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# Cushion seat design on manual wheelchair for people with paralysis using value engineering method to improve activity comfort: A preliminary study

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**Abstract.** Many people with paralysis feel discomfort in their activities on wheelchair. Assistive device which can increase comfort is cushion seat wheelchair, but cushion seat with special specification for people with paralysis has high prices. This research is a preliminary study to design alternative cushion seat which comfortable and affordable price for manual wheelchair using value engineering method. There are three criteria and eight subcriteria were raised which were processed by Analytical Hierarchy Process (AHP). Three subcriteria were selected for the priority of requirement design, there is user's maneuver support as selected subcriteria 1 weighing 0.64221, lumbar protection as selected subcriteria 2 weighing 0.72054 and suitability of cushion seat material to maintain the gluteal temperature as selected criteria 3 weighing 0.83333. Based on selected subcriteria, three alternative designs were raised which were processed with AHP. Selected alternative is cushion seat with backrest, foam and gel modification which were measured based on selected subcriteria that selected subcriteria 1 weighing 0.70536, selected subcriteria 2 weighing 0.68032, selected subcriteria 3 weighing 0.74084.

## 1. Introduction

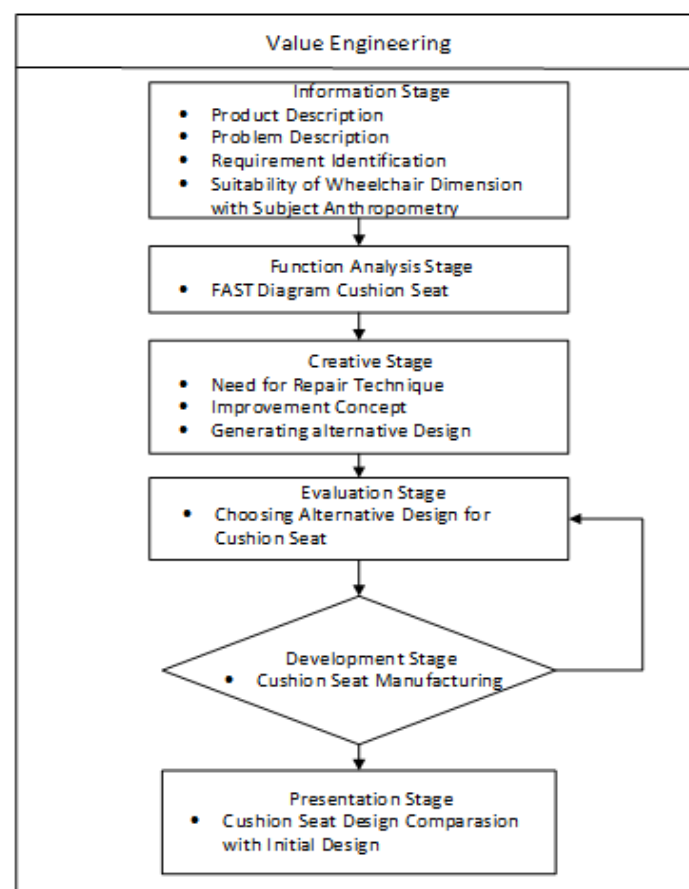
Mobility or mobilization is the ability of individuals to move freely, easily and healthy [1]. Mobilization of a person transitions namely lifestyle, disease, culture, energy level, and age [2]. The condition of a person who changes physical limitations called immobility. Individuals who add immobility consist of the elderly, individuals with diseases lower than 3 days or more, individuals who prefer anatomic functions due to physiological changes (loss of motor function, stroke, and wheelchairs), use external devices and use displacement [3]. Individuals who transcend mobility are not able to carry out independent activities and have a dependence on others as in the budget [4]. Impaired physical mobility in a person such as lower-limb paralysis. Paralysis is a condition in which a person reduces his ability to move one or more bodies, temporarily and permanently. Paralysis can occur completely. The type of paralysis that becomes two, total paralysis which is paralysis that is released is nothing at all in the muscle and partial paralysis which is paralysis where the muscle can still be moved properly or weakly [5]. Everyone who needs the help of a car (aids) that can support daily activities. Auxiliary devices are tools that can support activities if there are people who are disabled, injured or people who have started further [6]. In general, many tools used in the form of wheelchairs, to support the activities of someone who adds paralysis. It is necessary to help assist with



