Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri

Vol. 10, No. 1, 2024

Design of Ergonomic Lesehan Chair to Minimize Musculoskeletal Disorder When Carrying Out Student Learning Activities in Confined Spaces

Nabila Ratu Nisrina[1], Andrianto[2], Ica Ramawisari[3]
[1,2,3)] Program Studi Sarjana Desain Produk Fakultas Industri Kreatif, Universitas Telkom, Bandung
Email: nabilaratunisrina@student.telkomuniversity.ac.id, andriantoandri@telkomuniversity.ac.id, ramawisari@telkomuniversity.ac.id

ABSTRACT

The increasing population has an impact on limited land, especially boarding houses for students. The room size for residential boarding houses is limited so that supporting facilities such as tables and chairs are readjusted. Lesehan tables are often used as furniture options for most student boarding houses, due to their simple shape and affordable prices. However, this is not supported by the ability of the lesehan table to accommodate the ergonomic needs of the user's sitting, which if it lasts long and repetitive will result in musculoskeletal disorder. Therefore, the design of ergonomic lesehan chairs is needed for student productivity and health. The research method used is a mix method starting with direct observation of boarding houses around Bandung, literacy studies related to ergonomics, anthropometry and sitting on the floor. The design method is UCD where the user's problems are solved by prioritizing their needs. The results obtained with this design can reduce pain in several parts of the body, can support student learning productivity and to minimize musculoskeletal disorder.

Keywords: Lesehan chair, musculoskeletal, ergonomics

Introduction

The more the times develop, the more the population of its residents, based on data from the Central Statistics Agency of Bandung Regency, the population of the city of Bandung reaches 3,623,790 people and for student groups and students in the city of Bandung reaches 544,300 people. The more population the land area is, the narrower the land area, with the limited land available, housing with a narrow space is one of the solutions that can be applied and the type of furniture that is suitable to support comfort and productivity, both simple and minimalist [1], [2]. Especially boarding houses which are usually chosen as temporary residences by students. Boarding house housing is a type of vertical housing, where tens or even hundreds of rooms are provided in a limited land so that the area of the room provided is also very limited. According to Amril (1997), a standard size bedroom in the United States (U.S.) has a minimum area of 7.43 m2 with the shortest side size of 2,438 m. However, in practice, many boarding house sizes in Indonesia do not meet U.S. standard sizes due to the narrowness of land owned by boarding house owners. Based on the results of the field survey, boarding houses in the Bandung area have an average area of 2 x 3 meters, 3 x 3 meters, 3.5 x 3 meters and 3 x 4 meters, most of which are facilitated by private bathrooms, cabinets, mattresses and lesehan tables [3]–[5].

Lesehan table is cheap and simple furniture to make it easier for users to do activities such as studying. The need for lesehan table facilities is fairly high, this is reflected through the high demand in online stores where data was obtained on November 20, 2022 on the online shopping platforms Tokopedia and Shopee, it can be calculated that one online store can sell an average of 20-200 units of lesehan tables per month. It's just that based on existing data, the lesehan chair as a means of complementing the lesehan table on the market is still few that accommodate based on Indonesian anthropometry while the product must adjust to the human being, not the other way around. In carrying out learning activities in the lesehan position (sitting on the floor) humans will be in that position for a long period of time and continue to repeat every day, if not facilitated with the right lesehan chair, it will have an impact on musculoskeletal health [6]–[8].

According to Ulfa (2017), Musculoskeletal or Skeletal or also commonly referred to as the skeletal system is composed of bones where the human body consists of 206 bones. The most important bone part is the spine because the spine functions as a support for the shape of the human body. Musculoskeletal Disorder (MSD) is a disorder or damage that affects the musculoskeletal system of the human body, especially in bones, tendons, joints, ligaments, cartilage, nerves, and blood vessels. These injuries can occur due to repetitive movements, pressure or force, and vibration on the human body during certain work activities. Symptoms of musculoskeletal disorder related to learning activities can be observed in the workplace when there is a difference between the physical capacity of the human body and the physical requirements of the task. MSDs can be associated with activity and working conditions, and can contribute significantly to the development of the disorder.

The World Health Organization (WHO) is aware of this condition resulting in pain and functional disorders that affect the neck, shoulders, elbows, forearms, wrists, and hands [9]–[12].

The relevance of MSD disorders is reported to continue to increase at young productive age and is stated to be the highest contributor to disability globally and decreased productivity [13]–[17]. In a sitting position while studying for a long time and repeatedly, pain complaints in this position often appear in muscle tissue as well as joints ranging from mild to severe. If the posture or posture of sitting while learning puts a load on the body but is not prevented, it will cause MSD condition. Not only starting to improve sitting posture but supporting products such as chairs must also adjust to human needs, in the lesehan sitting position this time if the lesehan chair is not safe and comfortable, the posture and human skeleton will experience permanent distortions in body shape health.

Based on Hedge [18]–[22] in the book Ergonomic workplace design for health, wellness, and productivity, ergonomics focuses on the study of humans applied to furniture design to fit people at work, school, or home, so that it is more comfortable, less stressful, and can achieve higher productivity. Creating a good ergonomic design for safe learning and working activities is essential to maximize worker performance and minimize the risk of musculoskeletal injury. The lesehan chair must meet specifications such as being able to support the user's load, good durability, according to body size, stable, and have the right parts or features for user safety and comfort. As already explained, the author has the idea to design an ergonomic lesehan chair to support the human body as best as possible, including considerations such as posture, comfort, support, and health [23]–[27].

Research Methods

This study uses a mixed method, where this design requires data collection and analysis with a combination of qualitative and quantitative. This method aims to collect data, analyze data, interpret evidence. Mixed method is a research approach that combines qualitative and quantitative forms. This approach involves philosophical assumptions, the application of qualitative and quantitative approaches, and the mixing of the two approaches in a single study [28][29], [30]. In the qualitative method, the researcher conducted literature observations in the form of books, journals, and articles about MSD, furniture, and ergonomics to strengthen the foundation of this design and research. For the quantitative method, the researcher distributed the questionnaire to target users according to the age range, namely late adolescence (17-25 years old), the purpose of this questionnaire was to find out the size of the room, the duration of learning, and complaints when carrying out learning activities in a lesehan attitude. The hope to be obtained is that this lesehan chair can support productivity and minimize MSD injuries when carrying out learning activities. The data collection technique is carried out in several stages, namely direct observation by documenting the condition of the Indekos rooms around Bandung, the condition and size of the lesehan table used as well as looking at various designs of lesehan chair products on the market. Furthermore, the initial questionnaire and Nordic Body Map (NBM) were disseminated, after which the author conducted interviews with several prospective users of the research object, and the author used the theoretical foundation based on literature as facts and general descriptions as research support. After the author obtained data based on the results of observations, questionnaires, and documentation, then the author combined the results from the source by comparing the observation data and the results of the questionnaire of the respondents for the design parameters. The design method in this product design uses the user-centered design (UCD) method which is a design method centered on potential users [31]–[38].

