

# Design of Elderly Reading Chair to Decrease Musculoskeletal Disorders by Using Quality Function Deployment (QFD) Method

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## Abstract

The increase in the number of elderly people is quite high in Indonesia so that supporting tools are needed to create healthy, active, and productive elderly people. Some of these activities are able to keep the mind healthy and can help maintain mental health. Based on the initial research, it was found that there were disorders from the elderly related to the body parts movement systems. Therefore, it is necessary to design an ergonomic facility for the elderly to reading books so that it can reduce musculoskeletal disorders and provide comfortness to the elderly. The design facility is a reading chair for the elderly, where in this study the design uses the Quality Function Deployment (QFD) method. Based on the research, the elderly need a reading chair with a comfort cushion and backrest, equipped with a footstep, has an adjustable table, has a drinking spot, easy to move, strong and has long life durability. The results of the reading chair design are made according to the dimensions of the elderly anthropometry with adjusted percentile calculations. The result of the satisfaction level test showed that some of the respondents 'attributes are more satisfied with the renewal reading chair design than the competitors'.

## Keywords

Elderly, Quality Function Deployment, Reading chair, Muskuloskeletal Disorders, and Ergonomic.

## 1. Introduction

Elderly is part of family members and community members whose numbers are increasing in line with the increase in life expectancy (Arlianty et al. 2015). WHO data shows the number of elderly people aged 65 or over is growing rapidly with most of the increase occurring in developing countries (WHO 2011). Whereas in Indonesia the percentage of elderly people has doubled (BPS 2019) with young elderly at 63.82, middle elderly at 27.68, and elderly at 8.50 percent (BPS 2019). Biological, physical, psychological, and social changes for the elderly will have an impact on all aspects of life including health (Suhermi et al. 2020). The decline in the ability of the elderly can be observed from several aspects, namely social, economic, physical, and mental aspects (Arlianty et al. 2015). Early health development for the elderly is needed so that the elderly remain healthy, independent, and productive

(Kemenkes RI 2016). For this reason, elderly activities are needed according to their interests and hobbies so that their bodies and minds are active. Activities such as learning new skills, reading books, making handicrafts, doing simple maintenance work are some of the activities that can sharpen the brain so that it can keep the mind healthy and maintain the health of metals (Halaweh et al. 2018). The activity of reading books has many benefits for the elderly, including relaxing the mind, maintaining memory, preventing disease, making sleep patterns better, and extending life (Beritagar.id 2021).

Based on interviews with young elderly with a background of retired teachers, around 70% often read books to reduce boredom at home and 30% do other activities. The places commonly used to read the respondents are sofas/chairs, beds, and sitting on the floor. Activities of the elderly reading books often feel complaints because the facilities or places used by the elderly for reading are not ergonomic. Parts of the body that experience pain are the nape, back, and waist caused by sitting too long on a chair or the floor. When reading a book sitting on the floor, the respondent had difficulty standing because the sitting position was too low and the knee had begun to weaken. A person who reads a book for a long time with bad posture such as bowing, holding a book statically, and bending over will experience disorders of the musculoskeletal system. Injury to the musculoskeletal system is a disturbance that is felt due to posture that is not ergonomic (Anita et al. 2014).

Research related to facility design for the elderly has been carried out, Hasbi et al. (2020) carried out a design to improve the ablution place for the mosque in the Kuala Nerus district for the elderly by considering the ergonomic and anthropometric aspects of the elderly with the aim of increasing the comfort and safety of the ablution place for the elderly Winata et al. (2020) designed an ergonomic waiting chair for the elderly using the Pahl and Beitz method at the XYZ Sidoarjo clinic which aims to minimize complaints felt by the elderly such as back and buttock pain. Nuriman et al. (2018) designed a moveable sitting chair facility for the elderly which aims to make it easier for the elderly to move places while doing their activities. Habib (2017) evaluates the ergonomics suitability of bathroom facilities with physiology and anthropometry of the elderly which aims to describe the ergonomic suitability of bathroom facilities based on physiological and anthropometric factors of the elderly. Adianto et al. (2016) designed an ergonomically designed waiting chair for pregnant women and the elderly at train stations which aims to reduce the physical complaints felt by pregnant women and the elderly who are users of waiting chairs at train stations. Sari (2010) designed an ergonomic food trolley for the elderly with a case study of the UPTD dharma Bakti Surakarta nursing home which aims to reduce fatigue and pain complaints in the elderly's body parts when carrying out food and beverage delivery activities. Previous studies have shown that the elderly need specially designed facilities that are tailored to their needs to make it easier for the elderly to do activities and are adjusted to elderly anthropometry so that the elderly feel more comfortable and safer when doing their activities.

