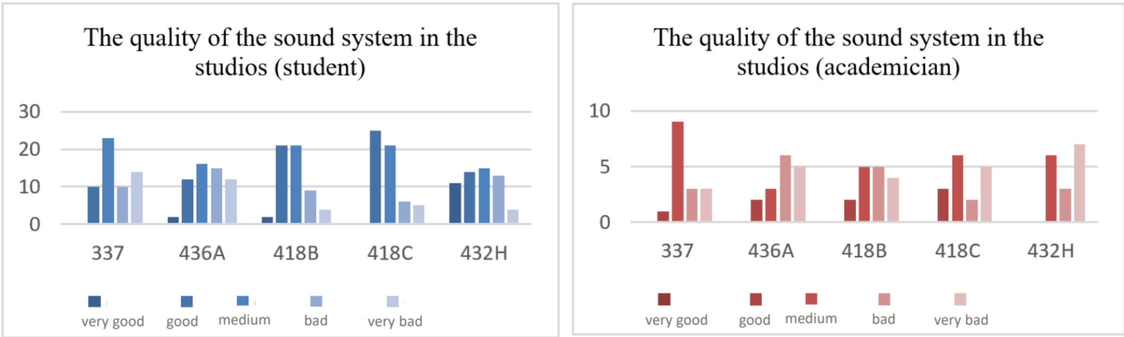

Figure 9. Students' and academicians' responses regarding the quality of the sound system of the studios (Created by authors)

The survey responses regarding temperature conditions in the studios indicated general dissatisfaction, with the majority of participants reporting a moderate level of discomfort. A comparison of temperature evaluations between students and academic staff revealed notable discrepancies. While students rated the temperature in Studio 418B as higher, academic staff rated the temperature in Studio 436A as more comfortable. Conversely, the temperature in Studio 337 was rated lower by academic staff compared to student assessments, whereas the relatively lower temperature evaluation for Studio 436A remained consistent across both groups. However, the overall class-based evaluation of thermal comfort within Studio 436A exhibited variability, suggesting differing perceptions among respondents (Figure 10).

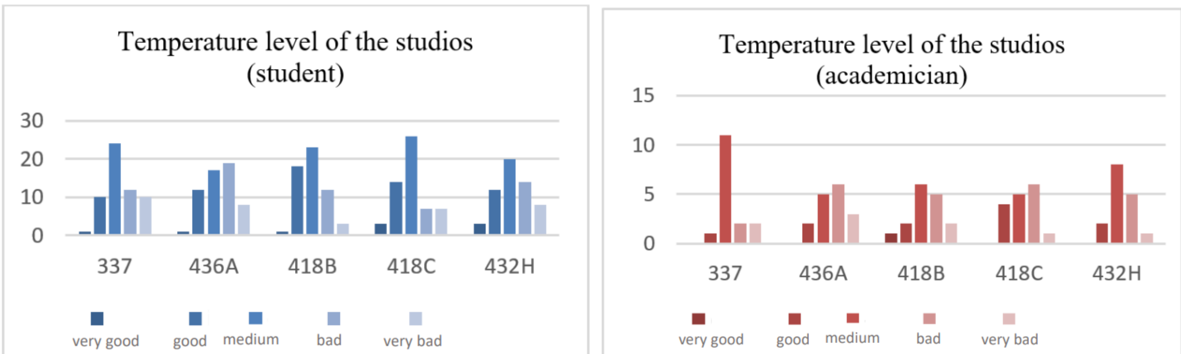

Figure 10. Students' and academicians' responses regarding the temperature level of the studios (Created by authors)

According to the survey results, students rated the noise level as high in Studio 432H and low in Studio 436A. Conversely, academic staff rated the noise level as high in Studio 436A and low in Studio 418C, indicating a divergence in perception between the two groups.

Responses regarding thermal comfort in the studios were generally assessed as poor or fair. When analyzed on a class basis, students rated the sound temperature level as high in Studio 418C and low in Studio 436A. In contrast, academics rated the temperature level in Studio 337 as high, while Studio

436A received a lower rating. Notably, the relatively lower heat level rating in Studio 436A remained consistent, whereas class-based evaluations of comfort demonstrated variability (Figure 11).

