Evaluation of Human Factors in Redesigning Library Bookshelves for The Blind Using The Ergonomic Function Deployment (EFD) Method

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Abstract

Along with the times, human desires and demands for quality products and their functions are increasing. SLB Negeri Pembina Pekanbaru is a school that handles students with mental, physical, and intellectual limitations or also known as disabilities. This research is a follow-up study from previous researchers, which aims to evaluate and provide improvements to the prior design. Open-ended questions were conducted to the parties involved, namely the SLB Negeri Pembina Pekanbaru employees and staff, which amounted to 3 people. The interview results showed that the design of the blind bookshelf from the previous researcher had several shortcomings, such as braille letters that were not following the student's anthropometric size and heavy materials that made the product difficult to move. The design concept was not yet user-friendly, so students still needed help with these difficulties—the teacher picking up books. The ergonomic Function Development method is used in this study to discover and identify criteria for the needs and dimensions of the product according to the wishes of consumers. This study describes four design concepts, which will be carried out in a screening and concept assessment stage. The screening and assessment results provide concept 2 as the chosen concept, which has advantages. It is easier for users to use a bookshelf, more structured book preparation, and a minimalist appearance.

Keywords
Anthropometry, Continuous Improvement, Disability, Ergonomic Function Deployment (EFD), Product Design.

1. Introduction
Human needs are growing in the era of wanting quality products following complex functions. It can make people have the latest ideas to create product designs with added functionality and product value for users. Increase the added value of a product. It is necessary to redesign the product according to consumer needs. Assess whether consumer needs have been met or not. One of them can be seen in how comfortable consumers are in using a product using an ergonomic point of view.

According to Marimin (2016), quoted by Prabowo and Zoelangga (2019), design is a dimension that offers many emotional aspects in influencing customer satisfaction. User satisfaction also needs to be carried out in schools, including Special Schools. Extraordinary Schools have several things that need to be developed, such as library bookshelves. Special School students certainly have remarkable cabinets for mental limitations, such as blind, physically handicapped, mentally retarded, autistic, and other mental limitations, to facilitate them in the learning process. SLB Pembina Pekanbaru is a special education and special service (PK-LK). This school handles students who have mental, physical, and intellectual limitations or are called disabilities. SLB Pembina Pekanbaru has library

facilities to help support the learning of children with special needs, one of whom is blind. This research is a continuation of a study conducted by Agnesia Keke in 2019, namely designing library cabinets for people with disabilities and visual impairments. The interview results showed that the design of the blind bookshelf (Figure 1) from the previous researcher had several shortcomings, such as braille letters that were not following the student's anthropometric size and heavy materials that made the product difficult to move. The design concept was not yet user-friendly, so with these difficulties, students still needed help teachers picking up books.

Figure 1. Blind Bookcase (Before Redesign)

One method that can be used as an approach to improve a design is Ergonomic Function Deployment (EFD). Ergonomic Function Deployment (EFD) is a development method that adds a new relationship between consumer desires for products from an ergonomic aspect. The product attributes used from the ergonomics aspect: ENASE (Effective, Comfortable, Safe, Healthy, and Efficient). (Purnamayudhia and Subaderi, 2020).

This method has the advantage that the design is carried out based on the interpretation of user needs by considering the desired ergonomic aspects (Anshori, 2020). The Ergonomic Function Deployment (EFD) method can also be used for other designs, such as furniture design research. Based on the problems above, researchers are interested in redesigning the bookshelves using the Ergonomic Function Deployment (EFD) method to get a more user-friendly design conducive to the visually impaired. Anthropometric data as supporting data in the process of making library cabinets.

1.1 Objectives

The purpose of this research is to redesign the ergonomic bookcase of the library for the visually impaired according to the user's needs using the Ergonomic Function Deployment (EFD) method to facilitate the use of the cupboard.