Results and Discussion

Results of *the Nordic Body Map* (NBM) Questionnaire

The NBM questionnaire is one of the measuring tools used to find out the parts of the muscles that experience complaints ranging from discomfort (somewhat painful) to very painful. There are 27 parts of the human body in this questionnaire, where respondents will choose the score of pain experienced in the limb.

Note:

a. 152 respondents filled out this questionnaire where they had done learning activities in a lesehan attitude without being facilitated by any sitting mats, carried out in a minimum duration span of 30 minutes.
b. Learning activities include activities: reading, writing, and typing.

Score Description:

A = Not Sick
B = Quite Sick
C = Painful
D = Very painful

Table 1. NBM Questionnaire Results

No.	Location	Grade Of Complaints			
		A	**B**	**C**	**D**
0	Upper Neck	42	61	37	12
1	Lower Neck	12	68	50	22
2	Left Shoulder	55	61	28	8
3	Right Shoulder	46	63	33	10
4	Left Upper Arm	97	39	15	1
5	Back	7	38	59	48
6	Right Upper Arm	85	56	9	2
7	Waist	3	46	69	34
8	Buttock	18	56	53	25
9	Bottom	18	57	51	26
10	Left Elbow	100	38	14	0
11	Right Elbow	92	46	12	2
12	Left Lower Arm	104	43	5	0
13	Right Lower Arm	98	46	5	3
14	Left Wrist	103	39	9	1
15	Right Wrist	82	56	11	3
16	Left Hand	125	20	7	0
17	Right Hand	99	40	10	3
18	Left Thigh	89	48	11	4
19	Right Thigh	90	47	10	5
20	Left Knee	73	55	21	3
21	Right Knee	75	54	19	4
22	Left Calf	96	33	17	6
23	Right Calf	93	35	16	8
24	Left Ankle	89	38	23	2
25	Right Ankle	96	31	20	5
26	Left Foot	116	20	14	2
27	Right Foot	117	20	12	3

Conclusion	It can be concluded that the parts of the body with the highest pain complaints (B, C, D) are in the parts of (0) upper neck, (1) lower neck, (2) left shoulder, (3) right shoulder, (5) back, (7) waist, (8) buttock, (9) bottom. So the focus of designing the lesehan chair is to minimize the pain and potential of MSD experienced at the point of body parts (0), (1), (2), (3), (5), (7), (8) and (9).
Potential Disruption	1. Referred Back Pain: Pain is felt in the lower back and in the groin, buttocks and upper thigh area and rarely below the knee. Pain can vary from constant ordinary pain to sudden sharp sensations (Flex Free, 2016). 2. Axial Back Pain: Back pain is limited to the lower back area. Unlike other lower back pains, this type of pain is not felt all the way to the buttocks, thighs and legs, or other areas of the body. Pain that gets worse in certain positions, for example sitting for a long time (Flex Free, 2016). 3. Radicular Back Pain *:* Radicular back pain often arises as a result of pinching/inflammation/injury to the spinal cord and is usually triggered by certain activities and positions, such as sitting or walking. The pain is felt in the back of the leg up to the calf or leg. Directly all the way from the

specific nerve roots of the spine. Radicular back pain is accompanied by muscle weakness, numbness, tingling and loss of reflexes (Flex Free, 2016).

4. *Impingement:* Inflammation of the shoulder tendon, which is caused by the pinching of the shoulder muscle tendon due to certain movements performed repeatedly or due to a trauma, resulting in one of the shoulder movements being disrupted (Flex Free, 2023).
5. Neck Muscle Tension: can occur due to doing certain activities for a long period of time, and sitting for a long time can make the neck and shoulder muscles painful. This can cause the muscles in the neck to become weak. If the neck muscles are weak, it can cause the neck joints to become stiff and have difficulty moving the neck (Flex Free, 2022).

Source: Author Data

Needs Description Study

In designing a lesehan chair, various needs are needed to form a complete design. Starting from materials, shapes, functions, systems, colors, and many others.

Lesehan Chair Parameters

Table 2. Lesehan Chair Parameters

No.	Part	Description	Detail
1.	Chair Frame 	The chair frame functions as the main support for the body when sitting and other complementary parts of the chair such as *cushions* (seat and sender).	- The seat frame uses iron material. - The sender can *be adjusted to the recline level* . - There is a sender support when changing *the recline level* . - *Foldable Frame* when *cushion* is removed.
2.	Seat *Cushion* 	Seat *Cushion* is a padded part of the seat and its purpose is for the comfort of the buttocks, hips, and thighs.	- The seat *cushion* must have sufficient thickness - The seat *cushion* must be higher than the seat frame so that the *coccyx* (tailbone) does not hurt. - The seat *cushion* must *support the shape of the* user's *hips and buttocks* in a sitting position. - The material must be soft, solid, not sultry and comfortable. - The seat *cushion* can be detached and washed (*attach-detach & washable*).
3.	Back *Cushion* 	It is a soft part for the seat backrest, functioning for the comfort of the spine, especially *the intervertebral discs*, shoulders and neck.	- It must *support* the ideal shape of the spine. - The material must be soft, solid, not sultry and comfortable. - Can be detached and washed (*attach-detach & washable*).
4.	Iron Material	Iron is a sturdy, easy-to-obtain material and free to be created with welding techniques. The disadvantages are quite heavy.	- The material is strong and able to withstand body weight for a long time. - Maintenance is quite easy.

			
5.	Cushion fabric color 	Color has a meaning and psychological impact on humans. Therefore, as a designer, choosing colors is one of the important aspects for the function and aesthetics of the product.	- The brown color provides a feeling of warmth, comfort, and security. Chocolate is often described as natural, grounded.

Source: Author Data

Chairs have their own criteria, according to *the book Ergonomic workplace design for health, wellness, and productivity (2017)* the following are some of the chair requirements summarized from ANSI HFES 100 of 2007 ***(****Chair Requirements Summarized from ANSI HFES 100)* which have been adjusted for the needs of chair design:

Table 3. Office Chair Standard by ANSI HFES 100

Items	Requirements
Chair	- Must have lumbar (spine) support - Must have a *recline* backrest (can lean or lie down in a relaxed position with your back supported). - Must have a seat that can be adjusted in height and tilt. - Must support at least one of the other two sitting reference postures in addition to the upright sitting posture. - Must provide support to the user's back and thighs in the selected reference posture.
- **Seat pan and *backrest adjustment***	- It must be able to adjust the height. - It should have an adjustment for the slope.
- ***Backrest***	- The user's body should not be restricted to a position in front of the vertical. - It must allow for angle adjustment between the backrest and the seat pan to an angle of 90° or greater. - Must allow the user to lie down at least 15° from the vertical.
- **Width of the seat base**	- Must be at least 45 cm wide.