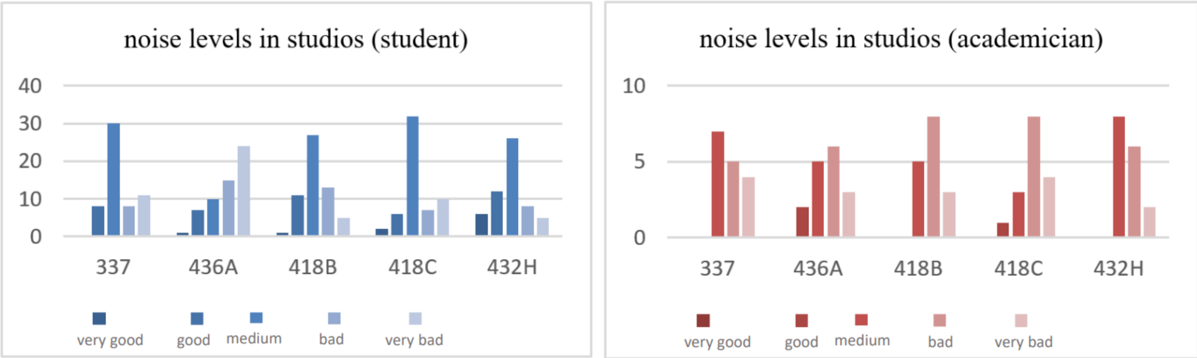

Figure 11. Students' and academicians' responses regarding the sound level of the studios (Created by authors)

The general assessment of natural and artificial lighting levels in the studios as moderate suggests that the positioning of window openings and the number of fluorescent lighting elements are adequate. Additionally, the skylights within the corridors and the glass-enclosed eastern façade of the building further contribute to this outcome. The high level of natural light within the spaces is directly attributed to the extensive use of transparent, permeable materials on the building's facades.

The low to moderate satisfaction levels regarding thermal comfort are presumed to result from challenges in manually controlling indoor temperature and the localized cooling effect of ceiling-mounted air conditioning units. Furthermore, the skylights in the corridors, the glass-covered corridors along the eastern façade, and the absence of terrace roofing have made thermal comfort regulation more challenging, contributing to the lower levels of user satisfaction.

The auditory comfort levels in the studios were found to be insufficient, as indicated by the predominantly poor or moderate ratings regarding the sound system and noise levels. This inadequacy is likely due to the conversion of corridor spaces into studios, which has compromised acoustic performance. Additionally, the cassette flooring system appears to have adversely affected overall sound quality, further diminishing auditory comfort.

This study is distinguished from existing research by its focused examination of the ergonomic needs of design studios, rather than conventional classroom environments. While many studies address general educational spaces, this research delves into the unique challenges faced by design studios, which serve as spaces for both creative and technical activities. Additionally, it includes the perspectives of both academic staff and students, providing a comprehensive analysis of various comfort conditions and their direct effects on the functionality of these specialized spaces. This approach offers valuable insights into how these environments can be optimized to enhance the productivity and well-being of both students and academic staff. This research offers important data for improving the effectiveness of these transformation processes within existing structures, while also emphasizing the pivotal role of ergonomic design in fostering better educational outcomes.

4. Discussion and Conclusion

In educational buildings, which require intensive use, spaces reconfigured to meet new functional demands must be designed in accordance with the functional, ergonomic, and comfort conditions essential for effective adaptive reuse. As emphasized by Kuru & Canbay Türkyılmaz (2019), conducting ergonomic assessments is crucial in determining the spatial, organizational, and functional quality of a building. This study revealed that several converted design studios failed to meet certain ergonomic conditions, particularly when repurposed with different functions.

An evaluation of spatial comfort in the analyzed studios demonstrated various challenges in spaces that had been adapted for use as design studios. The most significant issues observed in these converted areas include the remnants of former corridor elements, such as pre-existing sound systems and structural traces, which remain visible within the studio environment. Additionally, obstructions in visual connectivity between the blackboard and desks, along with narrow and elongated layouts, were found to negatively impact classroom communication and effective learning. In terms of circulation and desk ergonomics, a minimum transition distance of 60 cm between desks was determined to be sufficient. While inactive corridors allow for flexibility in circulation, the absence of enclosed wall surfaces prevents their alternative use for storage, such as cabinetry or shelving. The study underscores the potential utilization of inactive corridors for multifunctional purposes in future designs.

