Product Design of Adjustable Mini Static Bicycle Using Nigel Cross Method

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Abstract

Stroke is one of the leading causes of death and the leading cause of disability in the elderly, ranking it the third most deadly medical condition in the world. Restoration of motor function as a support for body movement in post stroke clients is very important. The aim of this research is to develop a therapeutic aid for the rehabilitation process for post-stroke patients, which is foot therapy that will be developed with a therapeutic device using hands. Product design according to Nigel Cross is divided into seven steps, each of which has its own method. The nigel cross method applied to Adjustable Mini Static Bicycle products produces black colour product, product dimensions are 36x38x21 cm, product material is iron, product weight is 3 kg, used for training muscles and nerves, product uses button cell battery, with energy capacity 270 mAH, adjustable height up to 55 cm, additional acupuncture feature and hanger. It is found that W (wish) is 7 and D (demand) is 3 so that it is obtained W> D. Therefore, it can be concluded that the designer is adept at designing products because they have adjusted to the needs of consumers. The price to be issued in the product design process is IDR 317,100.

Keywords
Product Design, Nigel Cross, Rehabilitation, Physiotherapy, Stroke

1. Introduction
Non-communicable diseases have killed 41 million people every year or equivalent to 70% of deaths globally. One of the four main non-communicable diseases according to WHO is cardiovascular disease and stroke. Stroke ranks the second leading cause of death in the world and caused 6.2 million deaths in 2011 (Syafni 2020).

Stroke basically still has the potential to recover after going through a stroke. However, patients who are able to survive post stroke have challenges in life. Stroke patient is likely to experience paralysis of half the body, difficulty to talk to other people (aphasia), slanted mouth (facial drop), weak arms and legs, impaired body coordination, mental changes, emotional disturbances, communication disorders, and loss of sense of taste. These residual symptoms can affect the physical, psychological and social aspects of the patient which will also have an impact on reducing productivity and quality of life both permanently and temporarily. Furthermore, physical effects can also appear such as partial paralysis, communication disorders and cognitive disorders. The most common deficit experienced by stroke patient that involves motor action. This physical paralysis can occur immediately and usually the patients notice that they cannot move their arms and legs on one side of the body (Pambudianto and Batan 2013).

Moving the feet on the human body can also be a stimulus for other parts of the body. Activities that can be imitated such as walking or stepping, this movement can be modified by pedaling the legs. Physical activity for building strength can help the body's muscles work in holding something. Mini static bicycles can be moved easily when not in use, or in other words easy to store, they are simple and light in shape (Kesuma et al. 2019).

The aim of this research is to develop a therapeutic aid for the rehabilitation process for post stroke patients, which is for foot therapy and developed with hand therapy tools.

2. Literature Review

Nigel Cross Definition

Product design according to Nigel Cross is divided into seven steps, namely clarifying objectives, determining functions, compiling requirements, determining characteristics, generating alternatives, evaluating alternatives, and detailing improvements (Suprayitno et al. 2018).

Ergonomic Product Design

For patients who have had a stroke, medical rehabilitation interventions are very important to return patients to independence in taking care of themselves and carrying out activities of daily life without being a burden to their families. It is necessary to strive to keep the post stroke patient active to prevent complications from bed rest and stroke repeated (*secondary prevention*). Complications of bed rest and stroke repeatedly will exacerbate disability and cause other diseases that can even lead to death (Koesdijati and M 2017).

The ergonomics approach of a work system must be adapted to the main roles and functions of the components of the work system involved, namely humans, machines/equipment and the physical work environment. The role of humans in this case is based on their abilities and limitations, especially those related to aspects of observation, cognitive, physical or psychological. Work machines/equipment also functions to increase human capabilities, not cause additional stress due to workload and are able to carry out certain jobs that are needed but are above the capacity or abilities possessed by humans (Saptaputra et al. 2021).

Product design is a design that consists of a series of sequential activities; therefore, the design is then referred to as the design process which includes all the activities contained in the design (Anjani et al. 2021).

