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Effect of Using Non-Ergonomic Chairs on Industrial Engineering Students

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This research discusses and analyses the use of non-ergonomic chairs by industrial engineering students. The background of this research is that students spend many hours studying, most of them seated. Non-ergonomic chairs make students less comfortable in the learning process. The use of non-ergonomic chairs are for long periods of time can cause damage to MSDs, with complaints of muscle pain in the shoulder area, neck stiffness, and back pain. The research data was taken from Industrial Engineering Department students in 2016 by conducting interviews and receiving questionnaires. An evaluation of lecture chairs is carried out in accordance with ergonomics and anthropometry. The results of the interviews and questionnaires on the chairs of the Industrial Engineering Department provided that most students claimed to be uncomfortable using the lecture chairs. Results Retrieving data is then analysed to obtain improvements. The recommended improvement is to redesign the lecture chair using human body dimensions (Anthropometry).

Key words: *Chair, anthropometry, ergonomics, injuries.*

Introduction

Lecture activities are carried out five days a week, students spend considerable time sitting in lectures. An ergonomic chair is needed, so that students are focused and comfortable when completing lecture activities. Both static and dynamic activities are used as a basis for measuring body size. The science of ergonomics that deals with the dimensions of the human body is anthropometry. Anthropometry is a science that specifically studies the measurement of the human body to formulate differences in size of each individual or group (Panero and

Zelnik, 1979). Anthropometry is needed as a reference to the carrying out of adjustments to work equipment, furniture, clothing, and any other equipment that is directly related to human activities. Anthropometry is related to the measurement of the state and physical characteristics of humans, such as size of the head, hands, body, hips, and all the way down to the feet. Measurement data is used as a reference for product design in accordance with user needs.

Several complaints arose from the observations of 50 respondents from Industrial Engineering students at Brawijaya University in 2016, they are as follows:

Table 1: Lecture chair Problems Results

Problems	**Respondents**
The size of the table is less extensive	7
Seating size is not wide	7
The size of the table on the bench is too short	3
Seat (cushion) on the chair is comfortable	3
Leg position when sitting is comfortable	2
Back seat size is too short	3
The distance between the table and seating is too short / narrow	4
Trouble getting out / standing from the chair	5
Feeling back pain when sitting	8
Feeling neck and shoulder pain when sitting	8

Complaints arise when students they sit for a long time in a position that is not ergonomic. Sitting in non-ergonomic positions for a long time can cause MSD injuries, and lead to complaints of muscle pain in the shoulder area, neck stiffness, and back pain.

Based on the problems that have been described above, it is necessary to evaluate the ergonomics and anthropometric measurements of, as well as redesign, student's lecture chairs. This must be done so that a comfortable lecture chair is generated using a proper anthropometric approach.

Research Objectives

Based on the background of existing problems, this study aims to evaluate the principles of ergonomics in the lecture chairs of the Industrial Engineering Department, Brawijaya University.

Research Limitations

This research is limited in the following ways:

1. The anthropometric data is all Indonesian; and
2. It is assumed that Indonesian anthropometry data can represent the anthropometry of students at the Department of Industrial Engineering, Brawijaya University.

Literature Review

In this section, the existing subject literature will be discussed.

Ergonomics

Ergonomics is a term that originated in or around 1949; it comes from the Latin words, *Ergon*, which means work, and *Nomos*, which means natural law or principle. Thus, ergonomics can be defined as the study of human aspects in the work environment in terms of anatomy, physiology, psychology, engineering, management, and design (Nurmianto, 2004).

It is necessary to apply the principle of ergonomics to complete all human activities in good condition and reduce the risk of injury during such. The importance of ergonomic principles is used to help people work productively without feeling any pain. Ergonomics are generally divided into two points of view, namely micro ergonomics and macro ergonomics. Micro ergonomics is ergonomics that examines human-machine interactions, human-work environment interactions, interactions between software enthusiasts, and human-employee interactions. Whereas, macro ergonomics examines human-organizational interactions that involve work system analysis at all levels of the organization.

Musculoskeletal Disorders **(MSDs)**

Musculoskeletal Disorders (MSDs) usually involve muscles, tendons, nerves, and support structures. MSDs are nontraumatic soft tissue disorders caused or exacerbated by interactions with the work environment (Silverstein and Evanoff, 2006). According to the Bureau of Labor Statistics, MSDs are often referred to as ergonomic injuries, ie injuries or diseases that affect the body's connective tissue such as muscles, nerves, tendons, joints, cartilage, or spinal discs. According to Bridger (1995), the organs of the human body that make up this system include:

1. Bones - are composed of tissue that is very difficult to use as forming bonds and it protects the internal organs.

2. Cartilage - This network functions as a link between bones, within this network the bone movement is relatively small, thus protecting it from bone displacement.
3. Ligament - Ligaments function as connecting parts and attach to the bone at the ends; ligaments play an important role in protecting joints.
4. Muscle - Muscles are often referred to as the means of active motion. Muscle cells produce body heat to maintain body heat stability due to external influences.