An assessment of studio equipment in relation to spatial comfort revealed that the heights of tables, chairs, boards, and power outlets were appropriate for the average anthropometric characteristics of students. However, ergonomically adjustable equipment, such as drafting tables with customizable height and angle settings, was identified as a more suitable alternative. Regarding visual comfort, the study found that improper window dimensions relative to the size and location of the classroom resulted in either excessive or insufficient natural light, both of which negatively impacted the learning environment. The quantity, placement, and size of windows, along with the ratio of open to closed surfaces, were found to have a significant influence on natural lighting conditions. Instead of relying on fluorescent-type artificial lighting, the study suggests utilizing bulbs with color temperatures closer to natural daylight, which would contribute to improved visual comfort.

In evaluating thermal comfort, the study observed that artificial climate control was primarily achieved through the use of ventilation grilles and air conditioners. However, difficulty in manually controlling air conditioning units was found to negatively affect thermal comfort levels. Additionally, an excessive number of window openings contributed to heat loss in winter and excessive heat gain in summer, further challenging temperature regulation within the studios.

The study identified several key acoustic challenges impacting auditory comfort in the design studios. It was found that cassette flooring contributed to sound transmission issues, particularly in the rear rows of classrooms. While limited window openings restricted natural light intake, they also prevented external noise intrusion, thereby offering a trade-off between visual and auditory comfort. Additionally, spatial noise generated by ventilation systems was found to increase indoor noise levels, thereby reducing acoustic comfort. Lastly, the depth of certain studios made it difficult for sound to reach the rear of the classroom, further exacerbating auditory comfort issues. It is evident that factors such as room location, dimensions, window placement, and ventilation design influence various ergonomic criteria in a complex and interrelated manner. The architectural structure of the building, its spatial organization, and its intended function play a determining role in ergonomic conditions.

Research on educational environments has demonstrated that classrooms with windows providing natural views positively influence student performance (Lassonde et al., 2012). Conversely, furniture that is not proportionate to body size can lead to postural discomfort (Mehrparvar et al., 2015), and improper seating arrangements can reduce student engagement (Hira, 1980). Learning environments have been shown to affect student participation, cooperation, and task orientation, while ergonomically designed furniture enhances on-task behavior, posture, core strength, and academic performance (Smith, 1998; Smith, Henning & Smith, 1994). Moreover, inadequate classroom design has been linked to a 10–25% decline in student performance (Caldwell, 1992). This study evaluates the positive and negative effects of ergonomic conditions in design studios, which serve as specialized learning spaces for architecture students. The findings highlight the importance of aligning studio design with anthropometric standards to support multifunctional and flexible usage in architectural education.

5. Recommendations

Existing research demonstrates that classroom environments can exert both positive and negative effects on learning activities and user experience. Thus, measuring comfort parameters, conducting user satisfaction surveys, and implementing effective modifications are essential for enhancing academic performance and user well-being.

This study contributes to the academic discourse by thoroughly examining the ergonomic conditions of design studios, addressing a gap in the existing literature. It emphasizes the importance of ergonomic design in optimizing educational environments, particularly in design studios, which must accommodate both creative and technical activities. By offering practical recommendations, this research seeks to enhance productivity for both students and academic staff.

Additionally, the study underscores the necessity of integrating ergonomic considerations into educational settings where functional modifications and spatial transformations frequently occur. It highlights the need to optimize design studios for multifunctional use, providing valuable insights for future architectural design practices and improvements in educational environments.

Acknowledgements and Information Note

The article complies with national and international research and publication ethics. Since the survey was conducted in 2018, ethics committee approval is not required.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

References

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2010). Thermal Environmental Conditions for Human Occupancy, American Society Of Heating, Ventilating and Air-conditioning Engineers, Atlanta. (ASHRAE, ANSI/ASHRAE Standard 55-2010).

Arpacıoğlu, Ü. (2012). Mekânsal kalite ve konfor için önemli bir faktör: Günışığı, *Mimarlık Dergisi*, 2012, (368), 48-52.

Bilmez, D. H., Çelik, K., Diri, C. & Arpacıoğlu, Ü. (2022). Evaluation of architectural workshops in terms of acoustic comfort conditions: YADYO workshop example of Çukurova University Department of Architecture. *Journal of Architectural Sciences and Applications*, 7 (2), 852-870. doi: https://doi.org/10.30785/mbud.1153583

Building Bulletin 101. (2006). Ventilation of School Buildings, Regulations, Standards, Design Criteria, Version 1.4.