Based on the problems described, this study carried out an ergonomic facility design for use by the elderly when reading books so as to reduce musculoskeletal disorders and provide a sense of comfort to the elderly. The facility design is in the form of a reading chair for the elderly, where in this study the design of a reading chair for the elderly uses the Quality Function Deployment (QFD) method. The choice of design concept using the QFD method is because this method is a planning method

## **2. Methods**

### **2.1 Research Objects and Subjects**

The object of this research is the design of reading chairs for the elderly in order to provide comfort for the elderly and reduce musculoskeletal disorders when reading books. While the research subjects were retired teachers in the Bodeh sub-district, amounting to 46 people with a total sample size of 16 people. The sample taken has the following inclusion criteria: (1) young elderly retired teachers aged 60-69 years; (2) Has no limb defects; (3) Not totally blind or still able to read.

### **2.2 Variables and Variable Operational Definitions**

A variable is an attribute, objects or activities that have certain variations that are determined by researchers to study or draw conclusions (Sugiyono 2013), in this study the dependent variable is Musculoskeletal Disorders (MSDs) and the independent variable is Voice of Customer (VoC) and Anthropometry of the elderly. The following is the operational definition of each variable:

- a. Musculoskeletal Disorders (MSDs)

Musculoskeletal Disorders (MSDs) are a group of symptoms or disorders related to muscle tissue, tendons, ligaments, cartilage, nervous system, bone structure, and blood vessels (OSHA 2000). In this study, Musculoskeletal Disorders is a muscle disorder that is felt in the elderly which is caused by posture errors in reading books with complaints of pain, tingling, or stiffness in the muscles, nerves, and bones of the movement system as measured by the Nordic Body Map (NBM).

b. Anthropometry

Anthropometry is a study that is concerned with measuring the dimensions of the human body. Anthropometric data is used for various purposes, such as designing work stations, work facilities, and product design in order to obtain appropriate and proper sizes with the dimensions of the human limbs that will be used (Anthropometri Indonesia 2013). Anthropometry used in this research is popliteal height dimension, popliteal butt dimension, hip width dimension, body thickness dimension, arm reach dimension, sitting elbow height dimension, sitting shoulder height dimension, shoulder width dimension. These dimensions are measured using a measuring instrument (ruler/meter) in centimeters and the percentile is calculated.

c. Voice of Customer (VoC)

VoC is a process used to capture customer needs for product design. VoC is a term used to describe customer needs or requirements. VoC is obtained in various ways, namely direct discussions or interviews, surveys, focus groups, customer specifications, and observations (Suwandi 2016). In this study, VoC was obtained by direct interviews with research samples related to the wishes of the elderly for the design of the reading chair to be made.

## 2.3 Research Procedures

Research procedures that will be done in this study, among others:

a. Preparation phase

This is done before the research process takes place. The things that are prepared include: (1) Determining the research sample, in this study the determination of the sample; (2) Preparing an NBM questionnaire to identify the complaints of Musculoskeletal Disorders that are felt by each respondent. The questionnaire will be distributed to the sample of respondents in the study and each respondent will check each complaint statement at the level of the perceived complaint; (3) Prepare a questionnaire on the level of importance to give the respondent's level of importance to the attributes that will be applied to the reading chair design. The questionnaire will be distributed to the sample of respondents in the study and each respondent will carry out a checklist on each product design attribute according to the level of importance of each respondent; (4) Prepare a HOQ Matrix which is used to show the relationship between customer desires and design parameters; (5) Prepare measuring instruments such as rulers/meters and stationery, these tools are used to take anthropometric measurements for each research sample.

b. Data Collection Stage

The stages of data collection in this study were as follows: (1) Collecting data related to elderly complaints when reading using interviews and questionnaires Nordic body map; (2) collecting data on the needs of the elderly in the reading chair design using interviews; (3) Collecting anthropometric data for the elderly.

c. Design Stage

In general, the process carried out in this study is divided into three stages.