2. Literature Review

Ergonomics is a science that studies and examines the limitations and advantages of humans, then the information obtained will be used to design products, machinery, facilities, environment, and work system. The main objective of an ergonomic application is the application of good aspects of health, safety, and working comfort to achieve a good quality of work. At a higher level, ergonomics aims to create optimal working conditions (Pradani, et al, 2019). According to (Tarwaka, Ha.Bakri, & Sudiajeng, 2004) quoted (Ahmady, et al, 2020), ergonomics can be applied to work systems and are defined as rules and norms that identify the limits of the human body at work and apply techniques to improve performance. Quality of life. In general, ergonomics deals with the problems faced and the relationship between humans and their work. Ergonomics also makes work more effective, comfortable, safe, healthy, and efficient (ENASE).

According to Dweyer (2013), quoted by Prabowo and Zoelangga (2019), Product development is an activity or activity carried out in the face of possible changes in a product to a better direction so that it can provide superb usability and satisfaction.

The design parameters are defined as follows according to Urlich and Eppinger (2013) in the quote Prabowo and Zoelangga (2019):

1. Style describes the appearance of a product
2. Durability describes the operating life of the product under normal conditions or is damaged
3. Reliability is a measure of the probability that a specific product will not be damaged or fail within a certain period
4. Easy to repair (repairability) measures the ease of repairing the product when the product is damaged.

Anthropometry comes from the Greek "Anthropos," which means human, and "metron," which means size so anthropometry can be interpreted as a human body measurement. Anthropometric data is usually used in ergonomics to determine the physical dimensions of workspaces, equipment, furniture, and clothing to avoid physical discrepancies between the equipment and product dimensions and the appropriate user dimensions (Bridger, 2003).
Ergonomic Function Deployment (EFD) is the concept of Quality Function Deployment developed by adding a new relationship after a customer's need or desire for ergonomic products (Damayanti, 2000). The EFD approach achieves the ENASE principles of Effective, Comfortable, Safe, Healthy, and Efficient. By achieving the ENASE principle, ergonomic product improvements can be achieved and reduce the risk of MSDs. (Dwyantoro dan Rahayu, 2018).

In solving a problem using the EFD method, it is necessary to take steps, namely (Cundara, et al, 2018):

1. Identify Customer Needs
   These needs are expressed in statements from interviews, then translated into consumer needs arranged based on the level consumers want.
2. Create a design matrix (Planning matrix)
   a. Determining the Level of Consumer Interest
   b. Measurement of Consumer Satisfaction Level

$$\frac{\sum(\text{average attributes of consumers})}{\text{number of respondents}}$$

   c. Target Value Determination
   d. Determination of Improvement Ratio (Improvement Ratio)

$$\text{Improvement Ratio} = \frac{\text{Goal}}{\text{Current Satisfactions Performance}}$$

   e. Sales Point Determination

Table 1. Sales Point

Score	Meaning
1	No selling point
1.2	Medium selling point
1.5	Strong selling point

   f. Raw Weight Determination

RW = Importance to Customers x Improvement Ratio x SP

   g. Normalized Raw Weight Determination

$$\text{Normalized Raw Weight} = \frac{\text{Raw Weight}}{\text{Raw Weight Total}}$$

3. Preparation of Technical Interests
4. Determine the relationship between consumer needs and technical interests. This determination shows the relationship (Relationship Matrix) between each customer's needs and technical interests.
5. Prioritization
6. Preparation of HOE (House of Ergonomics)