Terms Of Reference (TOR)

a. Design description: Lesehan chair products are designed to facilitate student learning activities in narrow spaces, especially boarding houses in the Bandung area, where most of them use lesehan type tables. Due to the less than ideal environment and position, this lesehan chair has the function of minimizing Musculoskeletal Disorder (MSD).
b. Design limitations: Target users of male and female students with an age range of 17-25 years (late advence), Lesehan chairs use the Indonesian anthropometric data bank., Lesehan chairs can only be used in a lesehan sitting position.
c. Design considerations: The lesehan chair is used when indoors, The design of this lesehan chair focuses on learning activities, The ergonomic aspect is prioritized in the design, This lesehan chair can only be used by 1 person.

Anthropometric Size

Table 4. Anthropometric Dimension Size 17-25 Years

Dimension	Information	5%	50%	95%
D1	Height	149.67	164.95	180.24
D5	Hip Height	86.29	96.01	105.67
D8	Height in sitting position	66.85	86.86	106.87
D10	Shoulder height in a sitting position	47.21	61.02	74.83

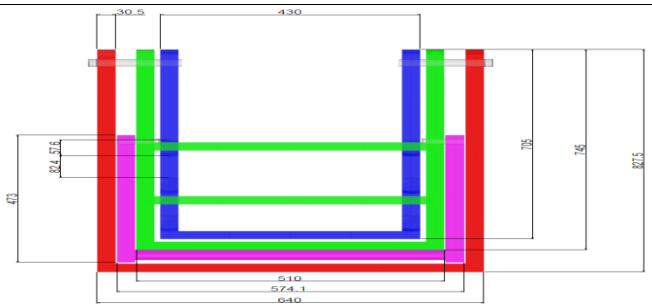
D17	Shoulder width	32.97	41.88	50.79
D18	Upper shoulder width	25.37	34.28	43.2
D19	Hip Width	25.62	36.11	46.59
D22	Upper arm length	22.13	37.17	52.21
D23	Length of forearm	34.03	42.81	51.6
D26	Head length	15.87	19.02	22.17
D27	Head width	13.06	15.79	18.53
D30	Leg Length	20.96	24.73	28.51

Source: antropometriindonesia.org

The following is data on the size of each percentile, where 5% is a low percentile (small), 50% is a medium percentile (medium), and 95% is a high percentile. According to Putra, in the Tempo.co article in 2023, Indonesia was named as the country with the lowest average population height, which is 62.2 inches or 157.98 centimeters. Therefore, the 50% percentile is ideal for use in designing because it already includes the average size.

Lesehan Chair Size

Table 5. Lesehan Chair Size



No.	Part	Size (mm) W x L
1.	Seat Base Frame	827.5 x 640
2.	Senderan frame (*back rest*)	745 x 510
3.	Senderan Buffer	473 x 574.1
4.	Senderan Level (*recline*)	705 x 430
5.	Frame Thickness	30.5
6.	Distance Between Holes	82.4
7.	Hole Size	57.6

Source: Author Data

Determining the Color of the Lesehan Chair

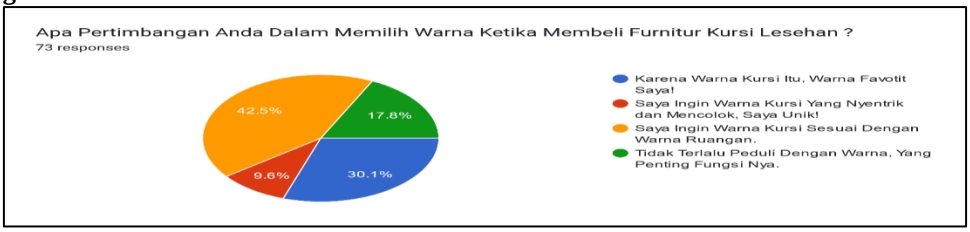


Figure 1. Diagram 1: Presentation of Considerations for Choosing the Color of the Lesehan Chair
Source: Author Data

As many as 42.5% chose the color of the furniture of the lesehan chair for the reason that it matched the color of the room they owned. 30.1% for the reason of their favorite color, 17.8% do not care much about the color of the lesehan chair, the most important thing is that the function for the needs is fulfilled and the remaining 9.6% like unique colors because they want to be different from others.

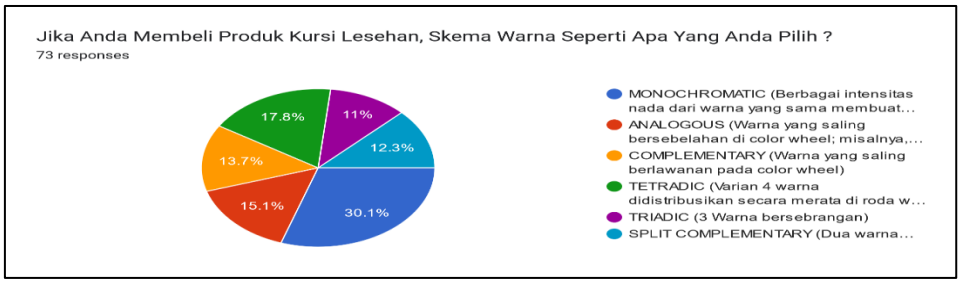


Figure 2. Diagram 2: Presentation of Interest *of Selected* Color Scheme
Source: Author Data

30.1% of respondents liked *monochromatic* colors, 17.8% liked *tetradic* colors, *15.1% liked* analog colors, *13.7% liked* complementary colors, *12.3% liked* split complementary, *and 11% liked* triadic *colors Colors that appear closer to the red end of the visible spectrum are said to be warm*) while colors that appear closer to the blue tip are said to be cold (Bailey, Reynold J., Grimm, Cindy M., Davoli, Chris, 2006). To determine the type of color group between *warm* and *cold*, the following results are obtained:

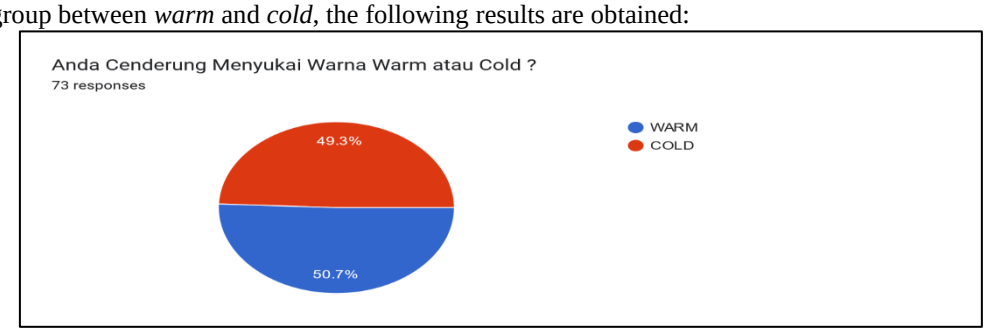


Figure 3. Diagram 3: Presentation of Interest of *Warm* and *Cold Color Groups*
Source: Author Data

Results were obtained with a fairly narrow difference, 50.7% liked warm colors and 49.3% liked cold colors. Backed up by data according to (Bailey, Reynold J., Grimm, Cindy M., Davoli, Chris, 2006) It is generally observed that warmer colors tend to appear more preferable to humans than cooler colors.