- 1) First step is to collect VoC to find the attributes desired by the elderly for the reading chairs that will be designed. The information obtained is used to combine, compare, and filter with the characteristics of technical ability in designing reading chairs.
- 2) The second stage is the preparation of the House of Quality (HOQ) as an effective tool used to translate consumer wants and needs into product or service design characteristics using a relationship matrix. The steps in compiling a House of Quality are briefly as follows:
  - a) Creating a customer requirement matrix
  - b) Creating a planning matrix, aims to measure consumer needs and establish performance goals.
  - c) Technical response, namely the transformation from non-technical consumer needs to technical data in order to meet these needs.
  - d) Determine the relationship between technical response and consumer needs. The desires of the elderly will be related to the characteristics of the design technique so that it will produce a correlation between customer desires and the characteristics of the design technique in the relationship matrix, and determine which ones have a strong, moderate, weak, and unrelated relationship.
  - e) Determine technical correlations to map relationships and interests or technical responses.
  - f) Determination of targets for improvement.
  - g) Information obtained from customers and technical characteristics of the designer will be processed using the Quality Function Deployment (QFD) model and the House of Quality (HOQ) matrix.

3). The third stage is the development of a reading chair for the elderly, then the concept of product design is made according to the needs and desires of the user. The design is made using Fusion 3D software to visualize the concept of a reading chair for the elderly according to the wishes of the user and the dimensions of the user's body size.

d. Analysis Phase

The analysis stage was carried out by testing the satisfaction level of the elderly regarding the renewal reading chair design with existing competitors' reading chairs. The satisfaction level test was carried out using a satisfaction level questionnaire which was then carried out by the homogeneity test using the F-test. This stage is carried out to determine the level of satisfaction of the elderly with the design of the two reading chairs.

### 3. Results and Discussion

VoC data collection was carried out using direct interviews where the interview material was related to the complaints that are often felt when reading books and materials related to features needed by the elderly in the reading chair design. Table 1 provides a breakdown of the VoC attributes and degrees of importance.

Table 1. Details of VoC attributes and degrees of importance

No.	Quality Dimensions	Attribute	Degree value interest
1	Features	The reading chair has a seat and soft backrest	4
2		The reading chair is equipped with drinking places	2, 4
3		The reading chair is equipped with spelling that can be adjusted to the height and the user comfort	3, 8
4		The reading chair is equipped with spelling that can be folded sideways	2, 4
5		Reading chair can be adjusted the altitude	3, 6
6	Reliability	The reading chair has a service life yang long (durable)	3, 6
7	Durability	The reading chair is strong to withstand the load brightly	3, 4
8	Conformance	Reading chair according to size elderly body	4
9	Performance	The reading chair is easy to move	2, 6
10	Aesthetics	The reading chair has a color pattern dan excellent model	2, 6

The VoC results and the degree of importance are used as input to create the HOQ matrix. Making the HOQ matrix requires Technical parameters. Technical parameters in the design of an elderly reading chair are material type, product weight, design innovation, user comfort, color and pattern of chairs according to the user, and adjustable chairs and tables. Based on the HOQ matrix, it is obtained the priority order and target design of the elderly reading chair which will be made with the characteristics as shown in Table 2.