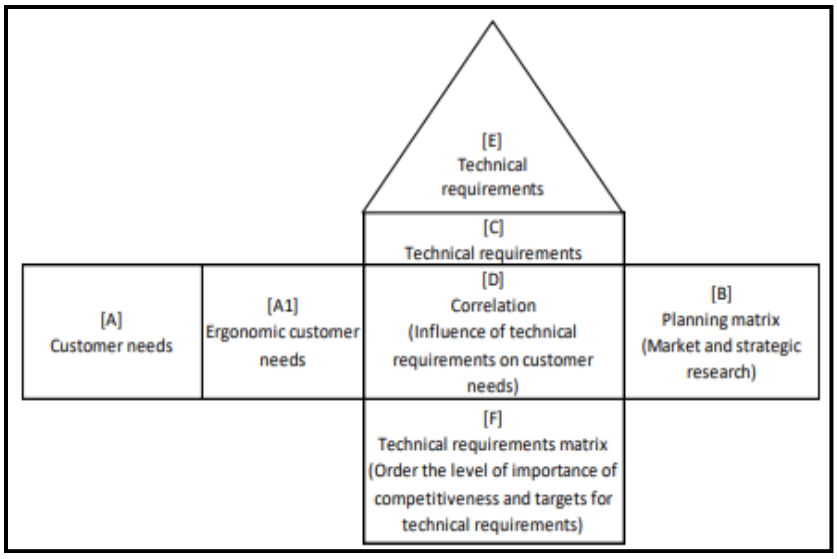

Figure 2. House of Ergonomic (HOE)

The product concept is a description or estimate of the technology, working principle, and product form. The output of this planning phase is the project mission statement which is used as the input needed to start the concept development stage and is a guide for the development team. There are two stages in concept testing, namely concept screening, which aims to narrow the number of concepts appropriately and quickly to improve concepts. Next is the concept of assessment, which is used to increase the number of alternative solutions that can better be distinguished between competing concepts. At this stage, relative importance is given to each selection criterion and focuses on better comparison results with an emphasis on each criterion (Ulrich and Eppinger, 2001).

3. Methods

The research was conducted at Pembina State Special School Pekanbaru. This school is located at Jalan Segar No. 46 Rejosari Village, Tenayan Raya District, Pekanbaru City, and was established by the Ministry of National Education in 1998. The Decree on the Appointment of the Pembina State SLB was issued by the Minister of National Education No. 13a/O/1998 on January 29, 1998. Information regarding data or problems regarding library bookshelf in Pembina State SLB Pekanbaru as a basis for conducting research. This information was obtained by observing observations and interviews with the school, namely the Pembina Pekanbaru State SLB teacher, and distributing open and closed questionnaires to determine consumer needs and satisfaction.

Based on data from research and a theoretical basis, the visible problem is that there are still complaints from teachers and students about taking books on the bookshelves of special libraries for the blind, namely the display of braille letters on the shelves that are still not following the anthropometric size of the fingers of students with visual impairments. In addition, the material that can be said to be still heavy is also one of the difficulties for students in taking books because they have limitations. With these difficulties, the students still need the teacher's help in taking the books from the shelves. This causes students with visual impairments to be less independent when choosing and reaching the desired books, so it is necessary to redesign the bookshelf to be ergonomic and user-friendly for students with visual impairments.

This research aims to make blind people translate braille well by redesigning and making it easier to use the bookshelves using the Ergonomic Function Deployment (EFD) method. The processed data are validity, reliability, implementation of Ergonomic Function Deployment (EFD), and concept testing. Data analysis in this study is defined, including data collection analysis, statistical test analysis, Ergonomic Function Deployment (EFD) analysis, concept design analysis, and analysis of final product specifications.

4. Data Collection

This research was conducted by conducting interviews and direct observations of SLB Pembina Pekanbaru and distributing open and closed questionnaires to determine consumer needs and satisfaction. The data obtained are the

total number of students, vision and mission, and the results of filling out a closed questionnaire to test the validity and reliability of implementing EFD.

4.1 EFD Questionnaire Data

The preparation of the closed questionnaire by providing more detailed statements related to the open questionnaire based on ENASE (Effective, Comfortable, Safe, Healthy, and Efficient) is as follows Table 2.

Table 2. Identification of Consumer Needs

Variable	Attribute	Statement
Effective	Utility	1. Easy to reach 2. Easy to move 3. A field of science separates books
Comfortable	Ergonomic Design	4. Has a design that is safe and comfortable to use (ergonomic) 5. Additional drawers for storage
Safe	Use Risk	6. No harm to users
Healthy	Reduce Musculoskeletal	7. Braille letters are located on an easily accessible surface
Efficient	Ease of Use	8. Have a bookshelf guide catalog 9. Strong and durable raw materials

5.Results and discussion

5.1 Validity Test and Reliability Test

Validity and reliability tests were carried out to determine the validity or suitability of the questionnaires used in measuring and obtaining research data from respondents. Validity and reliability tests were conducted using IBM SPSS Statistics 25.0 software.