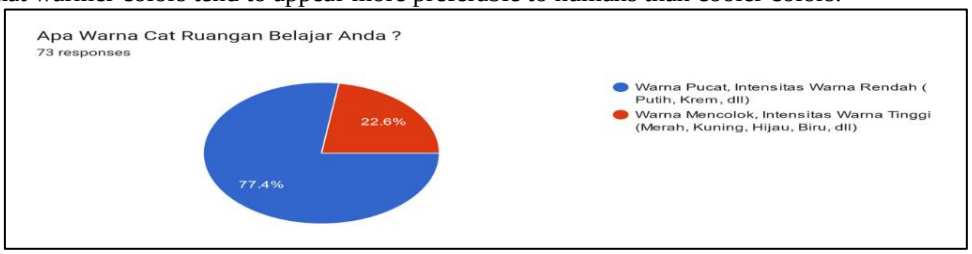


Figure 4.Diagram 4: Presentation of the Colors of the Study Room Used
Source: Author Data

Data was obtained as many as 77.4% used low-intensity paints, pale colors such as beige and white, the remaining 22.6% used paints with high color intensity such as red, yellow, blue, and green. Therefore, it can be concluded that the majority of students have pale room colors (white and beige), tend to like *warm* colors with *a monochromatic* scheme with considerations based on the type of lesehan chair furniture color according to the color of the room they have. Here are five warm color options with a monochromatic color scheme:

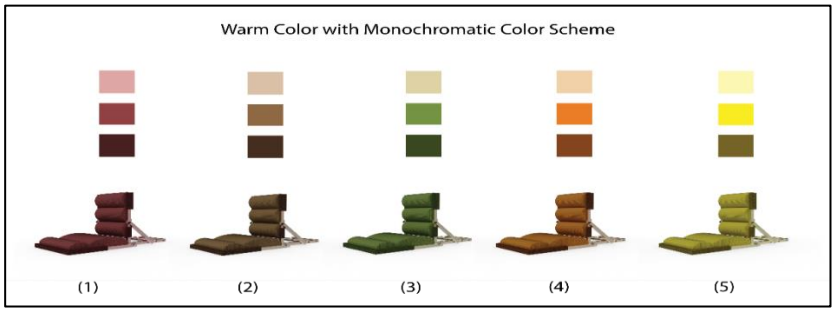


Figure 5. Warm color options with *a monochromatic scheme*
Source: Author Data

Based on the results of the analysis and discussion, the color of the second (2) seat was chosen because brown is considered neutral and natural. In addition to matching the color of white and beige walls. On the psychological side of color, brown is considered to evoke feelings of warmth, peace, and earthiness. Brown is able to convey emotions related to nature, as well as connoting organic and healthy feelings in general (Adobe, 2023).

Ideas and Sketches

An important stage in a design is to pour ideas into the form of writing or pictures.

Mind Mapping

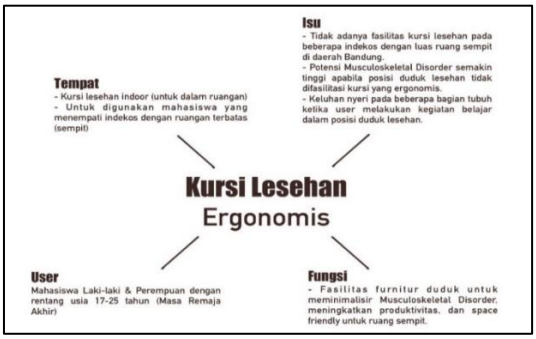


Figure 6. ***Mindmap***
Source: Author Data

Based on the image above, it can be concluded that the design of the lesehan chair is based on issues in the field, potential health distortions that will arise, and pain problems felt by users when learning in the lesehan position.

Mood Board

Figure 7. ***Mood Board***
Source: Author Data

The mood board above is made to describe the function, material, color, function and aesthetics that are to be achieved in the design of the lesehan chair later. *The mood board* serves as a representation of ideas that were initially still random to become more *detailed*. So that a product can be developed based on *a mood board*.

Image Chart

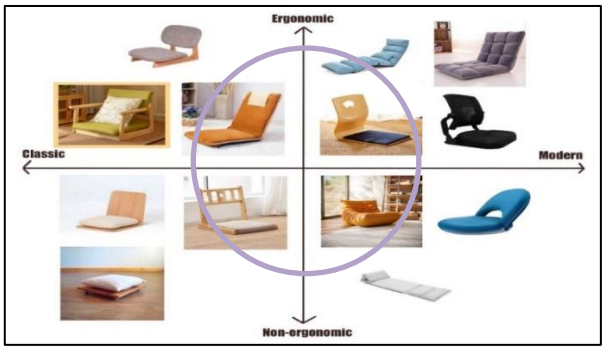


Figure 8. Image Chart
Source: Author Data

The image chart is made to determine the position of the product placement with the aim of design development, the direction of the design concept to be achieved in *this image chart* is that the lesehan chair product is between *classic-modern* and ergonomic.

Sketch

Sketch of Chair Frame

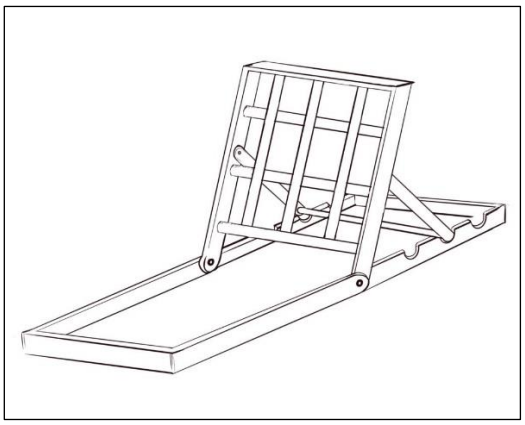


Figure 9. Sketch of Chair Frame 1
Source: Author Data

Sketch 1 was made because the design looks more classic, sturdy, and *simple*. However, it has a disadvantage, namely the size and thickness of the iron is too thin and may be very heavy.