The design process of a product to be produced must be able to fulfill several aspects, especially if the product will be used for human needs. Among them are aspects of ergonomics, *raw material aspects*, safety and environmental aspects. Environmental aspects are very important in producing products that are environmentally friendly, in the sense that these products can be designed in such a way starting from raw *material* until after use, the goods made can be *reuse* or recycled (Prasetya and Roepajadi 2022).

In addition to paying attention to ergonomic size and consumer desires, product design must also pay attention to strength and safety when used, so that it can be better than previous designs and can minimize the weaknesses of existing designs (Saputra et al. 2022).

Acupuncture is a treatment technique using needles. Acupuncture treatment techniques are performed with how to insert media in the form of needles into certain areas of the body. This treatment technique is usually done to relieve pain and also for certain medical treatment by means of needle insertion. Through acupuncture treatment techniques. If this is done, it is hoped that relaxation will occur in all blood vessels leading to the brain. In addition, for patients who do acupuncture it is expected that acupuncture can also reduce fluid retention in the body by pushing circulation of fluid to be excreted through urine. Acupuncture can enhance the rehabilitation of the lower extremities but did not provide significant results on upper extremity motor function (Setiawan et al. 2021).

Previous Research

In previous research, the tools used for post-stroke rehabilitation were Saeboflex and Pictor. Saeboflex is designed for wrist rehabilitation and grip strength. Pictor was designed to focus more on wrist rehabilitation driven by servo motors, so it is hoped that a wrist rehabilitation device that is comfortable, safe, strong, and inexpensive will be obtained. The design of the wrist rehabilitation device has a total length of 350.459 mm, a total width of 216 mm and a total height of 167.632 mm. The way the Wrist Rehabilitation tool's work is more or less the same as how the Pictor product works. One of the patient's hands is placed on the forearm plate, then the hand grips the handgrip. Then the hand adhesive belts are glued tightly, while the arm adhesive belts are not locked too tightly. This is intended to avoid injury to the patient's arm. The adhesive arm belt is still used because it prevents the patient's hand from moving in all directions which can cause the patient's arm to fall out of the rehabilitation device and can be fatal. After that arduino is turned on and the servo motor will automatically rotate according to the training program that has been prepared (Amali and Batan 2021).

Patients with stroke have disturbances in blood circulation, such as blockage or rupture of blood vessels in the part of the brain that can cause muscle weakness in sufferers. The use of acupuncture therapy can help improve blood circulation, besides that the benefits of acupuncture can improve the segmental, spinal, local systems, nerve regeneration, help nerve cells, help improve body condition which is characterized by an increase in muscle strength. This is also supported by research conducted by Hai Qiao Wang in 2020 stating that acupuncture therapy in patients with subacute hemorrhagic stroke is able to improve motor function and increase the ability of the lower extremities (Ulkhasanah et al. 2021).

3. Methods

The method for developing an ergonomic design for the Adjustable Mini Static Bicycle is the Nigel Cross Method. According to Nigel Cross, there are seven steps in product design, namely clarifying objectives, determining functions, compiling requirements, determining characteristics, generating alternatives, evaluating alternatives, and detailing improvements. A brief description of Nigel Cross Method can be seen below.

1. Clarifying objectives (Simanjuntak et al. 2020)

The first step in design is to seek to clarify design objectives. In fact, it really helps in the results at every step until the results are as expected. The end of this purpose clarification is a set of object design goals that must be made even though the goals made may change in the next design process.

2. Determining function (Sulaiman 2017)

Based on the objective tree method, the goal is to define the necessary functions and system boundaries of the new product design. In this step, the functional analysis method is used with the black box model.

3. Determining requirements (Khairannur et al. 2023)

After the function is defined, the next step is to develop requirements. This third step aims to make accurate manufacturing specifications necessary for the design.

4. Determining characteristics (Fahrudin 2019)

The next is a step called determining the characteristics, which aims to determine what targets will be achieved by the technical characteristics of a product so that it can satisfy consumer needs.

5. Generate alternatives (Mujiono et al. 2020)

The aim of this step is to generate alternative design solutions. The method used is the Morphological Chart method. This method encourages designers to identify or seek new combinations of elements.

6. Evaluate alternatives (Dharma et al. 2018)

The alternatives that have been generated will then be evaluated to choose which one is the best.