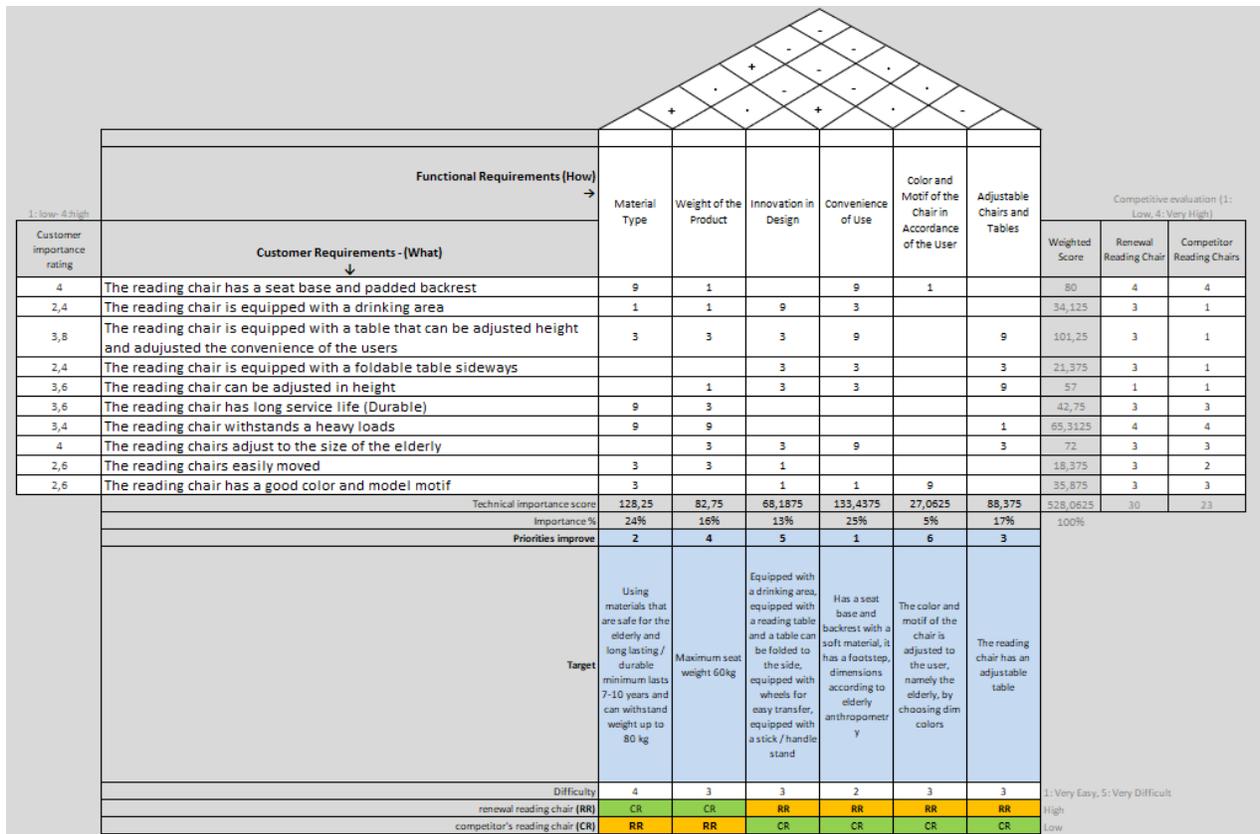


Figure 1. Results of the HOQ matrix

Table 2. The order of priority and target design of the reading chair for the elderly

No.	Priority	Design Targets
1	User convenience	<ul style="list-style-type: none"> <li>The reading chair has a seat and backrest with soft material</li> <li>The reading chair is equipped with a footrest</li> <li>Reading chairs have dimensions that match the anthropometry of the elderly</li> </ul>
2	Material	<ul style="list-style-type: none"> <li>The reading chair uses a material that is safe for the user</li> <li>The reading chair uses durable/durable materials, the target of using it lasts 7-10 years</li> <li>Reading chair can withstand weight 80kg - 100kg</li> </ul>
3	Adjustable chair and table	<ul style="list-style-type: none"> <li>The reading chair has an adjustable table</li> </ul>
4	Weight product	<ul style="list-style-type: none"> <li>The reading chair has a maximum weight of 80kg</li> </ul>
5	Design innovation	<ul style="list-style-type: none"> <li>The reading chair has a place to put a drink</li> <li>The reading chair has a table that can be folded sideways</li> <li>The reading chair is equipped with wheels for easy movement</li> <li>The reading chair has a stick or handle to make it easier when the user wants to stand up</li> </ul>
6	The color and motif of the chair according to the user	<ul style="list-style-type: none"> <li>The color and motifs of the chairs use faint color combinations such as brown, gray, etc.</li> </ul>

The elderly reading chair design that will be made using the QFD method will be compared with reading chairs that are already on the market. Figure 2 is a drawing of a competitor reading chair model that is already on the market and is commonly used by people to read at home and relax. Based on the comparisons that have been made on the HOQ

matrix, it can be seen that the reading chair design that will be made is superior to competitors' reading chairs from several aspects such as feature innovation that is more suitable for user needs, comfort level and the design of the reading chair that will be adjusted so as to increase comfort.