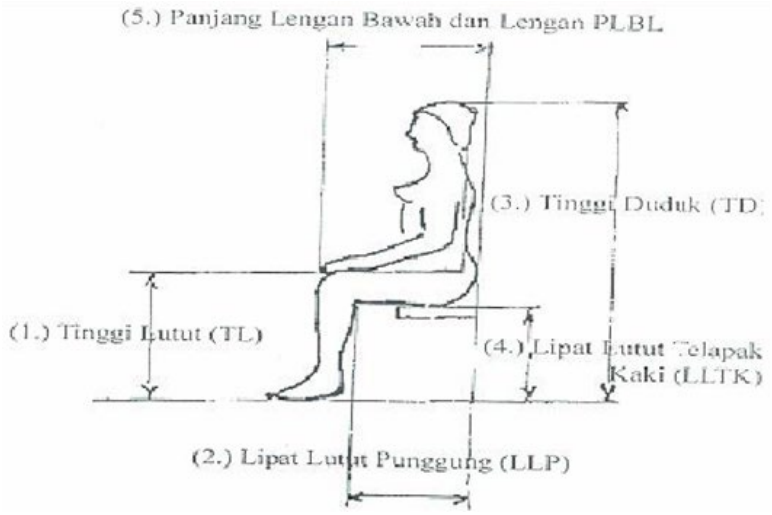
Antropometry

Anthropometry is the study of body measurements specifically body size, shape, strength and work capacity. According to (Wignjosoebroto, 2008), anthropometry is study related to the measurement of the dimensions of the human body. The field of anthropometry covers different sizes of the human body such as body weight, position when standing, when stretching arms, body circumference, leg length, and so on. Anthropometric data is used for various purposes, such as the design of work stations, work facilities, and product designs.

Picture 1 below shows a person sitting and being subject to anthropometric measurements; it is an illustration of a person sitting, whose posture requires ergonomic attention. Anthropometric data that is obtained will be widely applied, and its applications include the following:

1. Designing work areas (work stations, car interiors, etc.);
2. Designing work equipment (tools, machines, etc.);
3. Design of consumptive products (clothing, seating, tables, etc.); and
4. Designing the physical work environment.

Picture 1. Anthropometric Data Measurement



Research Method

Data collection was carried out by interviewing and distributing questionnaires to students of the Department of Industrial Engineering in 2016 at Brawijaya University.

The data that is collected is evaluated, subsequently, it is used to design lecture chairs that are in accordance with the principles of ergonomics and anthropometric measurements.

Results and Discussion

This section will discuss the results and the research, this includes identifying needs, evaluating ergonomics, assessing the impact of non-ergonomic chairs, and providing recommendations for ergonomic chair designs.

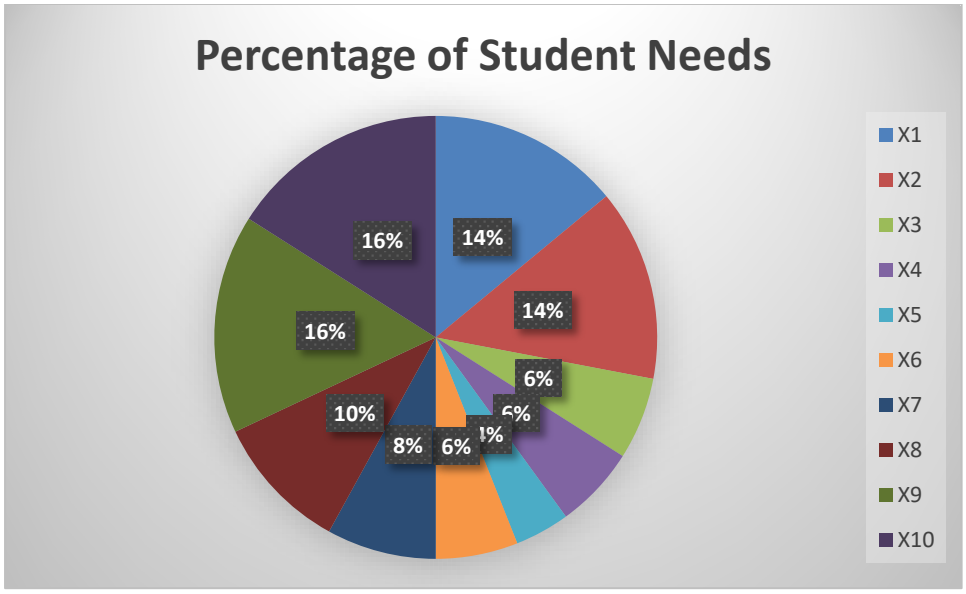
Identification of Needs

Based on the results of the questionnaire that was distributed to 50 students, students' needs for seats are revealed as seen in Table 2 below.