7. Detailing improvements (Oktaviani and Mauluddin 2021)

Detailed improvements are made to develop a product, improve its appearance, reduce its weight, lower its cost, and increase its attractiveness. All forms of modification can usually be divided into two types, namely modifications that aim to increase product value for buyers and reduce costs for producers.

The flowchart in developing an ergonomic design for Adjustable Mini Static Bicycle can be seen in Figure 1.

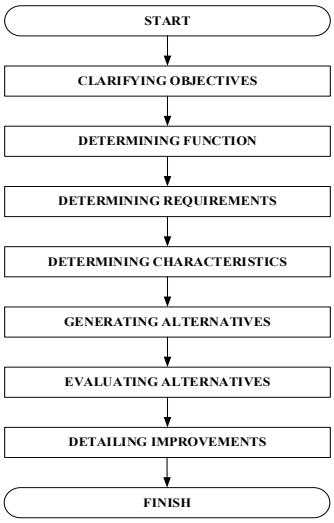

Figure 1. Flowchart Methods in Developing Ergonomic Design

4. Data Collection
Data collection was carried out using open questionnaires and closed questionnaires.

5. Results and Discussion
In this study, the method used is the Nigel Cross method. The design in this method has 7 stages. The following are the steps used in product design and analysis of results.

5.1 Clarifying Objective
The tree diagram of the design obtained from the results of the questionnaire can be seen below:

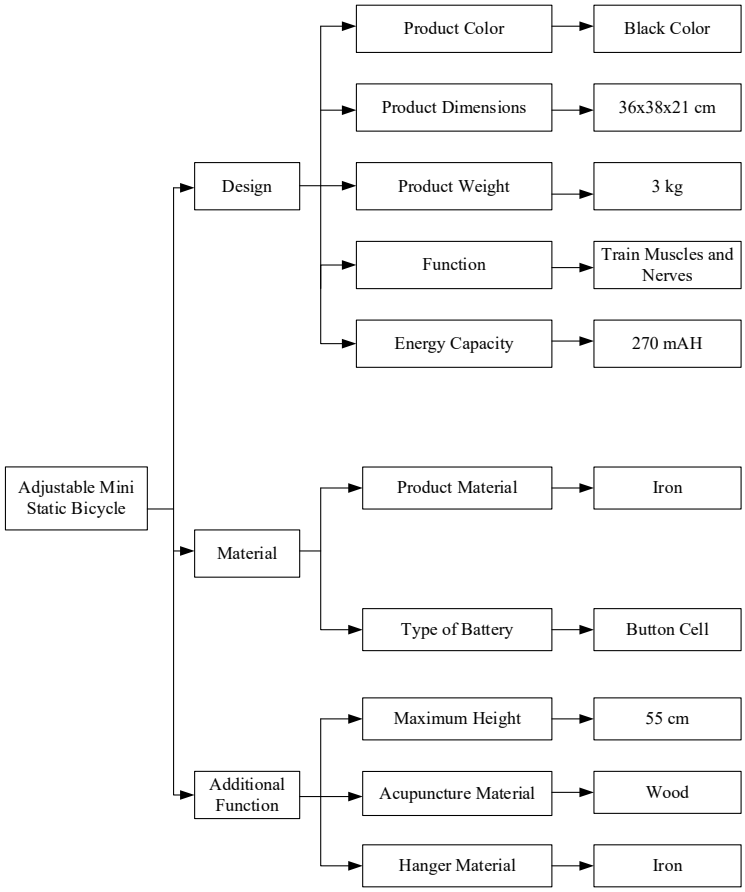

Figure 2. Tree diagram of the purpose of Adjustable Mini Static Bicycle

5.2 Determining Function
Determination of the function of the Adjustable Mini Static Bicycle product is determined by the following steps

