

## DEVELOPMENT OF ANTHROPOMETRY GAUGE

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### ABSTRACT

*LPSK&E is work system design and ergonomics laboratory at Atma Jaya Catholic University. LPSK&E is a laboratory applying ergonomics theories given in lectures and conduct a direct practice on the theory so that students can have a better understanding about the theory given in lectures.*

*The topic of this paper is to design a anthropometry gauge that can help measuring the body dimension which is difficult or cannot be measured by a gauge currently existing but stick to the needs of LPSK &E. Gauge that will be designed is also able to overcome the lack of a ruler and meter attached to a wooden stick.*

*The early steps of the design process are gathering data about user requirements, developing the concept using functional tree and morphological charts, and assessing concepts by Pugh method. The concept chosen from the assessment process is the concept of manual gauge which can measure vertical and horizontal distance, scale pointer in the form of slabs and the scale line perpendicular to the number, equipped with a lock and handling, and gauge can be placed neatly. The gauge's test is carried out by calibration, gauge's preparation time, measuring operation time, and gauge's storing time, as well as testing gauge based on technical requirements.*

**Keywords:** Gauge, Anthropometry, Functional Tree, Morphological Chart, Pugh Method

### 1. INTRODUCTION

LPSK&E is a laboratory of design and ergonomics work system at Atma Jaya Catholic University. LPSK&E is a laboratory that applied ergonomics theories given at lectures and conducts direct practice regarding the theory in order for students to have a better understanding on the given theory. LPSK&E practice the subject of ergonomics, and one of them is the Anthropometry.

Anthropometry gauge owned by LPSK&E are ruler, tape measure, tape measure tacked on a wooden bars, and Anthropometry chair. Each tool has it's disadvantages in doing measurements so that impedes the process of anthropometry body dimension data collection.

The problem in this paper is how to design an anthropometry gauge that can measure the dimensions of the body that are difficult to be measured by anthropometry chair, and reduce the limitation of other measuring instrument such as ruler, tape measure, tape measure and tacked on wooden bars. Therefore the purpose of

doing this paper are:

1. Design and make anthropometry gauge
2. Test the anthropometry gauge
3. Analyze the results of the anthropometry gauge test

Limitations of the research in this study are:

1. Measurement using anthropometry gauge is done in static state.
2. The dimensions of the body measured in sitting and standing position.
3. The Anthropometry gauge is designed to measure the body dimensions that cannot be measured by LPSK&E's gauge, especially for the Anthropometry Chair.

### 2. LITERATURE REVIEW

Ergonomics as the multidisciplinary nature of the disciplines in which is integrated with the elements of physiological, psychological, Anatomy, hygiene, technology and practice (Manuaba, 1992)

The term is derived from the word "anthropos (man)" which means man and "metron (measure)" which means the size

(Bridger, 1995). Definitively Anthropometry could be stated as a study that deals with the measurement of the dimensions of the human body.

Product development process according to Karl t. Ulrich and Steven d. Eppinger in his book entitled "Product design and Development" (2001) is as follows.

1. Identification of customer needs is an integral part of the product development process, and is the stage that most closely connected with the process of decline of the concept, the concept selection, the benchmark with a competitor and establishing product specifications.
2. On the concept development phase, the target market identified needs, alternative product concepts are generated and evaluated, and one or more of the concepts selected for further development and experiments. Where is the concept here is the description of the form, function, and appearance of a product and is usually accompanied with a set of specifications, analysis of competitors' products as well as consideration of the economical project.
3. Some of the concepts already established definitely has its advantages and disadvantages. Therefor the process of assessing concept selection concepts with customer requirements and other criteria, comparing the relative strengths and weaknesses of the concept, and choose one or more of the concept for the investigation, testing and further development.
4. Once the concept of the product to be developed has been established, the next step is to design embodiment design which at this step, the physical concept would be more visible. Or in other words we will "put meat on the bones".
5. Detailed Design is centered on making sure the details and add the less to ensure that a draft that has been proven and tested can be manufactured into a high quality product and cost-effective.
6. Testing a concept closely related to the concept of selection, where the second

activity aims to narrow your number of concepts that will be further processed. But testing the concept is different, because this activity focuses on the direct data collection of potential customers and only involve a bit assessment from a team of developers.