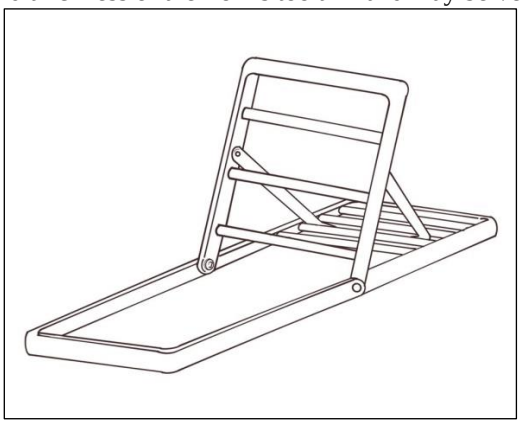


Figure 10. Sketch of Chair Frame 2
Source: Author Data

Sketch 2 was made because the design looks neater and *simpler*, the support level is made of ordinary partitions to make it easy to use. However, it has a disadvantage, namely the possibility that the frame is difficult to fold and heavy.

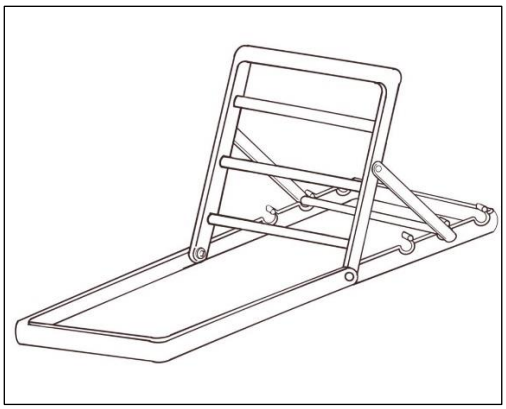


Figure 11. Sketch of Chair Frame 3
Source: Author Data

Sketch 3 is made differently at the level of the support, made undulating so that the sender is sturdy, but the weakness is that the frame may be difficult to fold.

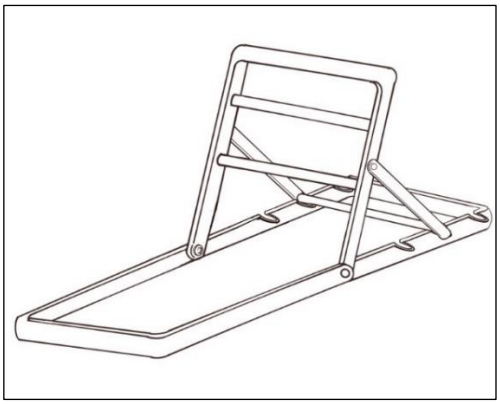


Figure 12. Sketch of Chair Frame 4
Source: Author Data

The sketch of the seat frame 4 was chosen as the final sketch with the consideration of a *foldable frame*, the design of the support hole is more sturdy and safe, the sender level is made (*Fouler* 90° to *Semi Fouler* 30° - 45°), the weight of the iron is slightly reduced.

Cushion Sketch

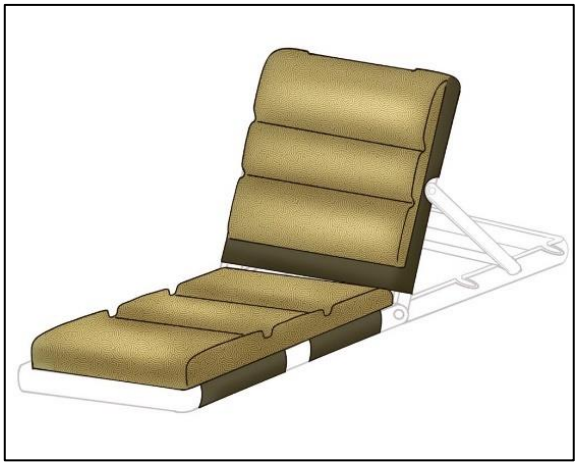


Figure 13. Sketch *of Chair Cushion* 1
Source: Author Data

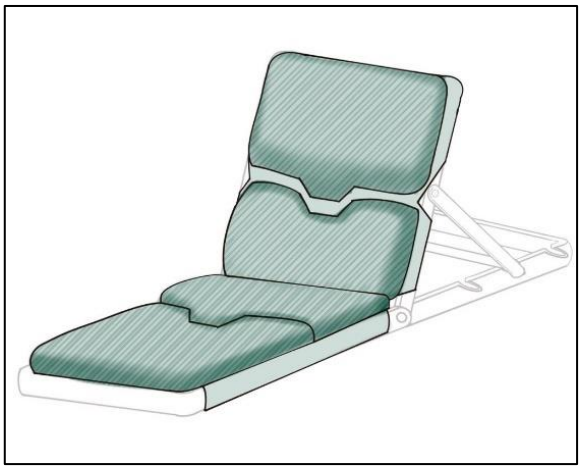


Figure 14. Sketch *of Cushion* Chair 2
Source: Author Data

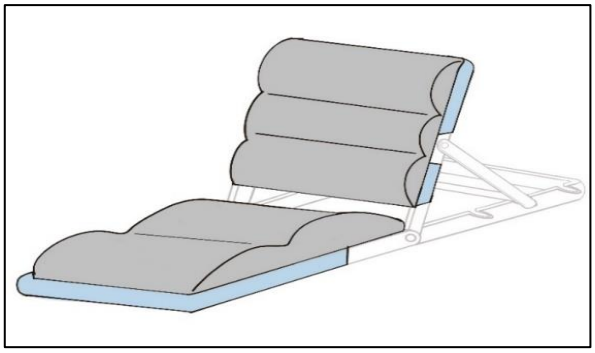


Figure 15. Sketch *of Chair Cushion* 3
Source: Author Data

The final cushion design was obtained as a sketch of the 3rd design, with consideration of the sender part in the 3-wave design so that it can support and not be easily sore and painful in the part (Neck, back and waist: *sacral, lumbar, thoracic, cervical*. Shoulder: *scapula*), the seat part in the design of 2 waves of different sizes. The largest size: the *coccyx* (tailbone) and buttocks are above floor level so that they are not easily sore and sore. Smallest size: so that when sitting in a sitting, the legs (thighs, calves, ankles) are not easily sore and sore