a. Overall design function with input and output transformation using blackbox

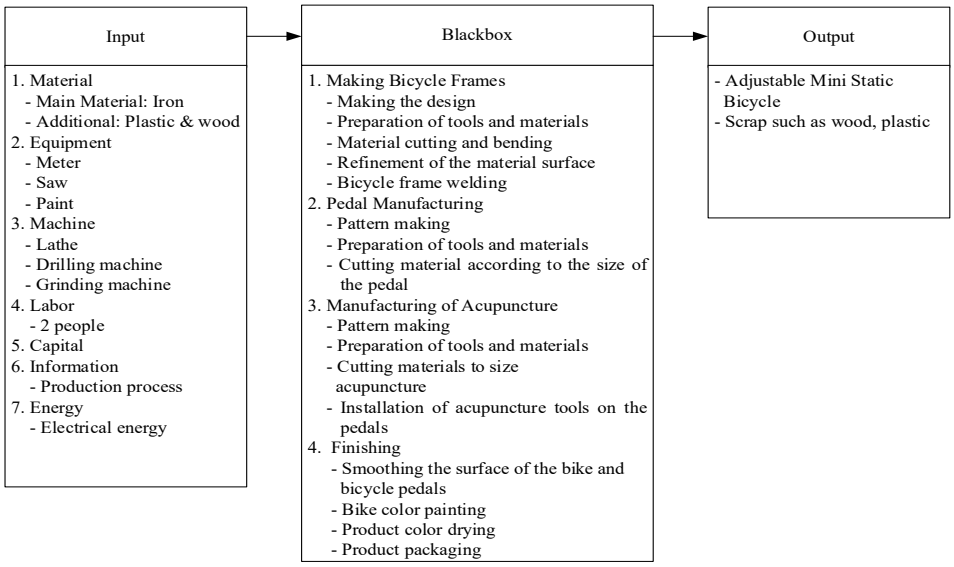

Figure 3. Adjustable Mini Static Bicycle Product Diagram

b. Block diagram display of interactions between sub-functions

The system is described separately so that the input, process and output can be clearly seen. The block diagram of the Adjustable Mini Static Bicycle product of group IV D can be seen in Figure 4.