Morphological Chart is a list or summary of the systematically shape changing analysis to find out how the shape of a product is made. In the chart, the combination of a possible solutions was created to form different products. Different combinations of concept can be selected from the chart, and also can headed to the new solutions that have not been identified before. Morphological Chart contains elements, components, or sub solutions that can be combined.

### 3. METHODOLOGY

Data collection is a very important early stage in designing a gauge. Data collection is done by way of an interview conducted on 30 speaker, they are LPSK&E Assistant and 2014/2015 odd semester LPSKE student , which has done practical work regarding Anthropometry.

#### 3.1 Data Collection

User needs are user's statement about the thing needed in a gauge. alat ukur antropometri mengenai hal-hal yang diinginkan untuk ada pada alat ukur. Identification of user needs is obtained from interviews about anthropometry gauge's user.

Interpret the needs of the user are activities that modify the customer statement in the form of the phrase "How do" product into a sentence that stated "what to do" product.

Users's needs hierarchy is important to classify user requirements into general categories to specific. User's needs have been grouped into 3 levels. The less specific user's needs also being describe apparently in the tertiary needs column.

Table 1. User's Needs Hierarchy

Primary Needs	Secondary Needs	Tertiary Needs
Result	Reading Accuracy	Measure accurately
		Measure quickly
	Ease of Reading	Scale easy to read
Operational	Ease of Preparation	Fast preparation
	Ease of Use	Light in using
		Measure body dimension complitely
		Measure quickly
	Kemudahan Dibawa saat Pengukuran	Light
		Easy to hold
Ease of Store	Fast storing	
	Easy to move	

Tertiary needs being realized in this product shall have its technical needs. Technical needs can be measured and have its unit so it can be realized and compare with other gauges.

Table 2. Technical Needs

Tertiary Needs	Technical Needs	Unit
Measure accurately	Level of accuracy	mm
Measure quickly	Measurement time	minute/ dimension
Scale easy to read	Scale number's size	cm
	Scale line's thickness	mm
Fast preparation	Preparing gauge's time	minute
Light in using	Gauge's weight ready to use	kg
Measure body dimension complitely	Dimensions that can be measured	unit

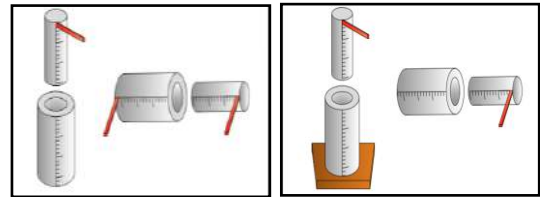
Table 2. Technical Needs (Continued)

Tertiary Needs	Technical Needs	Unit
Measure quickly	Time measurement	minute/ dimension
Light	Gauge's weight ready to use	kg
Easy to hold	Gauge's weight beeing use	kg
Fast storing	Storing time	minute
Easy to move	Gauge's weight + box	kg

### 3.2 Conceptualization

Morphological chart is a tool to develop concept. Here, concept for each function are found, which will be combined.

#### ❖ Performed Measurement



(manual measurement, have the zero pointer, gauge can't stand, gauge can be plug and remove) and 5(manual measurement, no zero pointer, gauge can stand, gauge can be plug and remove)

Figure 1. Concept combination 3

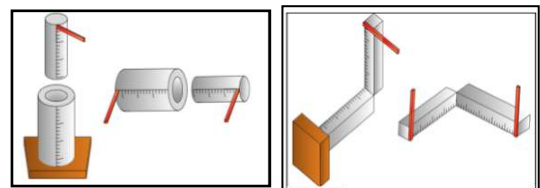


Figure 2. Concept Combination 7 (manual measurement, have zero point pointer, it can stand on its own, the removable gauges) and 8 (manual measurements, have zero point pointer, the gauge can stand, the measuring instrument can be folded)

#### ❖ Showing the Measurement Results

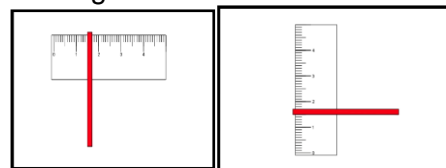


Figure 3. Concept Combination 2 (pointer scale in the form of slabs, the number aligned with line scale) and 4 (pointer scale in the form of slab, number parallel scale line scale)