assistive technology that is tailored to the needs of users to improve the ability of disabled people [7]. Wheelchairs as a tool that is used to improve the mobility of someone who has a deficiency, such as people who experience physical difficulties (people with lower-limb paralysis), hospital patients who are not able to do many activities, the elderly and people who have a high risk of being injured, if they walk alone [8]. The type of wheelchair that is widely used by people with paralysis in Indonesia is a manual wheelchair. 70% of wheelchair users ask for freedom of activity both inside and outside the room without the presence of a companion, although this activity is not easy. Terms of a wheelchair for paralysis mobility can be viewed from aspects of comfort, speed, and security [8]. The paralyzed comfort was determined in three dimensions namely wheelchair cushion, user posture cushion (user posture stability) and pressure release maneuver (pressure relief maneuver) in the gluteal muscle [9]. The comfort placed on firmness for wheelchair cushion, height for user safety posture, and coolness for gluteal pressure release maneuvers. According to the study involving 200 paralyzed respondents using wheelchairs, seat discomfort (seat discomfort) in gluteal was 57% and back discomfort (back discomfort) in the lumbar was 43% [10]. This preliminary research was conducted to get a wheelchair for people with disabilities at Balai Besar Rehabilitasi Sosial Penyandang Disabilitas Fisik (BBRSPDF) Prof. Dr. Soeharso Surakarta. The subjects were involved as many as 6 people to determine the magnitude of the influence of the wheelchair pads, posture position and pressure release maneuver on gluteal. This was done to learn some of the ways to implement assistive technology in the comfort of the design of seat cushions installed in wheelchairs.

## 2. Methodology

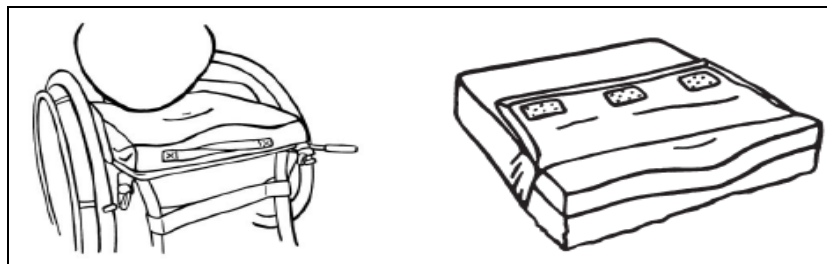
This cushion seat research used Value Engineering Method. Value engineering method flowchart which is used for cushion seat design in Figure 1.