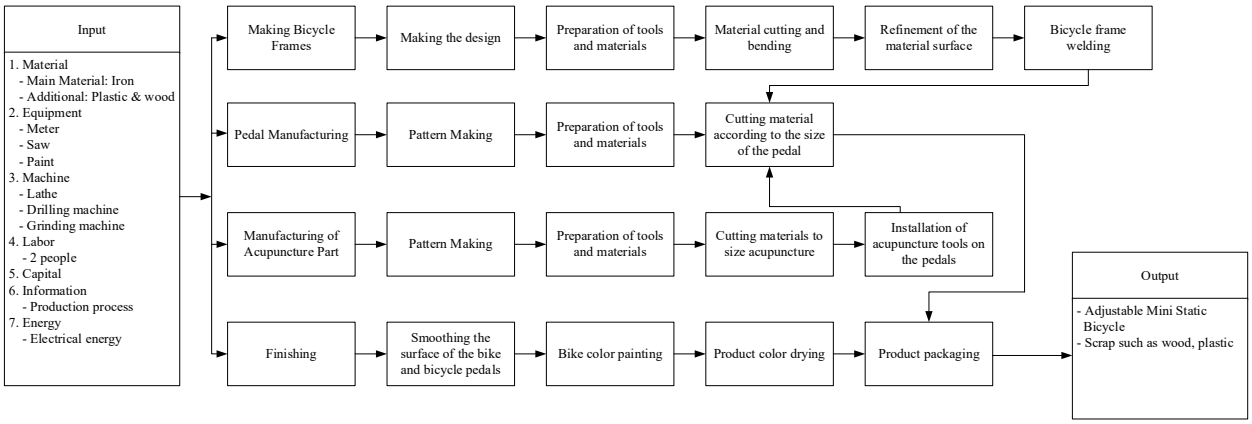

Figure 4. Adjustable Mini Static Bicycle Block Diagram

c. Limiting system in designing Adjustable Mini Static Bicycle

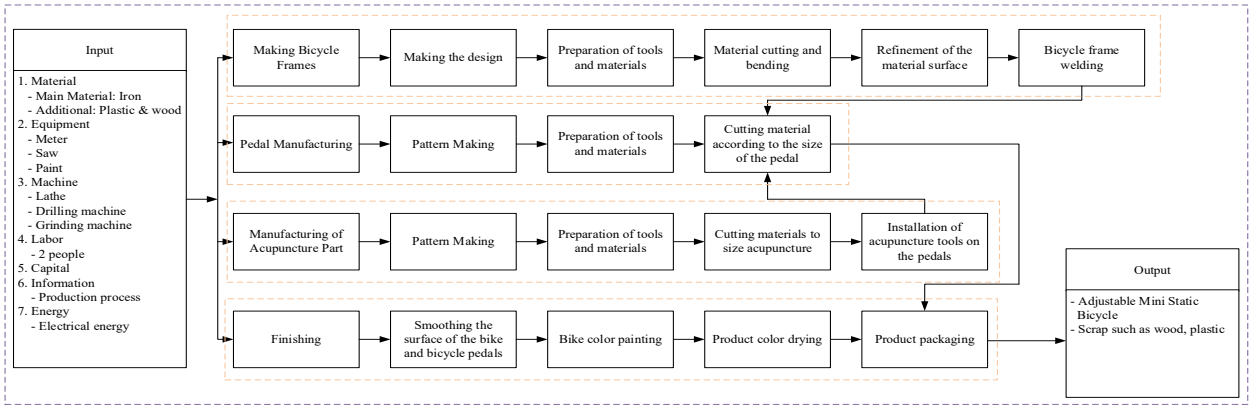

Figure 5. Adjustable Mini Static Bicycle Limiting System

d. The components needed in the implementation of the sub-functions

5.3 Determining Requirement

After the function is defined, the next step is to determine the requirement which can be seen in Table 1.

Table 1. Specifications of Adjustable Mini Static Bicycle

No.	Brainstorming Results	D /W	Consumer Desires
1.	The color of the product is black	W	The color of the product is black
2.	The product material is made of iron	W	The product material is made of iron
3.	The product dimensions are 36x38x21 cm	W	The product dimensions are 36x38x21 cm
4.	The product weight is 3 kg	W	The product weight is 3 kg
5.	The usage is to train muscles and nerves	W	The usage is to train muscles and nerves
6.	The battery type is button cell	W	The battery type is button cell
7.	The energy capacity is 270 mAH	W	The energy capacity is 270 mAH
8.	An additional feature with an adjustable height up to 60 cm	D	An additional feature with an adjustable height up to 55 cm
9.	An additional feature for the acupuncture is made of plastic	D	An additional feature for the acupuncture is made of wood
10.	An additional feature material for hanger is made of plastic	D	An additional feature material for hanger is made of iron

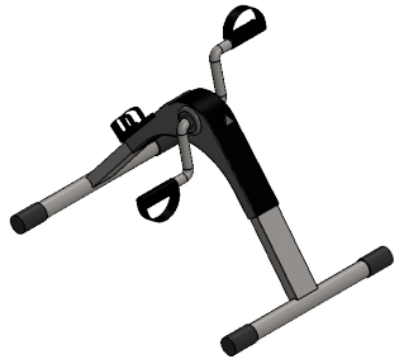

Figure 6. Adjustable Mini Static Bicycle Product

5.4 Determining Characteristic

House of Quality (HoQ) is used by translating customer needs or requests, based on market research and data benchmarking, it must be met on new product design. HoQ is a frame work that applied on Quality Product Deployment (QFD). QFD of Adjustable Mini Static Bicycle can be seen in Figure 7.