Technical Drawings

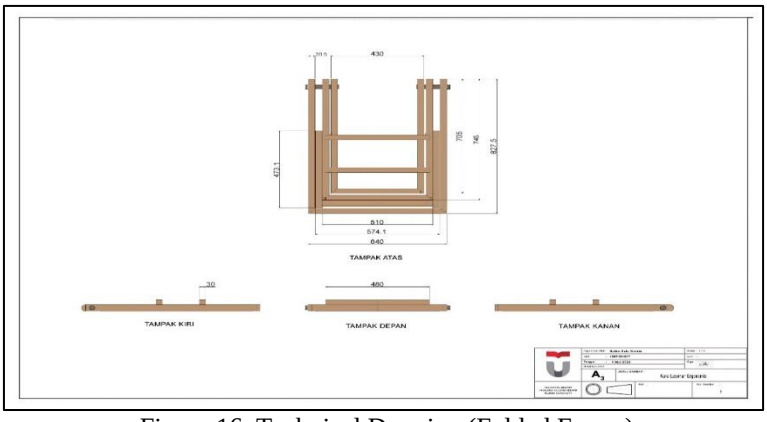


Figure 16. Technical Drawing (Folded Frame)
Source: Author Data

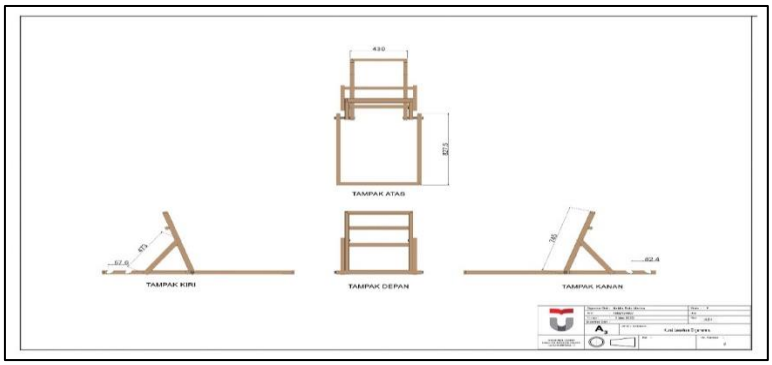


Figure 17. Technical Drawing (Open Frame)
Source: Author Data

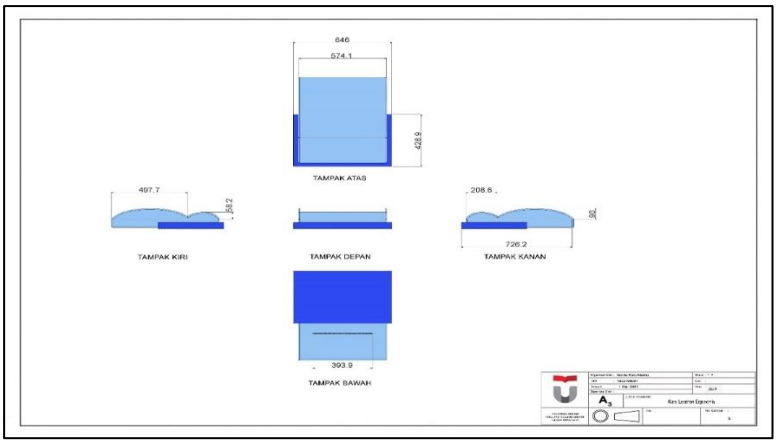


Figure 18. Technical Drawing (Cushion Holder)
Source: Author Data

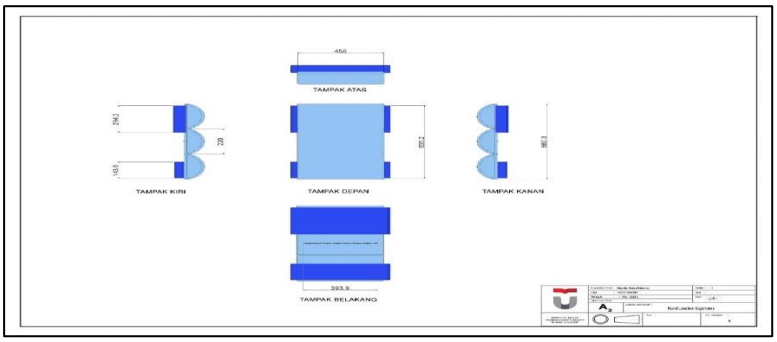


Figure 19. Technical Drawing (Senderan *Cushion*)
Source: Author Data

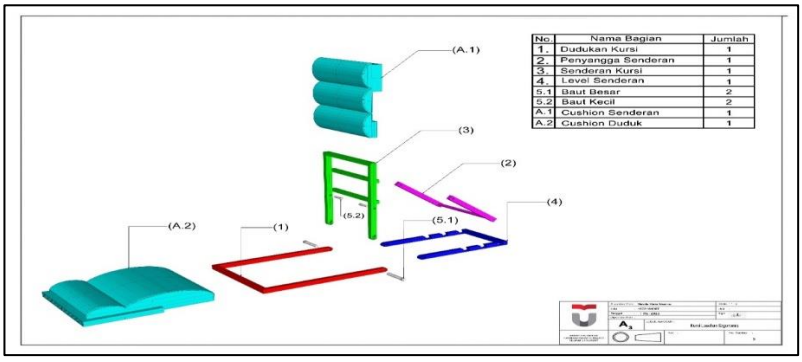


Figure 20. Exploded View
Source: Author Data

Figure 21. Perspective Images
Source: Author Data

3D Rendering

Figure 22. Rendering Chair 1
Source: Author Data

Figure 23. Rendering Chair 2
Source: Author Data

Operational Images

Figure 24. Operational Pictures of Lesehan Chair
Source: Author Data

Prototype Results

Figure 25. Lesehan *Chair* Prototype Results
Source: Author Data

Validation Results

The following are the results of the validation *of the prototype* of the lesehan chair (*90° fouler position*) which was tested on 15 respondents for 30 minutes, with scoring using a likert scale (1 – 5) in several aspects. The types of activities in this experiment are in the form of:

1. **Reading** (book 'Personality Based on MBTI', 10 minutes).
2. **Writing** (summarizing a few pages on paper in the book 'Personality Based on MBTI', 10 minutes).
3. **Typing** (summarizing a few pages in docx on the book 'Personality Based on MBTI', 10 minutes).