#### ❖ Storing the Gauge

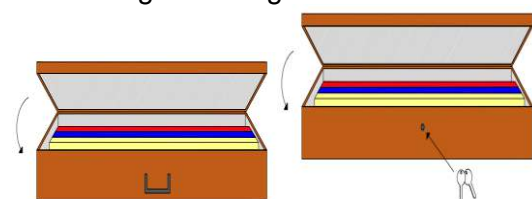


Figure 4. Concept Combination 6 (gauges are placed neatly, without lock, without handle), and 7 (gauges are placed neatly, with lock, without handle)

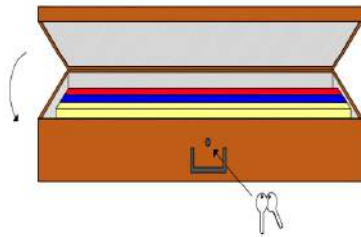


Figure 5. Concept Combination 8 (gauges are placed neatly, have a lock, with handle)

### 3.3 Concept Assessment

The Concept selection for performing measurement function selects 4 concepts to be assessed, they are concept 3 (manual measurement, have the zero pointer, gauge can't stand, gauge can be plug and remove), concept 7 (manual measurement, have zero point pointer, it can stand on its own, the removable gauges), and 8 (manual measurements, have zero point pointer, the gauge can stand, the measuring instrument can be folded).

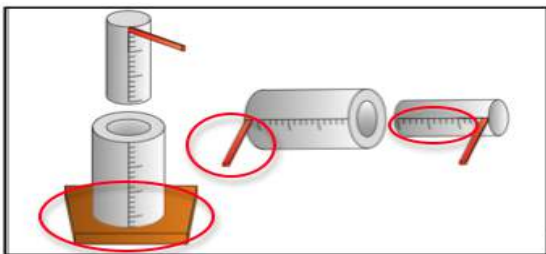


Figure 6. Chosen Concept for Performing Measurement

The concept selection for showing the measurement results get results where the two concepts will be votes. The concept is a concept 2 ( pointer scale in the form of slabs, the number aligned with line scale) and 4 (pointer scale in the form of slab, number parallel scale line scale). Based on the assessment of the selected concept, is concept 4.

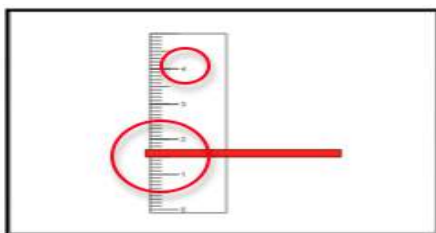


Figure 7. Chosen Concept for Showing the Measurement Results

On the function of storing the gauge, 3 chosen concepts with the highest value are the concept 6 (gauges are placed neatly, without lock, without handle), the concept of 7 (gauges are placed neatly, with lock, without handle), and 8 (gauges are placed neatly, have a lock, with handle).

The concept ultimately selected was the concept of 8, gauges are placed neatly, have a lock, with handle.

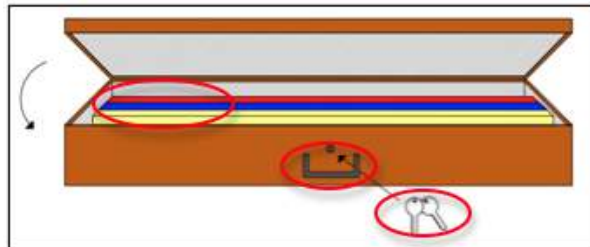


Figure 8. Chosen Concept for Storing The Gauge

### 3.4 Design of Gauge's Component

A gauge shall be designed in the form of antennas, where the length of a ruler can be adjust by the user. The ruler is made up of 3 bars that can be combined. This component will be complemented with the scale to indicate the size.

Foot's function is so that a ruler can stand by itself to simplify the vertical measurement. This component must be weighed over the bars so that the gauge does not easily uprooted because of the size of the ruler.

The last component is the scale pointer . This component has a form similar to the zero point, the pointer in the shape of the slab. These components can be adjust according to the dimensions measured.

### 3.5 Design of Gauge's Usage and Manufacturing

The first step, should know in advance which dimensions will be measured. The dimensions to be measured are sorted based on horizontal and vertical dimension. It is important to determine whether foot or zero pointer point is required.