**Figure 1.** Value engineering method for cushion seat design.

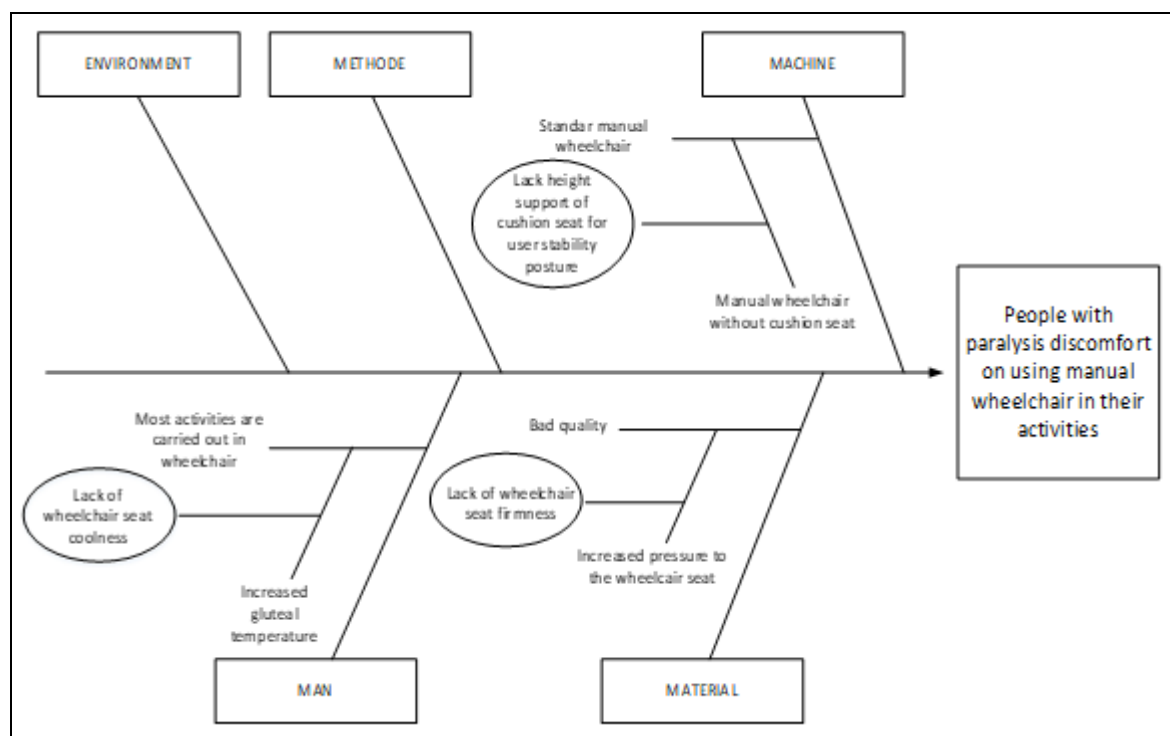
## 2.1. Information stage

**2.1.1. Product description.** World Health Organization (2008) explains that the cushion seat is part of a wheelchair in the form of seat cushion for wheelchair users. Its main function is the convenience of the wheelchair user. Seat cushion can provide comfort for a long time. The shape of the cushion seat attached to the wheelchair is explained in Figure 2.



**Figure 2.** Basic cushion seat.

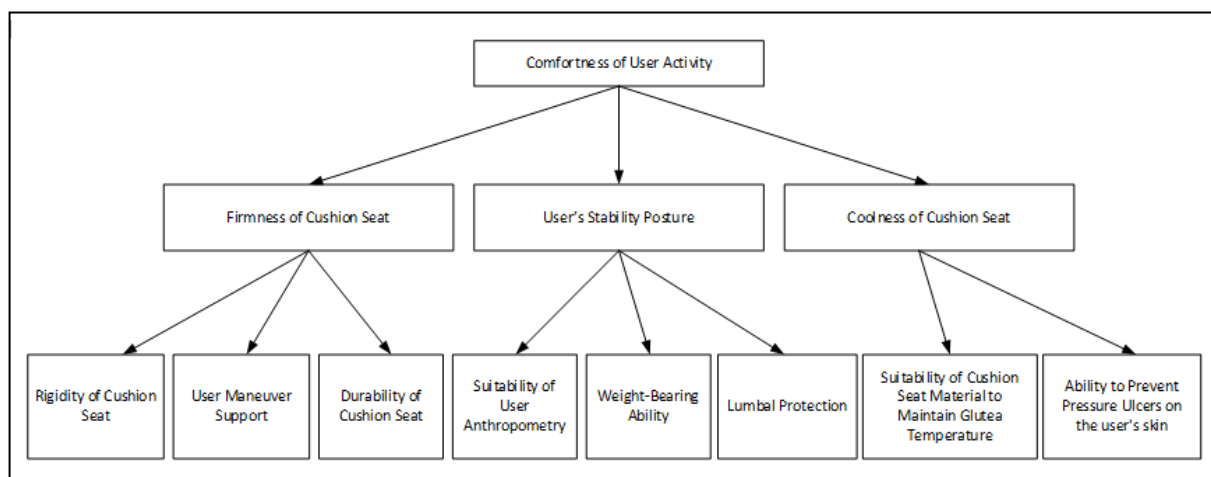
**2.1.2. Problem description.** The problem description is explained in cause effect diagram/ fishbone diagram. Cause effect diagram is explained in Figure 3.