1. Validity Test and Internal Factor Reliability Test

Table 3. Item Total Statistics

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
P1	31,29	45,571	,877	,960
P2	31,43	44,286	,903	,959
P3	31,29	43,571	,858	,960
P4	31,14	44,810	,854	,961
P5	31,43	44,286	,903	,959
P6	31,29	45,571	,877	,960
P7	31,57	41,952	,882	,960
P8	31,43	45,619	,780	,964

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P6	31,29	45,571	,877	,960
P7	31,57	41,952	,882	,960
P8	31,43	45,619	,780	,964
P9	31,43	43,619	,789	,964

Based on the Table 3 above, the corrected item-total correlation in the statement with the number of respondents is as many as seven students with visual impairments. Because the r_{table} uses a 95% confidence level, the rtable obtained is 0.7545. The statement is said to be valid if the value of r count > r_{table}. Judging from the table, if the value of r_{count} for all statements is greater than r_{table}, then all statements are declared valid.

Table 4. Reliability of Internal Factors

Reliability Statistics	
Cronbach's Alpha	**N of Items**
0,965	9

Based on the reliability statistics Table 4, Cronbach's Alpha value is 0.965 in this reliability test. The reliability test criteria can be good if it has a Cronbach's Alpha value > r_{table}. Because Alpha 0.965 > 0.6, the results of the questionnaire are reliable.

5.1.2 Implementation of Ergonomic Function Deployment

Implementing the EFD method aims to meet the cold needs and desires achieved so they can be fulfilled. (Figure 3)

Table 5 Normalized Raw Weight

No	Consumer Expectations	Skor	*Imp. Ratio*	*Sales Point*	*Raw Weight*	*Nor. Raw Weight*
1.	Braille letters are located on an easily accessible surface	4,00	3,12	1,5	4,00	0,1341
2.	Books are separated by field of science	4,42	3,11	1,5	4,42	0,1476
3.	Have a bookshelf guide catalog	4,00	3,50	1,5	4,00	0,1504
4.	Additional drawers for storage	4,14	1,30	1,5	4,14	0,0578
5.	Strong and durable raw materials	3,85	1,28	1,5	3,85	0,0529
6.	Easy to reach	4,00	2,81	1,5	4,00	0,1208

7.	No harm to users	4,00	1,75	1,5	4,00	0,0752
8.	Has a design that is safe and comfortable to use (ergonomic)	3,85	2,45	1,5	3,85	0,1013
9.	Easy to move	3,85	3,85	1,5	3,85	0,1593
	Total					**0,999**