Table 4. Vertical and Horizontal Body Dimension

No	Vertical Dimension	Horizontal Dimension
1	Stature	Upper Limb Length
2	Eye Height	Shoulder- Grip Length
3	Shoulder Height	Forward Grip
4	Shoulder Height	Span
5	Hip Height	Elbow Span
6	Knuckle Height	Chest Depth
7	Finger Tip Height	Abdominal Depth
8	Knee Height/ Knee Cap Height	Buttock-Knee Length/depth
9	Vertical, Overhead grip reach, Standing	Buttock-popliteal length/depth
10	Sitting Height	Elbow-Finertip Length/ length
11	Sitting Eye Height	Shoulder breadth, biacromial
12	Sitting Shoulder Height	Shoulder breadth
13	Sitting Elbow Height	Hip breadth
14	Thigh Thickness	
15	Buttock-popliteal Height	
16	Knee Height	
17	Arm Length, Vertical	
18	Down Grip Reach	
19	Overhead grip reach, sitting	
20	Shoulder-elbow length	

Take the bars and plug them. It can also being use only with 1 bar, depend on the dimension being measured.

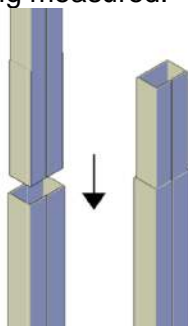


Figure 9. Plug the Bars

Then, put the scale pointer to the bars. The scale pointer is put in the groove.

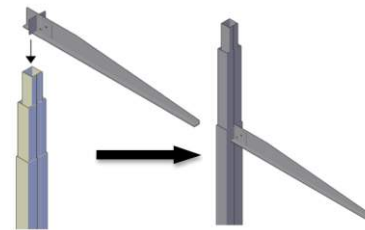


Figure 10. Attach the Scale Pointer

The last step is plug the bars to the base or zero pointer depending on the dimension being measured.

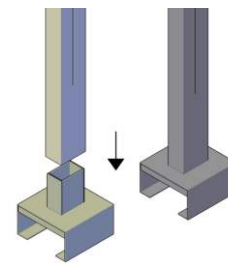


Figure 11. Place the Bars on the Base

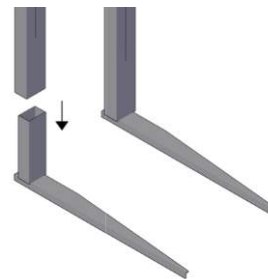


Figure 12. Place the Bars on the Zero Pointer

#### 4. RESULT AND DISCUSSION

At the beginning of doing gauge's design, there are dimension targeted to be measured using a designed gauge . The target set is all sitting dimensions . From 19 dimensions, this gauge can measure 18 dimensions.

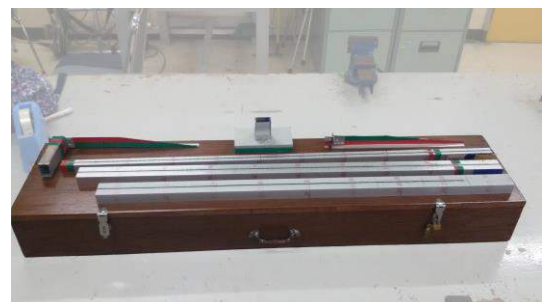


Figure 13. Component of Designed Anthropometry Gauge





Figure 14. Anthropometry Gauge for Vertical Dimension



Figure 15. Anthropometry Gauge for Horizontal Dimension

Calibration of anthropometry gauge is done by comparing the designed gauge and the meter. There is 1 mm difference in measurement results, it can still be tolerate considering the level of precision anthropometry gauge designed is 1 mm.

Table 5. Gauge Calibration

Dimension	Meter	Designed Anthropometry Gauge
D9	186.2	186.2
D1	152.5	152.5
D3	126.0	126.0
D15	<b>80.7</b>	<b>80.6</b>
D17	50.4	50.4
D31	30.2	30.2
D32	36.2	36.2
D33	34.2	34.2
D30	<b>40.0</b>	<b>39.9</b>
D29	30.1	30.1

Ranks				
		N	Mean Rank	Sum of Ranks
Alat_Ukur_Antropometri - Meteran	Negative Ranks	2 <sup>a</sup>	1.50	3.00
	Positive Ranks	0 <sup>b</sup>	.00	.00
	Ties	8 <sup>c</sup>		
	Total	10		

a. Alat\_Ukur\_Antropometri < Meteran  
b. Alat\_Ukur\_Antropometri > Meteran  
c. Alat\_Ukur\_Antropometri = Meteran