Caldwell, B. J. (1992). The Principal as Leader of the Self-managing School in Australia, *Journal of Educational Administration,* Vol. 30 No. 3. doi: https://doi.org/10.1108/09578239210014289

Dinçer, H. (1978). İnsanda Enerji Kullanımı ve Karşılanması. MPM Ergonomi Eğitim Programı, Kasım, Ankara.

Edholm, O. G. (1980). Çalışma İlmi (Ergonomie), (Çev. Sacid Adalı). İstanbul: Sakarya D.M.M. Akademisi Yayınları.

Grandjean, E. (1967). Précis d'ergonomie. Presses Academiques Europeenes.

Hira, D. S. (1980). An ergonomic appraisal of educational desks. *Ergonomics,* 23, 213–221. T.J.

International Organization for Standardization (2005). Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (ISO Standard No. 7730:2005). Access Address (30.06.2024): https://www.iso.org/standard/39155.html

İşeri, A. & Arslan, N. (2009). Estimated anthropometric measurements of Turkish adults and effects of age and geographical regions. *International Journal of Industrial Ergonomics*, 39(5): 860–5.

Kızılörenli, E. & Tokuç, A. (2022). Parametric optimization of a responsive façade system for daylight performance. *Journal of Architectural Sciences and Applications,* 7 (1), 72-81. doi: https://doi.org/10.30785/mbud.1038768

Kuru, R. & Canbay Türkyılmaz, Ç. (2019). Kütüphane yapılarının mekânsal organizasyonunun ergonomik açıdan değerlendirilmesi: Bahçeşehir Üniversitesi Kütüphane binası örneği. *Ergonomi*. 2(3), 153–166. doi: 10.33439/ergonomi.481138

Lassonde, K. A., Gloth, C. A. & Borchert, K. (2012). Windowless classrooms or a virtual window world: Does a creative classroom environment help or hinder attention?, *Teaching of Psychology,* 39(4), 262–267. doi: https://doi.org/10.1177/0098628312456618

Laville, A. (1976). I'Ergonomie. PUF Paris.

Mehrparvar, A. H., Mirmohammadi, S. J., Hafezi, R., Mostaghaci, M. & Davari, M. H. (2015). Static anthropometric dimensions in a population of Iranian high school students: Considering ethnic differences. *Human Factors*, 57(3), 447–460. doi: https://doi.org/10.1177/0018720814549579

Savanur, C. S., Altekar C. R. & De, A. (2007). Lack of conformity between Indian classroom furniture and student dimensions: proposed future seat/table dimensions. *Ergonomics*, 50:10, 1612–1625. doi: https://doi.org/10.1080/00140130701587350

Smith T. J. (1998). Context specificity in performance – the defining problem for human factors/ergonomics. In Proceedings of the Human Factors and Ergonomics Society 42nd annual meeting (pp. 692–696). Santa Monica, CA: Human Factors and Ergonomics Society.

Smith, T. J., Henning, R. H. & Smith, K. (1994). Sources of performance variability. In Salvendy G., Karwowski W. (Eds.), Design of work and development of personnel in advanced manufacturing (Chapter 11, pp. 273–330). New York: Wiley.

Temel, S. C. & Canbay Türkyılmaz, Ç. (2018). Geleneksel Safranbolu Evi'nin işlevsel dönüşümünde ergonomik tasarım faktörlerinin değerlendirilmesi: Curtlar evi örneği. *Ergonomi,* 1(3), 163-175.

Toka, C. (1978). İnsan-Araç Bağıntısında Ergonomik Tasarım İlkeleri. İ.D.G.S.A Yayın No: 73.

Turkish Standards Institution (2011). Light and lighting - Basic terms and criteria for specifying lighting requirements (TSE 12665:2011).

Yapıcı, F. & Baş, H. (2015). Verimlilikte ergonomik faktörler. *Süleyman Demirel Üniversitesi Mühendislik Bilimleri ve Tasarım Dergisi,* 3(3), ÖS: *Ergonomi,* 2015, 591-595, 2015 ISSN: 1308-6693

Yurdakul, S. (2018). İç Mekân Kalitesi Parameteleri ve Ölçümleri, Meksis Sunum. Access Address (30.06.2024): https://meksis.gov.tr/sayfa.aspx?ID=22

Zandvliet, D. B. & Straker, L. M. (2001). Physical and psychosocialaspects of the learning environment in information technology rich classrooms. *Ergonomics,* 44:9, 838-857. doi: 10.1080/00140130117116