**Figure 3.** Cause effect diagram.

Cause effect diagram or ishikawa diagram is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes. Discomfort of people with paralysis in their activities on manual wheelchair is the effect. While, lack of stability posture support in wheelchair seat, lack of coolness from wheelchair seat, and lack of firmness from wheelchair seat is the cause. So that, the background of the problem is how to design cushion seat on manual wheelchair for people with paralysis.

*2.1.3. Identification user design requirement.* The identification user design requirement use questionnaire with participatory method. This method is used because of the heterogeneous data which be processed in this research. This study began by submitting user requests through questionnaires distributed to a user of paralysis of manual wheelchair, a physiotherapist, and a manufacturer. The way to determine user needs through participatory questionnaires about the comfort of wheelchairs [10]. Initial observations, the subject complained of pain in the lumbar and glutea, repairing compressive wounds (pressure ulcers incident) in gluteal. The criteria proposed in the questionnaire. After that, an analysis and description of the requirements of cushion seat on manual wheelchair for people with paralysis. Goal, criteria and sub criteria is explained in Figure 4.



**Figure 4.** Goal, criteria, and sub criteria hierarchy.

Value Engineering (VE) is a management effort in analysing a problem on a project through a systematic and organized study to get the desired function, namely with optimal results, still managed for the creation, quality, and maintenance of the project. To obtain maximum results in an effort to save, the values of the work must be determined and returned first, which is used as a reference in the design of alternative designs. In terms of designing the cushion seat, it is expected to produce cushion seat products that have better performance and lower costs than previous cushion seat products. This solution is for many people with paralysis can not get cushion seat because of high prices.

The initial stage of VE is information stage. Starting from the results of identification of user needs generated. at this stage the anthropometric measurements of the subject were paralyzed by wheelchair users and wheelchair dimension measurements have been determined. Identification user with participatory questionnaire is processed with Analytical Hierarchy Process (AHP) method. Analytical Hierarchy Process (AHP) for select criteria is explained in Table 1.

There are criteria and sub criteria selected based on the biggest weight in Table 1. The selected sub criterias are user's maneuver support in firmness criteria, lumbar protection in user stability posture and suitability of cushion seat material to maintain glutea temperature in coolness criteria. The selected criteria and sub criteria are the focus of improvement.

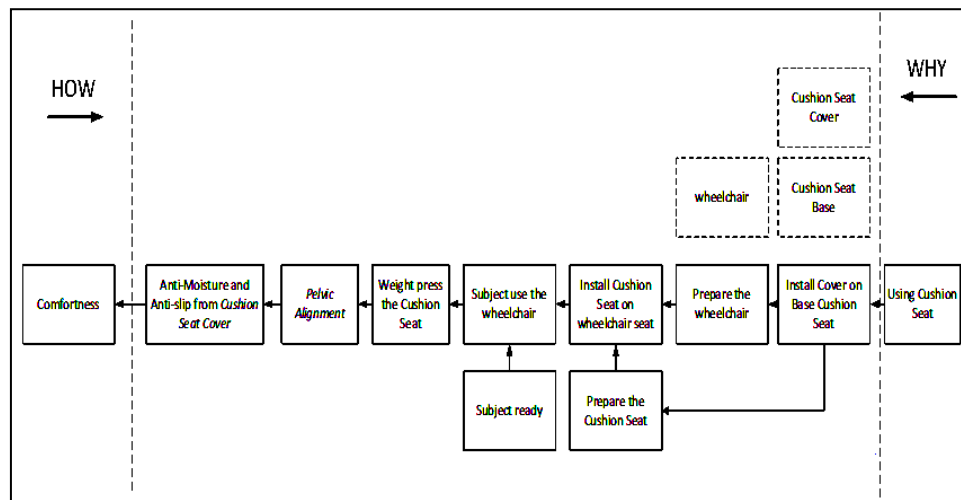
**Table 1.** Criteria and sub criteria weight.