Figure 2. Competitor seat models

After getting the concept of the reading chair design and before entering the visual design stage of the product design, perform the collection of user body size data or so-called body anthropometry. It is intended that the design of the product is made in accordance with the size of the user's body so that it can increase the user's comfort when using the product. The dimensions of the elderly chair design to be designed were adjusted with anthropometric data. The rules used for the design of elderly chairs are as follows:

1. The width dimension of the chair base (LAK) uses the hip width anthropometry (LP) using the 95th percentile. The measurement results using the 95th percentile are 38.51 with an allowance of 5 cm, so the dimensions of the SAR are 43.51 cm.
2. The height dimension of the seat (TAD) uses popliteal height anthropometry (TP) using the 5th percentile. The measurement result using the 5th percentile is 39.84 with an allowance of 5 cm, so the dimensions of the TAD are 44.84 cm.
3. The space between the table and the back (RMS) uses anthropometry body thickness (TB) using the 95th percentile. The measurement result using the 95th percentile is 20.31 with a 10 cm gap, so the RMS dimension is 30.31 cm.
4. The dimension of the seat back width (LSK) uses anthropometry Shoulder width (LB) using the 95th percentile. The measurement result using the 95th percentile was 45.49 cm. Then the dimensions of LSK are 45.49 cm.
5. Height dimension of the backrest (DTS) using high anthropometry in a sitting position (TPD) using the 95th percentile. The measurement result using the 95th percentile is 80.25 cm, so the dimensions of DTS are 80.25 cm.
6. The armrest length dimension (PST) uses the forearm length anthropometry (PLB) using the 95th percentile. The measurement results using the 95th percentile were 44.98 cm, so the dimensions of the PST were 44.98 cm.
7. The dimensions of the length of the reading table (PMB) are 32 cm, the width of the reading table (LMB) is 25 cm and the thickness of the reading table (KMB) is 1.7 cm. The size of the reading table is adapted from the size of the table used in similar products that are already on the market (product name: Cheetos lecture chair), using this size the table can be used to put books while reading. In addition, by using this size the table will be easier to use because the dimensions of the table used are still within the anthropometric average value of the length of the elderly's arm, which is 55.81 cm.
8. The dimensions of the beverage table length (PMM) are 44.98 cm, the width of the beverage table (LMM) is 26 cm, the thickness of the beverage table (KMM) is 2 cm and the diameter of the glass hole (DLG) is 9 cm. The length of the beverage table (PMM) is adjusted to the length of the armrest on the chair, the width of the beverage table (LMM) is adjusted to the size of the largest plate diameter on the market, which is 26 cm, the thickness of the beverage table (KMM) is rounded thicker than the reading table so that the table Stronger when used to put food and the size of the glass hole diameter (DLG) is adjusted to the diameter of the largest beverage bottle on the market, which is 8 cm (1.5 liters bottled drinking bottle) with 1 cm allowance. By using these dimensions, users have enough space to be able to put their drinks and food when reading books.
9. Reading table height dimension (TMB) using anthropometry elbow sitting height (TSD) using the 5th percentile. The measurement result using the 5th percentile is 17.61 cm, then the TMB dimension is 17.61 cm.

10. The height dimension of the drink table (TMM) using anthropometry Sitting elbow height (TSD) using the 5th percentile. The measurement results using the 5th percentile are  $17.61 \pm 2$  cm, so the dimensions of the TMM are 15.61 cm, made lower than the height of the sitting elbow so as not to cover the armrests on the chair.
11. The length dimension of chair base (PAK) uses popliteal length anthropometry (PP) using the 95th percentile. The measurement result using the 95th percentile was 49.34 cm. Then the dimensions of the PAK are 49.34 cm.

### 3.1 Renewal Design of Reading Chair

Figure 3 and Figure 4 are the results of the design of reading chairs for the elderly with measurements that refer to the results of anthropometric measurements and adjusted to the allowance by the researcher. The following is an explanation of some of the features found in the renewal reading chair design.