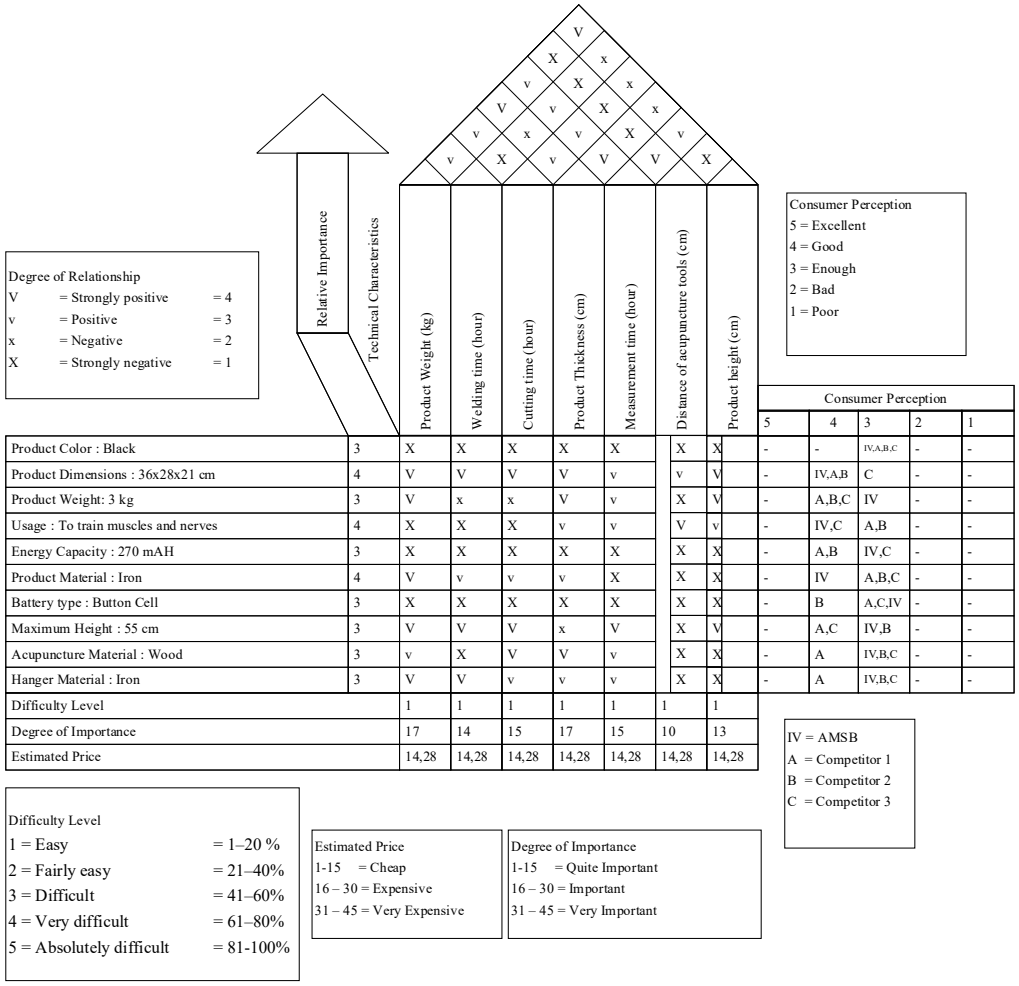

Figure 7. Quality Function Development (QFD) Adjustable Mini Static Bicycle Product

From the Quality Function Development (QFD) Adjustable Mini Static Bicycle we can conclude from the difficulty level, degrees of importance, and estimated cost, the most priority technical characteristics from the customer are product weight and product thickness with the value of difficulty levels are 1, the degrees of importance are 17 and the estimated costs are 14,28.

5.5 Generate Alternative

Generating alternatives can be used to achieve solutions to design problems that are applied as alternative choices from Adjustable Mini Static Bicycle products and the area of finding solutions will be expanded using the Morphological Chart.

Table 2. Morphological Chart Adjustable Mini Static Bicycle

No.	Characteristics	How to Achive the Functions		
		1	2	3
1.	Product Color	Purple	Black	Blue
2.	Product Dimensions	36x38x21cm	34x35x18cm	35x36x24cm
3.	Product Weight	4 kg	3kg	4,5 kg
4.	Product Usage	For exercising	Used as therapy tool	Train muscles and nerves
5.	Energy Capacity	250 mAH	270 mAH	280 mAH

6.	Product Material	Iron	Wood	Plastic
7.	Battery Type	AAA battery	Button cell	AA battery
8.	Maximum Height	55 cm	60 cm	65 cm
9.	Acupuncture Material	Steel	Wood	Iron
10.	Hanger Material	Wood	Plastic	Iron

From the morphological chart there are 3 alternatives on achieving function in Adjustable Mini Static Bicycle product for comparation using AHP and get an alternative evaluation by using gantt chart for the product alternatives.