Criteria	Weight	Sub criteria	Weight
Firmness of Cushion Seat	0.099906593	Rigidity of Cushion Seat	0.111754806
		User Maneuver Support	0.642210185
		Durability of Cushion Seat	0.246035009
User's Stability Posture	0.512980596	Weight-Bearing Ability	0.170704712
		Weight-Bearing Ability	0.1087497
		Lumbal Protection	0.720545589
Coolness of Cushion Seat	0.387112811	Suitability of Cushion Seat Material to Maintain Glutea Temperature	0.833333333
		Ability to Prevent Pressure Ulcer on the User's skin	0.166666667

*2.1.4. Suitability of wheelchair dimension with subject's anthropometry.* Wheelchair dimension and subject anthropometry is obtained in secondary data, such as cushion seat initial design and anthropometry data for people with paralysis [11]. The data is used to basic theory to define cushion seat's dimension which suitable for subject and wheelchair. So that the dimension is 40x40 centimetres.

## *2.2. Function analysis stage.*

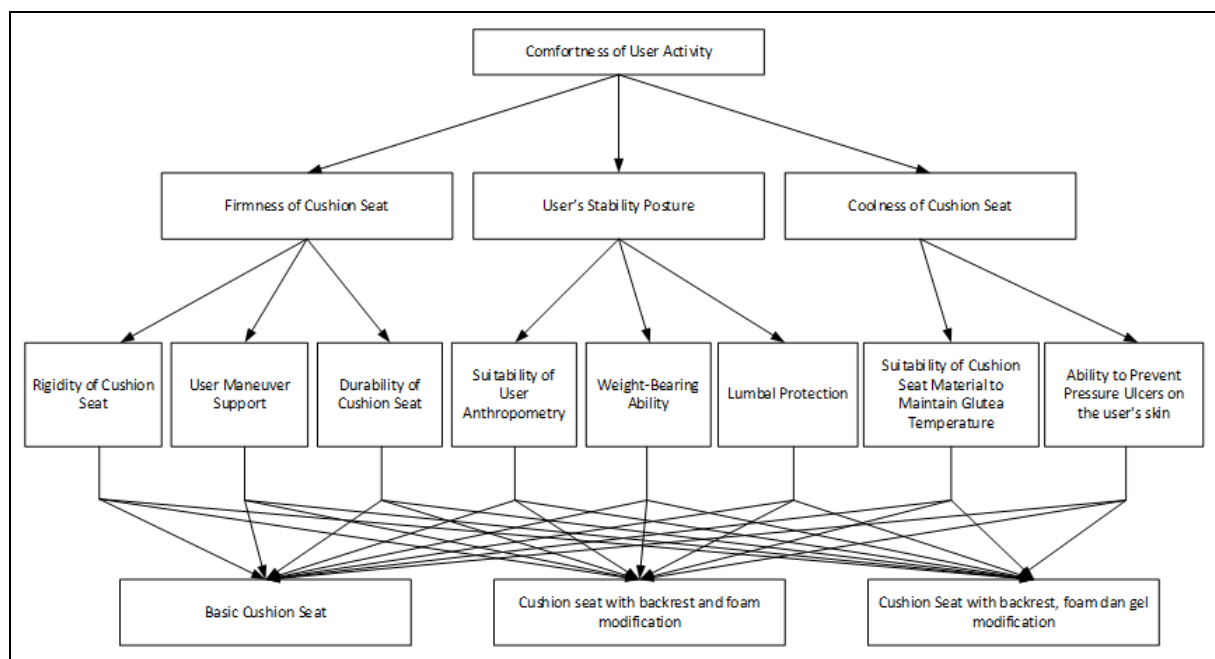
Function analysis stage is viewed Function Analysis System Technique (FAST) Diagram from cushion seat. FAST Diagram is explained in Figure 5.



**Figure 5.** FAST diagram of cushion seat.

### 2.3. Creative stage.

Creative stage generated the alternative design which is explained in Figure 6.