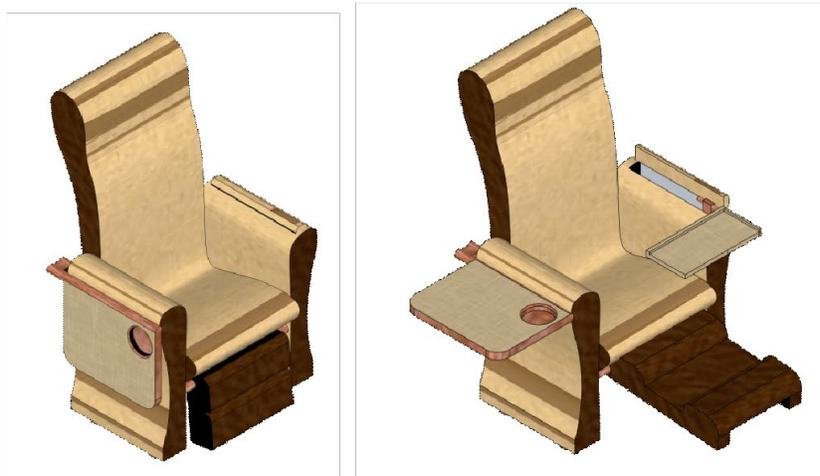


Figure 3. The design of the reading chair for the elderly

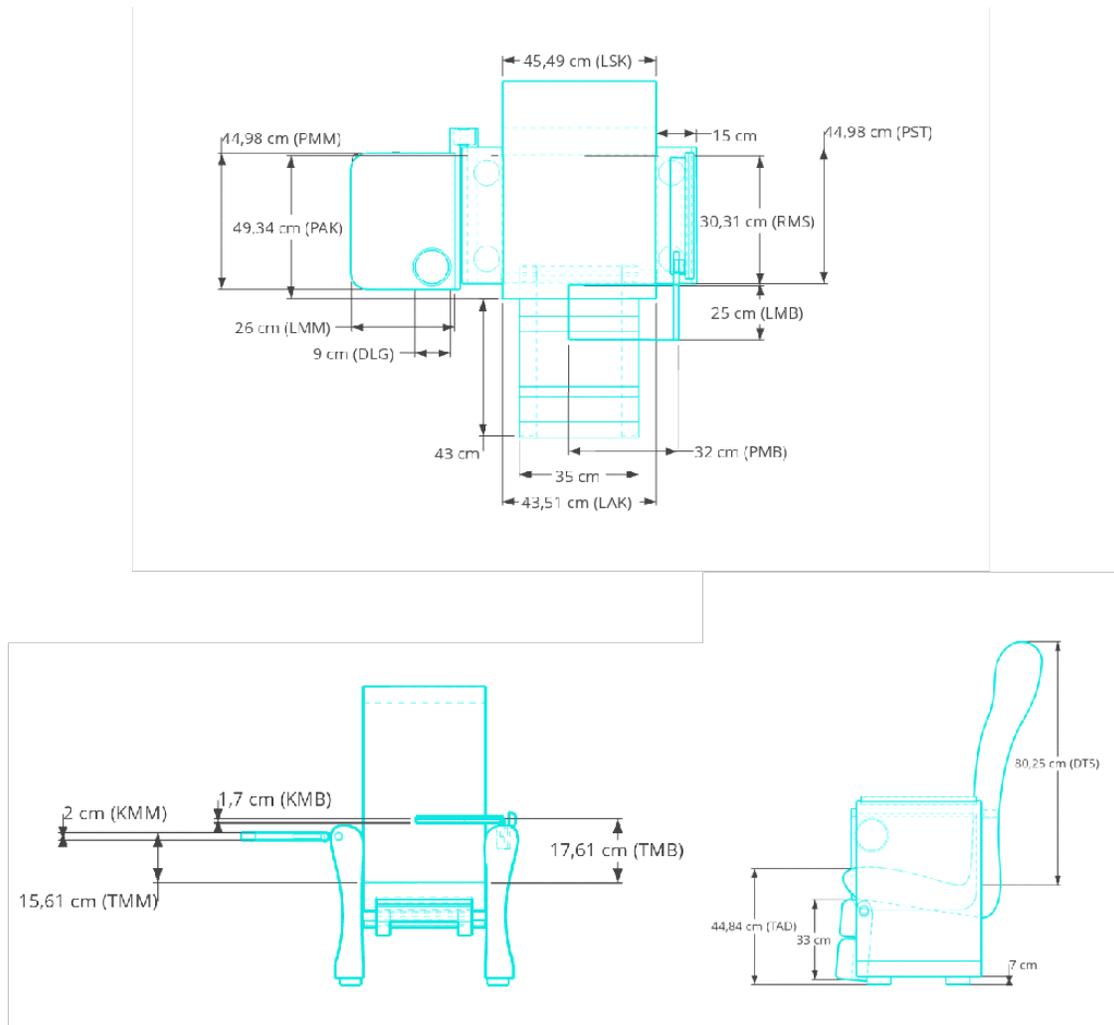


Figure 4. The dimensions of the reading chair design

1. Back of the chair

The reading chair for the elderly is designed to have a back that matches the anthropometry of the elderly in an upright and straight position. This is so that when sitting in chairs and reading books on the backs of the elderly they are still in an upright and straight position. When sitting, an upright and straight back is highly recommended. The forward bending position will make the neck and back pain, thereby reducing focus and concentration (Medcom.id 2017). In addition, make sure the position of the spine is in an upright position, to get this position, sit upright in a chair, the cartilage is against the back of the chair and make sure not to bend down because it will cause pain in the spine (Medcom.id 2017).

2. Have a table

The reading chair for the elderly is designed to have an adjustable table for placing books. This can reduce the risk of developing Musculoskeletal Disorders because the position that can cause Musculoskeletal Disorders is doing activities while holding work tools/objects in static conditions and in a bent condition (NIOSH 1997). With a table, the elderly no longer need to hold books in their hands so as to reduce the risk of Musculoskeletal Disorders in the hands and arms caused by holding books too long in a static condition. In addition, there is an adjustable table system, the elderly can adjust the height of the table and its tilt angle so that it can reduce the risk of Musculoskeletal Disorders in the nape/neck and aches in the upper back which are usually caused by reading too

bent for a long time. Then the table can be spaced from the user's body, so that when reading, the elderly can still lean on the back of the chair and the table can be spaced according to the user's wishes and comfort.

3. Has a footstep

Reading chairs are designed to have footsteps, this is because when reading a book, it is recommended that the position of the legs is straight so that blood circulation to the legs remains smooth, the thighs are parallel to the floor when the lower legs are perpendicular to the floor (Medcom.id 2017). Footsteps on the design of the elderly reading chair are used as a foot support when sitting in a reading chair. The tilt angle of the footstep can be adjusted according to the wishes and comfort of the user. The footstep can be raised until it is parallel to the floor so that when reading the book, the user can straighten his legs above the footstep so that blood circulation to the legs remains smooth so that it can reduce the risk of tingling in the legs due to being bent too long.

4. Have a drinking place