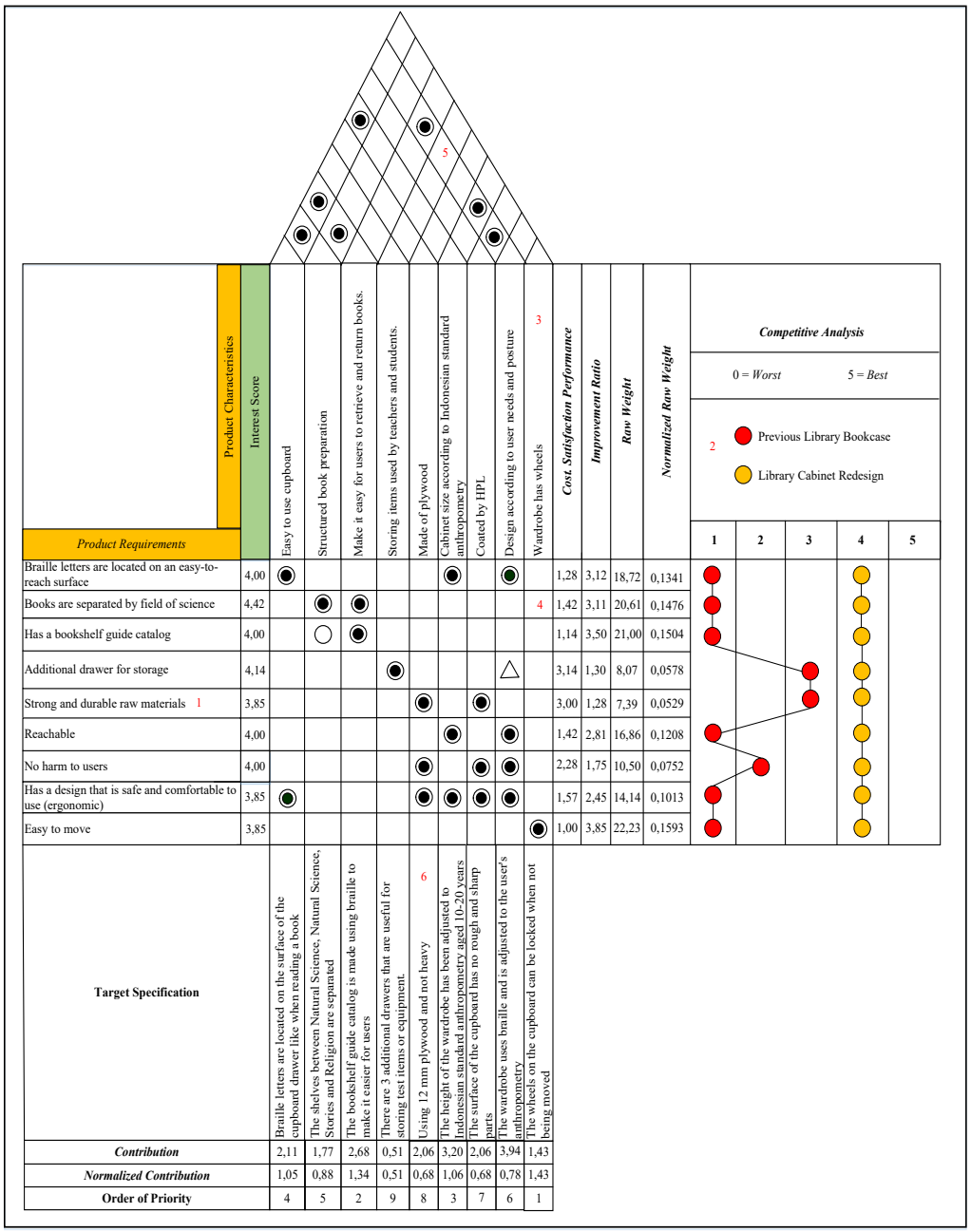


Figure 3. House of Ergonomic (HOE)

5.2 Concept Design

After carrying out the Ergonomic Function Deployment (EFD) stage, the next stage is to create a concept to select the final product design from several concepts that will be selected.(Figure 4)