Table 2: Identification of Needs

Number	Statement Needs	Symbol
1.	The table has a wide size	X1
2.	Chairs have a wide size	X2
3.	The size of the table of the chair has a sufficient height	X3
4.	Chairs have soft cushions	X4
5.	Leg position when sitting comfortably	X5
6.	Back of the seat back has a sufficient height	X6
7.	The distance between the table and the seat has a sufficient height	X7
8.	No difficulty getting out / standing from the chair	X8
9.	Do not feel back pain when sitting	X9
10.	Do not feel neck and shoulder pain when sitting	X10

Picture 2. Percentage of Student Needs



Evaluation of Ergonomics

The following are some of the results of the ergonomics evaluation:

1. The desk functions primarily as a place for students to write, while the seat serves to help them to be comfortable when writing or watching. The tables and seats in the Industrial Engineering Department are still not ergonomic for students as they are not large enough. Students who have large dimensions will have difficulty and feel uncomfortable when sitting on their undersized seats. It is necessary to design a table that considers anthropometric aspects and a chair that considers the size of the popliteal buttocks.
2. The backrest serves to make or improve one's comfort while sitting, it is very much needed for lecture activities and enables students to focus on receiving lecture material. The height of the seat backs at the Industrial Engineering Department are too short, meaning that the backrest is not designed in accordance with ergonomic considerations; students complain that the backrest makes them uncomfortable. The height of the back is too short, it cannot properly support a person's entire back. The back is also made of very thin material and when used for a long time it will feel uncomfortable.
3. The distance between the table and the seat is not ergonomically designed. The distance between the table and the seat is very short, when seated, students find it difficult to position their feet because their thighs are too tight against the table. This results in the poor foot comfort while seated.

Impact of an Ergonomic Chair

Based on the literature review, the use of non-ergonomic chairs can cause musculoskeletal disorders and fatigue, which can also lead to decreased productivity.

Ergonomic Chair Design Recommendations

The following is an analysis of ergonomic chair design recommendations by considering anthropometric dimensions. The first dimensions used is D17, which is the width of the shoulders in the 50th percentile, it measures at 38.75 cm. The second dimension is D10, which is the shoulder dimension when sitting at the 50th percentile; the back of the chair has a height of 54.89 cm. The third dimension is D14, which is a popliteal length at the 50th percentile, it is 39.88 cm. The fourth dimension is D16, which is the height dimension of popliteal at the 50th percentile, the seat height is 40.07 cm. The fifth dimension is D11 or the elbow height dimension in the sitting position at the 95th, the size is 38.47 cm. Dimensions D23, D28 and D24 as a measure of the distance back to the table in order to provide comfort to the user's space.

Based on the explanation above, the following is a recapitulation of anthropometric data used in chair design:

Table 4: Dimension of Anthropometry for Chair Design

No.	Anthropometric Dimensions	Percentile	Size	Information
1.	D10 (Dimensions of shoulder height in a sitting position)	50%	54,89 cm	To determine the height of the chair back
2.	D17 (Dimensions of shoulder width)	50%	38,75 cm	To determine the width of the chair back
3.	D23 (Dimensions of the length of the forearm)	95%	54,4 cm	To determine the minimum distance between the back and table
4.	D28 (Dimensions of hand length)	50%	17,05 cm	
5.	D24 (Dimensions of the length of the hand forward)	50%	66,18 cm	
6.	D11 (Dimensions of elbow height in a sitting position)	95%	38,47 cm	To determine the height of table from the chair.

7.	D19 (Dimensions of hip width)	95%	43 cm	To determine the length and width of the chair.
8.	D14 (Popliteal length dimensions)	50%	39,88 cm	
9.	D16 (Popliteal high dimensions)	50%	40,07 cm	To determine the chair height.

The following is an illustration of the lecture chair after being analysed using anthropometry:

Picture 3. Lecture Chair Re-design Results

Conclusion

From the results of the study, it can be concluded that students' have ten needs for the chair they are currently using. The evaluation conducted provides that the lecture chairs currently in use are not ergonomic. A new lecture chair design is needed; one that considers anthropometric aspects.

In the future, it is necessary to consider ergonomic aspects and anthropometric principles in the use of existing facilities in the Department of Industrial Engineering, Brawijaya

University. This must be done in order to provide comfort and prevent musculoskeletal disturbances that can cause a decline in one's productivity.

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