The reading chair has a place to store drinks and food which is attached to the reading chair, making it easier for the elderly to store their drinks while reading books. Drinking water is important for a person, including the elderly because the elderly are more prone to dehydration (Hellosehat 2019).

**3.2 Homogeneity Test**

Based on Table 3, the homogeneity test of the satisfaction level of the elderly is related to the attributes in the renewal reading chair and the competitor's reading chair.

Table 3. The results of the satisfaction level homogeneity test

Attribute	Sig.
The reading chair has a soft seat and backrest	0.058
The reading chair is equipped with a drinking area	0,000
The reading chair is equipped with a table that can be adjusted for the height and comfort of the user	0,000
The reading chair is equipped with a table that can be folded sideways	0,000
The reading chair is height adjustable	1,000
The reading chair has a long service life (Durable)	0.337
The reading chair is strong to withstand heavy loads	1,000
The reading chair is according to the body size of the elderly	0.937
The reading chair is easy to move	0.092
The reading chair has a nice color and style pattern	0.435

The results of the homogeneity test showed that there was no significant difference between the new chair designs and competitors with a significance value greater than 0.05 (sig.> 0.05). These attributes are that the reading chair has a soft seat and backrest, can be adjusted its height, has a long service life, is strong to withstand heavy loads, is in accordance with the body size of the elderly, is easy to move, and has a good color motif and model. Meanwhile, several attributes for the new chair design were significantly different from competitors' seats with a greater significance value of 0.05 (sig. <0.05). These attributes is a reading chair equipped with a drinking area, equipped with a table that can be adjusted in height and according to user comfort, and the table can be folded sideways.

**4. Conclusion**

Based on research that has been done, the elderly needs a reading chair with a soft seat and backrest, a reading chair equipped with a footstep, a reading chair that has an adjustable table, a reading chair that has a drinking area, a reading chair that is easy to move, a strong reading chair and has a useful life long. The results of the reading chair design are made according to the dimensions of the elderly anthropometry with adjusted percentile calculations. The results of the satisfaction level test, on some of the attributes of the respondents, were more satisfied with the design of the renewed reading chair than the Competitor's chair. This is because the renewal reading chair has features that competitors' reading chairs do not have.

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