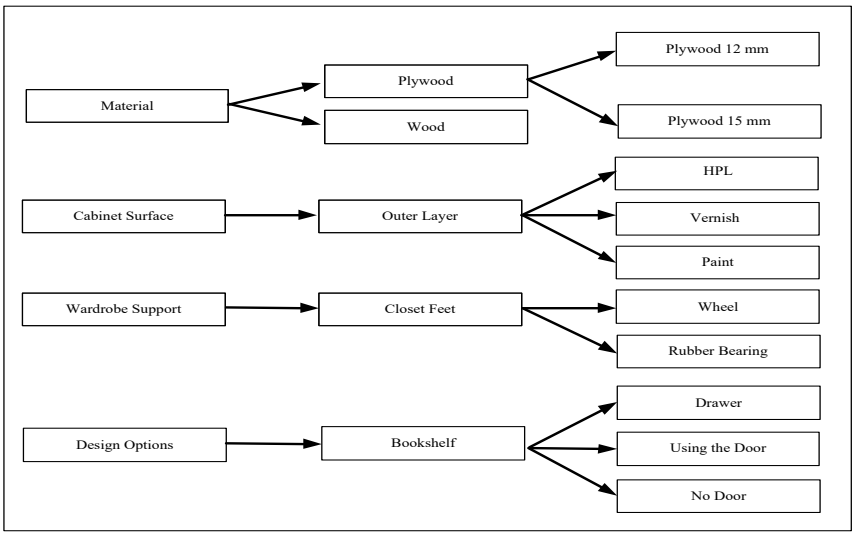


Figure 4. Classification Tree

5.2.1 Screening Concept

The purpose of the screening concept is to reduce the number of concepts correctly. This stage will produce one or more concepts obtained, with four alternative concepts obtained. The following is a screening concept process. (Table 6)

Table 6. Screening Concept

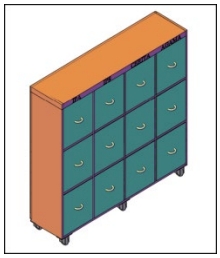
Selection Criteria		**Konsep**			
		Concept 1 (Reference)	**Concept 2**	**Concept 3**	**Concept 4**
Features	Additional drawer for storage	0	+	-	-
Reliability	Strong and Safe Material	0	+	+	+
Durability	Durability in Bookshelves Usage	0	+	+	+
Portability	Easy to Move	0	+	+	-
Aesthetics	Design according to user requirements	0	+	-	-
	Minimalist Design				
Price	Affordable prices	0	+	-	-
Quantity +		0	7	3	2
Quantity -		0	0	-3	-4

Quantity 0	6	0	0	0
Final score	0	+7	0	-2
Rating	3	1	2	4
Continue?	No	Yes	Yes	No

5.2.1 Scoring Concept

Concept assessment is a stage of assessing or differentiating concepts better, emphasizing each criterion. The concept assessment process can be seen as follows: (Table 7)

Table 7. Scoring Concept

Selection Criteria		**Load**	**Concept**			
			2 		**3** 	
			Rating	**Load Value**	**Rating**	**Load Value**
Features	Additional drawer for storage	**15%**	**3**	**0,45**	**2**	**0,3**
Reliability	Strong and Safe Material	**20%**	**3**	**0,6**	**2**	**0,4**
Durability	Durability in Bookshelves Usage	**15%**	**4**	**0,6**	**2**	**0,3**
Portability	Easy to Move	**20%**	**4**	**0,8**	**4**	**0,8**
Aesthetics	Design according to user requirements	**20%**	**3**	**0,6**	**2**	**0,4**
	Minimalist Design					
Price	Affordable prices	**10%**	**2**	**0,2**	**3**	**0,3**
Final score		**100%**		**3,25**		**2,5**
Rating				**1**		**2**
Continue?				**Yes**		**No**

From the results above, the chosen one is concept 2, with a final score of 3.25. Therefore, concept 2 will be applied to the design of the bookcase.

5.4 Final Product Specification

The final product specifications determine the components, sizes, and materials in the library bookcase product obtained from the chosen concept design, namely concept 2.

5.4.1 Anthropometry

Anthropometry is used to determine the size and dimensions of the product that will be designed based on the posture of students with visual impairments from 10 – 20 years old. The number of students with visual impairments is only seven people. This study uses Indonesian standard anthropometry adapted to the anthropometry of previous students so that students can use it the following year. (Table 8)

Table 8. Anthropometry

Anthropometric Data	Using Size	Percentiles	Size (Centimeters)
Height (TB)	bookshelves height	5th,50th and 95th	Senior High School = 165 Junior High School = 150 Primary School = 117
Forward Hand Reach (JTD)	Picking up books on the shelf	5th	29
Standing Elbow Height (TSB)	Drawer table height	50th	60
Palm Length (PTT)	Put braille	50th	12

The anthropometric data used in the design of this library bookcase are as follows:

1. Height (TB)
   Height is used as an adjustment to the height of the library bookshelf with a value of the 50th percentile. The middle percentile is used because the anthropometric size of the highest user's body height is not much different from the height of a medium-sized student. The width and height of the cabinets on each shelf are not only adjusted to Indonesian standard anthropometry but also take into account the anthropometry of students with visual impairments and estimate the length and width of the book paper.
2. Forward Hand Reach (JTD)
   The forehand reach is used as the width of the shelf in the library bookcase, the percentile used is the 50th percentile using a high forward hand reach so that when taking books, students with a low and high percentile forehand reach can use the cupboard comfortably.
3. Standing Elbow Height (TSB)
   Standing elbow height is useful for the height of the drawer table in the bookcase.
4. Palm Length (PTT)
   The palm length is used to measure the length of the location of the braille letters in the library bookcase.

The following are the results of the design on concept 2 and its dimensions:

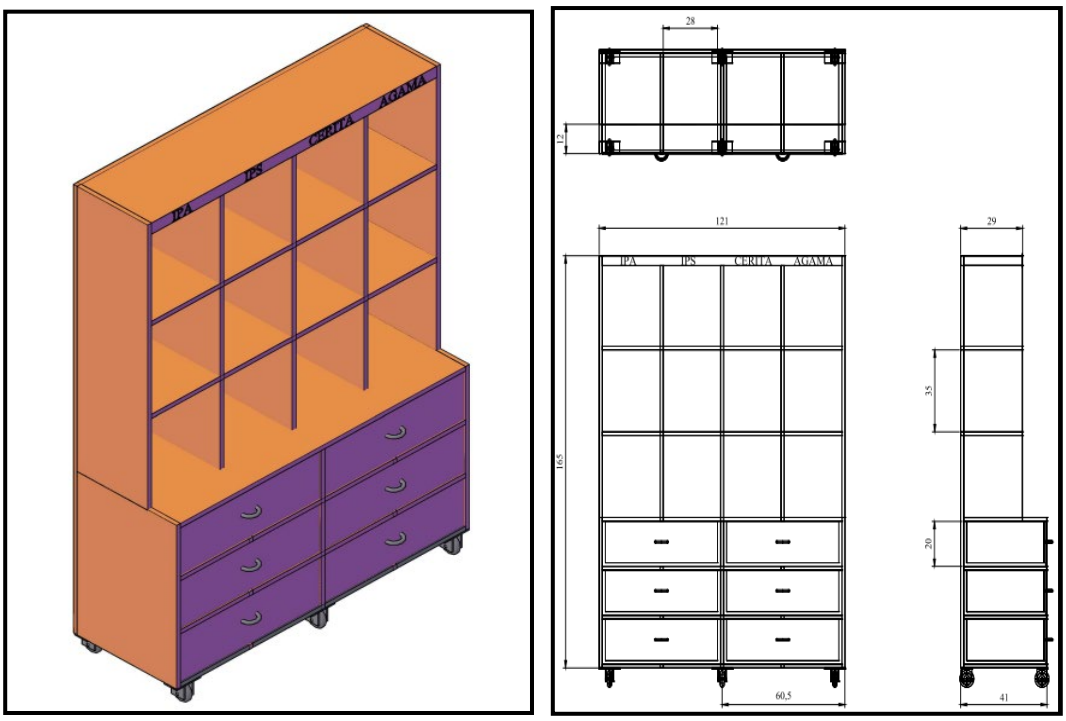


Figure 5. Library Bookcase Redesign

Figure 5 is the result of the design of the processing carried out, which will be made on the product to be designed. In the picture above, there are already sizes that will be used for the product to be designed. The advantages of this plan are:

1. The raw material used is plywood. The raw material is easy to find and lightweight
2. More efficient because books are separated according to the field of science and are easy to move because they use wheels
3. The size follows the anthropometric size of students and Indonesian standards

6. Conclusion

From the results of research conducted using the Ergonomic Function Deployment (EFD) method, user needs for redesigning bookshelves for the blind can be seen from the level of importance of consumer satisfaction obtained from the distribution of closed questionnaires. It was found that a cupboard with wheels became the priority, making it easier for users to retrieve and return books in the second priority order position, so changes had to be made.

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Biography

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