	Alat_Ukur_Antropometri - Meteran
Z	-1.414 <sup>a</sup>
Asymp. Sig. (2-tailed)	.157

a. Based on positive ranks.  
b. Wilcoxon Signed Ranks Test

Figure 16. Print Screen Result of SPSS Wilcoxon Test

H0 = there is no significant difference in meter and anthropometry gauge measurement results

H1 = there no significant difference in meter and anthropometry gauge measurement results

Test criteria: Reject the zero hypothesis (H0) If p-value less than 0.05.

From the table of Test Statistics, the value of Z is equal to 1.414. If the level of significance 0.05 and uses a two-sided test, the critical value for Z between -1.96 and 1.96, which means it is in the acceptance of H0. So is the value of p-value e is 0.157 (< 0.05) then accept the zero hypothesis (H0). So the conclusion is there is no significant difference in meter and anthropometry gauge measurement results

Gauge's weight is the weight of a measuring instrument which is ready to be used to measure the body dimensions. Users need a light gauge. The target weight of the gauge set is 2 kg. Overall gauge weight is equal to 1.3 kg. Thus, the criteria of light equipment has been achieved.

The size of the gauge carried is based on the largest cross-sectional area. The target is set equal to less than 1000 cm<sup>2</sup>, and the size of the gauge when is 400cm<sup>2</sup>.

The measurement is retrieve done from the user take all the components until the user is finished compiling all components. Targets set for Anthropometry preparing gauge is 3 minutes. The time measurement is approximately 1 minute.

Table 6. Recapitulation Gauge's Preparation Time

User	Gauge's Preparation Time (Second)
Mellisa T	57
Tazya	62
Ivana T	61

On the measurement of the vertical dimension, there is no additional burden to the user because the Anthropometry gauge design can stand on its own. The load of the gauge is 1.3 kg whereas targets set for the weight of the appliance when operated is as big as 1.5 kg. Then the weight criterion at the time operated gauges has been achieved.

The accuracy level of a gauge indicates the accuracy of the results. Target of precision is equal to 1 mm. This criteria has been achieved. The smallest unit that can be measured by a anthropometry gauge is 1 mm.

The number of body dimensions that can be measured by the anthropometry gauge is of 18 dimensions in sitting position and 14 dimensions in a standing position. Targets set for the height of scale number on the scale is 1 cm. The size of scale numbers written on the designed anthropometry gauge is 0.8 cm

The measurement time is the time required by the user to get the measurements done. Measurements conducted 10 dimensions at once. The time target specified to measure 1 dimension is 1 minute. On the time measurement, the average time takes to measure 10 dimensions is 7.6 seconds, or 0.76 seconds to 1 dimension. Below is a table of time measurement of 10 dimensions.

Table 7. Time to Measure 10 Dimensions

Name	Time (Minute/10 dimension)
Subject A	7.28
Subject B	7.55
Subject C	8.02

Gauge storage time is the time it the user to remove the designed anthropometry gauge components, then put it in the storage. It brings the average done in 142 seconds, or as long as 2.37 seconds.

Targets set for Anthropometry gauge storage is for 5 minutes.

Table 8. Anthropometry gauge's Storage Time

Name	Time (Second)
Subject A	146
Subject B	142
Subject C	138

Gauge eight is the weight of the stored measuring instrument. it was measured along with the container. The target set for the gauge and the container is 2 kg. Because of the difficulty to obtained the plastic material, then prototype that resembles its original form with the use of wood was created. The estimated weight of the boxes using plastic material is 2 kg.

### 5. CONCLUSION

1. The Concept chosen for performing measurement function concept 7 (manual measurement, have zero point pointer, it can stand on its own, the removable gauges).
2. The concept chosen for showing the measurement results is concept 4 (pointer scale in the form of slab, number parallel scale line scale).
3. The Concept Chosen for storing the gauge is concept 8 (gauges are placed neatly, have a lock, with handle).
4. Anthropometry gauge is test based on technic needs, calibration, and the compliance with the target.
5. The results of the calibration test is a difference of 1 mm 2 dimensions.
6. Of the 19 targets, 18 dimensions are reached.
7. Anthropometry gauge can measure 32 body dimensions.

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