Table 6. Lesehan Chair Validation Results

Likert Scale Caption				
1	**2**	**3**	**4**	**5**
Strongly disagree	**Disagree**	**Nertal**	**Agree**	**Strongly Agree**
Validation Results				
Information:				
LA:	Upper Neck			
LB:	Lower Neck			
BKN:	Right Shoulder			
BKR:	Left Shoulder			
ALSO:	Back			
PIN:	Waist			

	PAN:	Buttocks
	PIP:	Butt Cheeks
"Is the Lesehan Chair comfortable to use (name of body part)?"		
RESULT	**Read**	LA: 53.3% Agree, 13.3% Strongly Agree, 33.3% Neutral LB: 46.7% Agree, 20% Strongly Agree, 33.3% Neutral BKN: 53.3% Agree, 46.7% Strongly Agree, 0 Neutral BKR: 53.3% Agree, 46.7% Strongly Agree, 0 Neutral EVEN: 80% strongly agree, 20% agree, 0 neutral PIN: 53.3% Agree, 46.7% Strongly Agree, 0 Neutral PAN: 66.7% Agree, 33.3% Strongly Agree, 0 Neutral PIP: 66.7% Agree, 33.3% Strongly Agree, 0 Neutral
	Write	LA: 53.3% Agree, 13.3% Strongly Agree, 33.3% Neutral LB: 46.7% Agree, 20% Strongly Agree, 33.3% Neutral BKN: 60% Agree, 40% Strongly Agree, 0 Neutral BKR: 60% Agree, 40% Strongly Agree, 0 Neutral PUN: 66.7% Strongly Agree, 33.3% Agree, 0 Neutral PIN: 66.7% Agree, 33.3% Strongly Agree, 0 Neutral PAN: 80% Agree, 20% Strongly Agree, 0 Neutral PIP: 80% Agree, 20% Strongly Agree, 0 Neutral
	Typing	LA: 53.3% Agree, 13.3% Strongly Agree, 33.3% Neutral LB: 46.7% Agree, 20% Strongly Agree, 33.3% Neutral BKN: 60% Agree, 40% Strongly Agree, 0 Neutral BKR: 60% Agree, 40% Strongly Agree, 0 Neutral PUN: 66.7% Strongly Agree, 33.3% Agree, 0 Neutral PIN: 66.7% Agree, 33.3% Strongly Agree, 0 Neutral PAN: 80% Agree, 20% Strongly Agree, 0 Neutral PIP: 80% Agree, 20% Strongly Agree, 0 Neutral
Conclusion		It can be concluded based on the results of the validation above that in all parts of the body complained of, the soreness / pain is greatly reduced, but in the Upper Neck (LA) and Lower Neck (LB) parts further development of the cushion design of the lesehan chair is needed.

Source: Author Data

Conclusion

Based on the results of the design that has been carried out, it can be concluded that the design of ergonomic lesehan chair products in the background is due to the unavailability of lesehan chair facilities in most boarding houses around Bandung. The research method uses a mix method with literature observation and questionnaire results. The design of the lesehan chair product was carried out by prioritizing aspects of ergonomics, anthropometry, biomechanics and the results of the nordic body map questionnaire. The specifications of this lesehan chair are foldable frame, removable cushion, and minimize musculoskeletal disturbances. Based on the validation results, it is necessary to develop a chair frame design that is lighter and easier for users to use. Based on the validation results, it is necessary to develop a cushion design for the lesehan chair, especially for ease of detachment, safety and comfort in the upper and lower necks.

Reference

[1] K. B. Debnath and N. Kumar, "Advanced Collision and Obstruction Detection and Prevention using ESP-32 & Deep Learning.," *2023 2nd Int. Conf. …*, 2023, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10405347/

[2] H. N. P. Wisudawan, S. Murnani, and ..., "On-Device MFCC-CNN Voice Recognition System with ESP-

32 and Web-Based Application," *2023 15th Int. …*, 2023, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10317720/

[3] N. U. Arif, N. Nurhayati, and A. Asriyadi, "Desain Sistem Pengawasan Anak Menggunakan Mikrokontroler TTGO T-Call ESP 32," *Semin. Nas. Tek. …*, 2023, [Online]. Available: https://jurnal.poliupg.ac.id/index.php/sntei/article/view/4382

[4] G. R. Auwali, A. Ahfas, and S. D. Ayuni, "… ESP 32 Cam Berbasis Telegram untuk Meminimalisasi Pencurian: Motorbike Control and Safety Devices Using Telegram-Based ESP 32 Cam to Minimize Theft," *MALCOM Indones. J. …*, 2023, [Online]. Available: https://journal.irpi.or.id/index.php/malcom/article/view/923

[5] L. Aditya and A. R. Harahap, "… BANGUN PENERANGAN JALAN UMUM UNTUK MENGATASI KONDISI BERKABUT MENGGUNAKAN SENSOR LDR DAN SENSOR KABUT BERBASIS ESP 32," *J. ELEKTRO*, 2024, [Online]. Available: https://jurnalteknik.unkris.ac.id/index.php/jie/article/view/435

[6] R. Susanto, *Prototype Informasi Jumlah Pengunjung Pada Toko Asyifa Swalayan Menggunakan Mikrokontroler ESP 32*. repository.wicida.ac.id, 2024. [Online]. Available: https://repository.wicida.ac.id/5235/

[7] D. Y. M. Rao, B. Surendra, K. Govardhan, and ..., "AN IOT BASED SMART E-FUEL STATION USING ESP-32," *International Journal of …*. ijprems.com, 2023. [Online]. Available: https://www.ijprems.com/uploadedfiles/paper/issue_4_april_2023/31034/final/fin_ijprems1682319300.pdf

[8] N. O. Aminian, "Ergonomic Optimization of Airship Passenger Cabin Design Using RULA and Fuzzy Logic Decision Method," *J. Aeronaut. Astronaut. Aviat.*, vol. 56, no. 1, pp. 393–403, 2024, doi: 10.6125/JoAAA.202403_56(1S).28.

[9] U. Aakesh, Y. Rajasekaran, and ..., "Review on Healthcare Monitoring and Tracking Wristband for Elderly People using ESP-32," *2023 5th Int. …*, 2023, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10061134/

[10] R. S. Hadikusuma and R. Rahmadewi, "ANALISIS TRANSMISI DATA CITRA DIGITAL ESP 32 CAM PADA PROTOTIPE ROBOT PEMADAM API MENGGUNAKAN METODE KOMPRESI CITRA MJPG," *Barometer*. journal.unsika.ac.id, 2023. [Online]. Available: https://journal.unsika.ac.id/index.php/barometer/article/view/6401/3696

[11] V. Soni, T. Gurjar, S. Singh, V. Khanna, and M. Rani, "Arduino based face detection system for attendance using embedded system technology with Esp-32," *PRATIBODH*, 2023, [Online]. Available: http://pratibodh.org/index.php/pratibodh/article/view/60

[12] Y. Hermawan and A. Ridho'i, "Rancang Bangun Kamera Portabel Pemantau Ruang Brankas Berbasis IoT menggunakan ESP-32 Camera," *TEKNIKA*, 2023, [Online]. Available: https://jurnal.untag-sby.ac.id/index.php/teknika/article/view/8887

[13] N. HAMICI, *Design and Implementation of an Autonomous Mobile Robot Based on ESP-32*. dspace.univ-guelma.dz, 2023. [Online]. Available: https://dspace.univ-guelma.dz/jspui/handle/123456789/14998

[14] W. Bagye and M. F. Zulkarnaen, "Closed Circuit Television Cerdas Berbasis NodeMCU ESP-32," *Jambura J. Electr. …*, 2024, [Online]. Available: https://ejurnal.ung.ac.id/index.php/jjeee/article/view/21739

[15] A. I. Nugraha, D. Rosita, and L. A. Luki, *SMART AQUARIUM BERBASIS IOT MENGGUNAKAN MICROCONTROLLER ESP 32 PADA IKAN KOI*. repository.unim.ac.id, 2023. [Online]. Available: http://repository.unim.ac.id/id/eprint/4536

[16] S. An, "User perception and ergonomic display layout design of truck camera monitor system," *Int. J. Ind. Ergon.*, vol. 99, 2024, doi: 10.1016/j.ergon.2024.103547.