5.6 Evaluate Alternative

In this section, a gantt chart was made for the Adjustable Mini Static Bicycle product using the AHP approach. Here is a comparative value profile of Adjustable Mini Static Bicycle and alternative 1

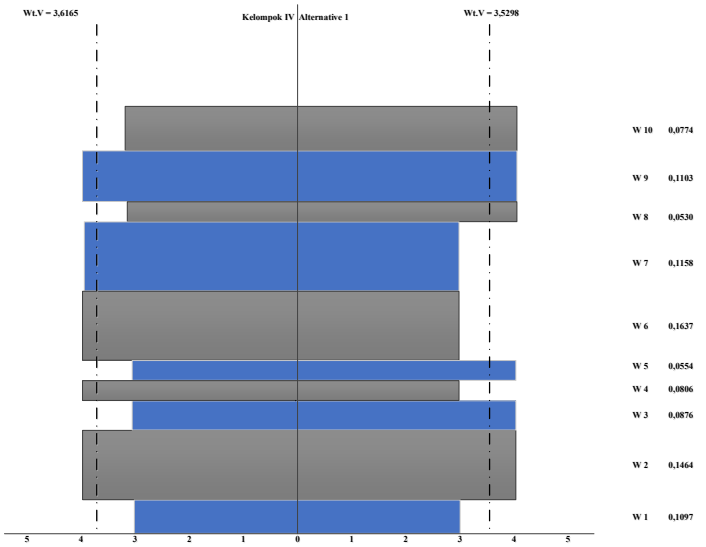

Figure 8. Comparative Value Profile of Adjustable Mini Static Bicycle and Alternative 1

From the comparative value profile of Adjustable Mini Static Bicycle and alternative 1, we can conclude that the largest weight is for attribute is found in W6, namely product material. While the smallest weight is W8, which is the maximum height.

5.7 Detailing Improvements

The selection of components that will be used in the tool assembly process or tool production is carried out along with the price of each component that makes up the product. The price obtained is the result of a survey directly in the market. The following are the repair details of the Adjustable Mini Static Bicycle

Table 3. Price Evaluation Results of Components to be Used

Component	Component Price (Rp)	Number of Components Needed	Total Price (Rp)
Iron	IDR 27.500/m	5 m	IDR137.500
Silicone	IDR 72.0000/10kg	2 kg	IDR 14.400
Wood	IDR 31.500/120x20cm	100 x 20 cm	IDR 31.500
Button cell	IDR 3.700/pc	1 pc	IDR 3.700
Spray Paint	IDR 65.000/pc	2 pc	IDR 130.000
Total			**IDR 317.100**

An alternative to Adjustable Mini Static Bicycle product is to replace components with other brands or other types at a very low cost, but the specifications and the quality are the same as the previous components. Then the best alternative is the second alternative with a total cost of IDR 317.100.

The solution taken in this design is the Adjustable Mini Static Bicycle has black colour product, product dimensions are 36x38x21 cm, product material is iron, product weight is 3 kg, used for training muscles and nerves, product uses button cell battery, with energy capacity 270 mAH, adjustable height up to 55 cm, additional acupuncture feature, additional hanger feature, and the price to be spent in the product design process is IDR 317.100.

6. Conclusion

The design process of a product to be produced must be able to fulfill several aspects, especially if the product will be used for human needs. Among them are aspects of ergonomics, *raw material aspects*, safety and environmental aspects. In addition to paying attention to ergonomic size and consumer desires, product design must also pay attention to strength and safety when used, so that it can be better than previous designs and can minimize the weaknesses of existing designs. From the Quality Function Development (QFD) Adjustable Mini Static Bicycle we can conclude from the difficulty level, degrees of importance, and estimated cost, the most priority technical characteristics from the customer are product weight and product thickness with the value of difficulty levels are 1, the degrees of importance are 17 and the estimated costs are 14,28. The solution taken in this design is the Adjustable Mini Static Bicycle has black colour product, product dimensions are 36x38x21 cm, product material is iron, product weight is 3 kg, used for training muscles and nerves, product uses button cell battery, with energy capacity 270 mAH, adjustable height up to 55 cm, additional acupuncture feature, additional hanger feature, and the price to be spent in the product design process is IDR 317.100.

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