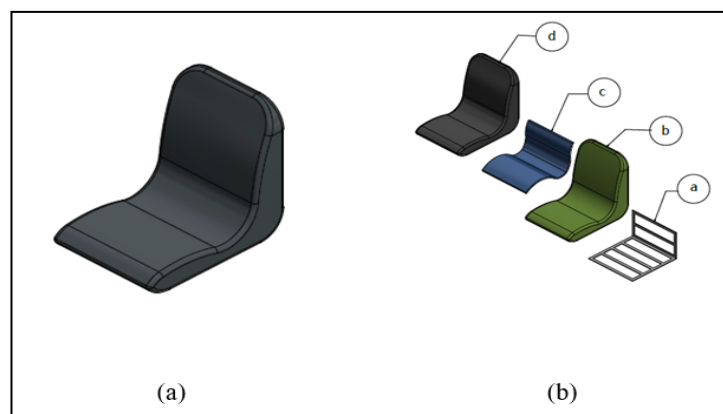
**Figure 6.** Alternative design of cushion seat.

Based on criteria and sub criteria weight, there are three selected sub criteria with highest criteria weight. The selected bicriteria's are user maneuver support in firmness of cushion seat criteria, lumbar protection in user's stability posture criteria, suitability of cushion seat material to maintain glutea temperature. The selected sub criteria are used to choose alternative design, there are standard cushion seat, cushion seat with backrest and foam modification, and cushion seat with backrest, foam and gel modification. Analytical Hierarchy Process (AHP) for select alternative design in Table 2.

**Table 2.** Alternative design weight in selected sub criteria.

		Subject Characteristics		
Alternative Design	Criteria	User Maneuver Support	Lumbal Protection	Suitability of Cushion Seat Material to Maintain Glutea Temperature
	Standard Cushion Seat	0.122633634	0.099851135	0.096282995
	Cushion Seat with Backrest and Foam Modification	0.171997785	0.219828351	0.162869564
	Cushion Seat with Backrest, Foam, and Gel Modification	0.705368581	0.680320514	0.740847441

Cushion seat with backrest, foam, and gel modification is selected as alternative design. The selected alternative design need dimension based on user anthropometry and manual wheelchair dimension in the further study. The selected design is explained in Figure 7.

**Figure 7.** The representation of selected alternative design.

The selected of alternative design for cushion seat is consist of frame (a), body (b), colling gel (c), backrest (d). This design is expected to resolve the problem so that the subject get the comfortness for activity in manual wheelchair.

The next step was evaluating the design and development of products with cushion seat support for manual wheelchair users. Value engineering final hangover is comparing chair cushion products that have been supported with existing products (Standard Cushion Seat) in Figure 8 [12].





**Figure 8.** Jay basic cushion seat.

### 3. Conclusions

This preliminary study for cushion seat design with several things discussed. In the cause-effect diagram, it is explained that the problem that arises is the discomforts of people with paralysis in wheelchair users in their activities. User requirements were studied and found that the main causes included, lack of stability posture support in wheelchair seat, lack of coolness from wheelchair seat, and lack of firmness from wheelchair seat. Based on the participatory questionnaire which involves a people with a paralysis wheelchair user, a physiotherapist, and a manufacturer, criteria and sub criteria are determined. The alternative design for the cushion seat is also determined with the Analytical Hierarchy Process (AHP) Method. The selected sub criteria are user maneuver support in the firmness of cushion seat criteria, lumbar protection in user's stability posture criteria, the suitability of cushion seat material to maintain gluteal temperature. Three sub criteria were selected for the priority of requirement design, there is user's maneuver support in firmness criteria as selected sub criteria 1 weighing 0.64221, lumbar protection in user stability posture as selected sub criteria 2 weighing 0.72054 and suitability of cushion seat material to maintain the gluteal temperature in coolness criteria as selected criteria 3 weighing 0.83333. The selected sub criteria are used to choose an alternative design. Based on selected sub criteria, three alternative designs were raised which were processed with AHP and an alternative is cushion seat with backrest, foam and gel modification which were measured based on selected sub criteria that selected sub criteria 1 weighing 0.70536, selected sub criteria 2 weighing 0.68032, selected sub criteria 3 weighing 0.74084. So, the selected alternative design is cushion seat with backrest, foam and gel modification. From this article, the major finding is the cushion seat design of a wheelchair for people with paralysis. Evaluation, development and presentation stage need further study.

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