[17] M. Ardiansyah, A. Febryan, A. Adriani, and ..., "RANCANG BANGUN SISTEM KEAMANAN RUMAH BERBASIS TELEGRAM MENGGUNAKAN ESP 32 CAM," *Vertex …*, 2023, [Online]. Available: https://journal.unismuh.ac.id/index.php/vertex/article/view/10246

[18] J. Wang, "3D standard motion time-based ergonomic risk analysis for workplace design in modular construction," *Autom. Constr.*, vol. 147, 2023, doi: 10.1016/j.autcon.2022.104738.

[19] N. T. Qurrahman, T. Hasanuddin, and ..., "Prototype Sistem Pengawasan Parkiran dan Kontrol Gerbang Menggunakan Esp 32 Cam dengan Notifikasi Telegram," *Bul. Sist. Inf. …*, 2023, [Online]. Available: http://103.133.36.110/index.php/BUSITI/article/view/1755

[20] P. R. Babu, P. Sridevi, R. Shamitha, and ..., "Smart Solar Energy Monitor Using ESP 32 Controller," *2023 7th …*, 2023, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10395644/

[21] A. L. Salsabila, I. G. P. Astawa, A. Budikarso, and ..., "Design and Implementation of Intelligent Systems Using ESP-32 Based Fuzzy Logic on Smart Agriculture System for Mustard Plants.," *2023 Int. …*, 2023, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10242499/

[22] M. B. Sadeva, *RANCANG BANGUN ALAT PENGHITUNG BIAYA PENGGUNAAN DAYA LISTRIK*

PADA KAMAR KOS BERBASIS ESP 32. repository.lib.pcr.ac.id, 2023. [Online]. Available: http://repository.lib.pcr.ac.id/id/eprint/1111/

[23] I. Diyasa, S. Winardi, M. Idhom, and A. Budianto, *PEMBELAJARAN INTERNET OF THINGS DENGAN MODUL TRAINER ESP-32*. books.google.com, 2024. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=gyDwEAAAQBAJ&oi=fnd&pg=PA44&dq=esp+32&ots=rUTfJK9VbJ&sig=BJs0rsoJ1_wN7DqA6L3cedwkaf4

[24] A. Kumar, "ESP 32-SLAVE DEVICE TO A HOST MCU," *IoT Based Systems*. ciir.in, 2023. [Online]. Available: https://ciir.in/doc/publication/IoT Based Systems_978-81-962230-4-5.pdf#page=25

[25] D. Pope, *Creating a Word Clock with an ESP 32*. digitalcommons.sacredheart.edu, 2023. [Online]. Available: https://digitalcommons.sacredheart.edu/acadfest/2023/all/140/

[26] R. A. Winata, *Design and Development of an ESP-32 Based Keyless Door Security System*. eprints.uty.ac.id, 2023. [Online]. Available: http://eprints.uty.ac.id/12231/

[27] Z. K. Farej and A. W. Talab, "Performance Validation and Hardware Implementation of a BLE Mesh Network by Using ESP-32 Board," *Int. Conf. Math. Model. ...*, 2023, doi: 10.1007/978-981-99-3611-3_27.

[28] D. Das, "Ergonomic design and evaluation of gemstone polishing workstation," *Int. J. Occup. Saf. Ergon.*, vol. 29, no. 4, pp. 1301–1318, 2023, doi: 10.1080/10803548.2022.2120282.

[29] B. I. Tawaddud, "Design and build a web-based Bulukumba Regency tourism information system from an ergonomic perspective," *AIP Conference Proceedings*, vol. 3070, no. 1. 2024. doi: 10.1063/5.0200224.

[30] H. Ghadimi, "Ergonomic Design and Assessment of an Adjustable Laptop Stand Used in the Typing Task," *Med. J. Islam. Repub. Iran*, vol. 37, no. 1, 2023, doi: 10.47176/mjiri.37.139.

[31] M. SUBKI, L. B. B. BAKAR, and ..., "Home Automation using ESP-32 Development Board with Alexa Voice Assistant and Manual Switch," *Prog. ...*, 2023, [Online]. Available: https://penerbit.uthm.edu.my/periodicals/index.php/peat/article/view/13104

[32] K. C. Mallampalli, "Task-Specific Ergonomic Workstation Design in Manual Cashew Kernel Separating Activity," *J. Inst. Eng. Ser. C*, 2024, doi: 10.1007/s40032-024-01028-0.

[33] M. B. Bhore, "Ergonomic Evaluation and Design of Workstation for Gemstone Polishing Workers," *Recent Patents Eng.*, vol. 18, no. 7, pp. 26–32, 2024, doi: 10.2174/1872212118666230810094823.

[34] N. Goleij, "Investigating the trends and causes of changes in human anthropometric dimensions over the past three decades: a challenge for ergonomic design," *Int. J. Occup. Saf. Ergon.*, vol. 30, no. 2, pp. 480–485, 2024, doi: 10.1080/10803548.2024.2318945.

[35] Z. Zhang, "ERGONOMIC DESIGN OF A VIRTUAL PROCTOR SYSTEM WITH RELIABLE FACE RECOGNITION AND TRACKING," *ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)*, vol. 8. 2023. doi: 10.1115/IMECE2023-112826.

[36] B. Wieczorek, "Ergonomic guidelines for the design interfaces of additive modules for manual wheelchairs: sagittal plane," *Sci. Rep.*, vol. 13, no. 1, 2023, doi: 10.1038/s41598-023-39085-7.

[37] B. Cășeriu, "Aspects Regarding the Ergonomic Design of Workstations in the Automotive Manufacturing Industry," *Lecture Notes in Networks and Systems*, vol. 928. pp. 238–248, 2024. doi: 10.1007/978-3-031-54671-6_18.

[38] N. K. I. Mayasti, "Evaluation of Non-Wheat Noodle Machine Design with An Ergonomic Approach," *BIO Web of Conferences*, vol. 69. 2023. doi: 10.1051/bioconf/20236905001.